CHAPTER 4

THEORY

38. Introduction

a. This chapter will aid the repairman in understanding the functions of certain circuits which may be slightly unconventional or appear complex in the complete schematic. With this knowledge, trouble shooting will be made easier and the repair work will be done more efficiently.

b. Radio Receiver R-274/FRR is of the superheterodyne type, having a frequency range of 540 kc to 54 mc. From 540 kc to 7 mc, it is a single superheterodyne receiver with a 455-kc intermediate frequency. From 7 mc to 54 mc, it is a double superheterodyne receiver, having both 6 mc and 455-kc intermediate frequencies. Provision is made for six crystal-controlled h-f oscillator frequencies from 1.5 mc to 29.7 mc.

c. An output terminal strip is included to which either one or more external speakers can be connected. There is also a jack for plugging phones into the output. Neither speakers nor phones are included with the basic equipment.

d. This receiver uses two stages of r-f amplification, one stage of 6-mc i-f amplification, three stages of 455-kc i-f amplification, and two stages of a-f amplification. It is capable of receiving and detecting both a-m waves and icw. Output from the 455-kc intermediate frequency is provided for use with other communications equipment, such as radioteletype, when necessary.

39. Block Diagram

(fig. 13)

a. The signal path through Radio Receiver R-274/FRR is shown in the block diagram (fig. 13). Study this block diagram and fix in mind the sequence of stages through which the incoming signal will pass before it reaches the output terminals.

b. The signal from the antenna is coupled to the 1st r-f amplifier (V1) through antenna transformer T6. After amplification, it is impressed on the grid of the 2d r-f amplifier (V2). The use of two pentode stages of r-f amplification gives sufficient gain for a good signal-to-noise ratio, and also provides for the maximum image and i-f rejection ratios. From the 2d r-f amplifier (V2), the signal goes to the 1st mixer (V3) where it is combined with the signal from either the vfo (V4) or crystal h-f oscillator V5, depending on the position of the VFO CRYSTAL switch. In the signal frequency range of 540 kc to 7 mc, the frequency of the vfo is always 455 kc higher than the signal frequency, so that the output of the 1st mixer (V3), which is the result of the combination, contains a 455-kc signal. This signal goes to the grid of the 1st 455-kc i-f amplifier (V9). From the frequency range of 7 mc to 54 mc, a better image rejection ratio can be obtained if the intermediate frequency is increased. Therefore, in this frequency range, the vfo is always 6 mc above the signal frequency. Thus, the output of the 1st mixer (V3) (in which the signal and the output of the vfo are combined) contains a 6-mc signal.

c. When the receiver is tuned to a frequency in the range of 7 mc to 54 mc, the i-f switch-over relay (K1) feeds the 6-mc output of the 1st mixer (V3) to the grid of the 6-mc i-f amplifier (V6) where it is amplified and where sufficient selectivity is provided to give a high degree of image rejection. However, more amplification and greater selectivity are required before detection. Therefore, the output of the 6-mc i-f amplifier (V6) goes to the 2d mixer (V7). The output of a 6.455 mc crystal-controlled oscillator (V8) also is injected into this 2d mixer (V7). As a result of the combination of these two signals, the output of the 2d mixer (V7) contains a 455-kc signal. This output then is fed through the i-f switch-over relay (K1) to the grid of the 1st 455-kc i-f amplifier (V9) for further amplification. Note that when the receiver is tuned to a signal in the frequency range from 540 kc to 7 mc, the output of the 1st mixer (V3) goes directly to the grid of the 1st 455-kc i-f amplifier (V9) so that when the signal reaches this point, the operation

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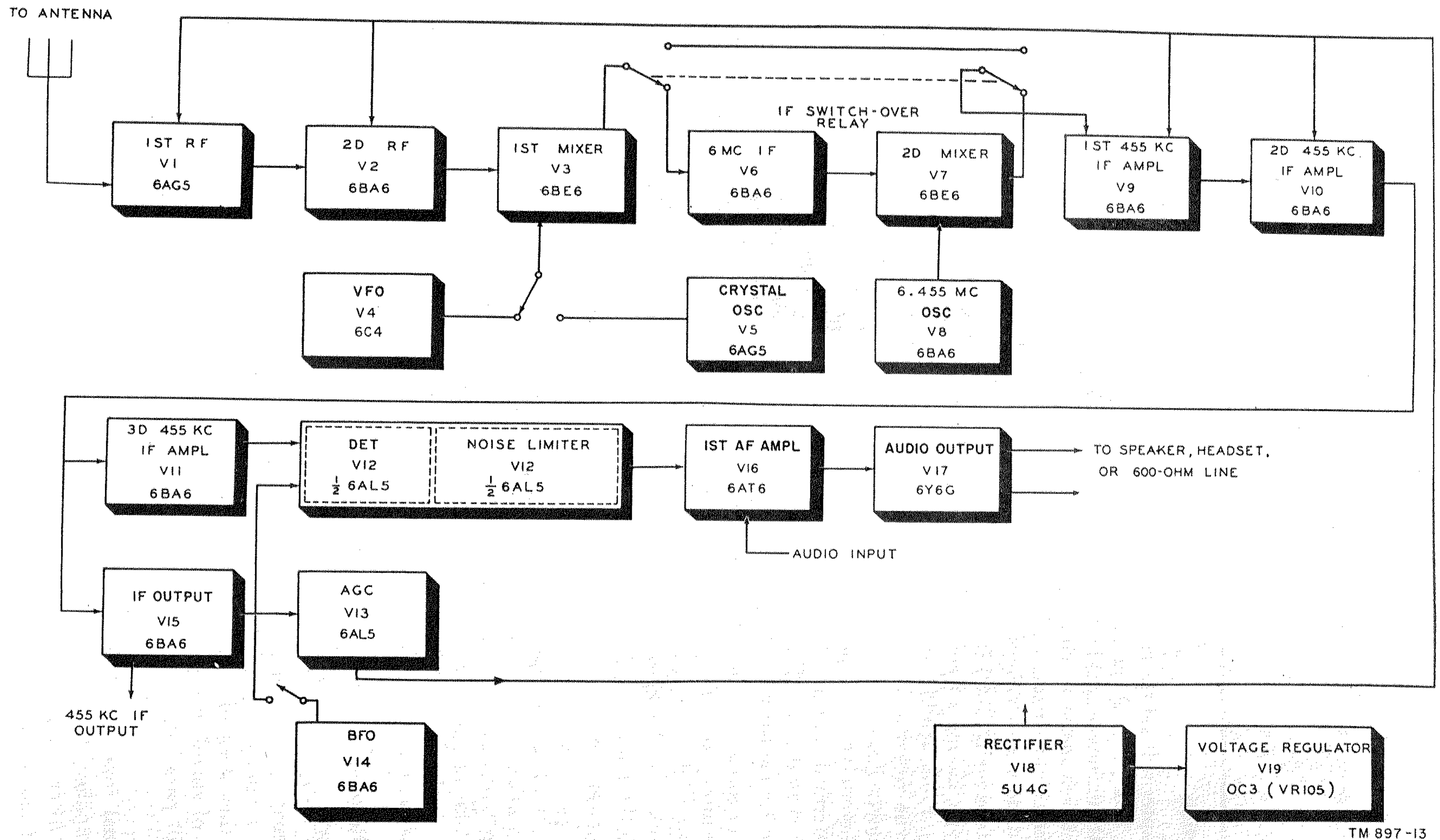


Figure 13. Radio Receiver R–274/FRR, block diagram.

is the same regardless of the frequency to which the receiver is tuned.

d. The 455-kc signal which goes to the 1st 455-kc i-f amplifier (V9) is amplified successively by the 1st (V9), 2d (V10), and 3d (V11) 455-kc i-f amplifier stages which provide the proper degree of selectivity. Provision has been made for variation of this selectivity according to the requirements at hand.

e. After it has passed through the 3d 455-kc i-f stage (V11), the amplified signal is sent to the audio detector (½ of V12) where it is demodulated and fed into the 1st a-f amplifier (V16). The output of V16 is coupled to the a-f output stage (V17) which amplifies the signal with power enough to actuate headphones or speakers, or to feed a 600-ohm audio transmission line. The noise limiter (½ of V12) can be switched in between the audio detector (½ of V12) and the 1st a-f amplifier (V16) when the reduction of static pulses or other electrical disturbances is desirable.

f. In order to have a good agc system without causing audio distortion, an agc duo-diode (V13) is connected in such a position in the circuit that it is isolated from the normal signal channels. The output of the 2d 455-kc i-f amplifier stage (V10) is transformer-coupled to the grid of the 3d 455-kc i-f amplifier stage (V11) and also to the grid of the i-f output stage (V15). The output of this tube, which couples into the agc system, also is isolated from the normal signal channel. The agc tube (V13) couples the negative bias, which the operator selects with the RF GAIN-AC control (R83), to the control grids of tubes V1, V2, V9, and V10. The rectified i-f signal superimposes additional negative voltage on the grid input circuit when a strong signal is tuned. The stronger the incoming signal, the greater the negative bias. Conversely, a small signal strength allows the over-all amplification to be greater. This produces a self-balancing arrangement in which the audio output voltage is held fairly constant even though the r-f signal strength varies greatly from station to station.

g. In order to hear c-w signals, a bfo (V14) is used. It generates a signal which is combined with the i-f signal at the audio detector (½ of V12) which detects both to produce an audio beat note which is amplified by the audio amplifiers (V16 and V17). The frequency of bfo V14 can be varied slightly above and below 455 kc to give the most effective audio note. During the silent periods between transmitter pulses, no 455-kc signal will be present at the detector input, and no beat note will be sent through the audio stages.

h. Some communication equipment, for example radioteletype, with which Radio Receiver R–274/FRR can be used, requires i-f output facilities. To give this service, a separate i-f amplifier stage (V15) has been provided. The signal from the 2d 455-kc i-f amplifier (V10) goes to the grid of V15 where it is amplified. The output is transformer-coupled to a low-impedance level so that it can be connected by coaxial cable to the external equipment. The i-f output stage also furnishes a signal to the agc circuit (*f* above).

i. A meter (M1) is provided to help in tuning and to give an approximate indication of the relative strength of the incoming signal. The meter circuit measures the voltage in the agc circuit when the AGC-MANUAL switch is in the AGC position. The meter circuit is not connected when the switch is in the MANUAL position. The amount of current through the meter is proportional to the average magnitude of the incoming signal.

j. The receiver operates from an a-c source (50 to 60 cycles) only. Source voltages of 95 through 260 volts can be used by the selection of the proper tap on the power transformer (T34). Rectifier tube V18 is a full-wave rectifier which supplies d-c plate power to the other tubes in the receiver. V19 is a regulator tube which provides constant plate voltage (regardless of the normal power source voltage fluctuations) to the critical circuits. Resistor R80 (ballast tube) provides constant filament voltage.

Note. Figures 14 through 20 are keyed to paragraphs 40 through 48 and assume operation with the turret switch in BAND VI. These connections are typical of operation in BAND VI or V and may be construed as typical of operation in BAND I, II, or III, except that the i-f switch-over relay (K1) is not actuated and the 6-mc strip (V6, V7, and V8) does not operate for BAND I, II, or III. By assuming operation in BAND VI, the theory of operation within the 6-mc strip may be included logically.

40. 1st R-F Amplifier

(fig. 14)

a. The r-f amplifiers must operate over the entire frequency range of the receiver. Because of the wide frequency range, a band selection arrangement must be used. This is accomplished by use of a four-section, six-position turret which makes

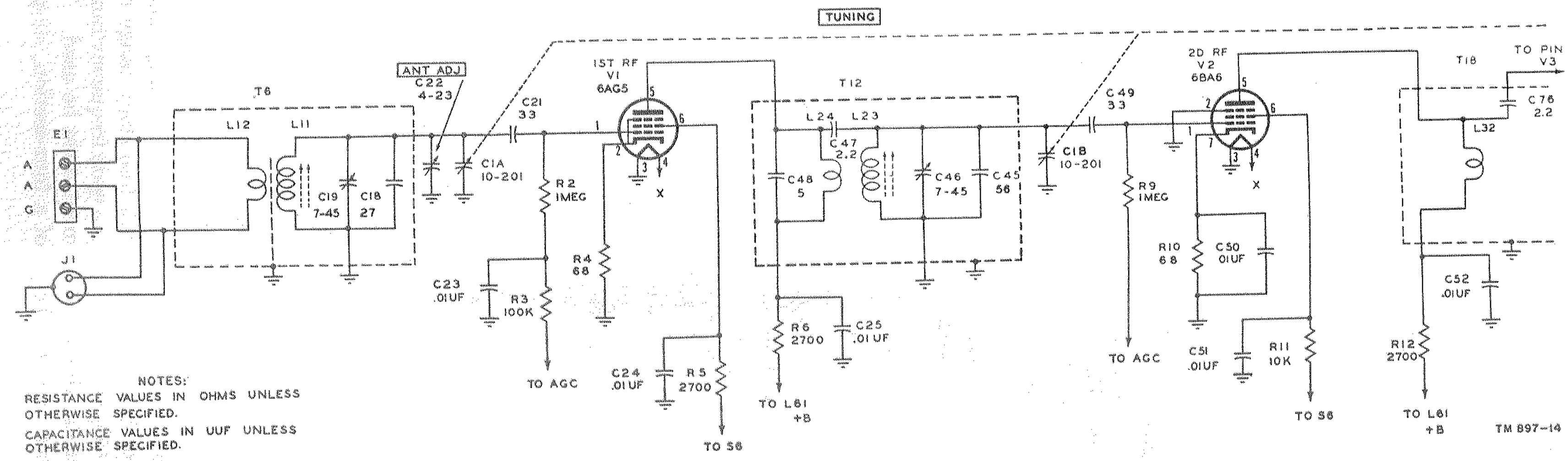


Figure 14. Radio Receiver R-274/FRR, functional diagram of 1st and 2d r-f amplifier.

all r-f and vfo coils easily available. All positions of this turret are shown in the complete schematic of figure 43, and one position corresponding to BAND VI is shown in figure 14.

b. In the partial circuit diagram of figure 14, it can be seen that the coupling of the antenna to the 1st r-f stage is through r-f transformer (T6) when the turret switch is in the BAND VI position. Note that the low-impedance (50-200 ohms) primary winding of T6 is designed to connect to a balanced, spaced-pair, twin-conductor, coaxial transmission line. The primary winding also is designed so that an unbalanced, single-conductor coaxial transmission line or single-wire lead-in from an antenna can be used by connecting terminal G of E1 to ground and the antenna lead to terminal A of E1. Capacitor C22 (ANT ADJ) is a front panel adjustment which compensates for variable antenna characteristics that cause detuning of the antenna input transformer. The secondary of T6 is tuned by capacitor C1A, and the signal is coupled to V1 by capacitor C21. Capacitors C18 and C19 limit the highest frequency to which the secondary of transformer T6 will tune. Tracking at the high end of the band is accomplished by adjustment of C19. Tracking at the low end of the band is made possible by means of the adjustable powdered-iron core inside transformer T6. Resistor R2 feeds agc voltage to the grid of V1. Resistor R3 and capacitor C23 form a filter which prevents any r-f or i-f signals of other amplifier stages from getting into the grid circuit of V1 through the agc line. R4 is the cathode resistor of V1 which limits its cathode current to a safe value when no agc voltage is being developed. Resistor R5 aids in decoupling the screen of V1, and capacitor C24 bypasses the screen to ground at the radio frequencies. Note that no screen voltage is applied when switch S6 is in the SEND position (fig. 29). In figure 43, resistor R1 is connected to a pair of turret contacts. These contacts are arranged so that R1 is connected across antenna transformer T5 (which is the BAND V transformer) when the turret is in the BAND VI position. This is to prevent any interaction between the transformer in use and the transformer for the next lower frequency band.

c. The output of the 1st r-f amplifier (V1) goes to the primary of r-f transformer T12. The low side of this primary winding is connected to +B through resistor R6. Resistor R6, in combination with capacitor C25, forms a filter which effectively prevents any r-f or i-f signals of other amplifier stages from getting into the plate circuit of V1. V1 is a type 6AG5 pentode tube, selected to give the best possible signal-to-noise ratio in this circuit.

41. 2d R-F Amplifier

(fig. 14).

a. The circuit of the 2d r-f amplifier, when the turret switch is in BAND VI position, also is shown in figure 14. The signal from VI goes to transformer T12, the secondary of which is tuned to the signal frequency by variable gang capacitor C1B. Capacitors C45 and C46 limit the highest frequency to which T12 can be tuned. Tracking at the h-f end of the band is accomplished by adjusting of C46. Tracking at the low end of the band is accomplished by means of the adjustable powdered-iron core inside of transformer T12 to improve gain. Capacitor C47 adds capacitive coupling to the inductive coupling between the primary and secondary of r-f transformer T12. It is used to increase the gain of transformer T12 at the high end of BAND VI. If this capacitor were not used, the gain would be different at the two ends of BAND VI. Capacitor C48 resonates the primary of transformer T12 at a frequency below the lowest frequency in BAND VI, and thereby improves the image rejection ratio.

b. The signal from r-f transformer T12 is coupled to the grid of the 2d r-f amplifier (V2) through coupling capacitor C49, which prevents the agc voltage from being grounded through the secondary of T12. Resistor R9 feeds the agc voltage to the grid of V2, a type 6BA6 pentode tube. This tube can be used because the 2d r-f amplifier (V2) does not have as much effect on signal-to-noise ratio as does the 1st r-f amplifier (V1). Resistor R8 is across a pair of turret switch contacts (fig. 43) which connect to BAND V r-f transformer (T11) when the turret switch is in the BAND VI position. It eliminates any reaction between the r-f transformer in use and the transformer for the next lower frequency band. R10 is the cathode resistor for V2, which limits its cathode current to a safe value, and capacitor C50 is the cathode bypass which effectively grounds the cathode of V2 insofar as r-f signals are concerned. R11 is the screen voltage-dropping resistor for V2, and screen bypass capacitor C51 grounds any screen r-f signals. No screen voltage is applied when switch S6 is in the SEND position (fig. 43).

c. The amplified signal in the plate circuit of V2 goes to the primary of r-f transformer T18 which is connected to +B through resistor R12. Resistor R12 and capacitor C52 form a filter which prevents r-f or i-f signals in other stages from getting into the plate circuit of V2 by means of the +B lead.

42. 1st Mixer

(fig. 15)

a. The 1st mixer stage, V3, is of the electron-coupled type (6BE6) which minimizes the effect of the r-f circuits on the vfo frequency stability.

b. The signal from the 2d r-f amplifier goes to r-f transformer T18, the secondary of which is resonated to the signal frequency by capacitor C2A. Capacitors C74 and C75 limit the highest frequency to which transformer T18 will tune. Tracking at the high end of BAND VI is accomplished by adjusting capacitor C75. Tracking at the low end of BAND VI is accomplished by adjusting the powdered-iron core inside transformer T18. Capacitor C76 adds capacitive coupling between the primary and secondary of transformer T18 to make the h-f end gain of the transformer as great as the l-f end gain. Capacitor C77 resonates the primary of T18 below the lowest frequency of BAND VI to improve the image rejection ratio.

c. The signal is coupled directly to the signal grid of the 1st mixer tube (V3). No agc voltage is applied to this tube because it would reduce the frequency stability of the vfo.

d. Resistor R17 is across a pair of turret switch contacts which connect to the BAND V mixer transformer (T17). It eliminates any reaction between the mixer transformer in use and the transformer for the next lower frequency band. R18 is the cathode resistor for V3 which limits the cathode current to a safe value. Capacitor C78 is the cathode bypass which effectively grounds the cathode where r-f or i-f signals are concerned. R20 is the screen voltage-dropping resistor for V3, and capacitor C79 is the screen r-f bypass capacitor. The screen voltage source for V3 is regulated to improve the frequency stability of the vfo.

e. Resistor R19 is the vfo injection grid resistor which permits the proper operating bias to be developed on the injection grid of V3 by the vfo signal. Coupling from the vfo is accomplished through the series combination of capacitor C80 and resistor R21. Capacitor C80 prevents injection grid resistor R19 from being shorted by the vfo circuits, and resistor R21 improves the isolation between the 1st mixer tube (V3) and the vfo circuits.

f. The signal in the plate circuit of V3 is always at the intermediate frequency of the receiver, since it is the result of mixing the r-f signal and the output of the vfo. When the receiver is tuned to any frequency between 540 kc and 7 mc (BANDS I, II, and III), the output of the 1st mixer contains a 455-kc signal, and it goes to the 455-kc i-f amplifiers. However, the image rejection ratio of the receiver would be very poor if an intermediate frequency of 455 kc were used when the receiver is tuned to higher frequencies. Therefore, when the receiver is tuned to frequencies between 7 mc

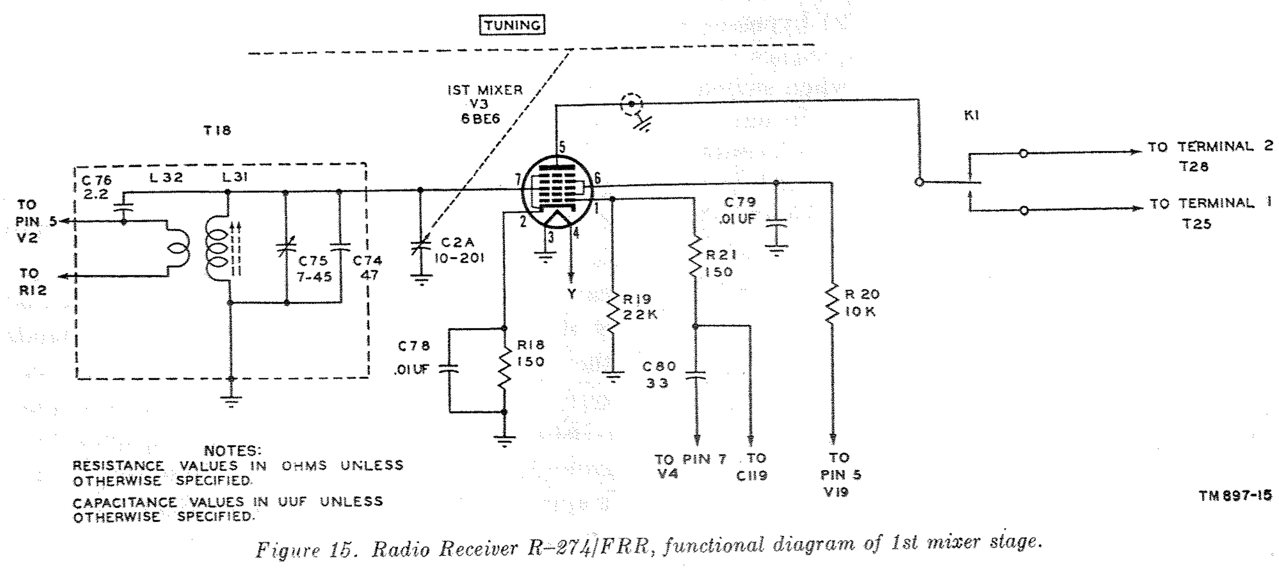


Figure 15. Radio Receiver R–274/FRR, functional diagram of 1st mixer stage.

and 54 mc (BANDS IV, V, VI), an additional i-f system is used. In these bands, the output of the 1st mixer tube (V3) contains a frequency of 6 mc which is sent to the 6-mc i-f amplifier. The switch-over is accomplished automatically by relay K1.

43. I-f Switch-Over Relay

(fig. 16)

a. Switch-over relay K1 has two sets of double-throw contacts and automatically switches the output of the 1st mixer tube (V3) into the proper i-f channel. When the receiver is operating in BAND I, II, or III, the i-f output of the 1st mixer tube (V3) is 455 kc and connections are made from the plate of the 1st mixer tube (V3) directly into transformer T28, from which the signal goes to the grid of the 1st 455-kc i-f amplifier (V9). Any signal which might be picked up in the 6-mc i-f amplifier (V6) or the 2d mixer tube (V7), or any spurious oscillation which may occur in these stages, will be shorted out because of the low-impedance ground circuit at the plate of the 2d mixer tube (V7). About −24 volts of bias is applied to the grid of the 6.455-mc oscillator (V8), and this prevents the tube from oscillating or conducting. When the receiver is operating on BAND IV, V, or VI, the i-f output of the 1st mixer tube (V3) is 6 mc, and connections are made from the plate of the 1st mixer tube (V3) to transformer T25, from which the signal goes to the grid of the 6-mc i-f amplifier (V6). A ground connection between the coil of relay K1 and the grid of the 6.455-mc oscillator (V8) removes the large bias (−24 volts) from the oscillator and allows it to operate on BANDS IV, V, and VI. The 455-kc output of the 2d mixer (V7) then is fed to transformer T28, from which it is fed to the grid of the 1st 455-kc i-f amplifier (V9).

b. The coil of relay K1 energizes when −24 volts from the main power supply of the receiver is applied. When BAND I, II, or III is in use, the −24-volt potential is applied to one terminal of the relay coil, but an open ground return at the other terminal prevents the relay from energizing. When BAND IV, V, or VI is in use, the open terminal of the relay coil is grounded directly, and the relay energizes, transferring both sets of contacts.

c. The −24 volts is produced between ground and the center tap of the plate voltage winding of the power transformer. The circuit consists of resistors R81 and R82, the series combination of R111 and R83, and R35 all connected in parallel. When the relay coil is switched into the circuit (energized), the coil replaces resistor R35 in the circuit, and R35 is open-circuited.

d. Four coaxial cables are involved in the i-f switching arrangement. One connects the output of the 1st mixer (V3) to the relay contacts. A second cable connects the output of the 2d mixer (V7) to the relay contacts. A third cable connects the output of the relay contacts to the 1st 455 kc i-f transformer (T28). A fourth cable connects the output of the 1st mixer at the contacts of relay K1 to the primary of 6-mc transformer T25. Each of these four cables has its shield grounded at one end only to prevent undesirable ground currents which would interfere with normal circuit operation.

44. Variable-Frequency Oscillator

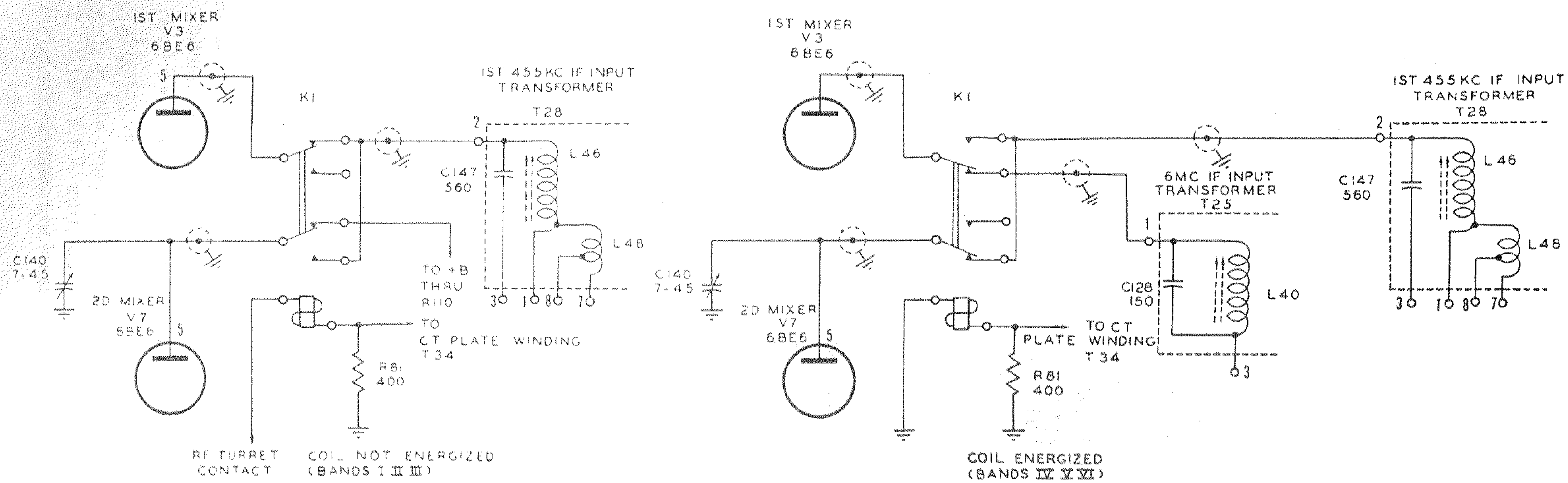
(fig. 17)

a. A partial schematic showing the vfo connected in BAND VI is shown in figure 17. A type 6C4 tube (V4) is used in a Hartley oscillator circuit. The grid of the tube is connected to a tap on the oscillator transformer to improve the frequency stability, on all bands except V and VI. On bands V and VI, the grid is connected to the high, or *hot*, end of the oscillator transformer. R27 is the grid resistor which develops operating bias for the tube. Resistor R27 is bypassed by capacitor C111 at radio frequencies.

b. The cathode of the vfo tube (V4) is connected to the tap of the oscillator coil, and the low end of the coil is grounded through a turret switch contact. The cathode r-f voltage is coupled out of the vfo stage through capacitor C80 and resistor R21 to the control grid input of the 1st mixer tube (V3).

c. The plate is connected to the low end of oscillator transformer T24 through capacitor C118. Plate voltage comes from the +105-volt regulated supply through VFO CRYSTAL switch S2 SECT. 2. Note that plate voltage is furnished to the vfo tube when switch S2 is in the VFO position only. When the switch is in any CRYSTAL position, the vfo does not function, but is replaced by the crystal oscillator, V5 (par. 45).

d. C2B is the variable capacitor used for tuning the vfo stage, and is ganged directly with tuning capacitors C1A, C1B, and C2A. C112 is the tracking capacitor which helps keep the oscillator



NOTES:
RESISTANCE VALUES IN OHMS UNLESS OTHERWISE SPECIFIED
CAPACITANCE VALUES IN UUF UNLESS OTHERWISE SPECIFIED

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Figure 16. Radio Receiver R-274/FRR, simplified i-f switch-over relay operation.

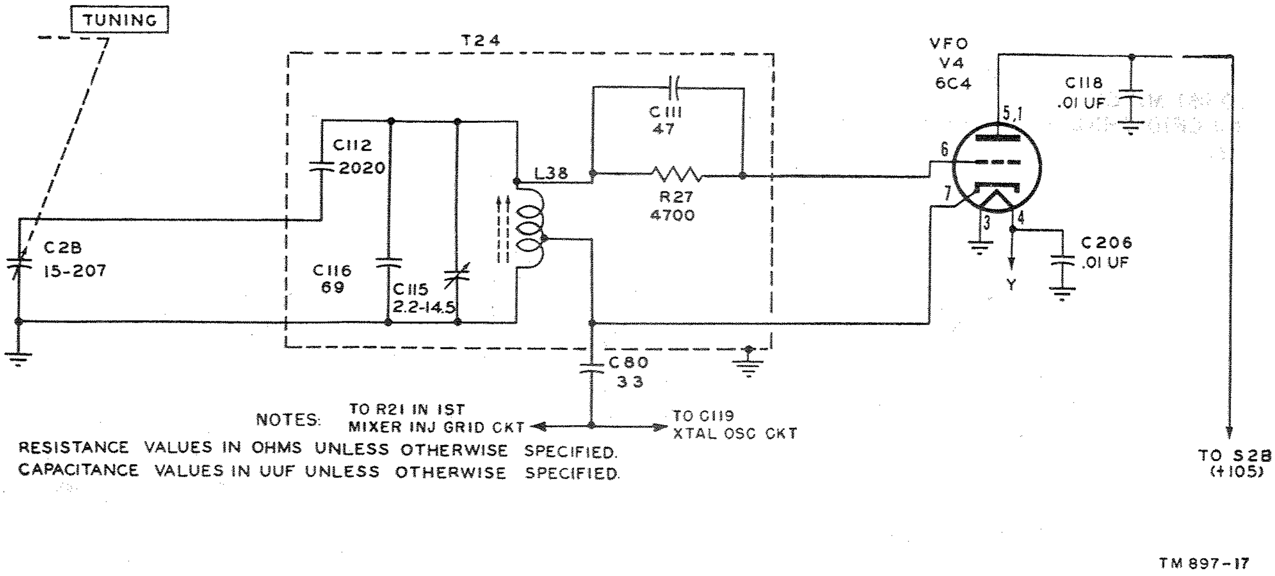


Figure 17. Radio Receiver R–274/FRR, functional diagram of vfo stage.

frequency exactly 6 mc above the signal frequency. C115 is the trimmer capacitor which assists in tracking and acts together with capacitor C116 to limit the highest frequency to which the stage may be tuned on BAND VI. Capacitor C116 is a temperature compensator which corrects the effects of temperature changes on the other oscillator circuit components. The 1-f adjustment is made by means of the powdered-iron core inside coil L38.

e. When the turret switch is set for operation in BAND VI, resistor R28 is connected across the BAND V oscillator coil in T23. This prevents the oscillator coil of the next lower band from absorbing any energy from the BAND VI oscillator coil.

45. Crystal Oscillator

(fig. 18)

a. A crystal oscillator using a type 6AG5 pentode tube (V5) may be used as an alternate h-f oscillator input for the 1st mixer tube (V3). It serves the same function as the vfo (V4), and replaces this stage when the VFO CRYSTAL switch (S2) is placed in any of its six numbered positions. Switch S2 SECT. 1 connects the output of the oscillator to the input of the 1st mixer tube (V3) in any of the crystal positions, and opens this circuit in the VFO position. Switch S2 SECT. 2 connects the plate of the variable frequency oscillator (V4) to +B regulated voltage when the switch is in the VFO position or the plate and screen of the crystal oscillator (V5) to the ordinary +B circuit in any crystal position. Switch S2 SECT. 3 is open in the VFO position or connects one crystal into the oscillator circuit in any of the six numbered positions.

b. There is a crystal socket provided for each of the six crystals. The crystals (Crystal Unit CR-18/U) are not furnished with the receiver but are provided (when requisitioned) for specified frequencies which will be set up as standard channels for normal communication operations within a specific area. Each crystal must operate at such a frequency that it will provide a beat frequency against the transmitted frequency to produce the proper intermediate frequency for amplification in the i-f stages of the receiver. The oscillator frequency always is above the incoming signal frequency. For example: if the frequency being received is 1,500 kc, the oscillator must be operating at 1,955 kc to produce a 455-kc i-f in the heterodyne action. Up to 7 mc, BAND III, the i-f is 455 kc, and the oscillator will operate at the incoming frequency plus 455 kc. Above 7 mc, the intermediate frequency in use is 6 mc, so the oscillator will operate at the incoming frequency plus 6 mc. Because of the selectivity of the r-f amplifier stages, the receiver has to be tuned manually to the incoming frequency. The frequency range reception for which the crystal oscillator may be used is 1.5 to 29.7 mc in BANDS II through V. The highest Crystal Unit CR–18/U frequency used is 11.9 mc. These units may be used as follows: For signal frequencies from 1.5 mc through 7 mc in BANDS II and

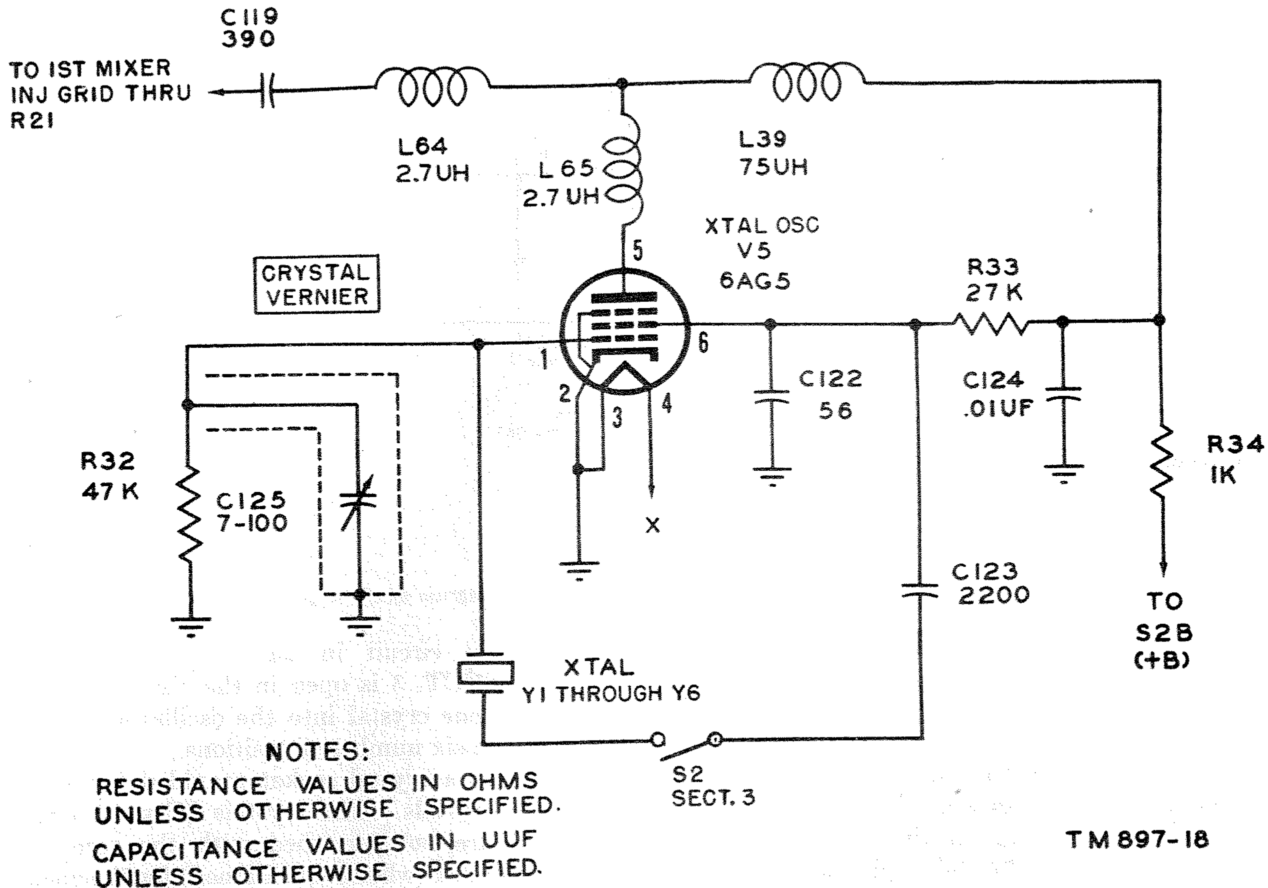


Figure 18. Radio Receiver R-274/FRR, functional diagram of crystal oscillator stage.

III, the fundamental crystal frequency is used. In the range from 7 mc through 13.8 mc in BAND III, crystals will be used at their 2d harmonic frequencies (two times the fundamental frequency). In the range from 13.8 mc through 29.7 mc, crystals will be used at their 3d harmonic. To determine the crystal frequency which should be chosen for use with an assigned incoming frequency, use the following formulas:

Fx=crystal fundamental frequency

Fs=signal frequency

IF=intermediate frequency

(1) For the signal frequency range of 1.5 mc through 7 mc (BANDS II and III), the intermediate frequency is 455 kc and

$$Fx=Fs+IF$$

Example: Determine the crystal to be used for an incoming signal of 1.8 mc.

$$Fx=1.8+.455=2.255 \text{ mc}$$

(2) For the signal frequency range from 7 mc through 13.8 mc (BAND IV), the intermediate frequency is 6 mc and

$$Fx=\frac{Fs+IF}{2}$$

Example: Determine the crystal frequency to be used for an incoming signal frequency of 11.15 mc.

$$Fx=\frac{11.15+6}{2}=8.575 \text{ mc}$$

(3) For the signal frequency range from 13.8 mc through 29.7 mc (BAND V), the intermediate frequency is 6 mc and

$$Fx=\frac{Fs+IF}{3}.$$

Example: Determine the crystal frequency to be used for an incoming signal frequency of 27.6 mc.

$$Fx=\frac{27.6+6}{3}=11.2\text{mc}\cdot$$

c. The crystal oscillator stage is connected as an electron-coupled oscillator. The crystal (Y1, Y2, Y3, Y4, Y5, or Y6) is connected from the control grid to the screen grid of the tube (V5) through switch S2, SECT. 3, when the switch is set in one of its six numbered positions. Note that each switch position number matches a crystal number (position 1 connects crystal Y1, etc.). The screen grid of the tube is the effective plate for the oscillator circuit. Capacitor C123 couples the crystal to the screen grid at the frequencies involved. Capacitors C122 and C125 are in series and assist the screen to control grid capacity to provide feedback for oscillation. Note that C125 is variable and is marked CRYSTAL VERNIER on the front panel. By changing the setting of this control, a limited variation of the crystal frequency can be effected (±50 cycles per mc). Grid leak resistor R32 will develop the proper operating bias for the stage. Screen voltage-dropping resistor R33 returns the screen to +B and limits screen grid current to a safe value.

d. The suppressor grid is tied to the cathode to minimize any secondary emission effects. The crystal oscillator radio frequency appearing at the plate of tube V5 is fed through inductors L65 and L64, capacitor C119, and resistor R21 to the injection grid of the 1st mixer tube (V3). Inductors L65 and L39 connect the plate to +B through R34 and prevent the oscillator radio frequency from feeding back into the +B circuit. Capacitor C124 is used for further bypassing this r-f variation to ground in both the screen and plate circuits.

46. 6-MC I-F Amplifier

a. The simplified diagram showing the 6-mc i-f amplifier which uses a type 6BA6 pentode tube amplifier V6 is shown in figure 19. Note that the input to this stage comes from the contacts of relay K1 (fig. 43), and that there is an input only when the proper contacts are closed, which occurs on BANDS IV, V, and VI.

b. The 6-mc signal is fed from the relay contacts of K1 to the primary of transformer T25. The signal is inductively coupled to the secondary from which it is fed through coupling capacitor C113 to the grid of V6. R114 is the grid resistor. Capacitor C128 resonates the primary of transformer T25 to 6 mc, and capacitor C129 resonates the secondary to the same frequency. Both of these capacitors are fixed; tuning is accomplished by means of powdered-iron cores inside transformer T25.

c. R39 is the cathode resistor for tube V6 which regulates the tube current to a safe value and develops the grid bias necessary for correct operation. Capacitor C131 is the cathode bypass which effectively grounds the cathode at the

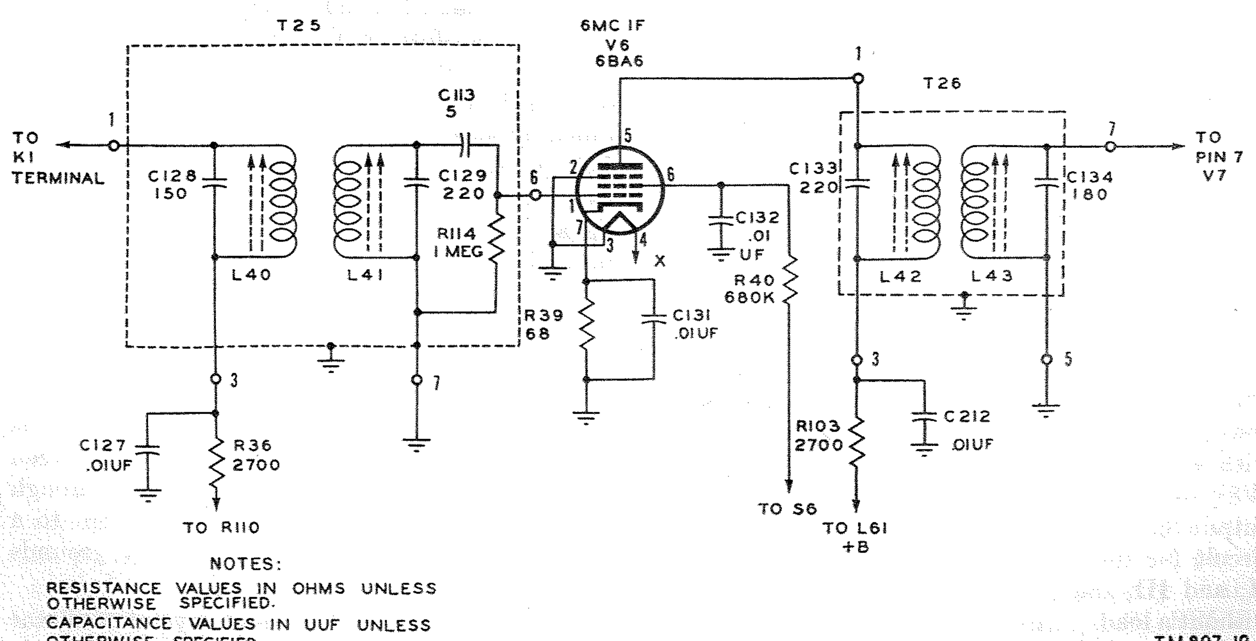


Figure 19. Radio Receiver R–274/FRR, functional diagram of 6-mc i-f stage.

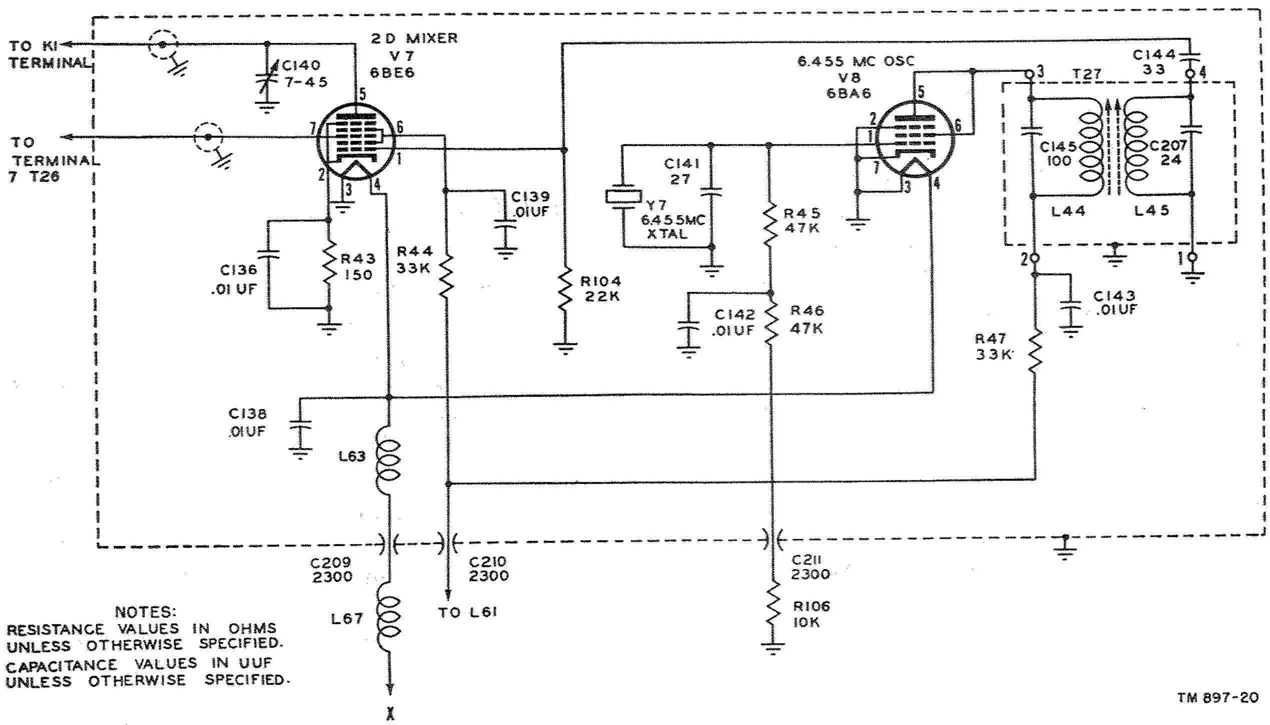


Figure 20. Radio Receiver R-274/FRR, functional diagram of 2d mixer and 6.455-mc oscillator.

intermediate frequency. R40 is the screen-dropping resistor which limits the screen current to a safe value. Note that no screen voltage is applied when switch S6 (fig. 43) is in the SEND position. Capacitor C132 effectively grounds the screen for intermediate frequencies.

d. The output of V6 is fed into the primary of T26, which is resonated to 6 mc by capacitor C133 and is tuned by means of a powdered-iron core inside the primary winding (L42). The lower end of L42 returns to +B through resistor R103. Capacitor C212 and resistor R103 form a filter which prevents any signal voltage from getting into the +B circuit, through which it could be fed into other stages.

47. 2d Mixer V7

a. The 2d mixer circuit is shown in figure 20. The 2d mixer tube (V7) is a type 6BE6 pentagrid converter tube which combines the 6-mc i-f signal with a signal coming from the 6.455-mc oscillator (V8) to produce a 455-kc signal. This 455-kc output then can be fed into the 455-kc i-f amplifier circuit for further amplification. In BANDS I, II, and III, the plate is shorted directly to +B without a load. Any spurious signals occurring at the plate of the tube are bypassed to ground through the power supply filter capacitors. In BANDS IV, V, and VI, the plate circuit includes the primary of the 1st 455-kc i-f transformer T28. This switching is accomplished automatically through the contacts of relay K1 (par. 43). The mixer tube plate current flows when the relay contacts are in either position.

b. The 6-mc i-f signal developed across the primary of transformer T26 (fig. 19) is inductively coupled to the secondary. The secondary is resonated to 6 mc by capacitor C134, and is tuned by means of a powdered-iron core inside the coil (L43). The 6-mc signal is fed from the secondary of transformer T26 directly into the signal injection grid of the 2d mixer tube (V7) through a coaxial cable. The purpose of the shield is to prevent any other signals from being picked up and fed into this grid.

c. R43 is the cathode resistor which limits the cathode current to a safe value. Capacitor C136 is the cathode bypass which effectively grounds the cathode at the signal frequencies. The screen (grid 6) of tube V7 is connected to +B through resistor R44 which limits the screen current to a safe value. Capacitor C139 effectively grounds the screen at the signal frequencies.

d. The output of the 6.455-mc crystal oscillator (V8) is fed through capacitor C144 into the first grid of tube V7. R104 acts as a grid leak resistor in this injection circuit and develops the bias under which the circuit operates.

e. In BANDS IV, V, and VI, which are the bands using the 6-mc i-f strip, the output of tube V7, containing a 455-kc signal frequency, is fed into the primary of the 1st 455-kc i-f transformer (T28). The increased amount of coaxial cable used to connect the 2d mixer (V7) to transformer T28, over that used to connect the 1st mixer (V3) to transformer T28, upsets the tuning of the primary of transformer T28. Variable capacitor C140 is adjusted to compensate for this tuning shift in transformer T28.

f. Two choke coils (L63 and L67) are placed in the filament supply lead to reduce any tendency for signal frequencies to be reflected through the filaments of other tubes. These coils are common to the filament lead of the 6.455-mc crystal oscillator (V8).

48. 6.455-mc Crystal Oscillator V8

a. The functional diagram of the 6.455-mc crystal oscillator is shown in figure 20. It is a crystal-controlled oscillator using a type 6BA6 pentode tube (V8) connected as a triode. The output is fed to the first grid of the 2d mixer (V7) to be mixed with the 6-mc i-f signal to produce a 455-kc i-f signal at the plate of V7. In BANDS I, II, and III, the oscillator (fig. 43) has −24 volts of bias applied, and does not function. In BANDS IV, V, and VI, this bias is removed, allowing the stage to oscillate as required.

b. The crystal (Y7) is connected from the control grid to the cathode of the tube (V8). The cathode is grounded and the grid return, consisting of resistors R45, R46, and R106 in series, is grounded through the contacts of the turret switch when the receiver is operating in BAND IV, V, or VI. Operation in BAND I, II, or III opens the grounded connection and causes the grid to be returned to −24 volts dc through the coil of relay K1. Capacitor C141 is placed in parallel with the crystal to assist in stabilizing the frequency of oscillation and in minimizing the effects which might occur in changing crystals due to the variable amounts of capacity across various crystal holders. Capacitor C142 is an i-f bypass to prevent any 6.455-mc oscillation from being carried out of the subchassis which incloses the 2d mixer and 6.455-mc oscillator stages.

c. The screen grid tied to the plate of the tube (V8) is used as the plate of the oscillator circuit. The effective plate is connected to +B through the primary of transformer T27 in series with resistor R47. Capacitor C145 and inductor L44 form a fixed tuned tank circuit with a resonant frequency of 6.455 mc. The oscillator output is developed across this tank and is inductively coupled to the secondary coil (L45). Capacitor C207 broadly tunes the secondary coil of T27 to the output signal of the oscillator. Coupling to the 2d mixer is accomplished through capacitor C144. Capacitor C143 and resistor R47 form a filter to isolate the oscillator frequency from the +B circuit.

d. The suppressor of the tube (V8) is tied to the cathode and ground. This helps to stabilize the output of the tube.

e. Inductors L63 and L67 provide r-f isolation in the filament supply lead (par. 47*f*).

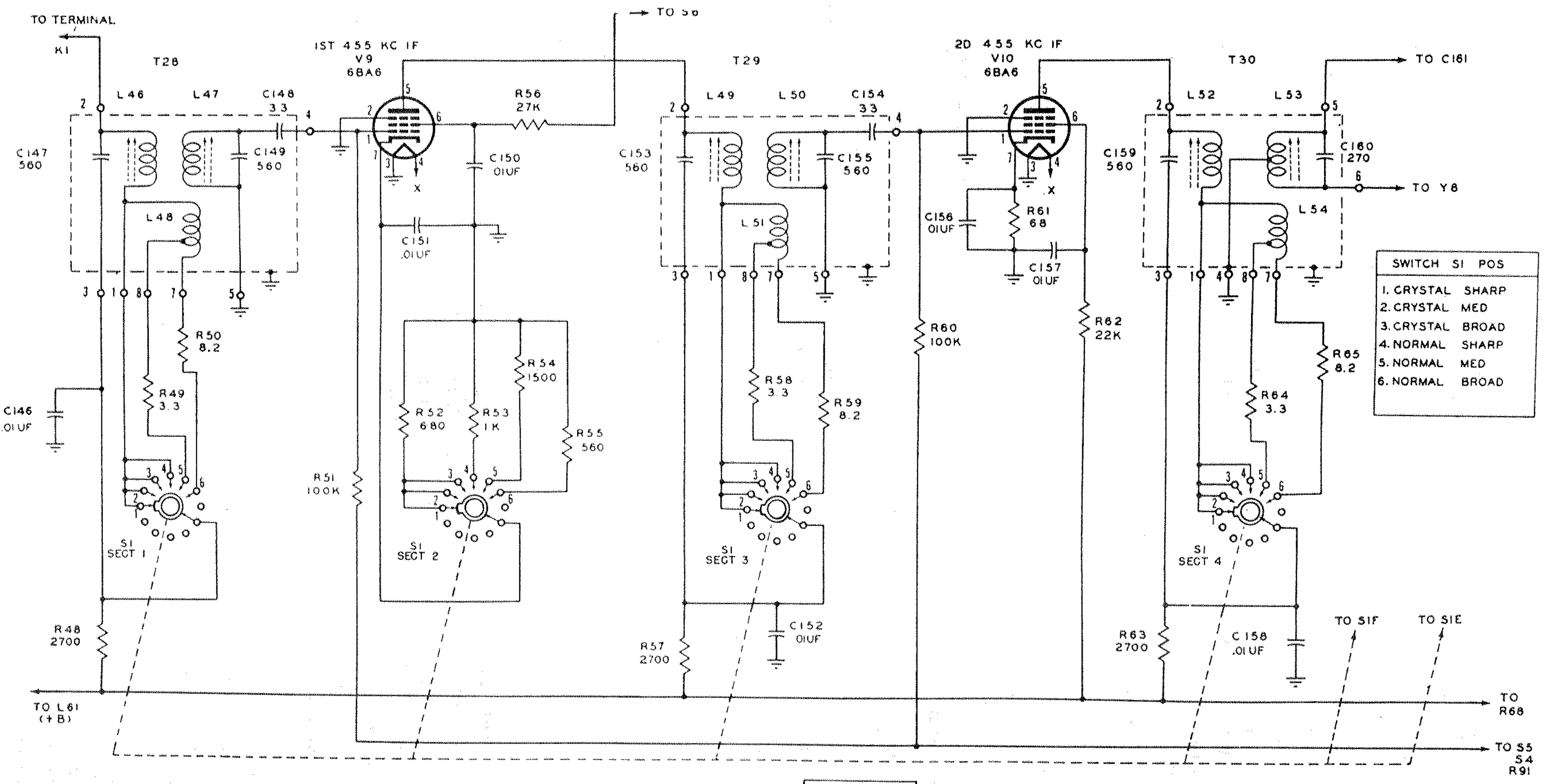
49. 1st 455-kc I-f Amplifier V9

The circuit of the 1st 455-kc i-f amplifier is shown in figure 21.

a. The 455-kc i-f amplifier stages are used at all times because they provide most of the amplification and control the receiver selectivity. When the set is tuned in BAND I, II, and III, the signal to the 1st 455-kc i-f amplifier comes from the 1st mixer (V3) through the contacts of relay K1. When the receiver is in BAND IV, V, or VI, the signal comes from the 2d mixer (V7) through relay K1.

b. The 455-kc i-f signal is fed to the primary of i-f transformer T28. The signal is coupled inductively to the secondary of transformer T28, and then goes to the grid of the 1st 455-kc i-f amplifier (V9) through coupling capacitor C148. Capacitor C148 prevents the agc voltage which is fed to the grid of tube V9 through resistor R51 from being shorted to ground through the secondary of transformer T28. Capacitor C147 resonates the primary of transformer T28 to 455 kc, and capacitor C149 resonates the secondary to 455 kc. Both of these capacitors are fixed; the tuning adjustments are the powdered-iron cores inside the transformer (T28). Since both the primary and secondary of transformer T28 are tuned, a high degree of selectivity can be obtained.

c. The tapped tertiary winding L48 (fig. 21) can be put in series with the primary of transformer T28 by means of switch S1 SECT. 1. This arrangement provides variable selectivity. There are six positions of switch S1 SECT. 1,



NOTES:
1. RESISTANCE VALUES IN OHMS UNLESS OTHERWISE SPECIFIED.
2. CAPACITANCE VALUES IN UUF UNLESS OTHERWISE SPECIFIED.
3. SWITCHES VIEWED FROM END OPPOSITE CONTROL KNOB.

TM 897-21

Figure 21. Radio Receiver R-274/FRR, functional diagram of 1st and 2d 455-kc i-f stages.

four of which have no effect on the 1st 455-kc i-f amplifier. In these four positions tertiary winding L48 is out of the circuit. In the fifth position of S1 SECT. 1, however, a part of L48 is in series with L46, the main portion of the primary, and in the sixth position, entire winding L48 is in the primary circuit. Physically, L48 consists of only a few turns of wire located very close to the secondary of T28. The inductance of L48 is so small that it does not appreciably change the tuning of the primary when switched into the circuit, but it greatly increases the coupling between the primary and secondary and consequently, increases the band width. The action of S1 SECT. 1 is as follows: The first three positions are for three degrees of crystal selectivity (par. 51*b*). The 1st 455-kc i-f amplifier circuit is the same for these three positions as for the fourth, which is the NORMAL SHARP position. The band width of the receiver in this position is about 3.25 kc. The fifth position of S1 SECT. 1 is the NORMAL MEDIUM position, and the band width is about 8.25 kc. In this position, a part of L48 is in the primary circuit. Damping resistor R49 also is in the primary circuit and prevents double peaks in the selectivity curve. The sixth position of S1 SECT. 1 is the NORMAL BROAD position, and the band width is about 14 kc. All of L48 is in the primary circuit, and damping resistor R50 prevents double peaks in the selectivity curve.

d. Since the primary of transformer T28 is connected to the plate of either tube V3 or V7, depending on which band is being used, the low side must return to +B. This return is made through resistor R48, which with capacitor C146, forms a filter preventing signals in the plate circuit of tube V9 from getting into other circuits of the receiver. R56 is the screen voltage-dropping resistor for tube V9, and capacitor C150 bypasses the screen to ground at 455 kc. No screen voltage is furnished when switch S6 is in the SEND position.

e. The cathode of tube V9 goes to ground through a resistor selected by switch S1 SECT. 2. Note that for the three crystal positions of switch S1 SECT. 2 resistor R52 is used. Resistor R53 is used in the NORMAL SHARP position, resistor R54 is used in the NORMAL MEDIUM position, and resistor R55 is used in the NORMAL BROAD position. This arrangement is made to compensate for the change in i-f amplifier gain which occurs when the coupling of the i-f transformers is changed. It also compensates for the difference in the audio signal out of the receiver, due to the change in band width. Capacitor C151 effectively grounds the cathode at 455 kc.

f. The output of tube V9 goes to the primary of the second 455-kc i-f transformer (T29) which is resonated by capacitor C153. Alinement of transformer T29 is made by means of adjustable powdered-iron cores. Transformer T29 has a tapped bandwidth expansion winding L51, which is switched in or out of this primary circuit in the same way as coil L48 in transformer T28. Damping resistors R58 and R59 are used to prevent double peaks in the selectivity curve of T29. The primary of transformer T29 returns to +B through resistor R57, which, with capacitor C152, forms a filter to prevent signals in the plate circuit of tube V9 from getting into other circuits through the +B lead.

50. 2d 455-kc I-f Amplifier V10

a. The 2d 455-kc i-f amplifier is shown in figure 21. The signal is coupled inductively from the primary of transformer T29 to the secondary which is tuned to 455 kc by capacitor C155. From the secondary of transformer T29, the signal goes through coupling capacitor C154 to the grid of the 2d 455-kc i-f amplifier tube (V10). Capacitor C154 prevents the agc voltage (which is fed to the grid of tube V10 through resistor R60) from being shorted to ground through the secondary winding of transformer T29. R61 is the cathode resistor for tube V10. It prevents the cathode current from exceeding safe limits when there is no agc voltage on the grid. Capacitor C156 is the cathode r-f bypass at intermediate frequencies. R62 is the screen voltage-dropping resistor for tube V10 which limits the screen current to a safe value, and C157 is the screen bypass capacitor.

b. The output of tube V10 goes to the primary of the 3d 455-kc i-f transformer (T30). This primary circuit is the same as the primary circuits for transformers T28 and T29. It is resonated to 455 kc by capacitor C159, and has the tapped expansion winding L54 which is controlled by switch S1 SECT 4. R64 and R65 are damping resistors which prevent double peaks in the selectivity curve. The primary of transformer T30 returns to +B through resistor R63, which with capacitor C158, forms a filter to prevent signals in the plate circuit of tube V10 from getting into other circuits through the +B lead.

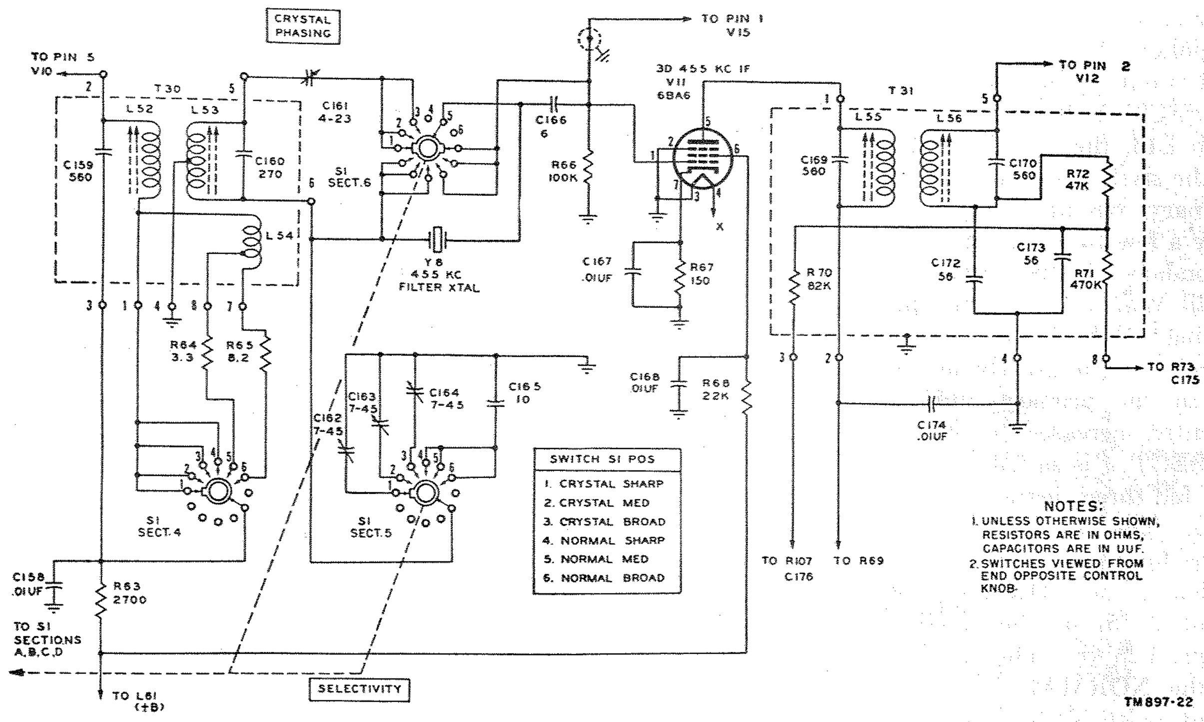


Figure 22. Radio Receiver R-274/FRR, functional diagram of 3d 455-kc i-f stage and crystal filter.

51. 3d 455-kc I-f Amplifier V11

a. General.

(1) The 3d 455-kc i-f amplifier circuit is shown in figure 22. R66 is shown as the grid leak resistor for tube V11. Resistor R67 is the cathode resistor which keeps the total cathode current within safe limits and develops the bias under which the tube operates. Capacitor C167 is the cathode bypass which effectively grounds the cathode at intermediate frequencies. R68 is the screen voltage-dropping resistor, and capacitor C168 effectively grounds the screen of tube V11 at intermediate frequencies. The output of tube V11 goes to primary L55 of the 4th 455-kc i-f transformer T31. This primary circuit is resonated by capacitor C169. It is returned to +B through resistor R69, which with capacitor C174, forms a filter which prevents the signal in the plate circuit of tube V11 from getting into other circuits of the receiver.

(2) The signal in the primary of transformer T30 is coupled inductively to the secondary which is resonated to 455 kc by capacitor C160. Note that this secondary (L53) is different from the secondary circuits for the preceding i-f transformers in that it is tapped, and the tap is connected to ground. This arrangement is used because this secondary drives the crystal filter when the latter is being used. The action of these circuits can be described best by considering the conditions when the crystal filter is in in use, and the normal or noncrystal mode of operation.

b. Crystal Operation. Switch S1 SECT. 5 and SECT. 6 (fig. 22) determine whether the operation includes or bypasses the 455-kc filter crystal. The total voltage across the secondary (L53) of transformer T30 can be thought of as two separate voltages. The first is the voltage from ground to the top portion of L53. This voltage sends i-f current through capacitor C161, through the parallel combination of resistor R66 and the input capacities of tubes V11 and V15, and back to ground. The second voltage is that from ground to the lower end of L53. This voltage sends a signal through crystal Y8 through R66 in parallel with the input capacities of tubes V11 and V15, and back to ground. At signal frequencies different from its series resonant frequency, crystal Y8 acts like a pure capacity. Therefore, since the two secondary voltages (in L53) are opposite in phase, the two currents through resistor R66 tend to cancel each other. In fact, when the phasing capacitor (CRYSTAL PHASING) C161, is adjusted accurately, these currents do cancel, and the voltage at the grids of tubes V11 and V15 is zero. Near series resonance, crystal Y8 does not behave like a high capacitive reactance but rather like a relatively low resistance. Therefore, the two currents will have a smaller phase difference as well as a considerable difference in amplitude, and some signal voltage will be developed in the input circuits of tubes V11 and V15. Because its Q is high, the losses in crystal Y8 are very small and therefore, the frequency range over which the voltage unbalance occurs is quite small. This is the reason for the high degree of selectivity of a crystal filter. To some extent, the equivalent resistance in the secondary circuit of transformer T30 affects the operation of the crystal filter. When this resistance is high (as it is when inductance L53 and capacitor C160 are *exactly* resonant at the series resonant frequency of crystal Y8), the selectivity curve is broadened, because the effective circuit Q is lowered. The bandwidth of the crystal filter circuit can be varied by the degree of mistuning of the secondary circuit of transformer T30. This is done to vary the bandwidth from 200 cycles to 500 cycles to 1,500 cycles as the selectivity switch is changed from CRYSTAL SHARP to CRYSTAL MEDIUM to CRYSTAL BROAD. When selectivity switch S1 SECT. 5 is in the CRYSTAL SHARP position (fig. 22), capacitor C162 is across part of the secondary of transformer T30. It is adjusted so that the secondary is mistuned just enough that the bandwidth is 200 cps. In the CRYSTAL MEDIUM position, capacitor C163 is in the circuit, adjusted to a different capacity, and the bandwidth is 500 cps. In the CRYSTAL BROAD position, capacitor C164 is in the circuit, and the mistuning of the secondary of T30 is very slight, therefore, the bandwidth is 1,500 cps. In actual operation of the receiver, the phasing control (capacitor C161) can be adjusted to give a high degree of rejection at a frequency slightly different from that at which maximum response occurs. Furthermore, the exact frequency at which this rejection occurs can be varied. This characteristic can be used to reject an undesirable signal which is at a frequency close to the frequency of the desired signal.

c. Normal (Noncrystal) Operation. The simplified equivalent of the 3d 455-kc i-f amplifier circuit (crystal filter), together with SECTS. 5 and 6 of S1, when the selectivity switch is in NORMAL SHARP position, can be pictured by considering all the sections of switch S1 to be placed in position 4 (NORMAL SHARP) (fig. 22). The voltage in the lower part of L53 is sent to the grid of tube V11 through capacitor C166. Capacitor C166 has a low value (6 uuf (micromicrofarad)) so that the gain under noncrystal conditions will be in the proper proportion to the gain under crystal operation. Capacitor C165 replaces variable capacitors C162, C163, and C164 which were in the circuit for crystal operation.

52. I-F Output

a. The simplified circuit diagram of the i-f output circuit is shown in figure 23. This circuit provides sufficient power at 455 kc to operate auxiliary devices such as radioteletype equipment. The i-f output circuit is designed to provide an approximate .25-volt output across a 70-ohm load with 2 uv r-f input signal. This circuit also feeds a signal through C171 to the agc diode (1/2 of V13). The amplitude of this signal depends on the amplitude of the carrier signal fed into the receiver at the antenna.

b. As seen in figure 23, the grid of the 455-kc i-f output tube, V15, is connected in parallel with the grid of the 3d 455-kc i-f amplifier tube V11. Thus, the same signal which drives tube V11 also drives tube V15. The output of tube V15 goes to the primary of transformer T32 which is resonated to 455 kc by capacitor C180. The secondary coil of transformer T32 is of the low-impedance type, that is, it consists of only a few turns, and it is not tuned. The output of this low-impedance secondary coil is connected to i-f output jack J2.

c. The low side of the primary of transformer T32 and the screen of tube V15 are connected to +B through resistor R75, which, with capacitor C179, form a filter which prevents signals in the plate and screen circuits of tube V15 from getting into other circuits of the receiver through the +B lead. R74 is the cathode bias resistor of tube V15. C178 is the cathode bypass capacitor which effectively grounds the cathode at intermediate frequencies.

d. The tuned primary of transformer T32 adds very little to the selectivity of the system. This means that any signal which gets into the grid of tube V15 is available at output jack J2.

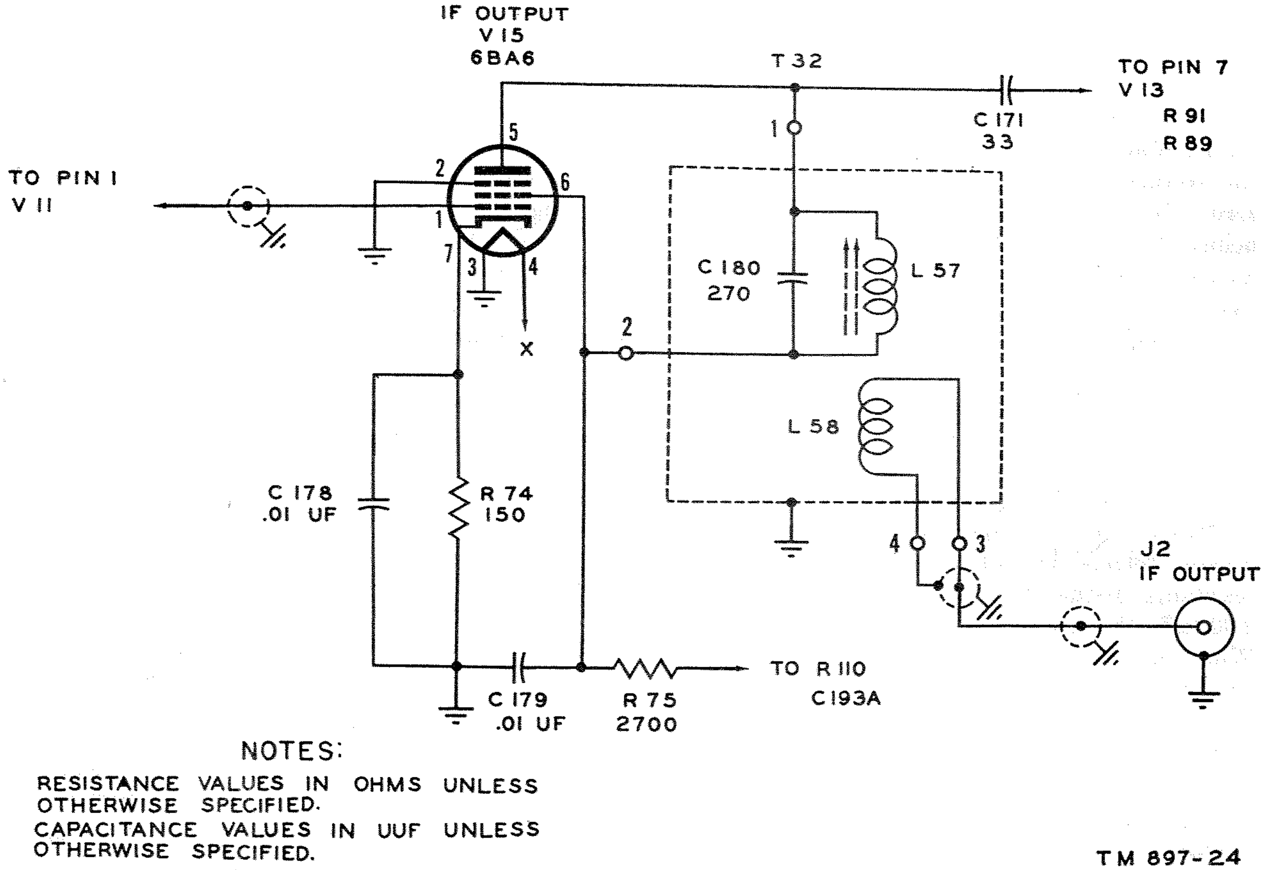


Figure 23. Radio Receiver R–274/FRR, functional diagram of i-f output stage.

53. Audio Detector

The simplified circuit diagram for the audio detector is shown in figure 24. It is a standard diode detector circuit which uses ½ of tube V12 (6AL5) for the diode. The signal in the primary of the 4th 455-kc i-f transformer (T31) is coupled inductively to the secondary which is resonated to 455 kc by capacitor C170. This voltage is impressed on the plate of the audio detector (½ of V12) and when this plate is driven positive with respect to the cathode, current flows through resistors R72, R70, and R107. No current flows during the negative half of the alternating voltage swing. The current through this path is a pulsating unidirectional flow. Capacitors C172 and C173 store up electrical energy during the passage of current and release it between pulses so that the actual current through the resistors is very nearly a smooth, direct current. Since the amplitude of the voltage impressed on the audio detector (½ of V12) varies with voice modulation, the amplitude of current pulses through the resistance paths also varies with modulation. Capacitors C172 and C173 are small; therefore, energy is not stored over the long periods of time required by the a-m frequencies, which are all much lower than the intermediate frequency. Therefore, the current through resistor R107 is direct current in nature (negative with respect to ground), and varying in magnitude according to the audio modulation. If the current through this resistor varies with modulation, then the voltage across it also must vary in the same way. This audio voltage is coupled through capacitor C176 and developed across resistor R108. The a-f voltage across resistor R108 may be coupled directly through coupling capacitor C200 to the input of the 1st a-f amplifier (V16), or it may have to pass through the automatic noise limiter (the second half of tube V12) before reaching the input to the audio amplifier. Switch S3, in the OFF position, sends the audio signal directly to the audio amplifier or, in the ANL position, sends the signal through the ANL (automatic noise limiter) before it goes to the audio amplifier.

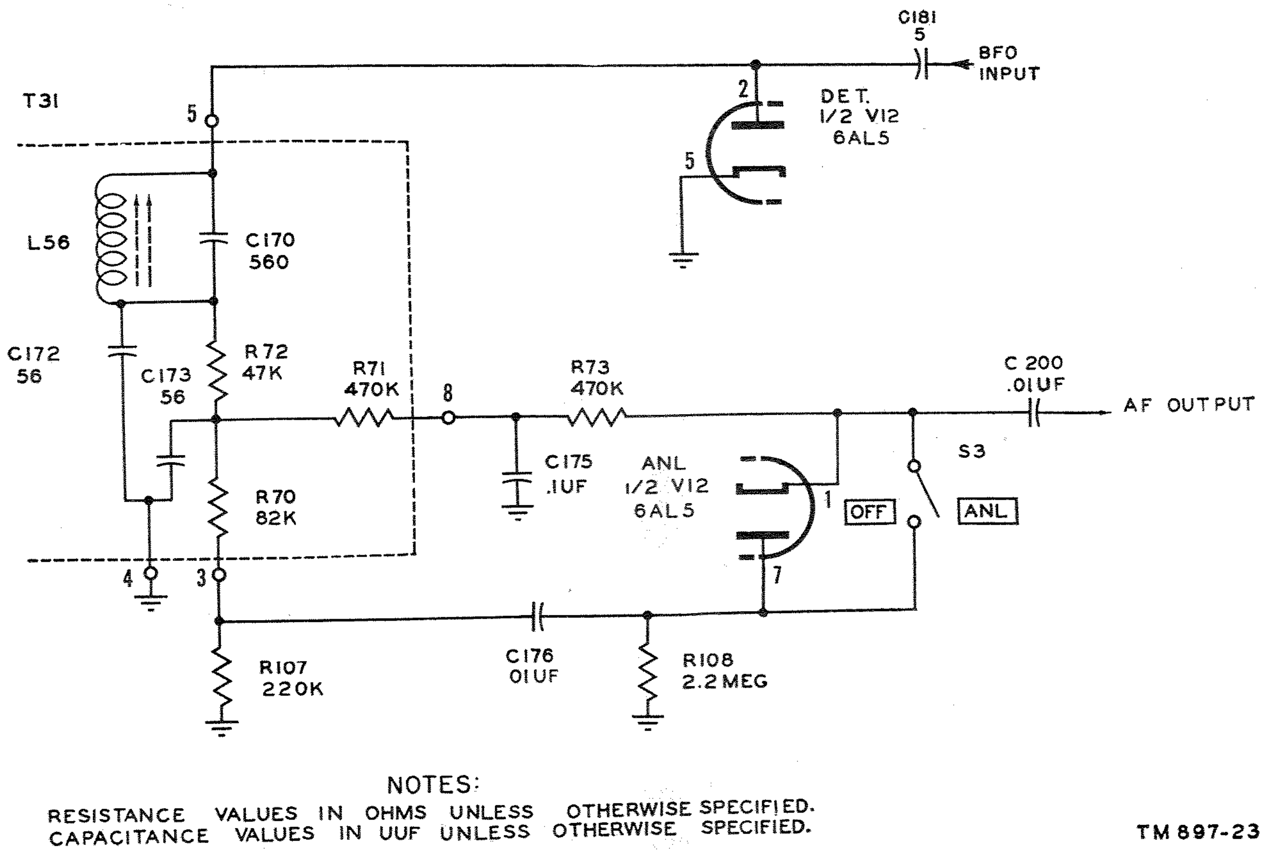


Figure 24. Radio Receiver R–274/FRR, functional diagram of the audio detector and anl stages.

54. Automatic Noise Limiter

The simplified ANL circuit diagram is shown in figure 24. When the ANL-OFF switch (S3) is in the ANL position, the audio signal must pass through the ANL diode (½ of tube V12) before it can reach the audio amplifier. The cathode of this diode is tied to the junction of resistors R72 and R70 in the audio detector circuit through series resistors R73 and R71. Resistors R71 and R73, together with capacitor C175, form a filter network to provide a smoothed-out negative d-c voltage to the cathode of the ANL which varies with the average level of the a-f signal. The audio voltage developed across resistor R108 is applied to the plate of the ANL when no noise is present. This audio voltage always will be positive with respect to the reference voltage at the cathode of the diode, and the signal will be coupled through to the audio amplifier input. Noise, due to static interference, will result in sharp peaks of negative voltage across resistors R107 and R108. Because of the time constant in the ANL cathode circuit, these pulses will not reach the cathode. When the noise pulse tends to feed through the audio circuit, the diode plate of the ANL tube (½ of V12) will be more negative than its cathode, and the noise pulse will be blocked before it reaches the audio amplifier.

55. Beat-Frequency Oscillator

(fig. 25)

a. For the reception of c-w signals, it is necessary to have a bfo. In this receiver, the bfo operates near 455 kc and is coupled directly to the audio detector input. The simplified schematic of the bfo circuit is shown in figure 25.

b. It can be seen in figure 25 that the bfo tube (V14) is connected in a Hartley type oscillator with the cathode connected to a tap on the oscillator transformer (T33). R76 is the grid resistor which permits bias to be developed on the grid, and capacitor C184 is the means of coupling the grid to the high side of the oscillator transformer (T33). The oscillator transformer is resonated to 455 kc by capacitor C185 which has a fairly high value (680 μuf) so that the circuit will have good frequency stability. Capacitor C177 has a negative temperature coefficient so that the

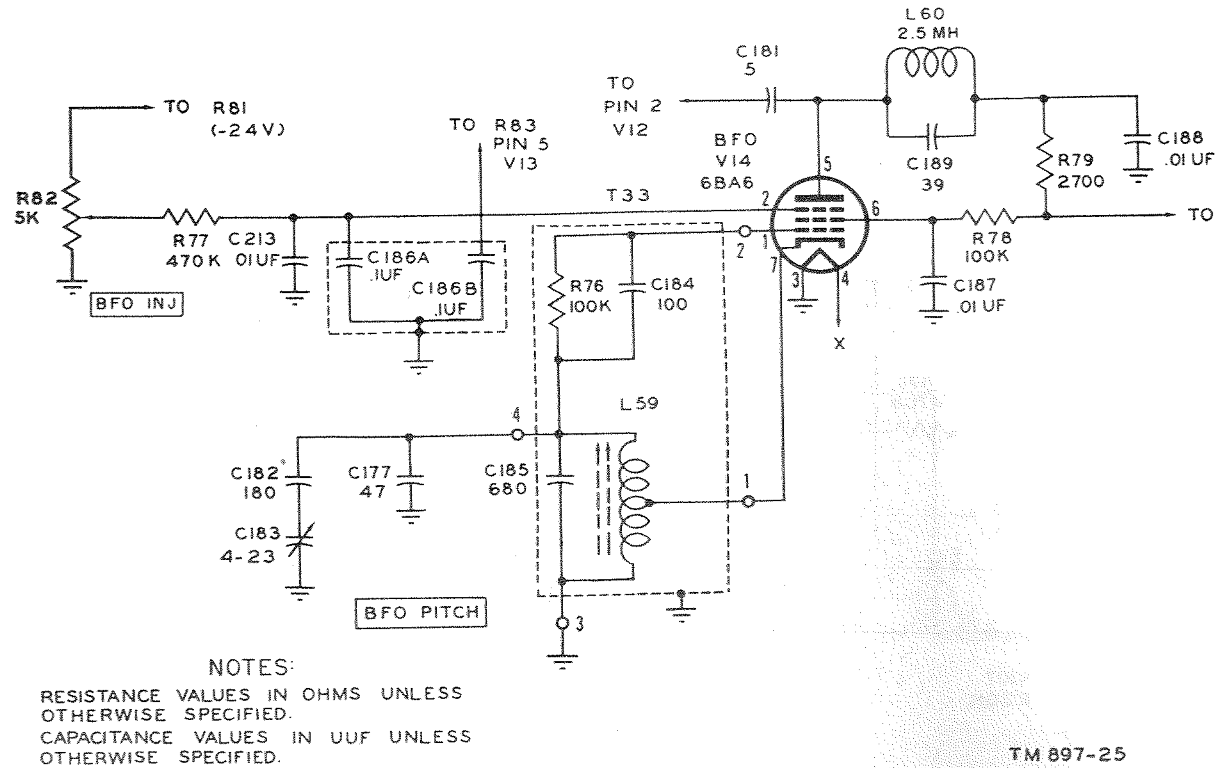


Figure 25. Radio Receiver R–274/FRR, functional diagram, bfo stage.

frequency of the oscillator will not change as the receiver warms up or as the ambient temperature changes. Capacitor C183 is the BFO PITCH control by which the frequency of the bfo can be varied above or below 455 kc. Capacitor C182 limits the ability of C183 to change the oscillator frequency, and its value of 180 μuf was chosen so that C183 would change the frequency by plus or minus 3.5 kc of 455 kc.

c. The screen grid of V14 is the effective plate of the tube in the Hartley oscillator circuit. Since both the grid and the cathode are above ground, the *plate* can be grounded so far as the oscillator frequency is concerned. This is done by screen bypass capacitor C187. Screen grid voltage-dropping resistor R78 is of such a value that the amplitude of oscillation will be right for optimum mixing in the audio diode detector (½ of V12) circuit.

d. The output of the bfo is electron-coupled to the plate circuit of tube V14, where the voltage is developed across the parallel combination of r-f choke L60 and capacitor C189 which are broadly resonant to 455 kc. This output voltage is coupled by capacitor C181 to the plate (pin 2) of the signal audio diode detector (½ of V12) where it is mixed with the c-w signal to give an audio note. The small value of capacitor C181, plus the fact that the bfo circuit is of the electron-coupled type, results in a minimum of *pulling* of the bfo by strong signals.

e. The low side of L60 is connected to +B through resistor R79, which with capacitor C188 form a filter which prevents the bfo signal from getting into other circuits of the receiver. The CW-MODULATION switch S5 also is in this screen and plate return so that the bfo can be switched off during reception of a-m signals.

f. Sometimes, it is desirable to adjust the amplitude to the bfo output to give optimum mixing in the audio detector circuit. This is done by means of the BFO INJ control (R82) on the rear of the chassis. This adjustment varies the amount of negative bias applied to the suppressor of tube V14 and thus, effectively varies the degree of electron coupling between the beat-frequency oscillator and its output circuit, permitting an approximate ten-to-one variation of bfo injection to the audio detector. A filter composed of resistor R77 and capacitors C186A and C213 is used to eliminate any tendency for hum to be introduced into the suppressor of tube V14. The suppressor of V14 is bypassed to ground at the bfo frequency by capacitors C213 and C186A.

56. Automatic Gain Control

(fig. 26)

a. The automatic gain control operates in conjunction with the r-f gain control to provide a negative bias voltage for tubes V1, V2, V9, and V10, to control the over-all amplification of the receiver. When switch S4 (AGC-MANUAL) is in the MANUAL position, the RF GAIN-AC control (R83) acts alone to provide this bias. When switch S4 is in the AGC position, strong incoming signals will work through the agc tube (V13) to increase the bias beyond the amount selected by the manual RF GAIN-AC control (R83) and reduce amplification so that the a-f output will remain fairly constant for a variety of input signal strengths.

b. For a simplified schematic diagram of the bias voltage source with switch S4 set in the MANUAL position, refer to figure 26A. A regulated +105-volt source connects to resistor R84. Resistors R84, R86, R87, and R88 in series, form a voltage divider network to ground which results in creating a steady +10-volt value at the junction of resistors R84 and R86. Another network, using resistors R89 and R91 in series, connects the +10-volt junction to the slider arm on RF GAIN-AC control R83. When the RF GAIN-AC is turned fully clockwise, the tap is at the grounded end of resistor R83, and when the control is turned as far as possible counterclockwise (without turning off the a-c power), the tap is at the −18-volt d-c end of resistor R83. There is a 6-volt drop across resistor R111. C195 is a l-f bypass capacitor. The bias voltage output lead is connected to the movable tap on RF GAIN-AC control R83. Capacitors C58 and C186B smooth out the action of the RF GAIN-AC control. The voltage appearing as bias for tubes V1, V2, V9, and V10 is the same as that appearing at the movable tap of RF GAIN-AC control R83.

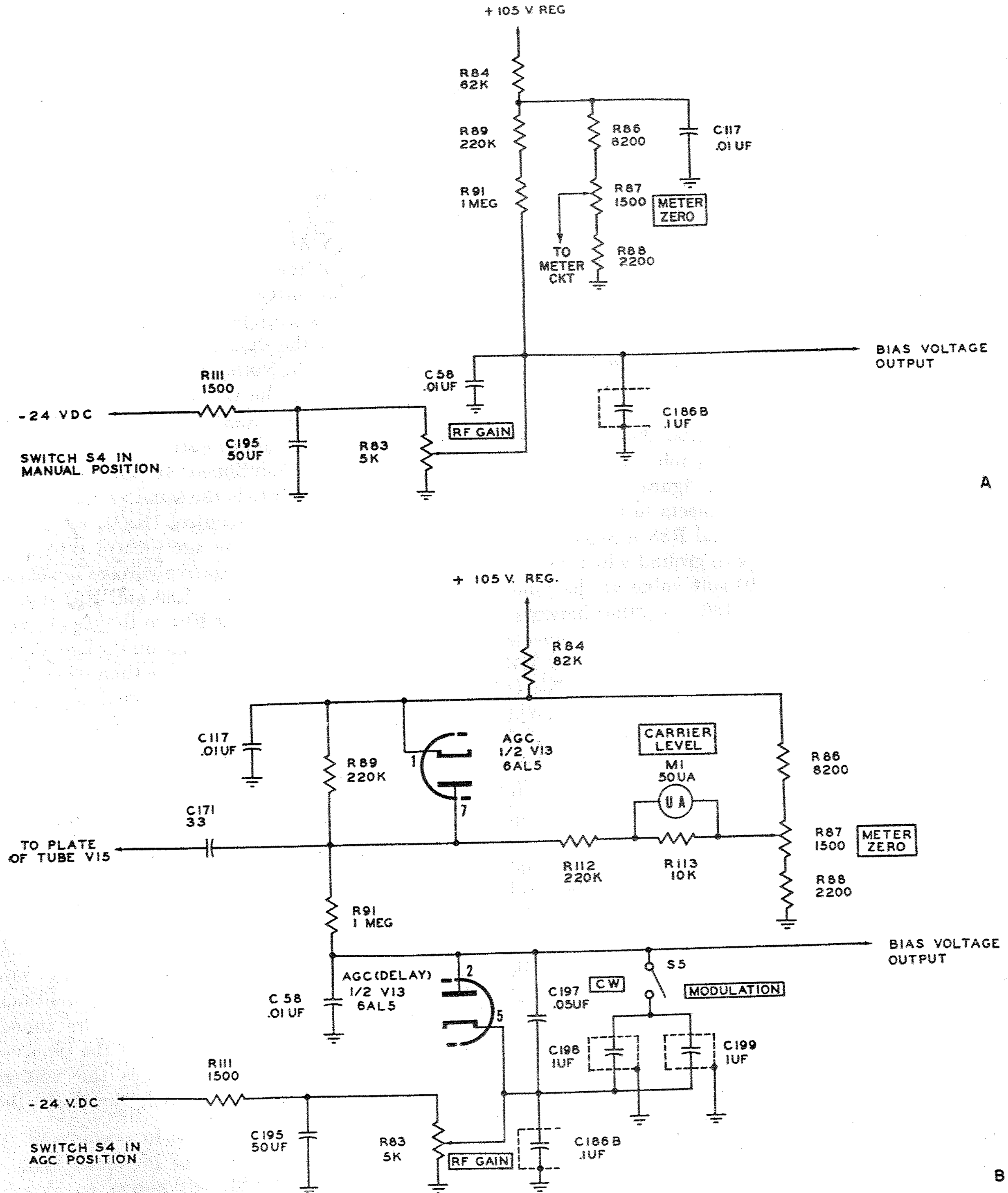
c. For a simplified schematic showing the bias voltage source with switch S4 set in the AGC position, refer to figure 26B. The bleeder network, consisting of resistors R84, R86, R87, and R88, from +105 volts regulated to ground, acts the same as explained in *b* above, with +10 volts direct current appearing at the junction of resistors R84 and R86. The second voltage network, using resistors R89 and R91 also is connected as explained in *b* above, except that an agc (delay) diode (½ of V13) is in series. The i-f signal at the plate of the tube (V15) is coupled through capacitor C171 to the agc diode plate (pin 7). The amplitude of this signal will be indicative of the input signal voltage to the 1st r-f amplifier (V1). The agc tube (½ of V13) is in parallel with resistor R89, which acts as the diode load. This circuit shifts the voltage appearing at the junction of resistors R89 and R91 in a negative direction. The larger the signal becomes, the greater the negative voltage will be. The voltage tapped on the RF GAIN-AC control (R83) is connected to the cathode of the agc (delay) tube (½ of V13). As long as the voltage at the junction of resistors R89 and R91 is more positive than the voltage at the cathode of the diode, the diode will conduct and will cause the voltage appearing at its plate to be the same as the voltage tapped on the RF GAIN-AC control (R83). This voltage is connected to the bias voltage output. As soon as the negative voltage developed at the junction of resistors R89 and R91 is the same as that tapped on the RF GAIN-AC control (R83), all current stops flowing through the agc (delay) tube (½ of V13), and any greater negative voltage developed at the junction of resistors R89 and R91 will be connected through resistor R91 to the bias voltage output. Since the plate voltage on the agc (delay) diode (½ of V13) is more negative than its cathode voltage, it will be cut off until signal strength is reduced. The values of resistor R91 and capacitors C58 and C197, which form a filter, prevent sudden changes in the automatic bias developed. For c-w operation, switch S5 connects capacitors C198 and C199 into the filter to increase the time constant and reduce any tendency to change the bias during periods of silence (spaces) between transmission times for this type of reception.

d. When switch S4 is set in the AGC position (fig. 26B), the CARRIER LEVEL meter is connected between the junction of resistors R89 and R91 and a tap on the METER ZERO potentiometer (R87). As the stronger signals are tuned, a corresponding change of voltage at the junction of resistors R89 and R91, changes the voltage applied to the meter circuit and, therefore, the current through it.

57. Carrier Level Meter

(fig. 26B)

a. The carrier level meter (M1) is a 50 microammeter with its scale marked in decibels. It shows the relative strength of the signal tuned by the receiver. It also may be used as a tuning



NOTES:

RESISTANCE VALUES IN OHMS UNLESS OTHERWISE SPECIFIED.
CAPACITANCE VALUES IN UUF UNLESS OTHERWISE SPECIFIED.

TM 897-27

Figure 26A and B. Radio Receiver R–274/FRR, functional diagram, agc and meter circuits.

meter if each incoming signal is tuned for maximum deflection of meter M1. Switch S4 must be in the AGC position for the meter to operate.

b. With a 2- to 3-uv input from the antenna to the antenna terminals, the voltages applied at the two ends of the meter circuit will be identical and no current will flow through the meter (M1). For adjustment instructions, refer to paragraph 87. When a stronger signal is tuned, the voltage at the junction of resistors R89 and R91 becomes more negative than the voltage at the tap on the METER ZERO potentiometer (R87), and a current will flow through the meter circuit. Resistor R112, in series with meter M1, limits the maximum flow of current to a safe value. The combination of resistor R112, in series and resistor R113, which is in parallel with meter M1, regulate the quantity of current which flows through the meter with respect to the voltage applied to the circuit.

c. Under normal conditions, with no tuned signal input to the 1st r-f amplifier, the voltage at the junction of resistors R89 and R91 will be a little more positive than the voltage tapped on METER ZERO potentiometer R87, and a small amount of current will flow through meter M1 in the direction opposite to normal, and the meter needle will deflect to the left-hand side of the scale. No damage will result since the force is very slight.

58. 1st A-f Amplifier

a. The 1st a-f amplifier (V16) is a resistance-coupled triode type 6AT6 tube, in which the diode plates are grounded and not used. The simplified circuit diagram is given in figure 27.

b. The audio signal from the diode detector and anl circuits is fed to the high side of the AUDIO GAIN control (R94) through coupling capacitor C200 which blocks off the d-c voltage from the anl load. A part of this audio voltage, depending on the setting of the AUDIO GAIN control, is sent to the grid of tube V16 where it is amplified. The output voltage appears across resistors R96 and R117 in the plate circuit of tube V16. Capacitor C196 improves the frequency response of the audio amplifier. The plate circuit is connected to +B through resistor R97. Capacitors C194A and C194B form a filter, with the aid of resistor R97, to prevent any audio frequencies from entering the power supply circuits.

c. R95 is the cathode resistor for tube V16 and provides the proper d-c bias between grid and cathode so that a minimum of audio distortion will be introduced by tube V16. Capacitor C202 is a bypass across R95 so that the cathode of V16 will be at ground potential insofar as the signal frequencies are concerned.

d. The receiver is provided with 2 terminals (AUDIO IN) so that external audio signals can be introduced to the audio section of the receiver and be amplified. One of these terminals is connected to the chassis, and the other is connected to the high side of the AUDIO GAIN control through coupling capacitor C201 which prevents d-c voltages from being impressed on the grid of tube V16.

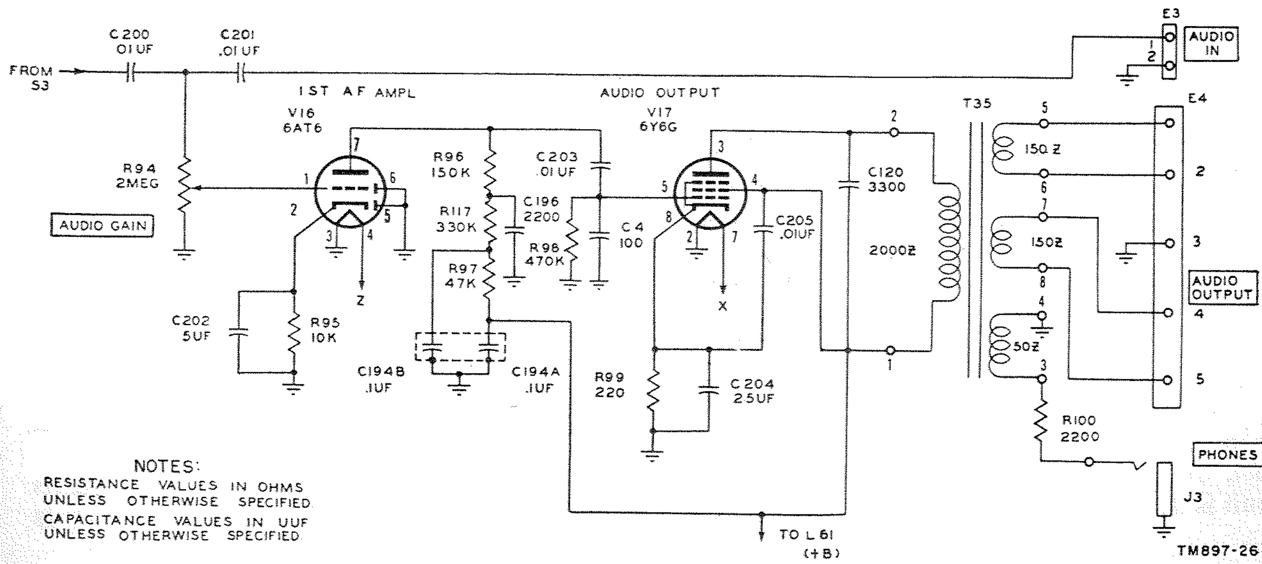


Figure 27. Radio Receiver R-274/FRR, functional diagram of the audio stages.

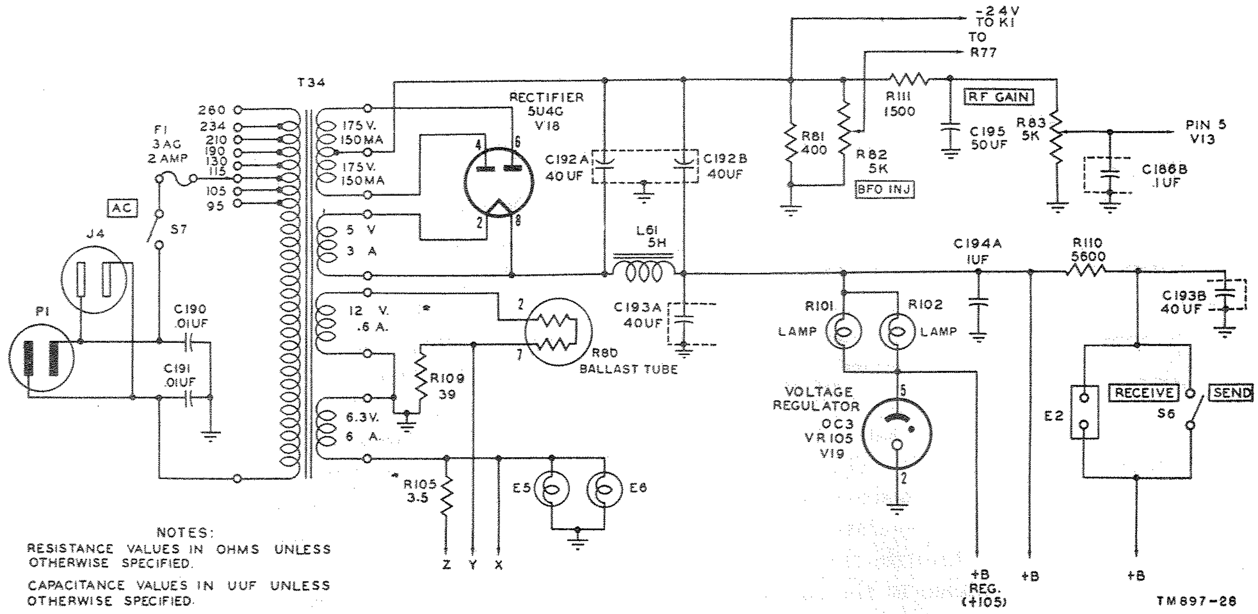


Figure 28. Radio Receiver R–274/FRR, functional diagram of the power supply.

59. Audio Output Amplifier

a. The a-f amplifier (V17) is capable of providing two watts of undistorted audio output. The simplified circuit is shown in figure 27.

b. The audio signal from tube V16 is fed to the grid of tube V17 through coupling capacitor C203 which prevents the d-c plate voltage of V16 from appearing on the grid of V17. Resistor R98 is the grid return of V17. Capacitor C4 is an r-f bypass, used to short out any spurious r-f voltages. The audio signal on the grid of V17 is amplified and goes to the primary of the audio output transformer T35 which has three secondary windings. Two of the secondary windings on T35 are 150-ohm windings and are connected to the audio output terminal board at the rear of the receiver. A ground terminal 3 also is provided. With this arrangement, a 600-ohm output load, either balanced or unbalanced, can be matched. Also, since the two secondaries constituting the 600-ohm output circuit are individually wired to the audio output terminal board (E4), a d-c control system can be connected to the output circuit without causing any interference with the a-f output.

c. The third output winding on transformer T35 is connected to PHONES jack J3 on the front panel, through a 2,200-ohm resistor R100. This circuit is designed so that phones or either high or low impedance can be plugged into PHONES jack (J3) without changing the power output to the 600-ohm load. If J3 is short-circuited, the output power to the 600-ohm load is reduced by less than 1 db.

d. R99 is the cathode resistor for Tube V17 and provides the proper bias between grid and cathode for minimum audio distortion. It also limits the plate and screen currents to safe values. Capacitor C204 is the cathode bypass which effectively grounds the cathode of V17 insofar as a-f signals are concerned. Capacitor C205 suppresses spurious oscillations in V17. Since V17 (JAN 6Y6G) is a beam-power amplifier, such oscillations might occur if the screen were not bypassed directly to the cathode. The screen grid of tube V17 is connected directly to +B, and the plate is connected to +B through the primary winding of transformer T35. Capacitor C120 improves the frequency response of the audio output.

60. Power Supply

a. The power supply provides d-c plate and bias voltages and a-c heater voltage to all the circuits previously described. The simplified circuit is shown in figure 28.

b. Power for Radio Receiver R–274/FRR is brought in through power socket P1, which is connected in parallel with AC OUT receptacle J4. One side of P1 is connected to the common terminal of the power transformer T34; the other side goes through the power RF GAIN-AC switch S7, on the RF GAIN-AC control (R83), then through the 2-ampere fuse (F1) to the proper tap on the power transformer (T34) primary. The taps are connected to binding posts on the base of transformer T34. These binding posts are located under the chassis and are identified with the following markings: 260, 234, 210, 190, 130, 115, 105, and 95. Determine the value of a-c power voltage and connect the flexible lead to the binding post marked with the value which most nearly approximates the value of input voltage. The transformer (T34) is designed for operation at 50 or 60 cycles. C190 and C191 are filter capacitors which prevent unwanted r-f signals from getting into the receiver through the power supply.

c. The h-v (high-voltage), center tapped secondary of transformer T34 is connected to the two plates of power rectifier V18 (5U4G). The rectifier filament is connected to the 5-volt rectifier filament winding of T34. The center tap of the h-v secondary of T34 is connected to ground through the paralleled resistors R81, R82, R111, R83, and R35, so that approximately −24 volts direct current appears between the high side of these resistors and ground. One side of the filamentary cathode of tube V18 is connected through filter choke L61 to the various B+ load circuits. Capacitors C192A and C192B filter out the a-c ripple voltage across the entire B+ rectifier system, and capacitor C193 further reduces the ripple or hum voltage from B+ to ground. Capacitor C194A assists in the filtering of the B+ lead, since electrolytics are inefficient at higher frequencies. Capacitor C195 filters the ripple across the bias voltage resistors R81, R82, R111, R83, and R35. Since it is desirable to stabilize (against normal power source voltage fluctuations) the voltage on the variable frequency oscillator plate, the 1st mixer screen, the bfo screen and plate, and the CARRIER LEVEL meter circuits, a voltage regulator, V19 (OC3, VR105) is included in the power supply. This is connected to +B through the parallel combination of R101 and R102, each of which is a 7-watt, 110-volt lamp. If one should fail, the other will permit operation of the receiver until a replacement can be obtained. In order to desensitize the receiver under some operating conditions, switch S6 (SEND-RECEIVE) has been incorporated in the +B lead to the screens of tubes V1, V2, V6, and V9. This permits the receiver to be desensitized without stopping the oscillators. The SEND REC terminal board (E2) which is connected in parallel with S6 can be used to desensitize the receiver from a remote position. Set switch S6 to the SEND position before using a remote control switch.

d. The negative 24 volts across the parallel combination of resistors R81, R82, R111, R83, and R35 is used for three purposes. First, by means of the RF GAIN-AC control, R83, any desired portion of this voltage to −18 volts can be impressed on the grids of the r-f and i-f amplifier tubes through the agc and bias voltage lead, thereby, controlling the gain of the receiver. Secondly, by means of the BFO INJ control (R82), any desired portion of the −24 volts can be impressed on the suppressor grid of the bfo tube (V14) through resistor R77. This acts as a bias to regulate the degree of electron coupling to the plate of the bfo tube, regulating the amplitude of bfo signal to the plate of the audio diode detector. The third use for −24 volts is to provide cut-off bias to the 6.455-mc oscillator (V8) when the turret switch is set in BAND I, II, or III, or actuating voltage for relay K1 when the turret switch is set in BAND IV, V, or VI.

e. The heater circuits of tubes V1, V2, V5, V6, V7, V8, V9, V10, V11, V13, V14, V15, and V17 are connected directly to the 6.3-volt winding of the power transformer, T34. Tubes V12 and V16 are important from the standpoint of hum in the audio amplifier. Hum can be reduced by reducing the heater voltage of a tube. Therefore, the voltage on the heaters of V12 and V16 is reduced by resistor R105 to approximately 5.5 volts. The heater voltage regulation of the vfo tube (V4) and on the 1st mixer tube (V3) has an important bearing on the frequency stability of the receiver and must be maintained without reflecting any line voltage variations. Therefore, these two heaters are connected to a separate 12-volt winding in T34 through regulating resistor R80. This resistor drops the heater voltage on V3 and V4 to 6.3 volts, and, in addition, maintains a nearly constant current through these tubes regardless of line voltage fluctuations. The two pilot lights (E5 and E6) are connected directly to the 6.3-volt winding on the power transformer (T34).

61. Control Circuits

Terminal board E2, with connections which parallel the SEND-RECEIVE switch (S6), may be used to connect a switch at a remote position to activate or desensitize the receiver. The remote switch should be a SPST switch. It should be insulated from ground because of the power supply voltage furnished through the switch for screen grid voltage on tubes V1, V2, V6, and V9. When the switch is closed, the voltage is applied to the screen grid circuits and the receiver is activated. This corresponds to the RECEIVE position of switch S6. When the remote switch is open, the screen grids receive no voltage and the receiver is desensitized without stopping the oscillators. This corresponds to the SEND position of switch S6. Note that switch S6 must be in the SEND position before the remote switch has any control on circuit operation. Note also, that the remote switch must be open before switch S6 has control of circuit operation.

CHAPTER 5

FIELD MAINTENANCE INSTRUCTIONS

Section I. TROUBLE SHOOTING AT FIELD MAINTENANCE LEVEL

Note. This chapter contains information for field maintenance. The amount of repair that can be performed by units having field maintenance responsibility is limited only by the tools and test equipment available and by the skill of the repairman.

Warning: There are certain points in the radio receiver that operate at voltages above 250 volts. These points are located in the vicinity of the power supply section and should not be touched while power is applied to the receiver. Be careful when handling or testing any part of the receiver while it is connected to the power source.

62. Trouble-Shooting Procedures

a. General. The first step in servicing a defective radio receiver is to sectionalize the fault. Sectionalization means tracing the fault to the *major component or circuit* responsible for the abnormal operation of the receiver. The second step is to localize the fault. Localization means tracing the fault to the defective part responsible for the abnormal condition. Some faults such as burned-out resistors, arcing, and shorted transformers can often be located by sight, smell, and hearing. The majority of faults, however, must be localized by *checking voltages and resistances.*

b. Component Sectionalization and Localization. A group of tests are listed below which are arranged to simplify and reduce unnecessary work in tracing a trouble to a specific component. The easy tests are used first; those that follow are more complex. Follow the sequence given. Remember that servicing procedure should cause no further damage to the receiver. In general, the trouble is traced to a section of the receiver; then the bad component in that section is located and the trouble remedied. The service procedure is summarized as follows:

(1) *Visual inspection.* The purpose of visual inspection (par. 35) is to locate any visible trouble. Through inspection alone, the repairman may frequently discover the trouble or determine the stage in which the trouble exists. This inspection is valuable in forestalling future failures and in avoiding additional damage to the receiver which might occur through improper servicing methods.

(2) *Input resistance measurements.* These measurements (par. 66) prevent further damage to the receiver from possible short circuits. Since this test gives an indication of the condition of the filter circuits, its function is more than preventive.

(3) *Operational test.* The operational test (par. 68) is important, because it frequently indicates the general location of trouble. In many instances, the information gained will determine the exact nature of the fault. In order to utilize this information fully, all symptoms must be interpreted in relation to one another.

(4) *Trouble-shooting chart.* The trouble symptoms listed in this chart (par. 69) will aid greatly in localizing trouble.

(5) *Signal substitution.* The principal advantage of the signal substitution method (pars. 72 through 75) is that it usually enables the repairman to localize a trouble accurately and quickly to a given stage when the location is not immediately evident from the above tests.

(6) *Stage gain charts.* These charts (par. 76) can be used to localize obscure, hard-to-find troubles

(7) *Intermittents.* In all these tests, the possibility of intermittents should not be overlooked. If present, this type of trouble often may be made to appear by tapping or jarring the receiver. It is possible that some external connection may cause the intermittent trouble. Test whatever can be tested in this case.

63. Trouble-Shooting Data

Take advantage of the material supplied in this manual. It will help in the rapid location of faults. Consult the following trouble-shooting data:

Fig. No.	Title
5	Radio Receiver R-274/FRR, tube location.
31	Radio Receiver R-274/FRR, chassis, top view.
32	Radio Receiver R-274/FRR, r-f chassis, bottom view.
33	Radio Receiver R-274/FRR, i-f and audio chassis, bottom view.
34	Radio Receiver R-274/FRR, 2d mixer and 6.455-mc oscillator chassis, bottom view.
35	Radio Receiver R-274/FRR, voltage and resistance measurements.
37	I-f switch-over relay connections.
43	Radio Receiver R-274/FRR, schematic diagram.

64. Test Equipment Required for Trouble Shooting

The test equipment required for trouble shooting Radio Receiver R-274/FRR is listed below. The technical manuals associated with the test equipment are also listed.

Test equipment	Publication
Signal Generator AN/URM-25 (range 10 kc to 50 mc).	Navships 91379
Signal Generator TS-497A/URR (range 2 to 400 mc).	TM 11-5030
Audio Oscillator TS-382A/U	TO 16-35TS382-2
Tube Testers I-177 and I-177-A	TM 11-2627
Frequency Meter Set SCR-211-(*) (range 125 kc to 20 mc).	TM 11-300
Frequency Meter TS-174B/U (range 20 to 280 mc).	TM 11-5044
Electronic Multimeter TS-505/U	TM 11-5511
Electronic Multimeter ME-6A/U	Navships 91269
Multimeter TS-352/U	TM 11-5527
Output Meter TS-585A/U	TM 11-5017

65. General Precautions

Observe the following precautions very carefully whenever servicing the radio receiver:

a. Be careful when the bottom cover is removed; dangerous voltages are exposed.

b. Use a cloth or tube puller when removing tubes; otherwise the hand or fingers may be burned.

c. When working on the top of the chassis, be careful not to bend the tuning gang capacitor plates; this could cause a short or a change of alinement.

d. Do not overtighten screws going through or threaded into plastic materials. This might strip the threads or produce cracks.

e. When changing a component that is held by screws or nuts, always replace the lockwashers.

f. Careless replacement of parts often makes new faults inevitable. Note the following points:

(1) Before a part is unsoldered, note the position of the leads. If the part, such as a transformer, has a number of connections, tag each of the leads to it.

(2) Be careful not to damage other leads by pulling or pushing them out of the way.

(3) Do not allow drops of solder to fall into the receiver, since they may cause short circuits.

(4) A carelessly soldered connection may create a new fault. It is very important to make well-soldered joints, since a poorly soldered joint is one of the most difficult faults to find.

(5) When a part is replaced in r-f or i-f circuits, it must be placed exactly as the original one was. A part which has the same electrical value but different physical size may cause trouble in h-f circuits. Give particular attention to proper grounding when replacing a part. Use the same ground as in the original wiring. Failure to observe these precautions may result in decreased gain or possibly oscillation of the circuit.

(6) Do not disturb the adjustment of METER ZERO control R87 or any of the alinement adjustments.

66. Checking B+ Circuits for Shorts

a. Many times a short circuit in the B+ line can disable the entire receiver; however, sometimes just one or a few stages will be affected. If the receiver is operated with a short circuit, other components may become overheated due to the increased current flow; sooner or later they will become defective. To check for these troubles without the danger of causing more damage, a resistance check should be made. Figure 29 is a simplified diagram of the B+ distribution throughout the receiver. In it are the paths which could offer short circuits. By using this diagram, in conjunction with the voltage and resistance chart

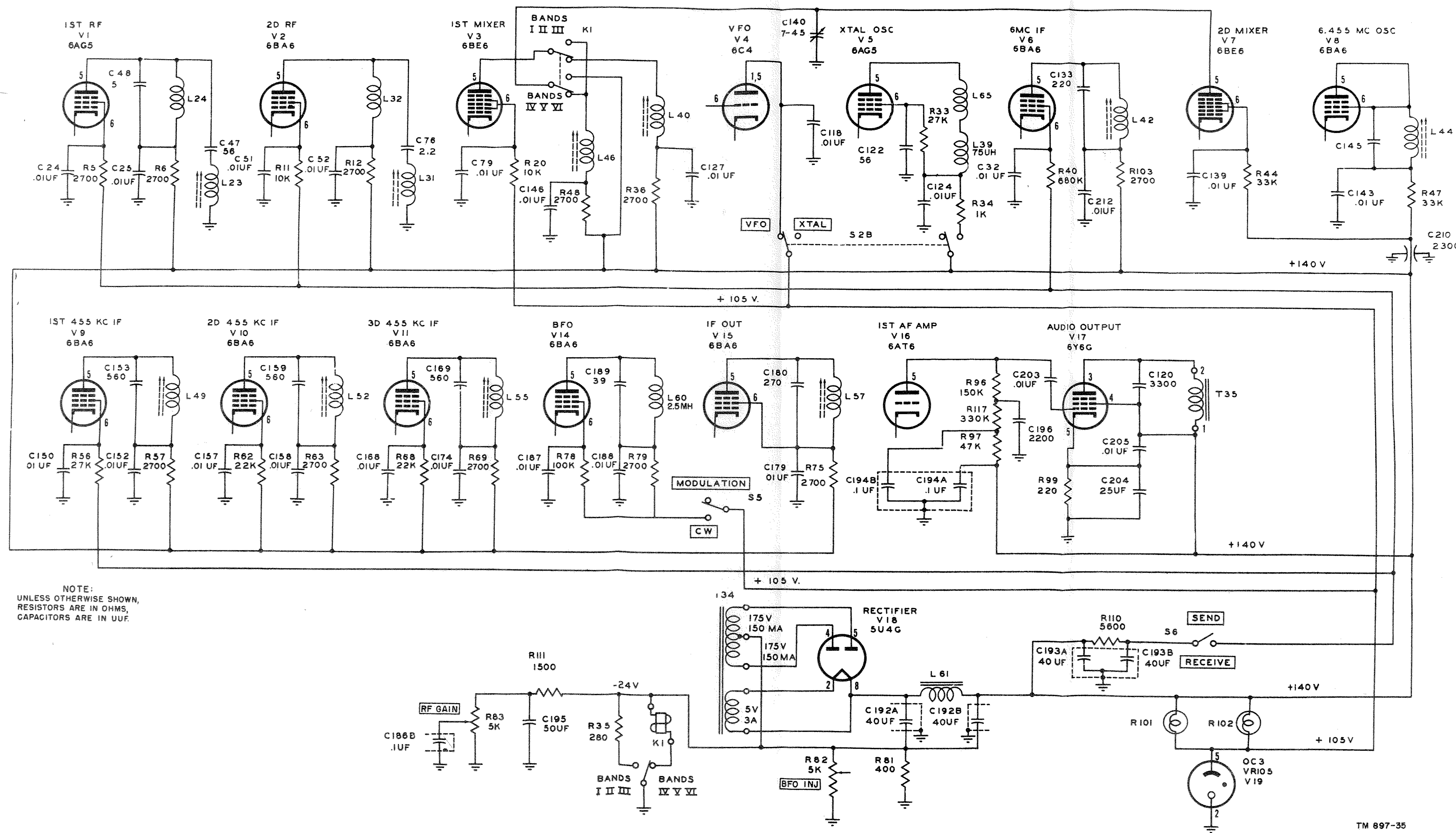


Figure 29. Radio Receiver R-274/FRR, +B voltage distribution.