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Department of Communication
April 1944

FIELD ARTILLERY
RADIO REPAIRMAN'S HANDBOOK

Short title: FARRH

Published April 1944 at the Field Artillery School and distributed with the approval of the Commanding General, Army Ground Forces, letter 300.5F/6 (14 April 1944) GNRQT-2/78390.

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Fort Sill, Oklahoma

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CHAPTER 1
GENERAL

1. PURPOSE. The purpose of this manual is to provide field artillery personnel with basic principles of maintenance and inspection of radio sets and to provide field artillery radio repairmen with fundamental techniques and procedures necessary to accomplish first and second echelon maintenance. A thorough knowledge of the principles of electricity and radio contained in TM 1–455, Electrical Fundamentals, and TM 11–455, Radio Fundamentals, is required. Ability to use the techniques contained in TM 11–453, Shop Work, is also necessary.

2. ECHELONS OF MAINTENANCE.

a. General. The basic policy to be followed in all maintenance and repair of communication equipment is prescribed in TM 38–250, Basic Maintenance Manual.

b. First echelon maintenance. The first echelon is preventive maintenance performed by the radio operator. This phase of maintenance is continuous regardless of time or location. Minimum training objectives include the following:

(1) Proper operation of equipment as specified in the appropriate technical manual.

(2) Proper care of equipment, including protection from weather and rough handling.

(3) Cleaning all external surfaces and removing dust and foreign matter (such as battery corrosion and excess grease) from internal parts.

(4) Preservation of exposed leather, web equipment, and external surfaces by timely and proper application of approved paints and preservatives.

(5) Inspection of equipment and installations to determine their ability to operate satisfactorily over the required distance.

(6) Minor adjustments necessary to transmit and receive on various frequencies. In the case of crystal-controlled radio sets, this includes changing crystals and retuning sets.

(7) Replacement of parts where replacement does not involve fixed electrical or mechanical connections. This includes

such items as antennas, vacuum tubes, microphones, headphones, batteries, power supply units, lead-in wires, and connecting cords and cables.

(8) Reporting all defects and troubles to the appropriate commander.

c. Second echelon maintenance. The second echelon maintenance is additional maintenance performed by the radio repairman and supplements that of the first echelon, it is limited largely by the tools, parts, and time available, and by the skill required to accomplish a particular job successfully. *In no case should adjustments or repair of a radio set be attempted in the second echelon unless successful completion is a certainty.* Minimum training objectives include the following:

(1) Periodic technical inspection of all radio sets.

(2) Additional preventive maintenance.

(3) Adjustment of any controls provided on the set. This includes tuning; alignment of RF, IF, discriminator, and BFO stages; neutralization; and adjustment of couplings.

(4) Location of electrical or mechanical defects.

(5) Determining if the necessary repairs can be made with the tools, test equipment, parts, and skill available.

(6) Repair of electrical or mechanical defects within the limits indicated in (5) above.

(7) Tagging sets which cannot be repaired in the unit, and indicating the defect for the convenience of the next higher echelon of maintenance.

(8) Making a final operating check to determine whether the set is operating satisfactorily and if it will communicate over its rated range.

(9) Reporting to the communication officer all sets which cannot be repaired in the unit.

CHAPTER 2
TEST EQUIPMENT

SECTION I
GENERAL

3. GENERAL. Test equipment of various types is used to control the operation, channel presetting, alignment, and testing of all field artillery radio sets. A thorough knowledge of the use of available test equipment is indispensable to repairmen. Appropriate technical manuals must be consulted to determine precise methods for using each item of equipment. The theory of operation of various types of meters is included in TM 1–455, Electrical Fundamentals.

4. CLASSIFICATION OF TEST EQUIPMENT. Test equipment may be classified according to its principal use as current measuring instruments, voltage measuring instruments, power-measuring instruments, continuity indicators, signal sources, signal tracers, and tube testers. All classes of test equipment except tube testers are considered in this chapter. Tube testers are discussed in chapter 3.

5. REPAIR AND MAINTENANCE. The extent of repairs which may be accomplished on test equipment by the repairman will be limited by the nature of the trouble, the individual repairman's skill and ingenuity, and by the equipment available.

SECTION II

CURRENT MEASURING INSTRUMENTS

6. METER MOVEMENT. Most current measuring meters use the same basic movement. A small coil, suspended on jeweled bearings and free to rotate against a retarding force of two spiral springs, is mounted between the poles of a permanent magnet. An electric current passing through the coil sets up a magnetic field around it which reacts with the permanent magnetic field and causes the coil, which has a pointer attached, to rotate on its bearings. Deflection of the pointer from zero will indicate the amount of current flowing. Each meter is designed to allow full scale deflection of the pointer when a definite current is flowing (commonly 1 milliampere, 400 microamperes, or 250 microamperes).

7. CONNECTIONS. When measuring current flow, the meter must be connected in series with the circuit being tested, so that all or a known proportion of the current flows through the instrument. If accurate measurements are required, the instrument resistance must be low in comparison to that of the circuit being tested.

8. DETERMINATION OF AMMETER RESISTANCE. To determine the resistance of an ammeter, connect a battery, ammeter, and variable resistor in series as indicated in figure 1. The variable resistor must be sufficiently large to limit the current through the meter to a safe value, and must be large in comparison to the resistance of the meter. Adjust the variable resistor until the meter reads full scale. Then connect a small variable resistor in parallel with the meter and adjust until the meter reads one-half scale. Measure the resistance of the shunt added with an ohmmeter. This will be equal to the resistance of the meter within practical limits.

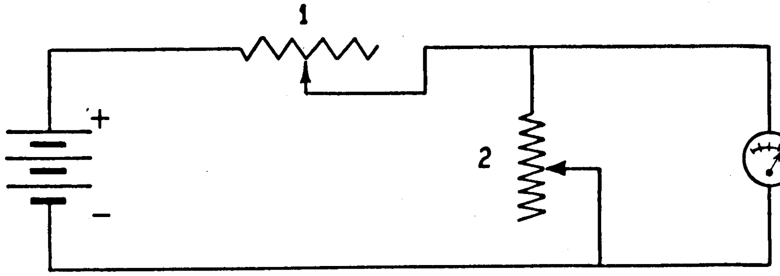


FIGURE 1. Determination of ammeter resistance.

9. CALIBRATION. To calibrate an ammeter or milliammeter, connect an ammeter which is known to be accurate in a circuit in which a steady value of current is flowing and measure the current. Then, substitute in the same circuit the ammeter to be calibrated and note its reading. If not identical to that of the meter of known accuracy, make whatever adjustments are provided by the manufacturer, or note the correction that must be applied to readings taken with this meter for future reference. This method is sufficiently accurate for use by repairmen.

10. EXTENDING AMMETER RANGE. To extend the range of an ammeter which has already been calibrated, a resistance of suitable value (shunt) is placed in parallel with the meter. If the meter resistance is known, the value of the shunt to be used for a particular range may be calculated by the formula $R_s = R_m/(N-1)$, where R_s is the resistance of the shunt, R_m is the resistance of the meter, and N is the number of times the range is to be extended.

11. CLASSIFICATION OF AMMETERS. Current measuring meters are classified as DC or AC, and may be further classified according to range, as milliammeters. Ammeters and milliammeters are frequently incorporated with voltmeters and ohmeters in multi-purpose instruments. Care must be exercised when using such meters to assure use of the proper scale and the correct setting of switches.

12. AMMETER PRECAUTIONS.

a. When measuring unknown currents, use the highest range of the meter.

b. Observe proper polarity for the meter.

c. Do not connect a DC meter into a circuit where AC is flowing.

d. Short circuit ammeters before making changes in the circuit being measured.

13. RADIO FREQUENCY AMMETERS. The basic meter movement is not satisfactory for measuring RF current directly. However, RF may be used to heat a thermocouple, and current flowing due to the potential difference developed in the thermocouple may be measured with a conventional meter movement. Since the potential difference developed in the thermocouple is directly proportional to the effective value of RF current, the meter may be calibrated to measure accurately the flow of RF current.

14. NEON LAMP. The presence of RF in a circuit may be discovered by touching a neon lamp to the circuit concerned. If RF is present, the lamp should glow. If the circuit contains an element where lines of force are concentrated, such as a coil, the lamp need only be placed in the vicinity of this element. This test will be satisfactory only where relatively large amounts of RF current are present, such as in most transmitter circuits.

15. INCANDESCENT LAMP. The presence of DC or AC in a circuit may be discovered by placing an incandescent lamp in series with the circuit. If current is flowing, the lamp should glow. The size of lamp used must be governed by the amount of current believed to be flowing. For very small currents, a flashlight bulb should be used, and even this may give a false indication of no current. RF current in a coil may be indicated by connecting a flashlight bulb in series with a loop of wire and inductively coupling the loop to the coil.

SECTION III

VOLTAGE MEASURING INSTRUMENTS

16. CONSTRUCTION AND CONNECTION. Meters for measuring the voltage difference between two points may operate on the principle of the basic meter movement (par. 6) or may involve the use of a calibrated electron-ray tube. Voltage measuring instruments must always be connected in parallel with the circuit element to be measured. The instrument resistance must always be high in comparison to that of the circuit element being tested.

17. DETERMINATION OF VOLTMETER RESISTANCE. Connect a battery and meter in series so that the battery causes full-scale deflection on the meter. Add sufficient resistance in series to produce half-scale deflection, and measure the resistance added by use of an ohmmeter. This will be equal to the resistance of the meter within practical limits.

18. CALIBRATION.

a. To calibrate a voltmeter, connect a voltmeter which is known to be accurate across a circuit element through which a steady value of current is flowing and measure the voltage drop. Then, substitute the voltmeter to be calibrated across the same circuit element and note its reading. If not identical to that of the accurate meter, make whatever adjustments are provided by the manufacturer, or note the correction that must be applied to readings taken with this meter for future reference. This method is sufficiently accurate for use by repairmen.

b. Measure the open circuit voltage of a fresh dry cell battery. This should be 1.53 volts. Calibrate the meter if possible, or note the correction that must be applied to the meter. For voltmeters with much greater ranges, use more than one dry cell battery. This method is sufficiently accurate for use by repairmen.

19. EXTENDING RANGE OF VOLTMETER. To extend the range of a voltmeter which has already been calibrated, a resistance of suitable value (multiplier) is placed in series with the meter. If the meter resistance is known, the value of the multiplier to use for a particular range may be calculated by the formula $R = R_m (N-1)$, where R is the multiplier resistance, R_m is the meter resistance, and N is the number of times the range is to be extended.

20. CLASSIFICATION OF VOLTMETERS. Voltmeters are classified as DC or AC, and may be further classified according to the internal resistance of the meter per volt.

21. VOLTMETER PRECAUTIONS.

a. When measuring unknown voltages, use the highest range of the meter.

b. Observe proper polarity for the meter.

c. Do not connect a DC meter into a circuit where AC is flowing.

d. Disconnect the meter before making changes in circuit being measured.

e. Make sure that the meter resistance which is affecting the flow of current in the circuit being measured is considered when interpreting results.

22. VACUUM TUBE VOLTMETER.

a. General. DC vacuum tube voltmeters (VTVM) are particularly useful because their input resistance (10 to 14 megohms) allows the meter to be connected to an operating stage of a radio set with negligible loading effect.

b. Circuit arrangement. A common type of vacuum tube voltmeter consists of a balanced bridge in which the plate resistance of a triode vacuum tube is one arm of the bridge, and a basic meter movement is connected across the bridge. The meter is made to read zero by adjusting the bias on the vacuum tube grid while the test prods are shorted together. The voltage to be measured is applied to the grid of the vacuum tube and the resulting apparent change in plate resistance of the vacuum tube unbalances the bridge and causes current to flow through the meter in proportion to the voltage being measured.

c. False zero. When small positive and negative voltages are to be measured, a VTVM may be set at false zero to facilitate work. With the meter actually measuring zero voltage (test prods shorted together), the grid bias is adjusted so that the meter pointer indicates some value greater than zero (e.g. mid-scale). If positive voltages are then measured, the meter will show an increase in deflection; and if negative voltages are measured, the meter will show a decrease in deflection.

d. Improvised vacuum tube voltmeter. An improvised VTVM may be constructed as indicated in figure 2. The meter range is changed by changing the vacuum tube grid bias. Calibration does not have to be exact if used only for indicating voltage peaks. However, if exact measurements are required, calibrate by measuring standard voltage sources. For accurate results, use a grid bias greater than the voltage to be measured. Plate current cut-off occurs at about minus 10½ volts bias. The base of a four prong tube may be used to connect to the battery BA-40. This meter may be used as a high resistance, low range milliammeter if calibrated against a known value of current.

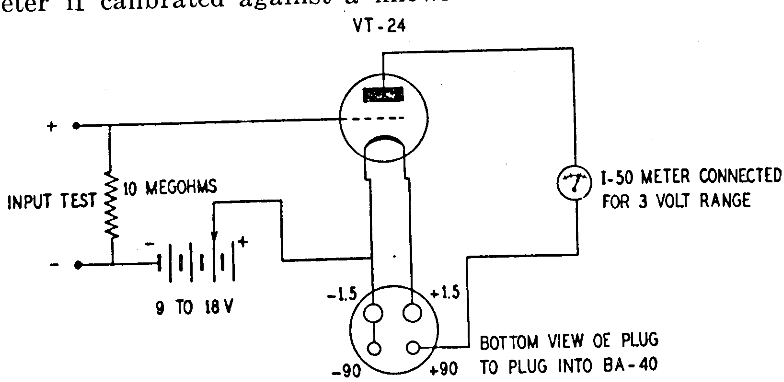


FIGURE 2. Improvised vacuum tube voltmeter.

23. ELECTRON-RAY TUBE.

a. General. An electron-ray tube may be used to indicate voltage peaks or dips, and, if calibrated, may be used to measure voltages within fairly broad limits. This instrument has a high input resistance and may be connected to an operating stage with negligible loading effect.

b. Circuit arrangement. A common type of electron-ray tube circuit consists of a triode and electron-ray indicator in one glass envelope as indicated in figure 3. The voltage to be measured is connected between the triode grid and cathode so that larger voltages will make the grid more negative. As the grid becomes more negative, the triode plate current becomes smaller, the deflector plate becomes more nearly same potential as the electron-ray target, and the dark section or shadow of the target becomes smaller. This instrument may be calibrated by applying a standard voltage to the triode grid and adjusting the plate voltage or grid bias so that the shadow just closes when that voltage is measured.

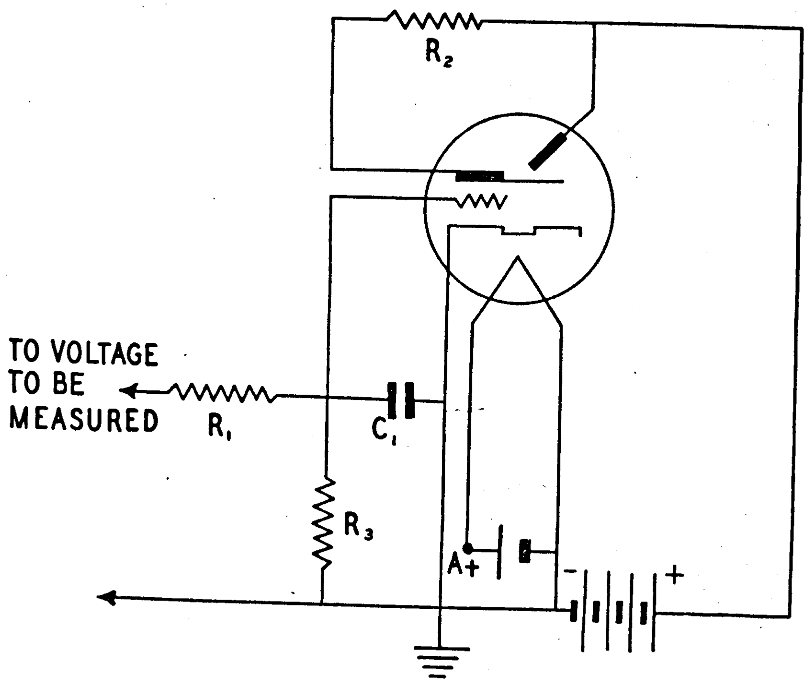


FIGURE 3. Electron-ray tube application.

24. INCANDESCENT LAMP. The presence or absence of a voltage between two points can be indicated by connecting an incandescent lamp between those points. The lamp will glow if a voltage is present. The size of lamp must be carefully chosen according to the voltage expected or this test will produce misleading results; for example, for small voltages a flashlight bulb should be used.

25. **HEADPHONES AND CONDENSER.** The presence or absence of a voltage between two points may be indicated by connecting headphones in series with a .01 microfarad condenser across the points where a voltage is to be measured. A click indicates the presence of a voltage and the loudness of the click indicates the relative magnitude of the voltage. This test should not be used for potentials over 100 volts.

SECTION IV

POWER MEASURING INSTRUMENTS

26. **GENERAL.** Electrical power consumed by a circuit requires that both current and voltage be considered. This can be done in DC circuits by measuring current using an ammeter and voltage using a voltmeter, and multiplying the two results to obtain power in watts. Power measurements are relatively unimportant to the radio repairman except in aligning or testing receivers. An output meter may be used for this purpose.

27. **OUTPUT METER.**

a. General. An output meter is designed to take output readings directly from the output circuit of any vacuum tube. A series condenser is provided to isolate the instrument so that DC potentials will not cause damage to the instrument.

b. Circuit arrangement. A common type of output meter employs a full wave bridge rectifier system and a basic meter movement which indicates power by measuring the current flowing through a standard resistor contained within the instrument. The total impedance across the input terminals is made constant on all ranges of the instrument so that the loading of the output tube will not be changed when the meter range is changed.

SECTION V

CONTINUITY INDICATORS

28. **GENERAL.** The continuity of a circuit or element of a circuit may be determined by means of a continuity tester. Its

essential parts are a source of power to provide current when the circuit is complete, an indicator to indicate the flow of current, and associated wiring and test prods. The actual resistance of a circuit may or may not be measured.

29. OHMMETER.

a. General. A series type ohmmeter is indicated in figure 4. The circuit is designed so that the battery can be adjusted to cause full-scale deflection of the meter when the test prods are shorted together. When the test prods are connected to an unknown circuit, the meter pointer will move down scale an amount proportional to the resistance of the circuit being measured. If the circuit is open or has extremely high resistance, the pointer will drop to indicate infinite resistance. The meter is normally calibrated in ohms.

b. Extending range. The range of an ohmmeter may be doubled by connecting sufficient external resistance into the circuit to cause the meter to read one-half scale and then adding sufficient batteries to cause the meter again to read full scale.

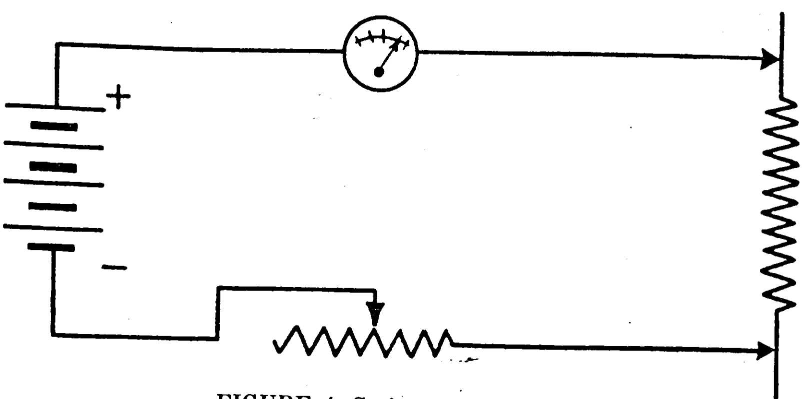


FIGURE 4. Series type ohmmeter.

30. HEADPHONES AND BATTERY. An elementary continuity tester is indicated in figure 5. When test prods are placed across a low resistance, a loud click will be heard in the headphones. A high resistance will produce faint clicks. More than 25 milliamperes flowing for a long period will damage the headphones.

31. LAMP AND BATTERY. An incandescent lamp may be substituted for the headphones in paragraph 30. This arrangement, however, is unsatisfactory for high resistances.

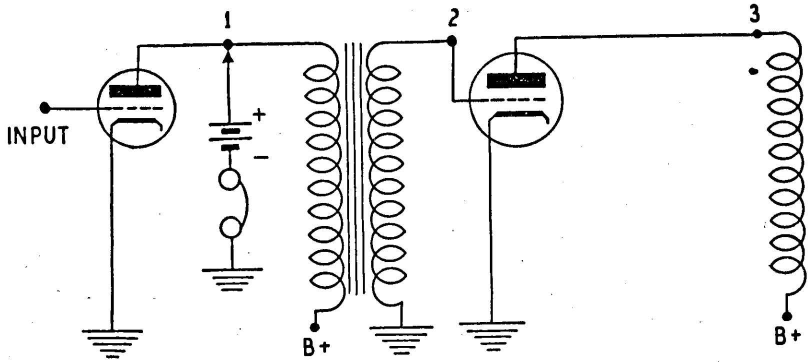


FIGURE 5. Elementary continuity tester.

32. VOLTMETER AND BATTERY. A voltmeter may be substituted for the headphones in paragraph 30. If the battery causes full-scale deflection when the test prods are shorted together, low values of resistance will be indicated near full-scale deflection, and high values near zero deflection. By comparing readings obtained with unknown resistors to those obtained with resistors of known value, actual resistances of unknown elements may be closely approximated.

SECTION VI
SIGNAL SOURCES

33. GENERAL. For testing and aligning radio receivers, signals of known frequency are required. These may be either modulated or unmodulated—usually the latter.

34. OSCILLATOR. A stable oscillator circuit, preferably crystal controlled, will provide a CW signal of constant frequency. This signal may be coupled directly to that portion of the radio set to be tested. A control is normally available so that the volume of the signal may be controlled. The manufacturer's instruction book should be consulted for details concerning construction, use, and maintenance of commercial oscillators.

35. HETERODYNE FREQUENCY METER. A heterodyne frequency meter is designed to measure or to radiate radio frequency CW signals on a wide range of frequencies. When used as a signal generator it should be coupled to the radio receiver through a .001 microfarad condenser to prevent undesired loading effects. The frequency meter should be used only when accurately calibrated. The manufacturer's instruction book should be consulted for details of construction, use and maintenance.

36. TRANSMITTER. A good transmitter capable of producing a signal of constant frequency may be used as a signal source. Power amplifiers should be disabled where possible to reduce output. If a modulated signal is required, this may be obtained by talking or whistling into the microphone. If the transmitter is crystal controlled and uses frequency multiplication, a wide variety of radio frequency signals may be obtained by selecting the proper crystal and harmonic to give the output frequency desired. Care is necessary to make certain that the correct harmonic is obtained. This may require the use of a frequency or wave meter.

37. RECEIVER AND TRANSMITTER. If a signal is required for aligning receiver stages, a good transmitter may be operated so that its signal is received on a good receiver of same type as the receiver under test. Connect the chassis of both receivers together and feed an RF, IF or AF signal as required from the good receiver to receiver under test by connecting corresponding grids of the desired stage together using a lead wire with a series condenser.

SECTION VII
SIGNAL TRACER

38. GENERAL. Signal tracers are frequently used to trace the progress of a radio signal through a receiver, and locate troubles. Signal voltages developed at any point in the receiver are transferred to the signal tracer as indicated below and the quality of the signal at that point is noted by listening at the reproducer of the signal tracer. Usually, the signal is traced first from the antenna of the receiver being tested and then progressively at various points to the reproducer of the receiver being tested.

39. AF SIGNAL TRACER. Audio frequency signals may be traced using conventional headphones in series with a condenser to prevent passage of DC through the headphones. Connect the headphones across any impedance where an audio voltage is developed.

40. UNTUNED SIGNAL TRACER. A schematic diagram for an improvised, untuned signal tracer capable of tracing signals through RF and IF sections, as well as through AF sections, is shown in figure 6. This circuit will respond to a wide range of frequencies, but will not indicate the frequency of the signal and is not satisfactory with frequency modulated signals. Connect the proper input terminals indicated in figure 6 across any impedance where an RF or AF voltage is developed and listen at the output of the signal tracer.

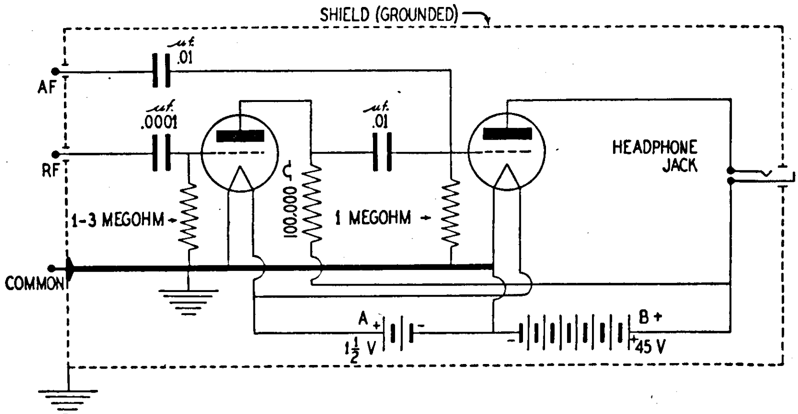


FIGURE 6. Untuned signal tracer.

41. GOOD RECEIVER. A receiver known to be good may be used as a signal tracer. Connect the chassis of a good receiver and the receiver being tested together and then transfer signals from the receiver being tested to the good receiver by connecting corresponding points in the desired stage of each, using a lead wire with a .001 microfarad series condenser.

CHAPTER 3

TESTING RADIO PARTS AND ASSEMBLIES

SECTION I

FUNDAMENTAL PARTS

42. GENERAL. Radio sets contain some or all of the following fundamental parts: resistors, condensers, coils, transformers, tubes, and electrical connections. Appropriate tests are given below for these parts. Unless otherwise indicated, all tests are for parts *not* connected in a circuit.

43. RESISTORS.

a. Classification. Resistors are either fixed or variable and are characterized by their ohmic resistance and wattage rating. They may be classified according to usage as: voltage dropping, current limiting, coupling, decoupling, filter, or load resistors. Resistors may develop opens or shorts and may change resistance.

b. Open. Open resistors may be discovered by testing with any appropriate continuity tester. If the resistor is open the continuity tester will indicate no flow of current.

c. Shorts. Shorted resistors may be detected by use of an ohmmeter. The ohmmeter will indicate zero resistance, or if only partially shorted, the ohmmeter will indicate a resistance between zero and the rated value.

d. Resistance changed. Resistors which have permanently changed in value may be detected by use of an ohmmeter. However, during operation of radios, resistors sometimes make erratic changes in value. This is evidenced by noisy operation in the reproducer. Figure 7 shows a circuit which may be used to check resistors for noisy operation.

44. CONDENSERS.

a. Classification. Condensers are either fixed or variable and are characterized by their capacity, working voltage, surge volt-

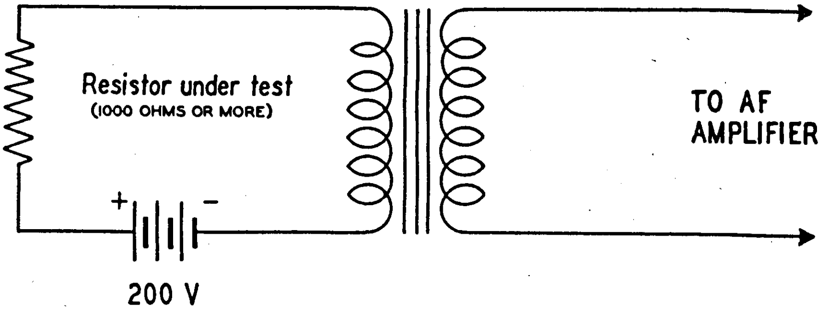


FIGURE 7. Circuit for testing noisy resistors.

age, and dielectric. They may be classified according to usage as: coupling, decoupling, bypass, DC blocking, filter, tuning, trimmer, and padder condensers. Condensers may develop opens, shorts, or leakage (high resistance short), and may change capacity. Electrolytic condensers should be tested by substitution since no other method is quite satisfactory. Condensers with air, paper, or mica dielectric may be tested as indicated below.

b. Working voltage test. Connect a DC power supply in series with a meter capable of measuring its highest voltage and test the condenser under its rated working voltage as indicated in figure 8. If the capacity of the condenser is more than .01 microfarad, failure to obtain an initial surge on the meter will indicate an open condenser. If the meter does not return to zero, a short is indicated.

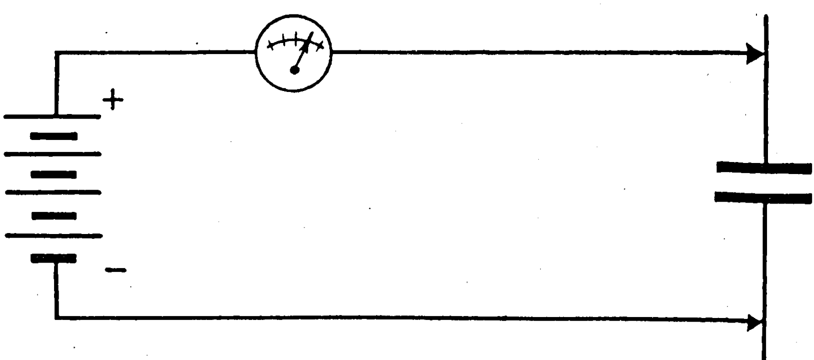


FIGURE 8. Condenser working voltage test.

c. AC voltage test. Connect an AC power supply and an AC meter capable of measuring its highest voltage in series and test condenser as in figure 8. Zero meter reading indicates an open condenser. Full voltage of the power supply indicates a shorted condenser. A good condenser will give a reading somewhat below full voltage. An AC voltmeter and 110 volt AC power supply may be used with condensers of known capacity to establish a comparison chart for determining unknown capacities. For condensers with capacities above .5 microfarad, a 15 watt lamp may be substituted for the meter and its brilliance used to indicate the condition of the condenser. Condensers to be tested with AC *must* be removed from the radio set.

d. Charge and discharge test. Condensers with capacities of less than .1 microfarad may be charged using a 3 volt battery and then discharged through headphones. A loud click indicates a good condenser, a weak click indicates leakage, and no click indicates a short or open. For larger condensers a 90 volt battery should be used. After one minute the condenser should be discharged by shorting with a screwdriver and the spark strength used to judge the condition of the condenser.

e. Ohmmeter test. Low capacity condensers may be tested using an ohmmeter. When connected to an ohmmeter, a good condenser will give an initial meter surge and then indicate infinite resistance. A shorted condenser will indicate a low resistance. An open condenser will give no initial surge on the meter. This method is not conclusive because it will not indicate a high resistance short.

45. COILS.

a. Classification. Coils may be fixed or variable and are characterized by their inductance and type of core. They may be classified according to usage as: RF choke, AF choke, filter, tuning, and load coils. Coils may develop opens, shorts, or grounds.

b. Opens. Any form of continuity tester may be used to check for open coils. If the coil is open, the continuity tester will indicate no flow of current.

c. Shorts. Shorts are difficult to locate by electrical test. RF coils should be inspected visually for shorts and AF coils may be checked by an ohmmeter if the resistance of the good coil is known.

d. Grounds. RF coils are usually wound on insulated forms and are not apt to have grounds. Coils using metallic cores may be checked for grounds using a continuity tester as in figure 9. If the coil is grounded, the continuity tester will indicate a flow of current.

46. TRANSFORMERS.

a. Classification. Transformers are characterized by their turns ratio, number of secondaries, type of core, and impedance. They may be classified according to usage as: RF, IF, AF, or power transformers. Transformers may develop opens, shorts, or grounds. Power transformers may have secondaries improperly connected.

b. Opens. Any form of continuity tester may be used to check for open transformers (figure 9). If the transformer winding is open, the continuity tester will indicate no flow of current. If the open is caused by "burning out", causes of high current must be investigated. RF transformers usually develop opens only.

c. Shorts. Shorts may be tested as indicated in figure 9. If the transformer windings are shorted, the continuity tester will indicate a flow of current. Shorts at radio frequencies only may be difficult to discover except by visual inspection or by substitution.

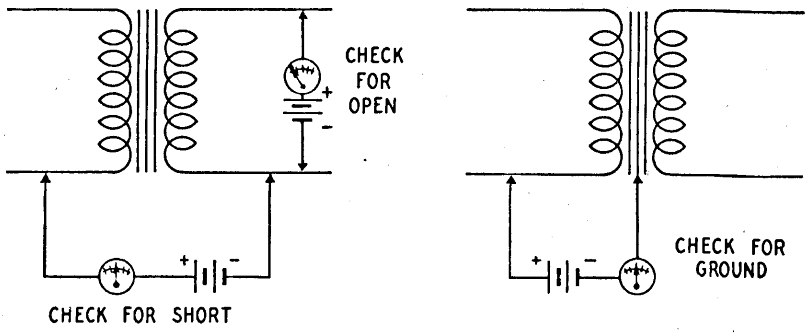


FIGURE 9. Testing transformer with continuity indicator.

d. Grounds. Grounds may be tested as indicated in figure 9. If the transformer winding is grounded, the continuity tester will indicate a flow of current. Grounded secondaries are frequently the cause of burned-out primaries, and are often indicated by heat, smoke, or unusual odors.

e. Identification of leads. The leads of power transformers which are not marked may be identified by placing each winding successively in series with a 60 watt lamp and 110 volt AC power supply. The primary winding will allow the lamp to glow faintly, the high voltage secondary winding will produce only a faint spark, and the low voltage secondary will allow the lamp to glow brilliantly.

47. TUBES.

a. Classification. Tubes may be high vacuum or gas filled, and are characterized by the number and arrangement of their elements, type of envelope, type of base, socket connections, and electrical characteristics. Tubes may be classified according to use as: oscillator, amplifier, detector, modulator, rectifier, voltage regulator, frequency converter, or electron-ray tubes. One tube may perform more than one function if suitable circuit changes are made. Open filaments, shorted elements, low emission (weak), open connections, cathode to heater leakage, and gassy tubes may cause partial or complete failure of tubes. Defective tubes are best discovered by substitution although numerous other tests are possible. When testing by substitution, always place the suspected tube in a good receiver or transmitter and check performance. This will eliminate the chance of ruining numerous good tubes by placing them in a defective radio set which may burn out their filaments, and will make trouble location easier when more than one trouble exists.

b. Base connections. Tube elements are brought from inside the tube to external connections at base prongs or a cap on top of the envelope. Schematic diagrams of radio sets indicate the prong number at which each tube element is terminated. A standard system used for numbering prongs viewed from the bottom of the tube base is indicated in figure 10. Seven-prong tubes which fit eight-prong sockets are numbered the same as the eight-prong except that the number of the missing prong is omitted.

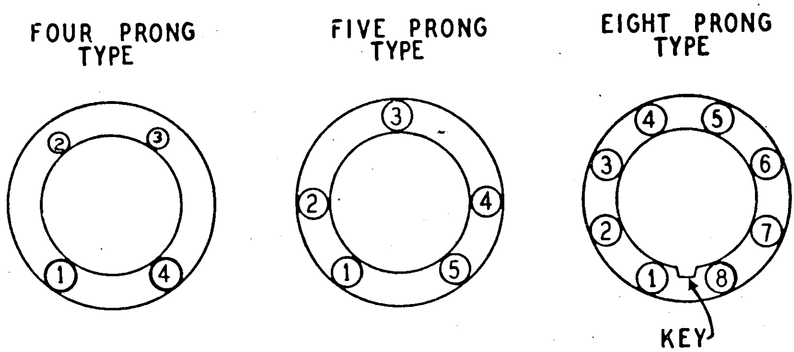


FIGURE 10. Tube base numbering system (bottom view).

c. Open filament. A continuity indicator will test for open filaments.

d. Shorted elements. If two elements of a tube are shorted together, a continuity indicator connected between external connections of these two elements will indicate a continuous path for current. Commercial tube testers usually include a short-circuit test of this nature.

e. Low emission. An operational test in a good radio set is the best test for low emission. Commercial tube testers provide an emission test in which all electrodes except the cathode are connected to the plate. The filament or heater is operated at rated voltage, and a low positive voltage is applied between the plate and cathode of the tubes. Relative electron emission is indicated on a series milliammeter. Low emission indicates that the tube is approaching the end of its useful life.

f. Open connections. Open connections are easiest to discover by substitution of the tube in a good radio set.

g. Cathode to heater leakage. Cathode to heater leakage is a form of short circuit and may be discovered in a similar manner using a commercial tube tester.

h. Gassy tubes. High vacuum tubes sometimes fail due to accumulation of gas in the envelope. This may be indicated by a tube tester, or a special test may be made for resistance coupled receiver amplifier tubes. With the suspected tube in a good receiver and receiving no signal, connect a vacuum tube voltmeter to measure grid voltage. A positive voltage on the grid will indicate a gassy tube if the coupling condenser from the preceding stage is not leaky. A gassy tube may be distinguished from a leaky coupling condenser because the latter gives a positive voltage immediately after the set is turned on, while the former must first warm up, and this may require several minutes. If in doubt, disconnect one side of the coupling condenser and repeat the test.

i. Transconductance test. Most commercial tube testers incorporate a test to determine the transconductance of the tube. Rated DC voltages are applied to each element of the tube. For a static test, the grid bias is changed and the corresponding change in DC plate current indicates the transconductance of the tube. For a dynamic test, an AC voltage is applied to the grid and the changing plate current indicates the transconductance of the tube.

j. Power output test. Commercial tube testers may include a power output test. Power developed in a plate load when an AC signal is impressed on the grid is determined. This provides an excellent test to determine the operating condition of the tube.

48. ELECTRICAL CONNECTIONS. Electrical connections in radio sets are of great importance and may cause a high percentage of all troubles. Defective connections may be discovered by visual inspection and by use of an ohmmeter. Connections should be *mechanically fastened* to sockets and terminals, and then soldered. Soldered connections made with a cold iron (resin joints) pull loose easily and may have high resistance as measured with an ohmmeter.

SECTION II
SPECIAL UNITS

49. GENERAL. Many special units or assemblies are used in radio sets. Tests indicated in this section are for units when *not* connected to radio sets unless specifically indicated otherwise.

50. CORDS, PLUGS, AND JACKS. A large proportion of all troubles in radio sets is due to defective cords, plugs, and jacks. Defects may be opens, shorts, grounds, defective connections, and corroded contacts. All defects may be discovered by means of visual inspection and testing with a continuity tester. The resistance of cords, plugs, and jacks should approach zero for each particular circuit. Electrical connections should be satisfactory, insulation undamaged and complete, conductors not grounded to shielding except when designed to be grounded, plugs and jacks fitted tightly, socket pins straight and well burnished, keys and keyways smooth and undamaged, and all sliding contacts well burnished.

51. SWITCHES. Most switches used in field artillery radio sets are mechanically operated and use sliding or knife contacts. Switches may develop opens, shorts, grounds, and high resistance contacts, and may be physically damaged so that proper contacts are not made. Visual inspection and testing with a continuity indicator should disclose all defects. Switches must be kept free from water and lubricants.

52. SHIELDING. In high frequency radio stages having high gain, shielding is employed to prevent undesired feedback. The input circuit, output circuit, and the tube should be shielded from each other and from other high frequency stages. Coils are usually mounted in shield cans, ganged tuning condensers usually have baffle plates mounted between sections, and tubes have metal shields which slip over the tube envelope. All shields should be grounded to the chassis by short and heavy connections. Metal tubes require no shielding. Lead wires may sometimes be shielded by enclosure in metallic sheathing which is grounded to the chassis. Shields should never be removed unless immediately replaced. Visual inspection and electrical checks of ground connections should adequately test shielding.

53. FUZES. Fuzes are used in radio sets to protect meters, tubes, and other equipment from excessive currents. Fuzes must *never* be short circuited. Whenever fuzes burn out, the cause of excessive current must be discovered and eliminated. Open fuzes may be discovered by visual inspection or by using a continuity tester.

54. CIRCUIT BREAKERS. Circuit breakers serve a function similar to that of fuzes and must *never* be tied down or short circuited.

55. RELAYS. Relays are used to complete electrical circuits and to regulate current and voltage of power supplies. When used to complete electrical circuits, the relay normally consists of an electromagnet and armature. A low voltage circuit energizes the electromagnet when a key or switch is operated, and the electromagnet attracts the armature thereby making or breaking one or more electrical contacts. The electromagnet coil may develop opens, shorts, or grounds and may be tested in the same manner as other coils. Tension of the armature restoring spring, the armature gap distance, and mechanical operation of the armature may be checked by visual or mechanical inspection. Pitted or sticking points may be checked by visual inspection or by noting irregular operation of the relay and arcing at the points. Relay points should never be touched by the fingers, as perspiration or oil will cause defective operation.

56. CRYSTALS. Quartz crystals used to control the frequency of oscillators are relatively free from trouble if carefully handled. Rough treatment may cause crystals to crack or connections to break. Crystals should be tested by installing in an oscillator circuit and measuring the rectified grid voltage developed while oscillating with a VTVM. Voltage measured should be compared to that of a crystal known to be good when used in the same circuit. The rectified grid voltage indicates the relative activity of the crystal, and in most applications will be negative 4½ volts or more.

57. COPPER OXIDE RECTIFIER. Copper oxide rectifiers may be tested by impressing, in turn, DC voltages of opposite polarity on the rectifier and measuring the current flowing with a milliammeter. Current flowing should be high in one case and very low in the other case.

58. THERMOCOUPLES. Thermocouples used in connection with the measurement of RF current may burn out due to currents greater than rated value flowing through the thermocouple. The most satisfactory method for testing is to substitute a good thermocouple. To prevent burning out, the position of thermocouple should be checked and changed if necessary to reduce the amount of current flowing through it.

59. METERS. Meters when used as part of a radio set may develop open or shorted coils in the movement, frozen bearings, broken glass, broken pointer, or may change calibration. Defects should be detected by visual inspection, by measuring voltage or current from a standard source, or by comparison with meters known to be good. If calibration is defective, the meter may be recalibrated by comparison with good meter (see pars. 9 and 18).

60. ANTENNA. Antennas may develop opens, shorts, or grounds; connections may become corroded; capacity grounds may exist; and the electrical length may be incorrect. Opens, shorts, and grounds will cause abnormally high or low antenna current when the transmitter is operating. Defective connections may be detected by visual inspection. Capacity grounds occur occasionally on vehicular installations. They may be caused by antennas being tied down with insulated wire, failure to remove coaxial connecting wire from the mast base when an ordinary lead-in is used, installation of the antenna too close to metal bows in the top of the vehicle, etc. Capacity grounds detune the antenna and may be detected by visual inspection and by trial and error changes. The physical length and construction of an antenna is specified by appropriate technical manuals for each installation and must be used exactly as specified. Any change in physical nature will change the electrical length and thereby detune the antenna.

61. DRY CELL BATTERIES. Dry cell batteries deteriorate with use and with age. Defective dry cell batteries may be detected by measuring the output voltage under normal load after the set has been turned on for at least five minutes. If the voltage is less than 80% of rated voltage, the battery should be replaced.

62. STORAGE BATTERIES. Vehicular storage batteries must be kept well charged at all times. The state of charge may be checked by measuring the specific gravity of the battery electrolyte with a hydrometer. For batteries used in temperate or cold climates, a fully charged battery will test between 1.275 and 1.300 at 60° F. For batteries used in torrid climates, a fully charged battery will test between 1.205 and 1.230 at 60° F. To correct actual specific gravity to 60° F, add .004 to the gravity reading for each ten degrees of electrolyte temperature above 60° F, and deduct .004 for each ten degrees below 60° F.

63. GENERATORS. High voltages may be obtained by means of hand or motor driven generators. These generators usually consist of an armature, a set of field coils with permanent magnet poles, and one or more commutators. The output windings are wound on the armature and terminate at segments of the commutator. The output voltage is removed from the commutator through a pair of carbon brushes and delivered to the radio set through a filter system. The output voltage is produced by rotation of the armature in a magnetic field. Common causes of trouble are: dirty generator; improper lubrication; worn or damaged brushes or brush holders; open, short or grounded field coils; open, short, or grounded armature; shorted or damaged commutator; open, short, or grounded filter system; or defective electrical connections. Visual inspection and tests of individual parts for shorts, opens, and grounds will indicate defects.

64. DYNAMOTORS. Dynamotors are similar to generators except that a low voltage commutator and winding are added to the armature so that the armature may be driven by means of a storage battery. Troubles and tests are identical.

65. VIBRATORS. Vibrators are used to feed pulses of current from a storage battery through the primary of a power transformer. Construction and operation is similar to that of relays. Low voltage from the battery is particularly hard on vibrators and will cause the points to stick. Vibrators are easiest to test by substitution in a power supply known to be good. When the input circuit is closed, operation of the vibrator may be checked by placing the fingers on the vibrator container. Vibration of a good unit can be felt.

66. HEADPHONES. A headphone consists of a diaphragm supported in an insulated shell, a permanent magnet, and two coils connected in series as indicated in figure 11. Audio frequency current in the coils causes their magnetic fields alternately to aid and oppose the field of permanent magnet, thereby causing the diaphragm to vibrate at an audio rate. A headphone unit may develop opens or shorts in the coil which may be detected

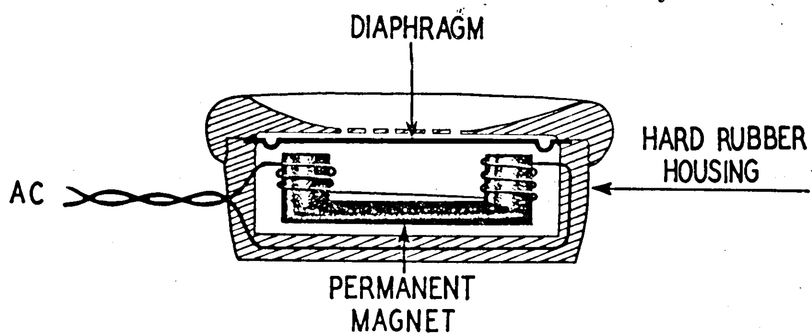


FIGURE 11. Headphone unit.

with a continuity tester. The diaphragm may become bent or broken or may be assembled incorrectly. Cords and plugs and electrical connections should be checked.

67. LOUDSPEAKER. A permanent magnet, dynamic loudspeaker is shown in figure 12. Audio frequency current in the voice coil causes its magnetic field alternately to aid or oppose the field of a permanent magnet, thereby causing the voice coil and cone to move back and forth at an audio rate. Opens, shorts, or grounds in the voice coil may be located using a continuity tester. If the voice coil is improperly centered, faulty reproduction or "scratchy" noises will be heard, and the voice coil must be carefully recentered by adjusting the location of the spider. Defects in the paper cone may be noted by visual inspection.

68. MICROPHONE. The carbon button microphone T-17 is used almost universally in field artillery units to convert sound into electrical energy. Its circuit is shown in figure 13. The carbon button is connected in series with the ring and sleeve of the plug when the microphone switch is closed. The plug tip and sleeve circuit, completed through the microphone switch, may be used

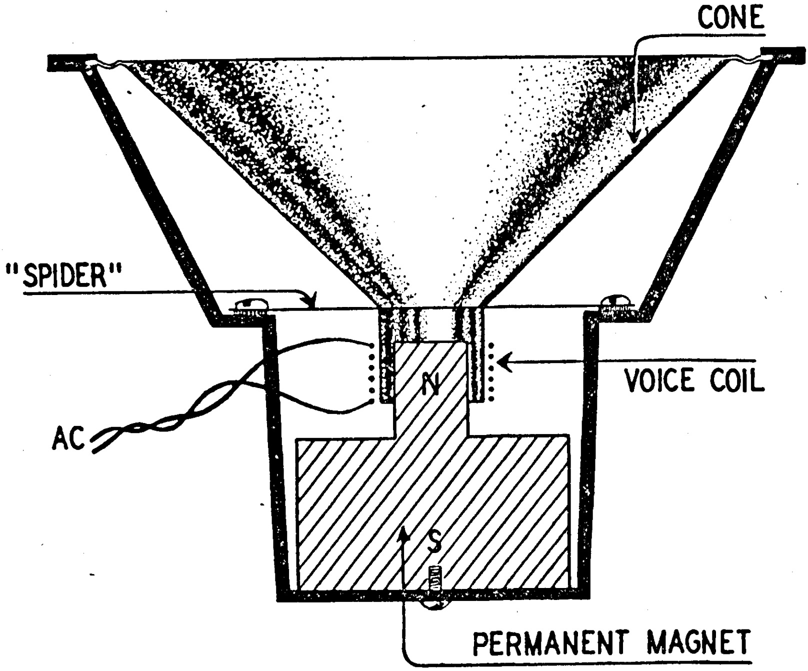


FIGURE 12. Permanent magnet, dynamic speaker.

to control operation of relays and power supplies in radio sets. Opens or shorts may be detected with a continuity tester. The ring-sleeve circuit should have 100–150 ohms resistance with the microphone switch depressed. Blowing into the microphone should vary this value. The tip-sleeve circuit should have 0–.5 ohms resistance with the microphone switch depressed.

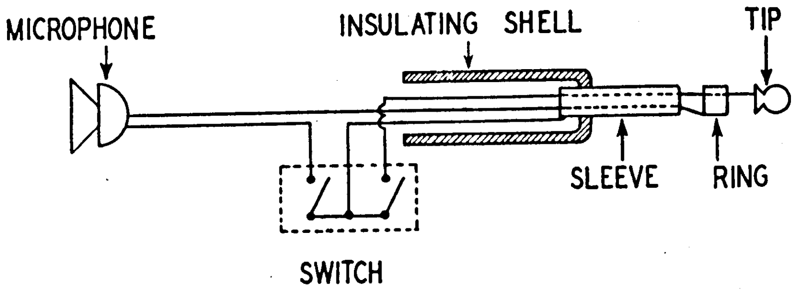


FIGURE 13. T–17 Microphone circuit.

CHAPTER 4
TESTING CIRCUITS

SECTION I
FUNDAMENTAL VACUUM TUBE CIRCUITS

69. GENERAL. When trouble has been isolated to a particular stage, individual circuits which make up that stage should be tested. Unless experience indicates the cause of trouble immediately, circuits should be checked in the following order: filament, plate, control grid, screen grid, and suppressor grid. These circuits sometimes include, or function with, special circuits indicated in section II. A circuit diagram of the radio equipment being tested should be consulted as tests are made in order to determine peculiarities of each particular circuit.

70. FILAMENT CIRCUIT. The filament circuit heats the cathode of the tube. This circuit will contain some or all of the following components: tube cathode or heater, power supply, switch, rheostat, cathode resistor, shunt resistors, fuze, voltage dropping resistors, and other tube cathodes or heaters in series or in parallel. Trouble may be caused by defects in any component or in wiring and connections. Test the power supply to determine the presence of rated voltage; test the tube for open filament shorted elements, improper type, or improper insertion in socket; test the entire circuit for continuity; and, test individual parts for opens, shorts, grounds, or changed values.

71. PLATE CIRCUIT. The plate circuit provides plate current for the stage and a load to develop the output voltage or power. This circuit will contain some or all of the following components: tube, power supply, plate load, voltage dropping resistors, cathode resistor, tuned circuit, coupling device, or decoupling device. Trouble may be caused by defects in any component or in wiring and connections. Test the power supply for rated voltage; test tube for open or shorted elements, improper type, improper insertion in the socket, gas in the envelope, or low emission; test the entire circuit from plate to cathode for continuity and total resistance; and test individual parts for opens, shorts, grounds, or changed values.

72. CONTROL GRID CIRCUIT. The control grid or input circuit controls the flow of plate current through the tube. This circuit will contain some or all of the following components: tube, bias supply, grid leak resistor and condenser, cathode resistor, grid load, tuned circuit, coupling device, or volume control. Trouble may be caused by defects in any component or in wiring and connections. Test the bias supply for rated voltage; test the tube for open or shorted elements, improper type, improper insertion in the socket, or gas in the envelope; test the entire circuit from grid to cathode for continuity and total resistance; and, test individual parts for opens, shorts, grounds, or changed values.

73. SCREEN GRID CIRCUIT. The screen grid circuit reduces the inter-electrode capacity between the plate and the control grid, and makes plate current relatively independent of small changes in plate voltage. Voltage is obtained from the same source as plate voltage but is usually somewhat lower. This circuit may contain some or all of the following parts: tube, power supply, voltage dropping resistors, cathode resistor, or decoupling device. Trouble may be caused by defects in any component or in wiring and connections. Test in the same manner as for plate circuits. An open screen grid circuit may cause the plate current to drop almost to zero.

74. SUPPRESSOR GRID CIRCUIT. The suppressor grid circuit is usually used to prevent secondary emission, but may be used for other purposes. When connected to the cathode inside the tube, no tests are possible. When used for modulation, the circuit will be similar to the control grid circuit and may be tested in the same manner.

SECTION II

SPECIAL VACUUM TUBE CIRCUITS

75. GENERAL. Special vacuum tube circuits are generally used in connection with or as a part of fundamental vacuum tube circuits. Circuit diagrams must be consulted while testing special circuits in a particular radio set.

76. COUPLING CIRCUITS.

a. General. Coupling circuits cause a transfer of voltage or energy from one stage to another due to a change of current in the first stage. Various types of coupling between vacuum tube stages are indicated in figure 14.

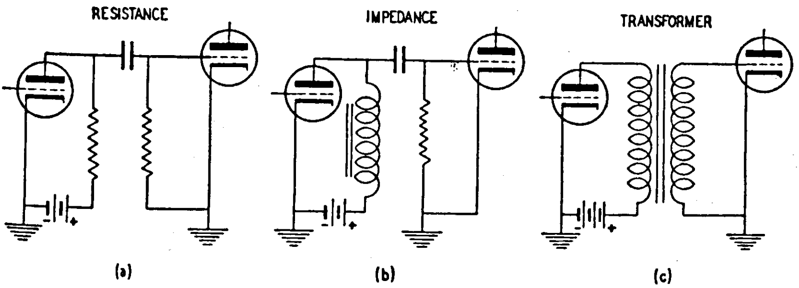


FIGURE 14. Coupling systems.

b. Resistance coupling. Troubles in resistance coupling circuits may be caused by defects in any component or in wiring and connections. If the resistors or the coupling condenser change in value, the frequency response may change. To test for a leaky coupling condenser while the receiver is operating, measure the grid voltage with no signal using a VTVM. Normal voltage is zero. If the coupling condenser is leaky, a portion of the DC plate voltage from the preceding stage will be impressed on the grid and will cause a positive voltage to be indicated.

c. Impedance coupling. Troubles in impedance coupling circuits may be caused by defects in any component or in wiring and connections. In some cases, leaky coupling condensers may be detected as in **b.** above.

d. Transformer coupling. Troubles in transformer coupling are those common to any transformer (par. 46), except that when the transformer windings are a part of resonant circuits additional troubles may arise. If the turns ratio of audio frequency transformers is changed, the response at high or low frequencies will be materially affected. Resonant coupling circuits may be tuned independently if the coupling is loose, but if the coupling is at the critical or greater degree, the tuning of one circuit will affect the tuning of the other. Under-coupling results in low transfer of power from one circuit to the other, and over-coupling results in broad frequency response and reduced sensitivity. To tune and couple two resonant circuits properly, proceed according to the set manufacturer's instructions.

77. FILTER CIRCUITS. Filter circuits are used to prevent or reduce fluctuations in DC potential from various causes. These circuits consist of one or more choke coils or resistors in series with the potential to be filtered and one or more condensers in parallel. Troubles may be caused by defects in any component or in wiring and connections. Test continuity of the circuit and test individual parts for opens, shorts, grounds, or changed value. If the filter circuit to be tested is a part of a power supply, or other unit, the only test which will positively indicate that it is good or bad is to substitute the power supply or other unit for one which is known to be good, and compare its operation with that of the good unit.

78. DECOUPLING CIRCUITS. Decoupling circuits isolate individual stages from each other when a common power supply is used. These circuits are commonly used as a part of plate and screen grid circuits, and usually consist of a suitable resistor in series with the power supply and a condenser in parallel. Components may be tested for open, shorts, grounds, and changed values.

79. BYPASS CIRCUITS. Bypass condensers are used to provide a low impedance path for AC around a source of DC potential. The condenser should be tested for opens and shorts. If the screen grid bypass is shorted, plate voltage will decrease; and if it is open, amplifiers may oscillate.

80. MANUAL VOLUME CONTROL. The signal output of radio receivers may be varied manually by means of a potentiometer across the load of an AF stage, or across the cathode resistor of an RF or IF stage when a variable-mu tube is used. In either case, the potentiometer becomes a part of the grid circuit and is tested as any variable resistor would be tested.

81. AUTOMATIC VOLUME CONTROL (AVC).

a. **General.** AVC provides relatively constant signal level from radio receivers regardless of changes in signal input due to fading, etc. A typical system is shown in figure 15. If the signal strength increases, negative voltage at the diode load increases and causes a more negative bias to be placed on the grids of RF or IF amplifiers. A time-delay filter is required to remove audio variations from the bias voltage.

b. Troubles and tests. Any component of an AVC circuit or its wiring and connections may be defective. If the AVC circuit is not operative, though the receiver is otherwise normal, a large

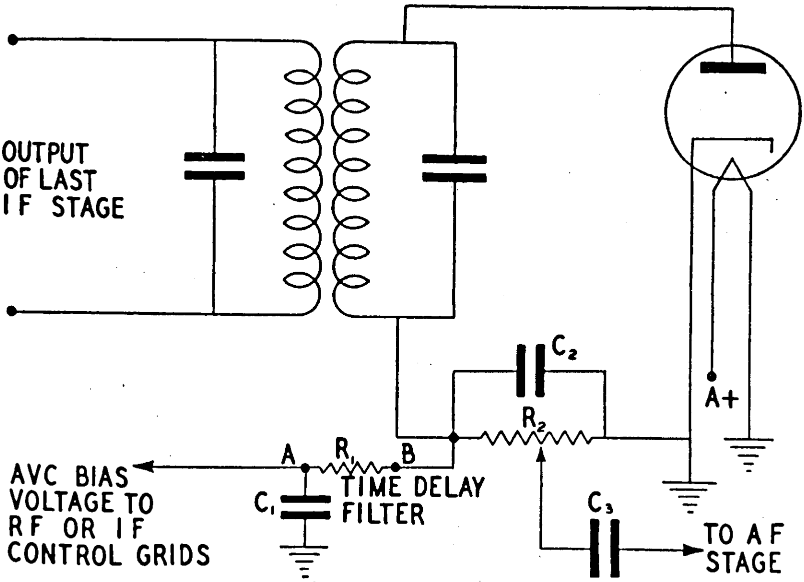


FIGURE 15. Typical AVC system.

increase in volume is noted when tuning from a weak to a strong signal. To isolate the trouble proceed as follows:

(1) Measure the voltage from control grid to ground on each stage affected by the AVC system, using a vacuum tube voltmeter while the receiver is tuned to a signal. A reading of minus one volt or more should be indicated, depending on the strength of the signal.

(2) If the voltage is correct on some stages and not on others, check the circuit between the grid of the defective stage and A of figure 15.

(3) If the voltage is incorrect on all stages, check the voltage between A and ground. This is the last point common to all stages.

(4) If the voltage is incorrect at A, check between B and ground. If the voltage is correct at B, the time-delay filter is defective.

(5) If the voltage is incorrect at B, check the voltage at the diode load resistor where the AVC voltage first appears.

82. DELAYED AUTOMATIC VOLUME CONTROL (DAVC). Negative AVC bias is placed on the grids in paragraph 81 with even a weak signal. This may be avoided by using a special DAVC diode circuit which prevents the AVC circuit from working until the AVC voltage exceeds a predetermined value. This circuit may have all of the troubles indicated in paragraph 81 and may also have a defective tube. Tests are similar to those set forth in paragraph 81.

SECTION III
POWER SUPPLY CIRCUITS

83. GENERAL. Circuits illustrated in this section are typical and simple illustrations. Actual circuits in each particular installation must be studied and tests modified to fit each individual circumstance.

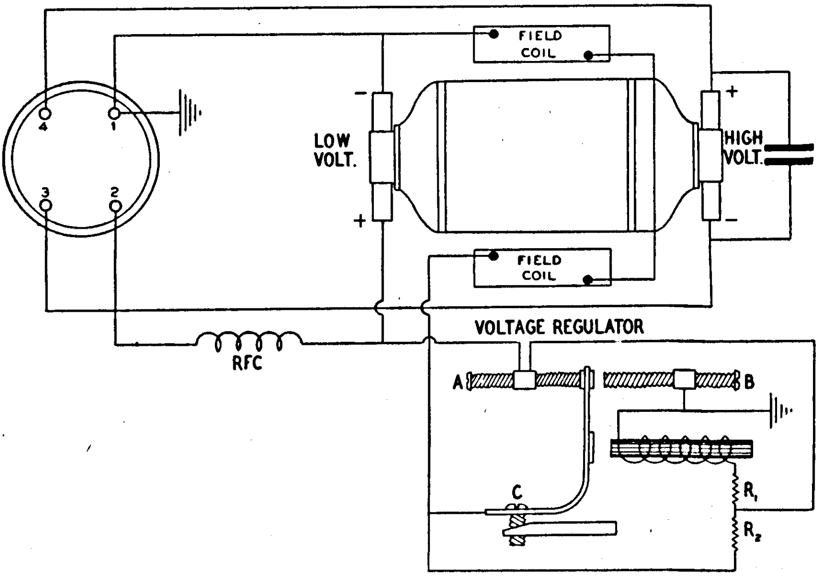


FIGURE 16. Generator circuit.

84. GENERATOR. A typical generator circuit is shown in figure 16. The armature is rotated by hand in a magnetic field and produces a low voltage output at socket terminals No. 1 and No. 2, and a high voltage output at socket terminals No. 3 and No. 4. Failure to operate may be caused by defects in any component, in wiring and connections, or adjustment of the voltage regulator. Test operation by connecting a DC voltmeter of suitable range to measure the low voltage output while the generator is being operated *under load.* Proper operation is indicated by the meter reading the correct voltage and with no flickering of the meter pointer. If the meter reads too low or too high, adjust the "C" screw, which changes tension on the armature of the voltage regulator, until the correct voltage is obtained. If the meter flickers, check the air gap between the armature and the electromagnet of the regulator and adjust the "A" screw to give the proper gap. Then, adjust the "B" screw until the flicker disappears. Check the instructions accompanying the generator for correct voltage and air gap distances.

85. INPUT CIRCUIT-VEHICULAR POWER SUPPLY. The input circuit of vehicular power supplies provides power from the vehicular electrical system to the input terminals of the dynamotor or vibrator power supply unit. This circuit will contain some or all of the following components: storage battery, vehicle charging circuit, fuze, and filter circuit. Trouble may be caused by defects in any component or in wiring and connections. Test the voltage at the input terminals to the dynamotor or vibrator power supply unit. This must not exceed manufacturer's specifications. Inspect the storage battery connections for dirty or corroded terminals. Inspect fuze and check the entire circuit for continuity.

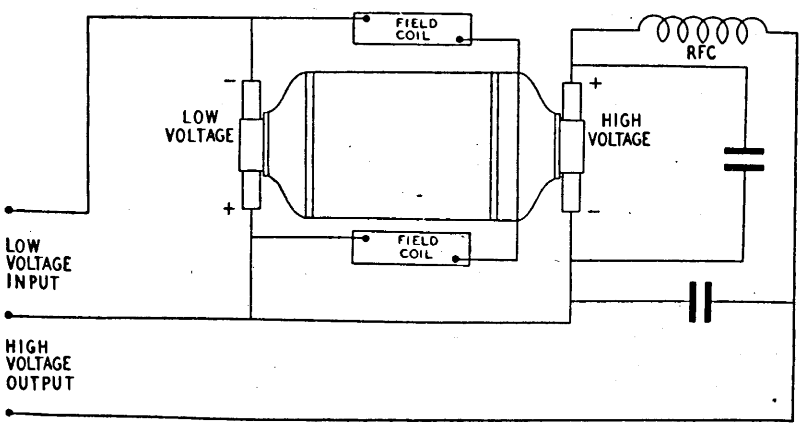


FIGURE 17. Dynamotor circuit.

86. DYNAMOTOR CIRCUIT. A typical dynamotor circuit is shown in figure 17. The armature is rotated in a self excited magnetic field by current from the input circuit. Failure to operate may be caused by defects in any component or in wiring and connections. Test by connecting a DC voltmeter of suitable range to measure the output voltage while the dynamotor is being operated *under load.* Fluctuating or low output may be due to brushes sticking in their holder, low brush spring tension, dirty commutator, high mica in commutator, commutator out of round, open circuit in the armature, or low input voltage. High output may be caused by high input voltage or grounded field windings. Noisy operation may be caused by loose mounting or by worn or dirty bearings caused by improper cleaning and lubrication.

87. NONSYNCHRONOUS VIBRATOR CIRCUIT. A typical nonsynchronous vibrator circuit is shown in figure 18. A vibrator unit interrupts the flow of DC from the vehicular storage battery through the primary of the power transformer at a rate of

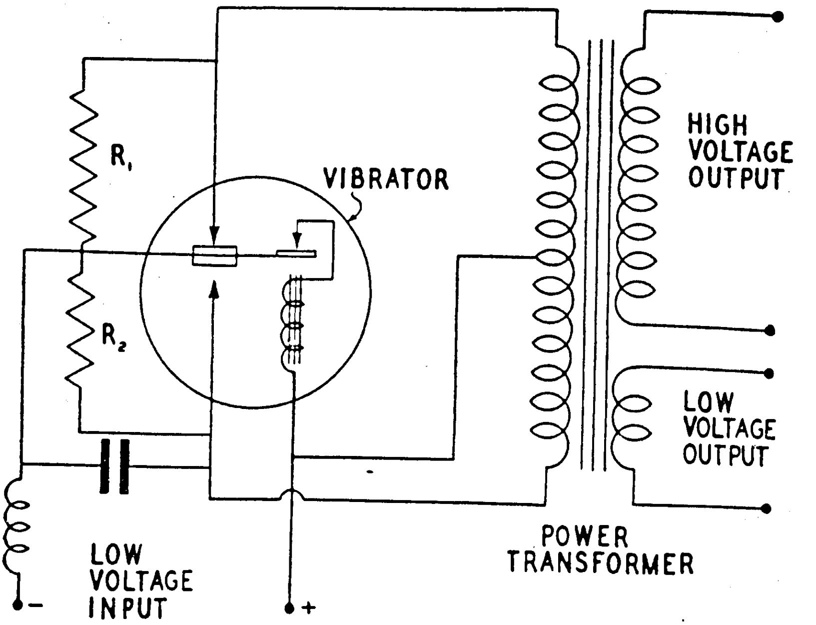


FIGURE 18. Nonsynchronous vibrator circuit.

approximately 60 cycles per second. The resulting voltage changes in the primary are stepped up so that high voltage AC is present at the terminals of the high voltage secondary and low voltage AC is present at terminals of the low voltage secondary. A rectifier system must be used to obtain DC voltage for radio equipment from the secondary. Resistors R_1 and R_2 prevent arcing at the vibrator points and may be replaced with suitable condensers to achieve the same effect. Defective operation may be caused by defects in any component or wiring and connections. Test by measuring the high voltage output with an AC voltmeter of suitable range. Operation of the vibrator unit may be heard or felt by touching the shield can. Absence of output voltage may be caused by sticking or open vibrator points, low input voltage, or open, short, or grounded wiring of power transformer. Check with a continuity tester. Low output voltage may be caused by low input voltage or by a shorted transformer secondary. High output voltage may be caused by high input voltage or by a shorted transformer primary. Sticking vibrator points are usually caused by low input voltage or by defective resistors or condensers across the vibrator points.

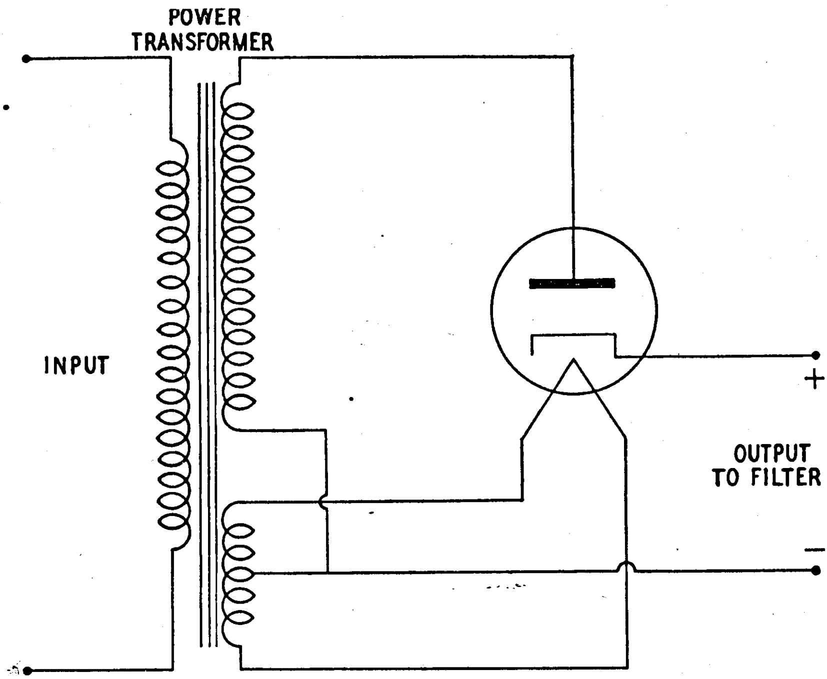


FIGURE 19. Half-wave rectifier.

88. RECTIFIER CIRCUITS.

a. **Half-wave rectifier.** A half-wave vacuum tube rectifier circuit is shown in figure 19. Test the DC output and the AC input, test tube and other components, test wiring and connections for continuity. If the AC voltage is within 15% of rated value, measure the plate voltage and current under load. Low plate voltage and low plate current indicates a weak tube. Low plate voltage

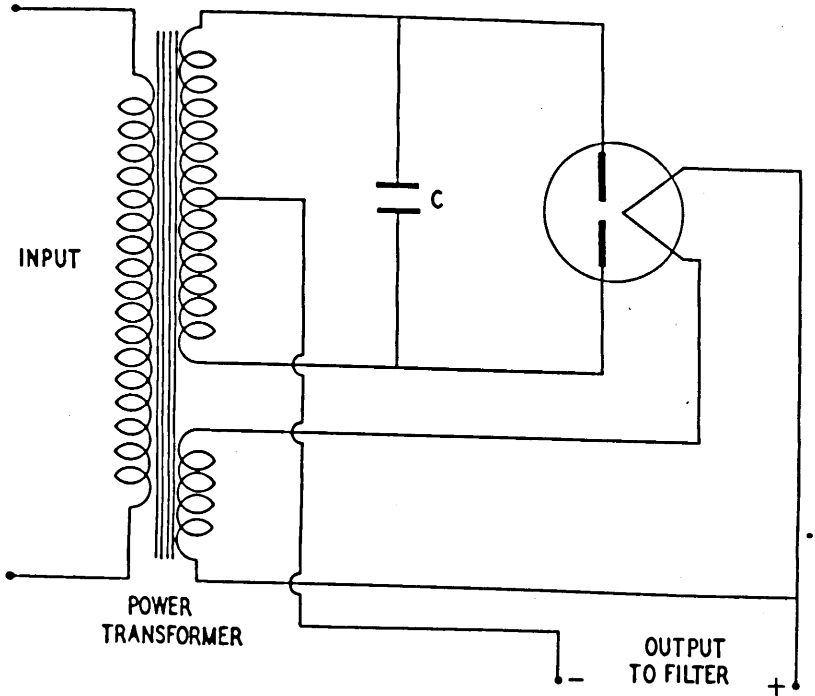


FIGURE 20. Full-wave rectifier.

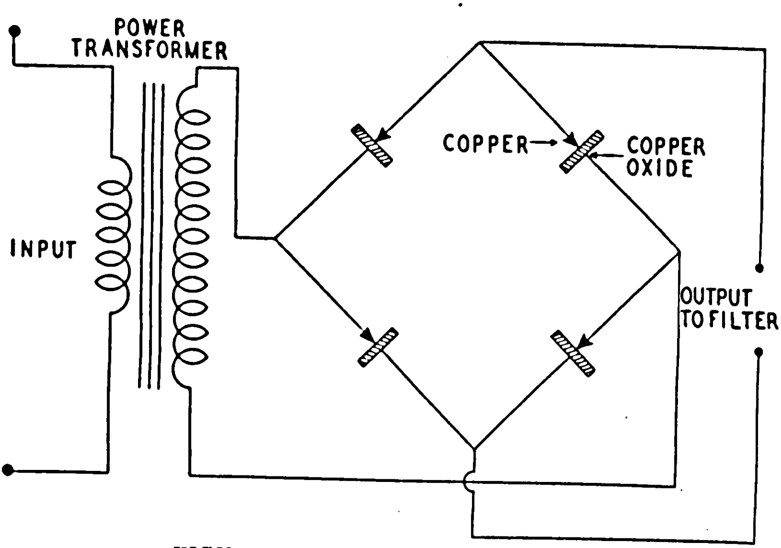


FIGURE 21. Full-wave bridge rectifier.

and high plate current indicates a short or ground. High plate voltage and high plate current indicates a short or ground in the transformer. High plate voltage and low plate current indicates an open circuit in the load.

b. **Full-wave rectifier.** A full-wave vacuum tube rectifier circuit is shown in figure 20. Buffer condenser C prevents arcing at the input. Test as in paragraph 88. A shorted buffer condenser may cause the vibrator to burn out, and should always be tested before replacing the vibrator unit.

c. **Full-wave bridge rectifier circuit.** A full-wave bridge-type copper oxide rectifier circuit is shown in figure 21. Test as in paragraph 88.

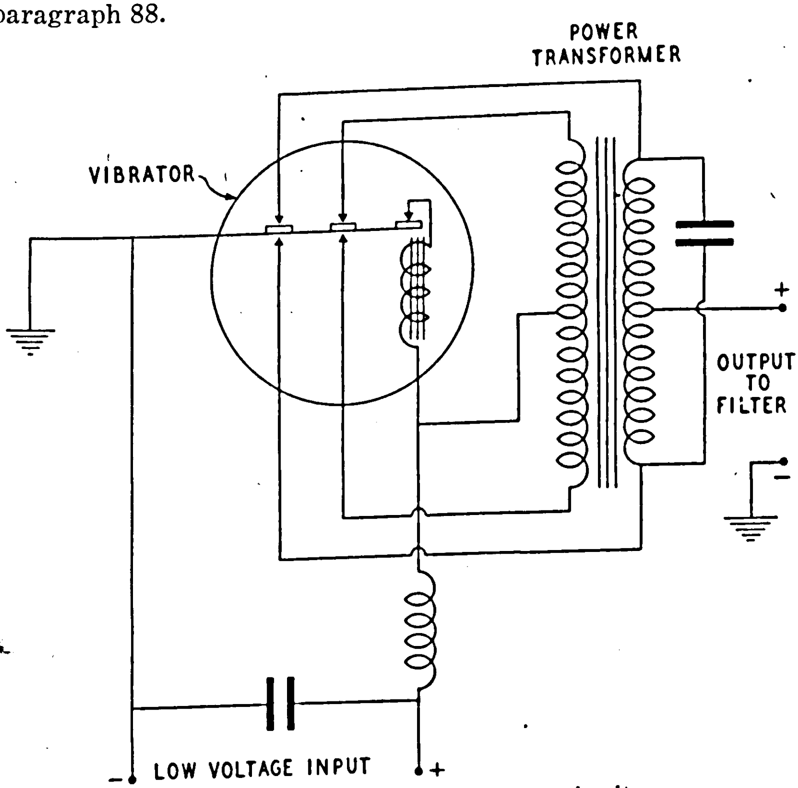


FIGURE 22. Synchronous vibrator circuit.

89. **SYNCHRONOUS VIBRATOR CIRCUIT.** A synchronous vibrator circuit is shown in figure 22. This circuit is similar to figure 18 except that two contacts have been added to the vibrator armature so that a separate rectifier circuit is not required to obtain DC output. Tests are the same as those mentioned in para-

graph 87 except that the output may be measured with a DC voltmeter.

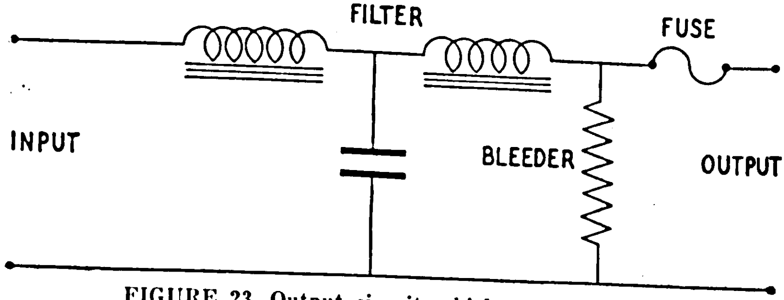


FIGURE 23. Output circuit-vehicle power supply.

90. OUTPUT CIRCUIT-VEHICULAR POWER SUPPLIES. Some dynamotor and all vibrator power supplies deliver their output to a circuit similar to figure 23. The filter circuit is required to eliminate variations and to provide steady DC voltages. Troubles may be caused by defective components, wiring or connections. Test the output using a DC voltmeter of suitable range. A high reading indicates trouble in a previous circuit. A low reading may indicate a defect in a previous circuit or in the filter network or bleeder resistor. Check these components for opens, shorts, grounds, or changed values.

CHAPTER 5
TESTING STAGES

SECTION I
RECEIVER STAGES

91. GENERAL.

a. Superheterodyne AM receivers. Superheterodyne amplitude modulated (AM) receivers are made up of stages indicated in figure 24. The beat frequency oscillator is not required when receiving modulated signals.

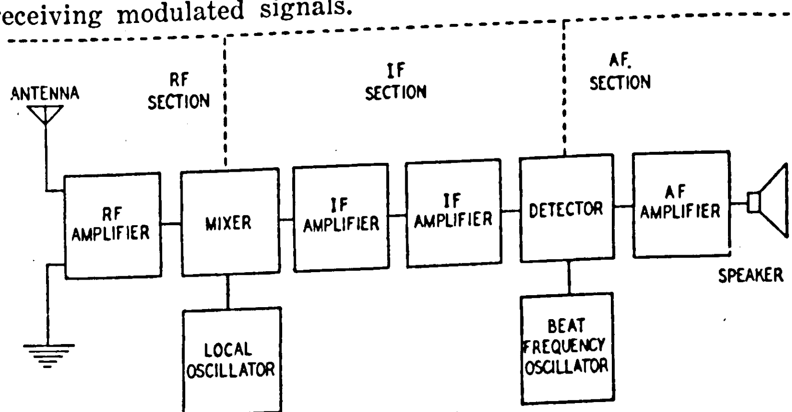


FIGURE 24. Superheterodyne AM receiver block diagram.

b. Superheterodyne FM receivers. Superheterodyne frequency modulated (FM) receivers are identical to AM receivers except that the detector stage is replaced by a discriminator stage, and a limiter stage is added between the last IF stage and the discriminator stage. Other differences are minor in nature and are indicated in the following paragraphs when necessary.

c. Tests. In the following paragraphs tests are outlined to provide an indication of troubles in a particular stage. Before testing any receiver stage for trouble, the repairman must check the power supply to assure proper operation of that stage. Otherwise misleading conclusions may be drawn from the tests indicated Manufacturers specify voltages and currents for proper operation of each radio circuit. These elements should be checked on all questionable receiver stages and should provide an indication of the particular circuit in which trouble exists when other than normal.

d. **Schematic diagrams.** Schematic diagrams of individual stages of a receiver are shown in succeeding paragraphs. These are simple, typical diagrams and are included to provide a better understanding of test procedure. When testing radios, the manufacturers diagram must be consulted and tests modified to suit each particular case.

92. RADIO FREQUENCY AMPLIFIER STAGE.

a. **General.** The purpose of RF amplifier stages is to increase signal voltage, improve selectivity, and to reduce image response. Normal operation is indicated by the ability of the stage to amplify a signal throughout its frequency band without distortion. A typical diagram is indicated in figure 25.

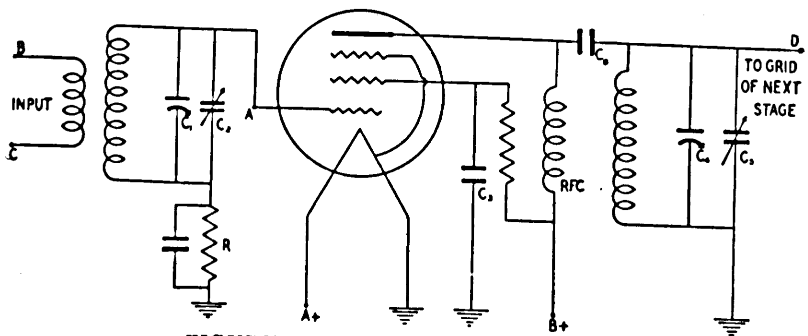


FIGURE 25. Tuned RF amplifier stage.

b. **Operation.** (1) Connect a VTVM to measure negative rectified voltage at the limiter grid or at the ungrounded side of the detector load (point A of fig. 30 or fig. 31) with respect to ground or cathode.

(2) Connect a signal source producing an unmodulated signal near the high end of the band to the amplifier input (points B and C of fig. 25).

(3) Set the RF tuning condenser (C_1) at the correct dial setting for this frequency.

(4) If a negative voltage is obtained on the VTVM, the stage is operating.

(5) Tune the signal source and the RF tuning condensers across the band and note operation at all frequencies.

(6) If the above procedure is impossible because of defective intermediate stage, connect an RF signal tracer (par. 40 or 41) to the output of the RF amplifier stage being tested (point D of fig. 25) and repeat as above, measuring the limiter or detector voltage of the signal tracer.

c. **Calibration.** With the signal source providing a signal at the high end of the band and the RF tuning condenser set at exactly the correct dial setting for this frequency, vary the RF trimmer condenser (C_2) to obtain maximum voltage on the VTVM in b above. NOTE: The trimmer condenser is mounted in parallel with the tuning condenser. Calibration is always done at the high end of the band because the capacity of the tuning condenser is nearest that of the trimmer at this point.

d. **Oscillation.** RF amplifiers may oscillate and produce squeals in the receiver. Remove the excitation from the stage and measure the grid voltage between A of figure 25 and ground with a VTVM. If zero, the stage is not oscillating. Check across the entire band. If the grid circuit does not have a resistive load, measure grid voltage of the following stage.

93. RADIO FREQUENCY OSCILLATOR STAGE.

a. **General.** The purpose of the RF oscillator in a receiver is to provide a locally generated signal which may be heterodyned with the incoming signal to produce the correct difference frequency. The local signal must be at least twice as great in amplitude as the incoming signal. A typical circuit is shown in figure 26.

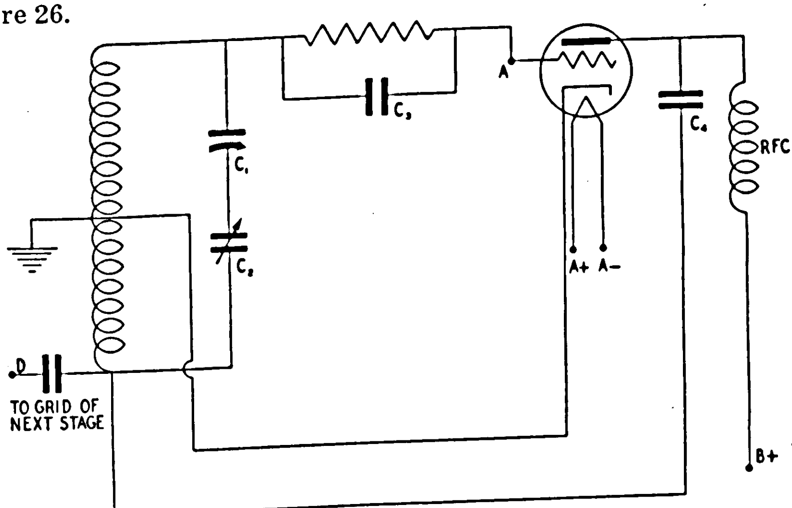


FIGURE 26. Shunt fed, Hartley oscillator stage.

b. Operation. Connect a VTVM to measure negative rectified voltage at the oscillator grid (point A of fig. 26) with respect to ground or cathode. If the oscillator is inoperative, the meter will indicate zero or the value of steady DC bias used. An increase in negative grid voltage when the stage is oscillating will indicate the relative amplitude of the oscillations. If the oscillator is crystal controlled, the grid voltage will indicate the relative activity of the crystal. Check operation throughout the frequency band. The rectified grid voltage should not vary more than 50% from average.

c. Alignment. Oscillator circuits must be aligned so that the correct difference frequency is produced when the locally generated signal is heterodyned with the incoming signal. Alignment may be accomplished by adjusting a padder condenser (C_2 of fig. 26) in series with the tuning condenser, or a trimmer condenser in parallel with the tuning condenser. If a padder condenser is used, alignment is made at the low end of the frquency band, since the reactance of the tuning condenser is nearest that of the padder condenser at that frequency. If a trimmer condenser is used, alignment is made at the high end of the frequency band. If the oscillator is crystal controlled, this adjustment is not available. To align, proceed as follows:

(1) After calibrating the RF amplifier stage (par. 92c), adjust the signal source and main tuning condenser to the low (high) end of the frequency band.

(2) Adjust the padder (trimmer) condenser to obtain maximum meter reading at the limiter grid or the ungrounded side of the detector load.

d. Tracking. The correct difference frequency must be produced throughout the band. Check at other frequencies, and if the RF amplifiers and RF oscillator do not "track" (change identical amount as the gang control is tuned) readjust both amplifier and oscillator alignment and calibration.

94. MIXER STAGE.

a. General. The incoming signal is heterodyned or electrically mixed with the locally generated signal in the mixer stage. This produces an intermediate frequency, equal to the difference between the original signal and the locally generated signal, which retains all frequency and amplitude variations contained in the original signal. A typical circuit is shown in figure 27.

b. Tests. The input of the mixer stage must "track" the RF amplifiers and the RF oscillator. The output stage must be

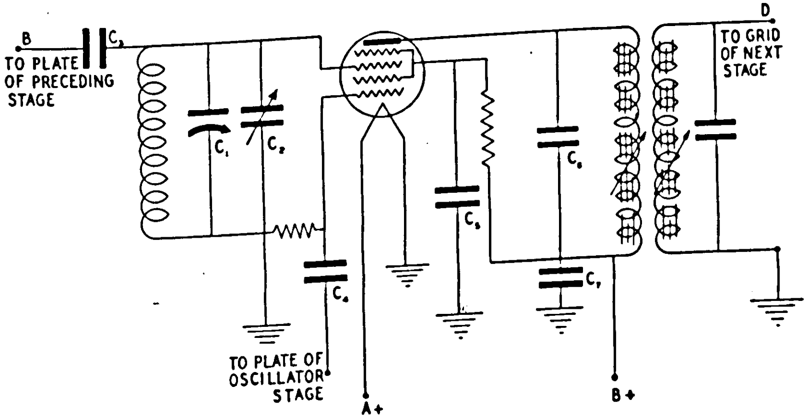


FIGURE 27. Hexode mixer stage.

tuned to the correct intermediate frequency. Tests for operation, alignment and tracking are the same as for RF amplifiers. The secondary may be permeability tuned (see par. 96).

95. CONVERTER STAGE.

a. **General.** A converter is a special purpose tube which performs the functions of both mixer and local oscillator. A typical circuit is shown in figure 28.

b. **Tests.** Tests are identical to those for oscillators and mixers (par. 93 and 94).

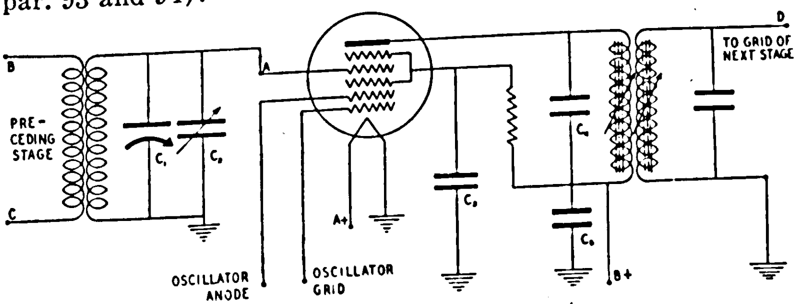


FIGURE 28. Pentagrid converter stage.

96. INTERMEDIATE FREQUENCY AMPLIFIER STAGE.

a. **General.** The purpose of the IF amplifier stages is the same as for the RF amplifier stages. However, due to operation at a lower and constant frequency, use of tuned-plate and tuned-grid circuits, and optimum coupling between stages, operation is better than that of RF amplifiers. The circuits may be tuned by means of trimmer condensers or by permeability tuned transformers.

The latter have iron cores (of special composition) which may be adjusted to change the inductance of the transformer windings. All coupling in IF stages is by transformer. Tuning of the IF stages must be broad enough to accept the proper band of frequencies. A typical circuit is shown in figure 29.

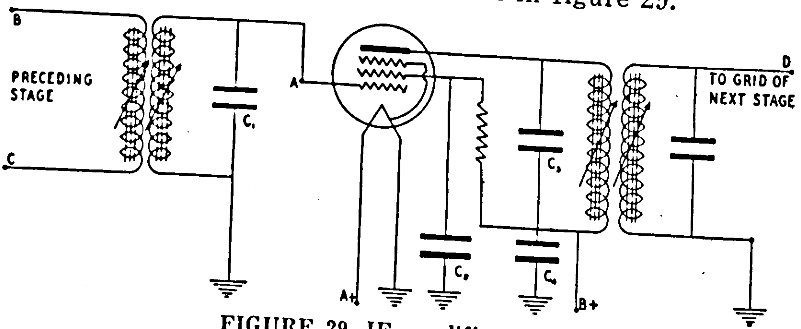


FIGURE 29. IF amplifier stage.

b. Tests. Tests for operation and alignment are similar to those for RF amplifiers. The correct IF signal should be fed to the mixer input (point B and ground of fig. 27) and the RF oscillator should be disabled. To check the band width, note the meter reading at the correct IF, and then shift the frequency of the signal source an amount specified by the manufacturer on each side of the correct IF and repeat the measurement. Readings should be approximately the same as at the correct IF.

97. LIMITER STAGE.

a. General. The limiter stage is a special application of an IF amplifier required in frequency modulated receivers to eliminate amplitude variations of the incoming signal. This is accomplished by operating the stage with low plate and screen grid voltages and with grid leak bias so that plate current saturation is obtained with relatively low input voltage. A typical circuit is indicated in figure 30.

b. Limiter Action. To test the action of the limiter stage, proceed as follows:

(1) Feed the correct IF signal into the mixer input as in paragraph 96 and disable the local oscillator. The strength of the IF signal should be very low.

(2) Connect a VTVM to measure DC limiter grid voltage (point A of fig. 30 and ground).

(3) Connect another VTVM to measure one half of the discriminator output (point E of fig. 32 and ground).

(4) Increase the strength of the IF signal gradually and note the meter readings. Both readings should increase gradually until limiting action starts. Then the limiter grid voltage should continue to increase while one half the discriminator output remains relatively constant.

(5) The limiter grid voltage at which limiting action starts is specified by the manufacturer.

c. **Alignment.** The input circuit is aligned in the same manner as the IF stages. The output circuit is aligned at the same time as the discriminator input, and a VTVM is connected to one half the discriminator output for an indication of proper alignment (see par. 99).

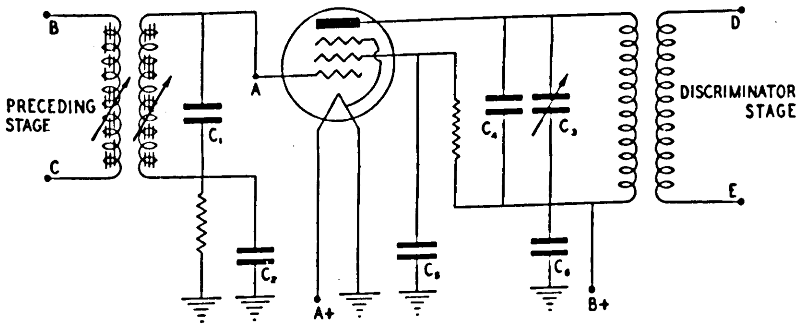


FIGURE 30. Limiter stage.

98. DETECTOR STAGE.

a. **General.** The purpose of the detector stage is to convert variations in amplitude of the incoming signal into audio frequencies. Superheterodyne amplitude modulated receivers usually employ a diode circuit similar to figure 31.

b. **Operation.** To test for operation of the detector circuit, feed an amplitude modulated signal into the receiver antenna circuit and connect headphones across the detector load (point A of fig. 31 and ground). The signal should be heard. If a modulated signal is not available, feed the correct unmodulated IF signal into the mixer input as in paragraph 96, connect a VTVM to measure negative DC voltage across the detector load (point A of fig. 31 and ground), and note the voltage developed.

c. **Alignment.** If a tuned circuit is included as in figure 31, align by using an unmodulated signal as in b above and by adjusting the trimmer condenser or coil to obtain maximum meter reading.

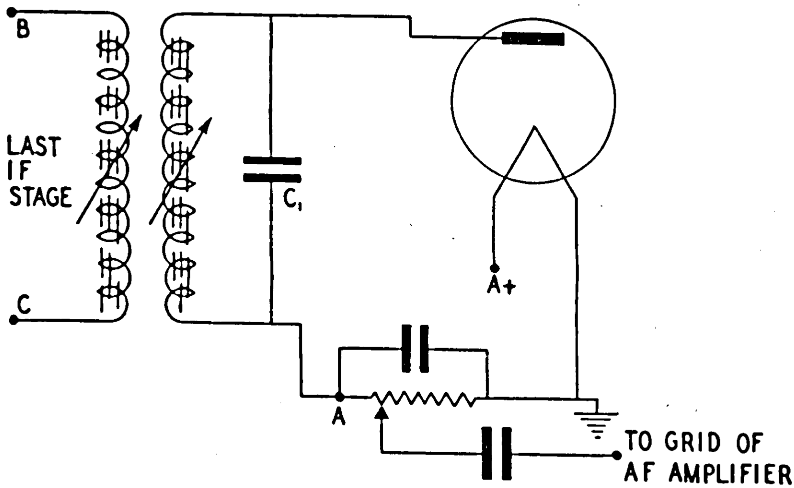


FIGURE 31. Diode detector stage.

99. DISCRIMINATOR STAGE.

a. **General.** The purpose of the discriminator stage is to convert variations in frequency of the incoming signal into audio frequencies. A typical circuit is shown in figure 32.

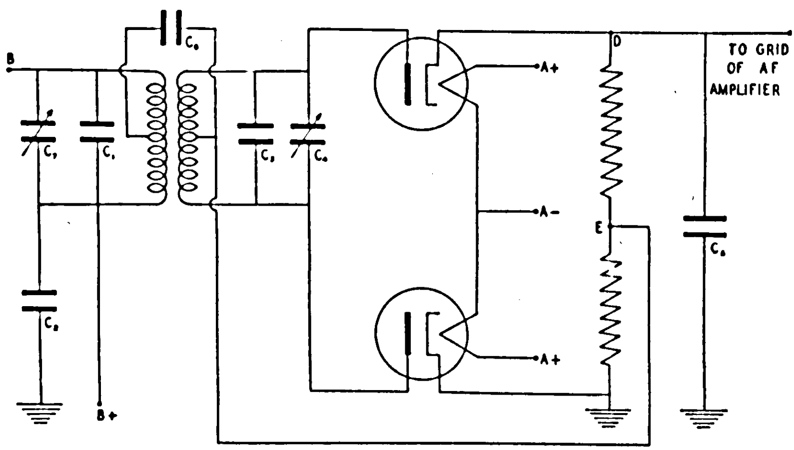


FIGURE 32. Double diode, differential discriminator stage.

b. **Operation.** Operation of the discriminator circuit may be checked by feeding a correct IF signal into the mixer input as in paragraph 96 and noting the presence of a negative voltage across one half of the discriminator load (point E of fig. 32 and ground) with a VTVM.

c. **Alignment.** The discriminator should produce maximum negative voltage in **b** above when the mean frequency is applied, and should produce zero voltage measured across the entire load (point D of fig. 32 and ground). To align the discriminator proceed as follows:

(1) Connect a VTVM to measure negative DC voltage across one half the discriminator load (point E of fig. 32 and ground).

(2) Feed a correct mean IF signal into the mixer input as in paragraph 96.

(3) Tune the discriminator primary (limiter plate circuit) to obtain maximum meter reading.

(4) Adjust the VTVM to indicate false zero as in paragraph 22c and connect to measure DC voltage across the entire discriminator output (point D of fig. 32 and ground).

(5) Tune the discriminator secondary to obtain zero voltage.

(6) Shift the frequency of the signal fed to the mixer equal amounts in each direction from the mean frequency and note that the reading of the VTVM increases and decreases equal amounts. This indicates that conversion of frequency variations into audio frequencies can be accomplished without distortion.

(7) If meter readings in (6) above do not change equal amounts, realign the discriminator by trial and error. That is, adjust the primary slightly different from its first setting and readjust the secondary, then repeat (6) and (7) above until the discriminator is properly adjusted.

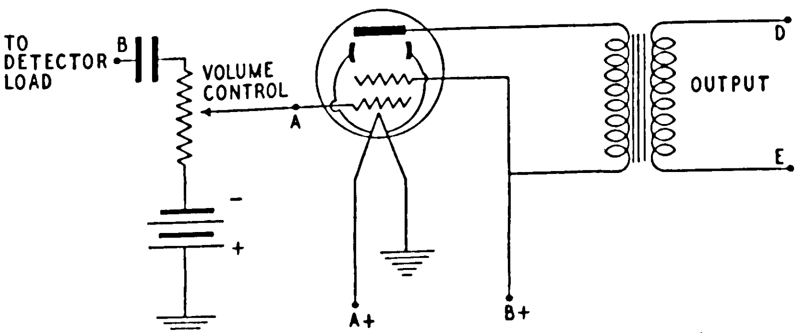


FIGURE 33. AF amplifier stage.

100. AUDIO FREQUENCY AMPLIFIER STAGE.

a. **General.** AF voltage amplifier stages are used to increase the audio signal voltage sufficiently to drive a power amplifier.

The power amplifier stage produces the power required to drive a loudspeaker or headphones. All voltage amplifiers operate class A, and power amplifiers operate class A, or class B in push-pull. Audio amplifiers must amplify without distortion. A typical circuit is shown in figure 33.

b. Tests. Operation of AF amplifiers may be checked by feeding an audio signal into the input circuit (point B of fig. 33 and ground) or by feeding a modulated RF signal into the antenna input and listening at the output with headphones.

101. BEAT FREQUENCY OSCILLATOR STAGE. For the reception of CW signals a BFO stage must be provided. This stage produces a local signal which heterodynes in the detector stage with the IF signal to produce a beat note in the audio range. When reception of modulated signals is desired, the BFO must be disabled. Testing is identical to that of the RF oscillator except that the frequency will be the same as the intermediate frequency. Alignment is accomplished by zero-beating to an incoming signal of the correct IF.

102. DC AMPLIFIER STAGE.

a. General. A DC amplifier stage may be used to amplify any DC voltage. A typical stage is shown in figure 34. Note that the polarity of the voltage is reversed. That is, a positive voltage applied at the input will cause the output voltage to become more negative.

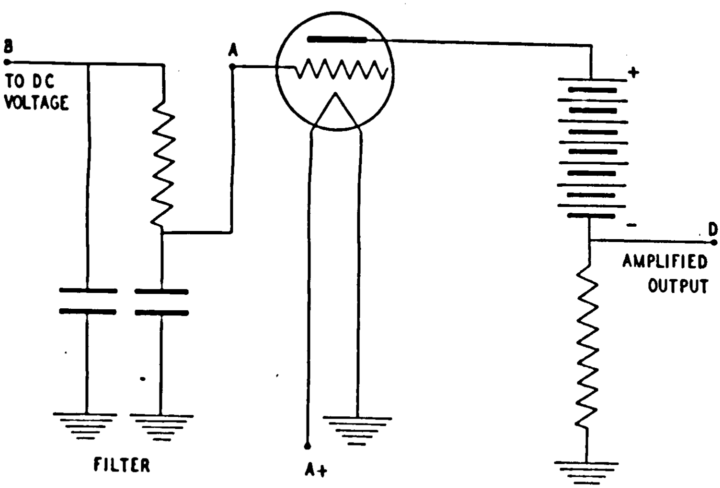


FIGURE 34. DC amplifier stage.

b. **Tests.** To test a DC amplifier stage, measure the voltage change at point A of figure 34 with respect to ground, and the voltage change at point D of figure 34 with respect to ground.

SECTION II
TRANSMITTER STAGES

103. GENERAL.

a. **CW transmitter.** Transmitters for CW telegraphy are made up of stages as indicated in figure 35. The number of amplifiers may vary according to the requirements of the system.

b. **AM transmitter.** Transmitters for amplitude modulated radio-telephony are identical to CW transmitters except that an audio section is added, and an RF amplifier stage is used to modulate the carrier.

c. **FM transmitter.** Transmitters for frequency modulated radio-telephony are identical to AM transmitters except that modulation of the carrier is accomplished by a reactance modulator stage or in a special non-linear coil, and one or more RF amplifiers are operated as frequency multipliers.

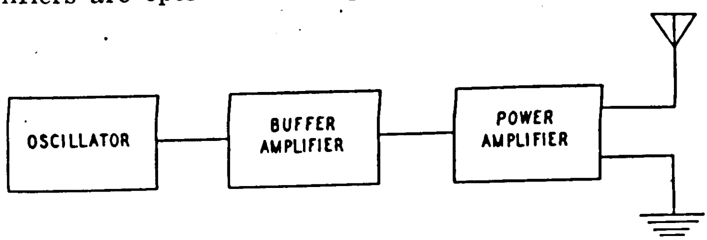


FIGURE 35. CW transmitter block diagram.

d. **Testing.** In the following paragraphs, tests are outlined to provide an indication of troubles in a particular stage. Before testing any transmitter stage for trouble, the repairman must check the power supply to prevent misleading conclusions when power supplies are defective. Extreme care must be exercised to avoid contact with high voltage in transmitters. When operation of a transmitter stage is doubtful, all voltages on tube elements should be checked and compared with manufacturer's specifications.

e. **Schematic diagrams.** Schematic diagrams of typical individual stages of a transmitter are shown in succeeding paragraphs. When testing radios, the manufacturer's diagrams must be consulted.

104. OSCILLATOR STAGE.

a. **General.** The oscillator stage generates a carrier wave whose frequency is determined by the constants of the circuit. Normal operation is indicated by the ability of stage to produce a signal of the correct frequency and of sufficient amplitude to excite the following stage. The circuit may be similar to that of figure 26 or may be crystal controlled as in figure 36.

b. **Operation.** Connect a VTVM at the grid of the oscillator (point A of fig. 36) and measure the negative rectified voltage with respect to ground or cathode. Zero voltage indicates an inoperative oscillator. The amount of rectified voltage indicates the relative activity of the crystal or amplitude of the oscillations. Consult the manufacturer's specification to determine if

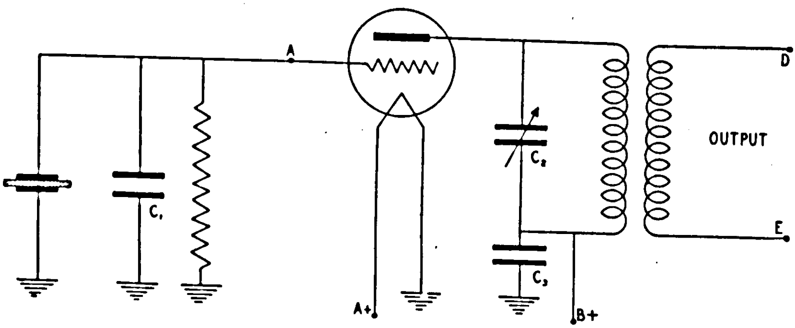


FIGURE 36. Crystal oscillator stage.

this is sufficient to excite the next stage properly, or compare results with the voltage obtained with same circuit in a transmitter known to be good. Check the operation throughout the frequency band of the oscillator. Operation may also be checked by tuning a good receiver to the oscillator frequency and noting the presence of a CW signal.

c. **Calibration.** If the oscillator is crystal controlled, the frequency is fixed by the crystal used and cannot be changed. If the oscillator is not crystal controlled, calibration is accomplished by zero-beating to a frequency meter or to a calibrated receiver. This may be done without electrical connections if the frequency meter or receiver is in close proximity to the transmitter. Set the oscillator dial at a frequency near the low end of the band and set the calibrated meter or receiver at the same frequency. Adjust the oscillator padder condenser (C_2 of fig. 26) until zero-beat is obtained. If a trimmer condenser is used, calibrate at the high end of the band.

105. BUFFER AMPLIFIER STAGE.

a. General. The purpose of the buffer amplifier stage is to provide a light, steady load and to isolate the oscillator from succeeding stages. A typical circuit is shown in figure 37.

b. Operation. Buffer operation may be checked by tuning a receiver to the output frequency and noting the change in volume of the CW signal when the oscillator is operating alone and when the buffer is also operating. Operation may also be indicated by coupling an RF current indicator (par. 14-15) to the plate tank circuit of the buffer and noting an indication of the presence of RF.

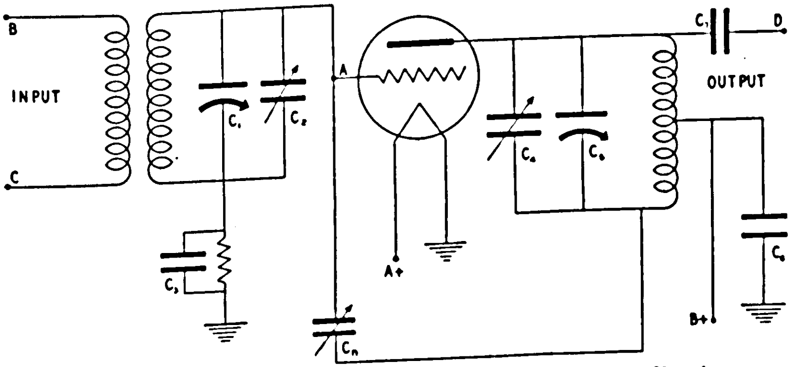


FIGURE 37. Buffer amplifier stage with plate neutralization.

c. Tuning. Tank circuits of buffer amplifiers must be tuned to resonance at the desired frequency. This is done by adjusting the grid and plate tuning condensers (C_1 and C_5 of fig. 37) to obtain maximum rectified grid voltage and minimum plate current, or maximum antenna current. If adequate meters are not provided as part of the radio set, proceed as follows:

(1) Connect a VTVM to measure negative rectified grid voltage (point A and ground of fig. 37).

(2) Excite the stage by operating the oscillator at desired frequency.

(3) Adjust the grid tuning condenser for maximum meter reading.

(4) Connect the VTVM to measure negative rectified grid voltage of the following stage.

(5) Adjust the plate tuning condenser for maximum meter reading.

d. Alignment. If gang tuning is used, the buffer tank circuits must be aligned to "track" other circuits. Proceed as follows:

(1) Connect a VTVM to measure negative rectified grid voltage (point A and ground of fig. 37).

(2) Excite the stage by operating the oscillator at a frequency near the high end of the band.

(3) Adjust the grid circuit trimmer condenser for maximum meter reading.

(4) Connect VTVM to measure negative rectified grid voltage of the following stage.

(5) Adjust the plate circuit trimmer condenser for maximum meter reading.

(6) If padder condensers or permeability tuned coils are used for aligning, continue.

(7) Excite the stage by operating the oscillator at a frequency near the low end of the band.

(8) Repeat (3), (4), and (5) above adjusting padder condensers or coil cores for maximum meter reading.

(9) Repeat the entire process until no further change in settings is required.

e. Neutralization. Due to the grid to plate capacitance of vacuum tubes, transmitter amplifiers may oscillate. To prevent oscillation, a system of neutralization is provided. Figure 37 shows a plate neutralization system in which a voltage is fed back from a balanced plate tank circuit to the grid circuit through a neutralizing condenser C_n so that it cancels the regeneration due to interelectrode capacitance. Grid neutralization is similar except that the voltage is obtained from a balanced grid tank circuit and fed to the plate circuit of the tube. To check the neutralization of an amplifier proceed as follows:

(1) Remove the plate voltage from the amplifier, but be sure that the filament is lighted.

(2) Feed an exciting signal from the previous stage into the grid circuit.

(3) Tune the plate tank circuit through resonance and note the presence or absence of RF in the plate tank at the resonant frequency. This will be accompanied by a dip in rectified grid voltage. To check, measure the rectified grid voltage with a VTVM and observe dip, or touch a neon bulb to the plate tank, or couple a flashlight bulb and loop of wire inductively to the low voltage end of the plate tank coil and observe the lamp light. If the amplifier is properly neutralized there should be no dip in rectified grid voltage, or no glow in the neon bulb or flashlight bulb.

(4) If (3) above indicates that the amplifier requires neutralization, continue.

(5) Adjust the neutralizing condenser with a screwdriver made of insulating material until the test indicates that the stage is neutralized.

(6) If an adjustment of the neutralizing condenser was required, retune or realign the grid circuit of the neutralized stage and the plate circuit of the preceding stage.

106. FREQUENCY MULTIPLIER STAGE.

a. **General.** Amplifiers operated as frequency multipliers are required in FM transmitters. Multiplication is accomplished by tuning the amplifier plate circuit to an harmonic of the grid circuit. Bias is always considerably past cut-off. Virtually any RF amplifier circuit may be operated as a frequency multiplier. A special type of multiplier stage is shown in figure 38.

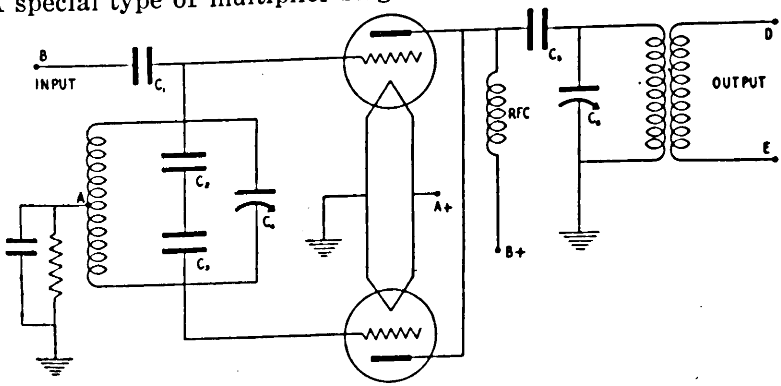


FIGURE 38. Push-push frequency multiplier circuit.

b. **Tests.** Tests and adjustments for frequency mutiplier stages are identical to those for buffer amplifiers except that in order to assure tuning the plate circuit to the correct harmonic of the input, a properly calibrated frequency meter must be used to check output of the multiplier. Neutralization of frequency multipliers is not required.

107. POWER AMPLIFIER STAGE.

a. **General.** Power is furnished to the antenna by a power amplifier stage. This stage is similar to other amplifiers except that it is designed to provide large quantities of power. If bias is provided by a grid leak, the stage must not be operated with low excitation, for this will allow very high plate current to flow and may burn out or damage the tube. A typical circuit is indicated in figure 39.

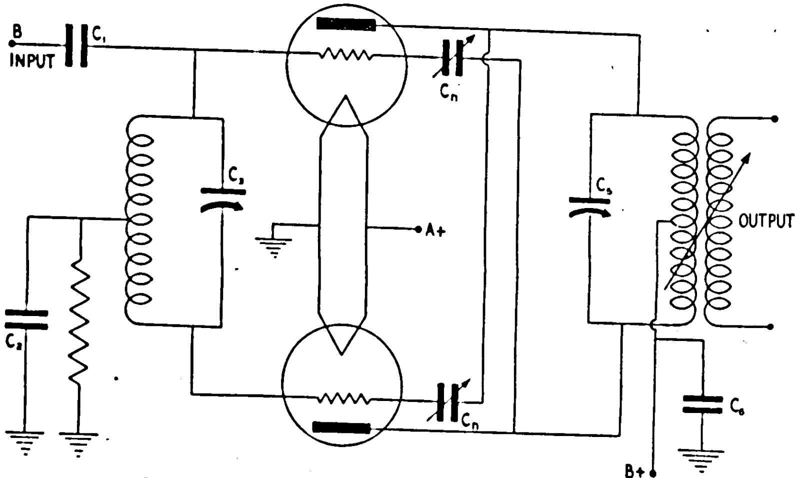


FIGURE 39. Push-pull power amplifier stage.

b. **Tests.** Tests and adjustments for power amplifier stages are identical to those for buffer amplifiers except that, since the power amplifier stage is coupled to the antenna, it is very important that changes in the antenna system or in antenna coupling do not detune the power amplifier plate circuit. The power amplifier plate current should be carefully checked to avoid excessive current. When properly tuned, the plate current will be a minimum. In adjusting push-pull neutralization, the two condensers should be adjusted together and their capacities should be kept equal to prevent unbalance and undesired coupling.

108. AUDIO SECTION. When the transmitter is amplitude or frequency modulated, an audio section consisting of one or more audio amplifiers may be used. Tests are the same as for the audio section of a receiver.

109 AMPLITUDE MODULATION.

a. **General.** Amplitude modulation may be accomplished in any RF amplifier stage. The audio voltage may be impressed on the plate, grid, or cathode to provide amplitude variations in the carrier wave. All amplifier stages after the carrier has been modulated must be class A or class B in push-pull. The modulated stage should be operated class C and excited to saturation.

b. **Test.** The most effective test of the modulated stage is measurement of DC plate current with a milliammeter. The average DC plate current should be the same both with and without modulation. With plate modulation, if the current decreases when modulated, possible troubles are: insufficient RF excitation, insufficient grid bias, or amplifier overloaded. If the plate current increases, possible troubles are: audio gain too great, incomplete neutralization of the modulated amplifier, or parasitic oscillation in the modulated amplifier. With grid modulation if the plate current decreases when modulated, probable troubles are: too much RF excitation, distortion in the audio section, or amplifier plate circuit not loaded sufficiently. If the plate current increases when modulated, possible troubles are: excessive audio voltage, distortion in the audio section, grid bias too high, or incomplete neutralization.

110. FREQUENCY MODULATION.

a. **General.** Frequency modulation may be accomplished by varying the frequency of the oscillator or by mixing the oscillator output and the audio output in a nonlinear device so that the phase of the carrier wave is modulated.

b. **Reactance modulator.** A typical reactance modulator circuit is indicated in figure 40. The oscillator must not be crystal controlled.

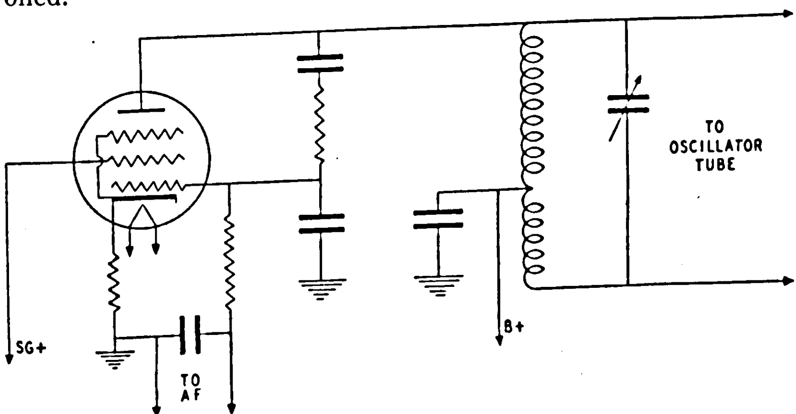


FIGURE 40. Reactance modulator stage.

c. **Nonlinear coil.** A typical nonlinear coil circuit is indicated in figure 41. The oscillator may be crystal controlled.

d. **Tests.** If the modulating voltage is nonlinear, that is, does not average zero, the carrier frequency will drift. This can be checked by modulating the transmitter and noting reception on a good receiver. If the carrier drifts, the probable cause of the nonlinear modulation is improper grid bias on the reactance

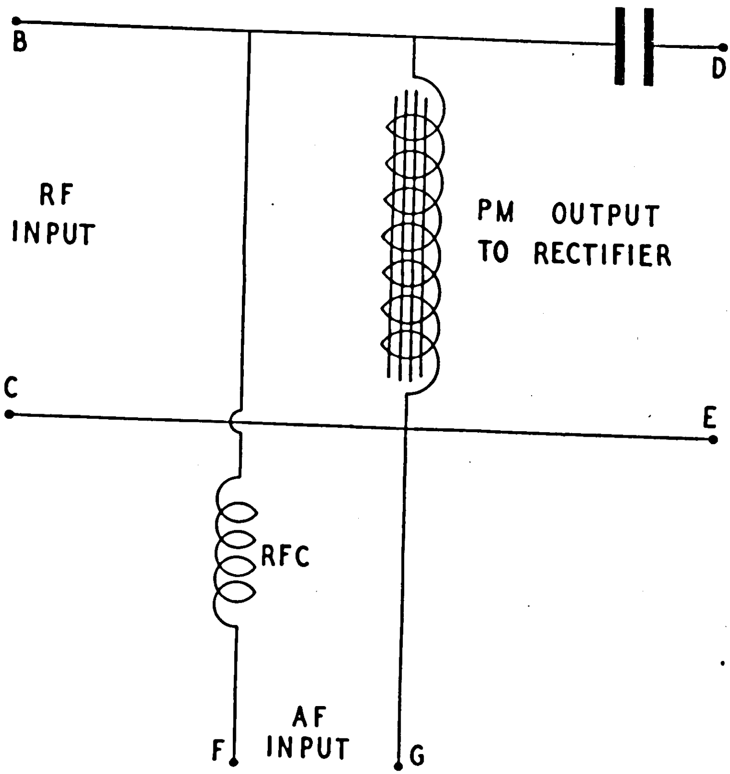


FIGURE 41. Nonlinear coil circuit.

modulator stage. Amplitude modulation in the transmitter output may be detected by observing the antenna current. It should not change when the carrier is modulated. The probable cause of amplitude modulation is improper tuning or coupling of the amplifier stages.

SECTION III
ALIGNMENT PROCEDURE

111. RECEIVER.

a. AM receiver. The following instructions may be used as a general guide for the complete realignment of superheterodyne AM receivers.

(1) Connect an output meter across the voice coil or to the plate of the output stage and ground, or cathode, if a modulated signal is to be used. Connect a VTVM to the AVC lead and

ground, or cathode, if an unmodulated signal is to be used. If an output meter is being used, disable the AVC system.

(2) Disable the RF oscillator by shorting the tuning condenser or by removing the crystal.

(3) Adjust a signal source to the correct IF and couple to the mixer input.

(4) Align all tuned circuits of the IF section for maximum meter reading, starting at the detector and working backward. Reduce the output of the signal source as each stage is brought into alignment. Keep the set volume control on full.

(5) Tune the set and the signal source to the high frequency end of the band. Couple the signal source to the antenna and ground. Restore the operation of the RF oscillator.

(6) Align the RF oscillator, mixer, and RF amplifier trimmers for maximum meter reading.

(7) If the RF oscillator uses a padder condenser, tune the set and signal source to the low end of the band and adjust the padder condenser for maximum meter reading. "Rock" the dial *slightly* while making this adjustment.

(8) Tune the set and signal source to the high end of the band, and readjust the RF oscillator trimmer. Restore the AVC if previously disabled.

(9) If a BFO is used, turn it ON and zero beat the receiver by adjusting the BFO trimmer or padder.

b. FM receiver. The above instructions are applicable to FM receivers except that the output meter cannot be used. A VTVM must be connected at the limiter grid and ground, or cathode, and an unmodulated signal should be used. Substitute the alignment of the discriminator instead of the detector in (4) above, and accomplish the discriminator alignment as indicated in paragraph 99c. Check band width of all IF stages as indicated in paragraph 97b.

c. Precautions. After aligning, check the operation of the receiver over the entire band. Oscillation may occur in the IF or RF stages, generally resulting in squeals as the set is aligned or tuned. Probable causes are poor ground connections at the condenser rotors or defective bypass condensers in cathode, screen grid, or plate circuits. Check the bypass condensers by shunting with a good condenser. An improper valve of screen grid voltage may also cause oscillation. Check the resistance of the screen grid resistor when this occurs. Oscillation in the IF section causes a continuous squeal which is independent of dial tuning.

112. TRANSMITTER. The following instructions may be used as a general guide for complete realignment of transmitters.

a. If the oscillator is crystal controlled, alignment of the stage is unnecessary. If not, align by zero-beating to a properly calibrated receiver or frequency meter.

b. Align each amplifier stage in turn by tuning its tank circuits for minimum plate current and maximum rectified grid voltage.

c. If multiplier stages are employed, a frequency meter must be used to insure tuning to the correct harmonic.

d. Check the neutralization of the amplifiers and neutralize if necessary (par. 105e).

CHAPTER 6

TESTING RECEIVER SYSTEMS

SECTION I

VOLTAGE AND RESISTANCE MEASUREMENTS

113. GENERAL.

a. Introduction. Voltage and resistance data on radio receivers provide the most accurate and effective means of isolating trouble to a particular stage or circuit. When a defective stage or circuit has been identified, the individual component or adjustment at fault may be located using methods outlined in previous chapters. Quicker but less effective methods of isolating defective stages are outlined in paragraphs 127 to 133. Voltage and resistance readings should be compared with the manufacturer's data to determine variations from normal. All voltage measurements are made with the receiver operating but receiving no signal unless indicated otherwise.

b. Continuity tests. Where continuity tests for components are suggested, the resistor, condenser, or other radio set part in doubt should be disconnected from the circuit before measuring its resistance or testing for short circuits, unless inspection of the circuit reveals that the component in question would not be affected by other circuits to which it is connected. CAUTION: Always remove power supply voltage before making continuity tests with an ohmmeter.

c. Manufacturer's data. With this method of testing, any set may be checked by following a systematic plan and proceeding from stage to stage. Manufacturer's voltage and resistance data for tube socket connections and other critical points in the set are not absolutely necessary. It is possible to assemble this data by measuring voltages and resistances on a similar set that is not defective. Lacking this, the marked value of certain items such as condensers and resistors, circuit tracing, and tube data will give a good idea of what to expect when testing. For instance, if the high voltage lead to the plate of an amplifier tube is connected through a resistor to the power supply, one can expect less voltage at the plate than at the power supply due to the voltage drop through the resistance. However, if the power supply was not defective and no voltage could be measured at the plate, it would indicate that the plate was shorted in some way or that the resistor was open.

d. **Power supply.** Satisfied that the tubes are not defective, the power supply should always be checked first to ascertain whether or not it is delivering the proper voltage or whether short circuits at some point are overloading the power supply and causing it to deliver less than the proper voltage. Likewise, an open in a high voltage lead to a stage in the radio set might cause the voltage at the power supply output to be higher than normal because the load on the power supply had been reduced.

114. VACUUM TUBE STAGES.

a. **Voltage measurements.** In general, the voltages indicated in figure 42 for pentode vacuum tube stages may be measured. Obvious modifications will be necessary for other types. Fewer measurements than indicated may be required to locate the defect.

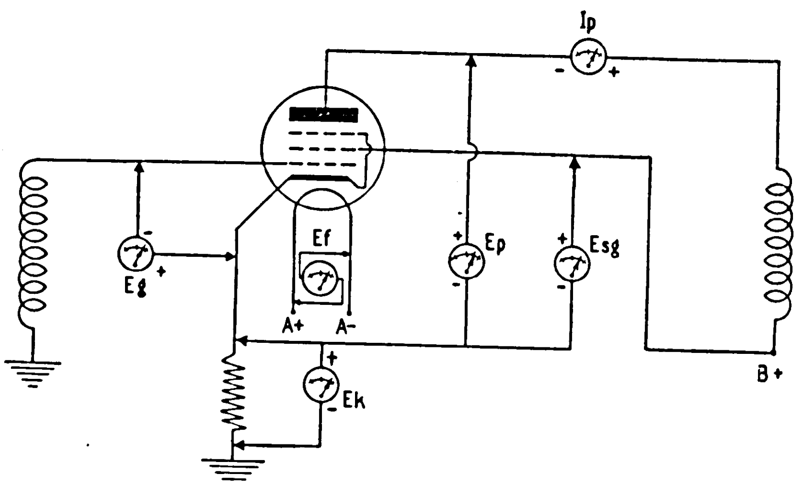


FIGURE 42. Meter connections for checking pentode stage.

b. **Abnormal indications.** Some abnormal indications and possible causes are listed below.

(1) *High filament voltage* (E_f). Burned out tube, transformer shorted or grounded, or dropping resistor shorted.

(2) *Low filament voltage.* Connecting wires shorted or grounded, or transformer shorted or grounded.

(3) *Zero filament voltage.* Open transformer, dropping resistor, filter choke, or series tube filament.

(4) *High cathode voltage* (E_k). Open bias resistor, excess plate voltage, or open grid circuit.

(5) *Low cathode voltage.* Low plate voltage, low screen grid voltage, or weak tube.

(6) *Zero cathode voltage.* Shorted bypass condenser or screen grid condenser, no plate voltage, or open plate circuit.

(7) *Positive grid voltage* (E_g). Leaky coupling condenser.

(8) *High negative grid voltage.* High plate voltage or high plate current.

(9) *Low negative grid voltage.* Low plate or screen voltage, low plate current, or weak tube.

(10) *Zero grid voltage (if incorrect).* Open grid circuit, shorted cathode condenser, open plate circuit, or no plate voltage.

(11) *High plate voltage* (E_p). Weak tube, or open plate circuit in other stages.

(12) *Low plate voltage.* Shorted plate circuit or screen grid condenser.

(13) *High plate current* (I_p). Open grid circuit, shorted cathode bypass condenser, or shorted coupling condenser.

(14) *Zero plate voltage.* Open plate circuit, or grounded plate lead.

(15) *Low plate current.* Open screen grid circuit, or low plate voltage.

115. TEST PROCEDURE. A typical circuit diagram for an AM superheterodyne receiver is shown in figure 43. All test points and part names used in paragraphs 116 to 126 refer to figure 43. For other receiver circuits, obvious modifications in procedure must be made.

116. POWER SUPPLY.

a. Power supply normal. The entire power supply may be tested by measuring the DC voltage between test points 4 and 1. If normal, proceed to test the audio output stage (par. 117).

b. Power supply voltage zero at test point 4. Remove the rectifier tube. Measure the AC voltage between test points 2 and 3, 2 and 1, and 3 and 1. If voltage is zero or far below normal, T1 is defective or shorted externally. If voltage is normal at test points 2 and 3 and zero at test point 4, C44 or C45 may be shorted,

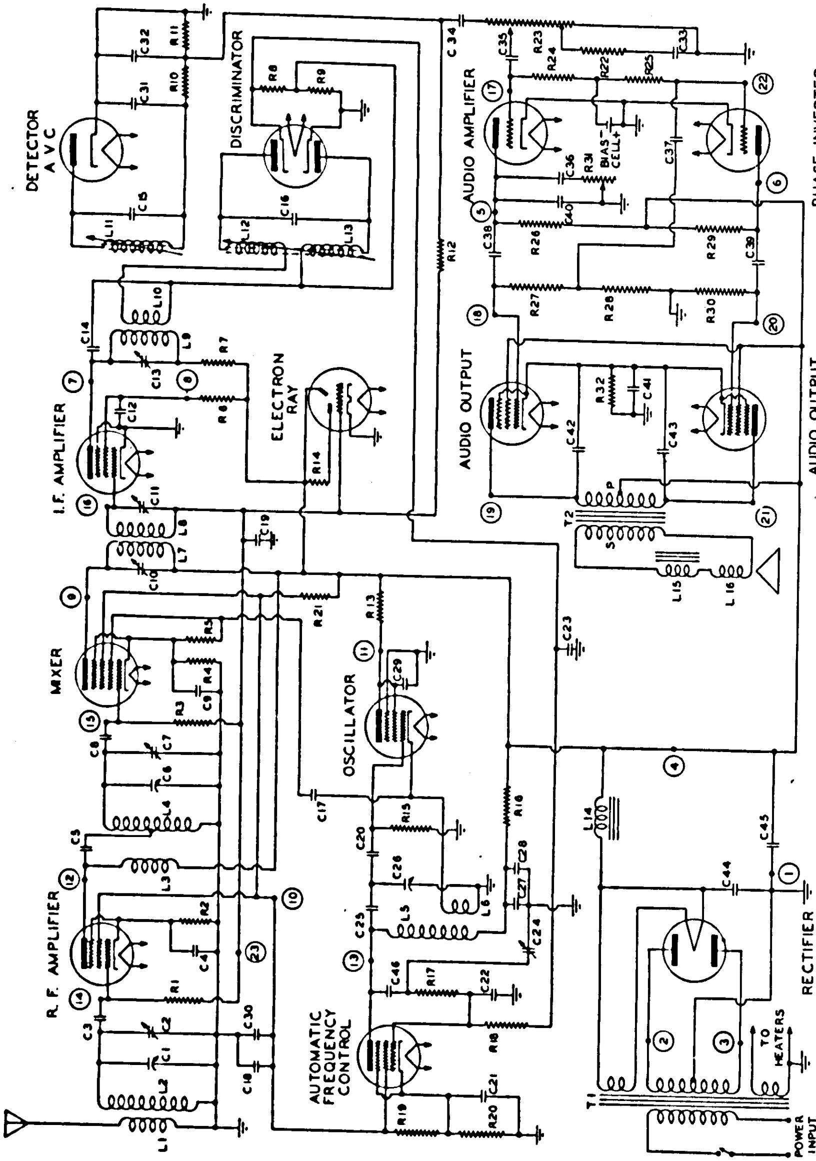


FIGURE 43. Superheterodyne AM receiver—schematic diagram.

L14 may be open or shorted to ground, a short may exist in the high voltage leads of components in the radio set stages, or the rectifier tube winding of T1 may be shorted to ground. Use an ohmmeter to test these components. To determine which stage is shorted, remove the high voltage leads at point 4 and reconnect them one at a time until the lead is found which causes the DC voltage at point 4 to drop below normal. When the defective stage is isolated, it can be tested to determine the cause of trouble.

c. DC voltage at test point 4 low. Follow the method outlined above. In this case, if C44 is open or has lost capacity, the voltage at test point 4 will be lower than normal.

d. DC voltage at test point 4 above normal. This condition indicates a reduced load on the power supply probably caused by an open in some stage. Check all tube element voltages until stage is found where normal voltages are not present. Then check all components between the tube elements and the power supply for open circuits. Check overall continuity of components and associated wiring.

117. AUDIO OUTPUT STAGE. Figure 43 shows a push-pull audio output stage. Measurements of tube element DC voltages should be made first, especially at test points 19, 21, 18, and 20. Then, proceed to the filament circuit and measure the AC voltage at each tube. T2, L15, L16, C42, C43, C41, R32, R27, R28, R30, C38, and C39 should be checked for opens, shorts, and changes in value. If C38 or C39 were shorted, a high positive voltage would be placed on the audio output tube grids and the tubes would draw excessive plate and screen grid current. C42 and C43, if shorted, would short the power supply and cause a heavy overload.

118. AUDIO AMPLIFIER AND PHASE INVERTER. Measure tube element voltages especially at test points 5 and 6. Check C36, R31, C40, R26, R29, C37, R24, R25, and cell "B" for correct values, shorts, or open circuits. For instance, if C40 were shorted or R26 open, there would be no voltage at test point 5.

119. SECOND DETECTOR. Check continuity and value of L11, L10, L12, L13, R10, R11, C31, C32, C34, R23, and C35. Filament voltage of diode tube should be checked. L10, L12, and L13 must be tested because they couple L11 to L9.

120. **IF AMPLIFIER.** Measure tube element voltages, especially at test points 7 and 8. Check continuity and value of L9, R6, R7, C12, and L8. Zero plate voltage (test point 7) would indicate L9 or R7 is open. Zero screen voltage (test point 8) would indicate R6 open or C12 shorted.

121. **OSCILLATOR.** Check tube element voltages, especially at test point 11. Measure resistance of R13, R15, L6, L5. Check C29, C20, C26, C25, C27, C28, C46 for opens and shorts. Check C17 and R5; these components are in the circuit which transfers the radio frequency energy from the oscillator to the mixer stage.

122. **MIXER.** Check tube element voltages, especially at test points 9 and 10. Zero voltage at test point 9 indicates an open in L7 or a short to ground. At test point 10, the screen grid voltage for the mixer, RF amplifier, and automatic frequency control tube may be measured. If it differs from normal, test C30, C18, and C21 for shorts, and R21, R19, and R20 for opens or changes from correct values. Test R4, C9, R3, C8, C7, L4, and C6. Note that a short in C5 would ground the high voltage measured at test point 9 unless the high voltage lead to L3 were removed before the mixer tube element voltages were checked.

123. **RF AMPLIFIER.** Measure tube element voltages, especially at test point 12. If the voltage at test point 10 was normal, the same voltage should appear at the screen grid terminal of the RF amplifier tube socket. Check resistance of R2 and R1, and check C5, C4, C3, C2, and C1 for shorts or open circuits. Check continuity of L1 and L2.

124. **AVC CIRCUIT.** The set must be working well enough to be able to tune in a strong signal. A low voltage should be present at test point 23 when the set is tuned to a signal. When no signal is being received, the voltage should decrease or fall to zero. Check C19 for short circuit, and R12 and R11 for opens or large changes in values.

125. **AUTOMATIC FREQUENCY CONTROL AND DISCRIMINATOR.** Check filament voltage of both tubes and the tube element voltages of the automatic frequency control tube, especially at test point 13. If no voltage is found at test point 13, measure R16. If voltage is low, test C46 for short. Check values of R8, R9, R17, R18, and check C22, C23, and C24 for shorts.

126. ELECTRON-RAY TUBE. Check tube element voltages. Voltage in the AVC circuit at test point 23 should vary with signals and should correspond to the voltage at the grid of the electron-ray tube. Check the value of R14.

SECTION II
SIGNAL TRACING

127. GENERAL. Signal tracing is the process of following a signal through a set and observing when it departs from normal behavior—that is, distorts, fades, etc. At the point where a departure from normal is observed, the set components are examined and tested to determine the exact cause. In the following method for signal tracing, all test points and part names refer to the AM superheterodyne circuit shown in figure 43. Obvious modifications must be made when applying these methods to other circuits.

128. TECHNIQUES.

a. Equipment. For locating a trouble in a defective receiver, there are two general requirements—a signal source of the proper frequency and some means of detecting the presence and quality of the signal. A signal generator may be used to provide the signal, or the signal may be "tuned in" from either a nearby or a distant transmitter. For checking the presence and quality of a signal, either the defective receiver itself or a special signal tracer (par. 38-41) may be used. The most appropriate technique will depend on which of the alternate types of equipment is used.

b. Working from reproducer to antenna. A signal of the proper frequency may be furnished by a signal generator—either by a commercial model or by bridging over from the appropriate stage of another receiver known to be in good working order. By beginning with the plate of the AF stage next to the reproducer and applying a signal to each stage in turn, working back towards the antenna, the defective set itself may be used to determine the presence and quality of a signal. Each circuit as it is added is tested for its ability to process the signal; if, for example, the signal is introduced into the grid circuit of the final IF stage and the signal in the reproducer distorts or fades out, the trouble can be assumed to be in a circuit of that stage since all other stages between the signal and the reproducer have previously been tested.

c. **Working from antenna to reproducer.** If a signal generator which can furnish the proper frequencies is not available, a signal may be "tuned in." Since the signal is RF, it is necessary to begin at the antenna. Some special means of checking for the presence of the signal must be used, since the RF cannot be used to operate the reproducer of the defective set directly. Instead, a signal tracer (either an untuned signal tracer or a receiver known to be good) must be used. The signal tracer is connected across successive stages working away from the antenna. The trouble has been located when the "tuned in" signal fades out or appears distorted in the reproducer of the signal tracer, since all stages between that test point and the antenna have previously been tested and found good.

d. **Precautions.** Neither of the two procedures described below gives results that are infallible. Either furnishes indications for the checking of certain components. Only when the exact component at fault has been discovered, the trouble remedied, and the set put in working order again can the work of the repairman be considered finished.

129. WORKING FROM REPRODUCER TO ANTENNA.

a. **Equipment.** Assume that no commercial signal generator is available, but another set of the same design as the defective set is at hand.

b. **Testing reproducer.**

(1) Turn both sets on and tune them to different frequencies. The good set should be tuned to pick up a modulated signal.

(2) Connect one lead from the top side of the secondary of T2 on the defective set to the same point on the good set; connect a second lead from the other side of the secondary of T2 to the corresponding point on the good set. If the signal is satisfactory in the defective set, the reproducer of that set can be assumed to be good. If not, check components of the circuit using methods in section I.

(3) The general rule for this and for succeeding stages: if the signal is satisfactory, pass on to the next stage; if not, check the components of the circuit and make necessary repairs.

c. **Testing AF circuits.**

(1) Remove leads.

(2) Connect one lead between the chassis of the two sets. This lead remains fixed throughout the remainder of the test.

(3) Connect another lead (which includes a .001 microfarad condenser) from test point 19 on the good set to the same point on the defective set. This bridges an AF signal from the good set to the defective set. If the signal is satisfactory, the plate circuit of this tube is good.

(4) Check the plate circuit of the second output tube in the same manner by moving the second lead from test point 19 on the defective set to test point 21.

(5) Shift the lead which includes the condenser to test point 18 on both sets. If the signal does not come through satisfactorily, check components of the various circuits associated with this tube.

(6) Change the lead from test point 18 on the defective set to test point 20. If the signal does not come through satisfactorily, check components of the various circuits associated with this tube.

(7) Shift the lead from test point 20 on defective set to test point 22. This checks the plate circuit of the phase inverter, including coupling to the output tube.

(8) Shift the lead from test point 22 on the defective set to test point 17. This furnishes a check (only partly reliable) of the grid and plate circuits of the AF amplifier.

(9) Shift the lead from test point 17 on the defective set to the ungrounded side of R11. If the signal is not satisfactory check coupling between 2d detector and audio stage and then make an additional check on the audio stage following.

(10) Functioning of some of the AF components of the second detector stage can be checked more conveniently when the IF portion of that stage is checked in a later step.

(11) A check of the discriminator circuit can be made more conveniently after all other stages of the set have been checked.

(12) With the exceptions noted, checking of the AF stages has now been completed. An AF signal from the good set is no longer required, so, remove the lead which has been attached to test point 18 on the good set. Remove the other end from test point 17 on the defective set.

d. Testing IF circuits.

(1) Attach the lead which includes the .001 microfarad condenser to test point 7 on the good set; connect the other end to the side of L11 connected to the plate of the second detector. This bridges an IF signal from the good set to the defective set. This connection checks the second detector stage. Pass on to the

next operation only if the signal is satisfactory. Otherwise, check components of the circuit in detail and make repairs.

(2) Shift the lead from L11 on the defective set to test point 16. This checks plate and grid circuits of the IF stage.

(3) Change the lead from test point 16 on the defective set to test point 9. This checks the plate circuit of the mixer.

(4) Checking of IF circuits has been completed. The IF signal from the good set is no longer needed, so remove the lead from test point 7 on the good set and from test point 9 on the defective set.

e. Testing oscillator.

(1) Tune in a signal on the good set. If the oscillator is tuned to a frequency above that of the incoming signal, tune in at the high end of the band; if below, tune at the low end.

(2) Chassis of sets may be left connected.

(3) Take the antenna lead from the good set and place it near the wiring of the oscillator of the defective set—to provide loose coupling.

(4) Tune the defective set until a beat note is heard. This note should appear when the setting on the dial differs from the setting on the dial of the good set by an amount equal to the IF. (The setting on the defective set will be below when the oscillator is tuned to a frequency above the incoming signal; above, in the other case).

f. Testing RF circuits.

(1) Tune the two receivers to the same frequency.

(2) Connect the lead including a .001 microfarad condenser from test point 15 on the good set to test point 12 (plate of RF amplifier) on the defective set, thus providing an RF signal. In RF stages, signal tracing is less reliable than in earlier stages. However, this connection gives a rough check of the control grid circuit of the mixer.

(3) Shift the lead from test point 12 on the defective set to test point 14 (grid of RF amplifier). This gives a rough check of the plate circuit of the RF amplifier stage.

(4) Remove the lead from test point 15 on the defective set and test point 14 on the good set.

(5) Connect the antenna lead-in from the good set to the antenna binding post on the defective set. Signal volume or background noise should grow stronger; if not, check the antenna circuit.

g. Testing frequency control circuits.

(1) The discriminator and automatic frequency control tubes included in the set are part of an automatic frequency control system.

(2) Tune in a strong local signal with the automatic frequency control switch closed, rendering the system inoperative.

(3) Open the switch and observe the quality of the signal; if the signal is still free from distortion, the system is either totally inoperative or functioning satisfactorily.

(4) Next, detune the receiver slightly; with the system in operation, the signal should remain satisfactory.

(5) Close the switch (receiver still detuned); some distortion should be evident, since the system is inoperative. If this test reveals that the automatic frequency control system is not operating normally, check components in detail and make necessary repairs.

h. Abbreviated procedure. To determine quickly in what section (AF, IF, RF) of the receiver the trouble is located, tests may be made in the following order:

(1) Perform the test described for the second detector (par. 129b(1)). If the signal comes through satisfactorily the reproducer and all audio circuits are good; if not, perform all steps in order from the reproducer to that point.

(2) Perform the test described for the plate circuit of the mixer (par. 129b(3)). If the signal comes through satisfactorily, all IF circuits are good; if not, perform tests in order as described in (paragraph 129d(1) and 129d(2)).

(3) Perform the test described for the antenna circuit (par. 129f(5)). If the signal comes through satisfactorily, the RF circuits and the oscillator are good; if not, perform all tests in order as prescribed in paragraphs 129e and 129f.

i. Testing FM sets. The tests as described above are applicable to FM as well as AM sets. The modulated signal tuned in on the good set must, of course, be FM.

130. WORKING FROM ANTENNA TO REPRODUCER.

a. Equipment. Assume that no commercial signal generator is available, and no other set of the same or similar design. A signal tracer (par. 40) is at hand.

b. Testing RF circuits.

(1) Turn the defective set on.

(2) Make sure that the signal tracer is connected to its batteries. Connect the common lead to the chassis of the set.

(3) Unless a very powerful signal is available to be tuned in, or unless the sensitivity of the signal tracer is improved, connections to the antenna, or the grid, or plate of the RF amplifier will not yield a signal strong enough to operate the headphones connected to the signal tracer.

(4) Connect the RF probe of the signal tracer to test point 16. Listen for a signal in the headphones of the signal tracer. The signal will probably be weak even in a normal set; if inaudible or distorted, check components of the circuits of the antenna, RF amplifier and mixer grid.

c. **Testing IF stages.**

(1) Move the RF probe to test point 9. The signal fed into the signal tracer is now IF, but since the tracer is untuned, the connection with the RF probe will pick up this signal, too. The signal should be louder, because of amplification in the mixer stage. If not, or if the signal is distorted, check the tube and components of the plate circuit of the mixer and of the oscillator.

(2) Move the RF probe to test point 16. The signal should be about the same level. If not normal, check components cf the grid circuit of the IF amplifier.

(3) Move the RF probe to test point 7. Signal strength should increase. If the signal is not normal, check the tube and plate circuit of the IF amplifier.

(4) Move the RF probe to the diode plate. Signal strength may drop slightly. If the signal is distorted or has faded out, check components of the detector stage.

d. **Testing AF stages.**

(1) For testing AF stages of the receiver, only the AF portion of the signal tracer is used.

(2) Connect the AF probe to test point 17. If the signal distorts or has faded out, check components of the AF amplifier grid circuit. Note, that adjusting the volume control should affect signal strength at this point. The volume control may have to be set high to hear the signal.

(3) Move the AF probe to test point 5. The signal should be stronger, due to amplification by the tube. If the signal is not normal, check the tube and plate circuit of this stage.

(4) Move the AF probe to test point 22. The volume control may again need to be set high. If the signal is not normal, check components of the grid circuit of this stage.

(5) Move the AF probe to test point 6. The signal should be stronger. If the signal is not normal, check the tube and components of the plate circuits of this stage.

(6) Move the AF probe to test point 18. In a normal set, the signal strength should be about the same as at test point 5. If not, check components of the grid circuit of this stage.

(7) Move the AF probe to test point 19. The signal should appear stronger. If not, check the tube and components of the plate circuit. If the signal is distorted also check components of the plate circuit of the second output tube.

(8) Move the AF probe to test point 20. Signal strength should be about the same as at point 6. If not, check components of the grid circuit of this stage.

(9) Move the AF probe to test point 21. The signal should appear stronger. If not, check the tube and components of the plate circuit of this stage.

e. **Checking reproducer.** If the preceding circuits have been checked and the signal found good, the signal should be good as it comes from the reproducer of the set; if not, check components of the reproducer circuit.

f. **Testing frequency control circuits.** For method of checking these circuits, see paragraphs 129g.

g. **Testing FM sets.**

(1) The AF stages and the reproducer of FM sets can be checked using the untuned signal tracer. To test the discriminator, connect the AF probe of the signal tracer to the ungrounded side of the discriminator output.

(2) A signal tracer of this type (par. 40) cannot, however be used to check the RF and IF stages. These stages can be checked if another FM set is available, using the method outlined in paragraph 129; for a check of all stages of an FM set, follow the routine described in that paragraph.

SECTION III

OTHER OPERATIONAL TESTS

131. **GENERAL.** Certain operational tests, such as circuit disturbance and stage muting, may frequently be used because of their time saving features. Complete reliance cannot be placed in these methods; however, frequent use of these methods will develop considerable skill in locating troubles rapidly. All test points and part names refer to the AM superheterodyne cir-

cuit shown in figure 43. Obvious modifications must be made when applying these methods to other circuits.

132. CIRCUIT DISTURBANCE.

a. General. Circuit disturbance testing usually affords a quick method of locating the stage that is defective in a completely inoperative receiver. This test is based on the principle that a sudden change of current through the reproducer will result in a click being heard from the reproducer.

b. AM testing.

(1) Turn the set on, allowing sufficient time to warm up. Open the plate supply of either of the output tubes. A click should be heard in the reproducer. If a click is heard, the output stages, reproducer, their coupling medium, and power supply are considered good. If no click is heard, the trouble lies in the tube or its circuits, or power supply, or in T2, L15, or L16. To check T2, L15, and L16, turn the set off. Apply 4½ volts across the plate leads of the output tubes. If a click is heard, T2, L15, and L16 are good. The trouble is in the power supply or in the B lead to the primary center tap of T2. If no click is heard, apply the 4½ volts across L15 and L16. If no click is heard at this point, one of these two coils is defective. If the click is heard, transformer T2 is defective.

(2) Open the plate supply of the audio amplifier tube. If this stage is operative, the plate current will go from some value to zero instantly, causing a change in grid voltage in the output tube. This will result in a click being heard in the reproducer. The plate supply may be opened by pulling the tube from its socket. If this is not convenient, the same result may be obtained by momentarily shorting the grid bias.

(3) To check the detector stage, apply 4½ volts between ground and the plate of the second detector (plus to plate). Be sure the volume control is turned to near maximum volume position. A click should be heard if this stage is not defective.

(4) The IF stages may be tested by the same method as used for the AF amplifier; or the grid may be touched by the finger to produce a click indicating the stage is good. In the process of producing clicks in the reproducer from stage to stage, when the point is reached where no click is heard, the trouble is generally between this point and the last point producing clicks.

(5) For the mixer, oscillator, and RF stages, the plate current can be changed by touching their respective stator plates of the ganged tuning condenser.

(6) In case of zero grid bias in any stage to be tested it may be found more expedient to pull the tube from its socket, or to apply a low value of grid bias by connecting 4½ volts between cathode and grid (minus to grid). Either method will result in a change of plate current if the stage and its circuits are operating properly, thereby causing a change in grid voltage on the following stage, ending with an audible click in the reproducer.

c. **FM testing.** Due to the leveling action of the limiter stage, circuit disturbance tests are not as precise with FM receivers, and certain modifications may be required. When an FM receiver is operating properly, with no incoming signal, a strong hiss is heard in the reproducer. This hiss is due to the action of numerous high gain amplifiers. If the hiss is strong in a defective receiver, the trouble is probably in or near the RF stages, and if the hiss is very weak, the trouble is probably in or near the AF stages. In FM sets it will often be necessary to add external grid bias to cause a good click to be heard through a properly operating stage. This may be done by connecting the plus side of a battery (4½ volts is usually enough) to the cathode, and the minus to the grid of a tube. A double click should be heard, one when the connection is made and one when the connection is broken.

d. **Precaution.** Circuit disturbance tests are not always conclusive, but in general lead quickly to the defective stage in a totally inoperative set. After the defective stage has been found by the circuit disturbance method, if the trouble is not obvious, or can not be located through the principle of a change of plate current causing a click in the reproducer, another test should be used to find the exact source of trouble within the defective stage. This will usually be the method outlined in section I.

133. STAGE MUTING. Stage muting is a rapid and usually effective method of isolating hum and noise generated within a set to the stage causing the trouble. To find the stage causing hum in figure 43 proceed as follows:

a. Pull one of the output tubes from its socket. Short the grid to ground on the remaining tube. If the hum disappears, insert the other tube and pull the tested tube from its socket. Repeat the test of shorting grid to ground on the inserted tube. If the hum continues when each tube is tested, the power supply is probably at fault. In all cases of push-pull output stages it will be found expedient to pull one tube from its socket before testing the other output tube.

b. To test the AF amplifier tube, short the grid to ground. If the hum is stopped, proceed to test the detector tube. When a point is found that does not stop the hum, the source of this hum will be found between this point and the last tested point that did stop it.

c. The detector stage may be tested by shorting the plate of the second detector tube to its cathode.

d. IF, oscillator, mixer, and RF stages may be tested in the same manner as used for the AF amplifier stage.

e. At very high and ultrahigh frequencies, and generally through FM receivers, an external grid bias will be found necessary to stop the action of a tube. The amount of voltage to apply between grid and cathode of a tube to stop its action will be determined by the characteristics of the tube and its circuits.

f. Stage muting will be found convenient for locating the stage originating a hum or oscillation, but, unless the exact cause is obvious, the test method indicated in section I must be used in locating the defective point of the stage.

CHAPTER 7

TESTING TRANSMITTER SYSTEMS

134. GENERAL. Voltage, current, and resistance data on radio transmitters provide the most accurate and effective means of isolating trouble to a particular stage or circuit. When the defective stage has been identified, the individual component or adjustment at fault may be located using methods outlined in previous chapters. All voltages should be measured with a high resistance DC voltmeter, preferably a VTVM, and all currents should be measured with a DC milliammeter unless otherwise indicated. Never work on a transmitter with full voltages applied unless no other way is possible. A thorough understanding of what each circuit is supposed to do is essential. Most transmitters have one or more voltmeters or ammeters as a part of the set. Normal readings of these meters should be known. When troubles occur, the repairman should endeavor to analyze the trouble from abnormal readings on the set before applying special test procedures. Troubles that are not caused by faulty tuning or bad tubes may be found by systematically checking each component for shorts, open circuits, or changes in values, and by testing the continuity of each circuit. Unless there is some indication which points to a specific stage where trouble is originating, it is best to work from the power supply through the oscillator and low power stages to the antenna.

135. METER INDICATIONS.

a. Antenna current. Normal antenna current will indicate that RF power is being delivered to the antenna, but will not indicate that the antenna is radiating properly. Abnormal antenna current may indicate improper excitation of the antenna or a defect in the antenna circuit.

b. Filament voltage. Abnormal filament voltage will indicate the same troubles as for receivers (par. 114).

c. Plate voltage. Abnormal plate voltage will indicate the same troubles as for receivers (par. 114).

d. Cathode voltage. Abnormal cathode voltage will indicate the same troubles as for receivers (par. 114).

e. Low plate current. Low plate current may indicate one of the following:

(1) Insufficient excitation.
(2) Soft tube (low emission).
(3) Low plate voltage.
(4) Grid voltage too high (negative).
(5) Improperly loaded.

f. High plate current. High plate current may indicate one of the following:

(1) Plate circuit not resonated.
(2) Grid bias too low (negative).
(3) Insufficient excitation.
(4) Gassy tube.
(5) Improper neutralization.
(6) Wrong degree of coupling between stages.

g. Rectified grid voltage. The rectified grid voltage of class C amplifiers will be normal if the grid circuit is properly tuned, if the plate circuit of the previous stage is properly tuned, if the coupling is correct, and, if the stage has sufficient excitation. Improper adjustment of any of these items will decrease the rectified grid voltage.

136. TEST PROCEDURE. Figure 44 indicates a simple circuit for an AM transmitter with crystal oscillator and suppressor grid modulation of the power amplifier stage. All test points and part names used in paragraphs 137 to 141 refer to this circuit. Obvious modifications in test procedure are necessary to adapt this method of testing to other transmitters.

137. POWER SUPPLY. This unit should be tested for normal output voltage while under load. However, a short circuit in a transmitter stage will cause an erroneous voltage measurement at the power supply. If the output under load is abnormal, continue to test the power supply as indicated in paragraph 116.

138. OSCILLATOR. Check all tube element voltages. If these are normal, test the oscillator by measuring the voltage drop across R1 using a VTVM. If the crystal is not oscillating, replace it or readjust the oscillator tank circuit (L1 and C2). A short in C3 or an open in C1 would prevent the oscillator from functioning. Zero plate voltage could be caused by an open or short in the R2-R4 circuit, a short in C1, or an open in L1.

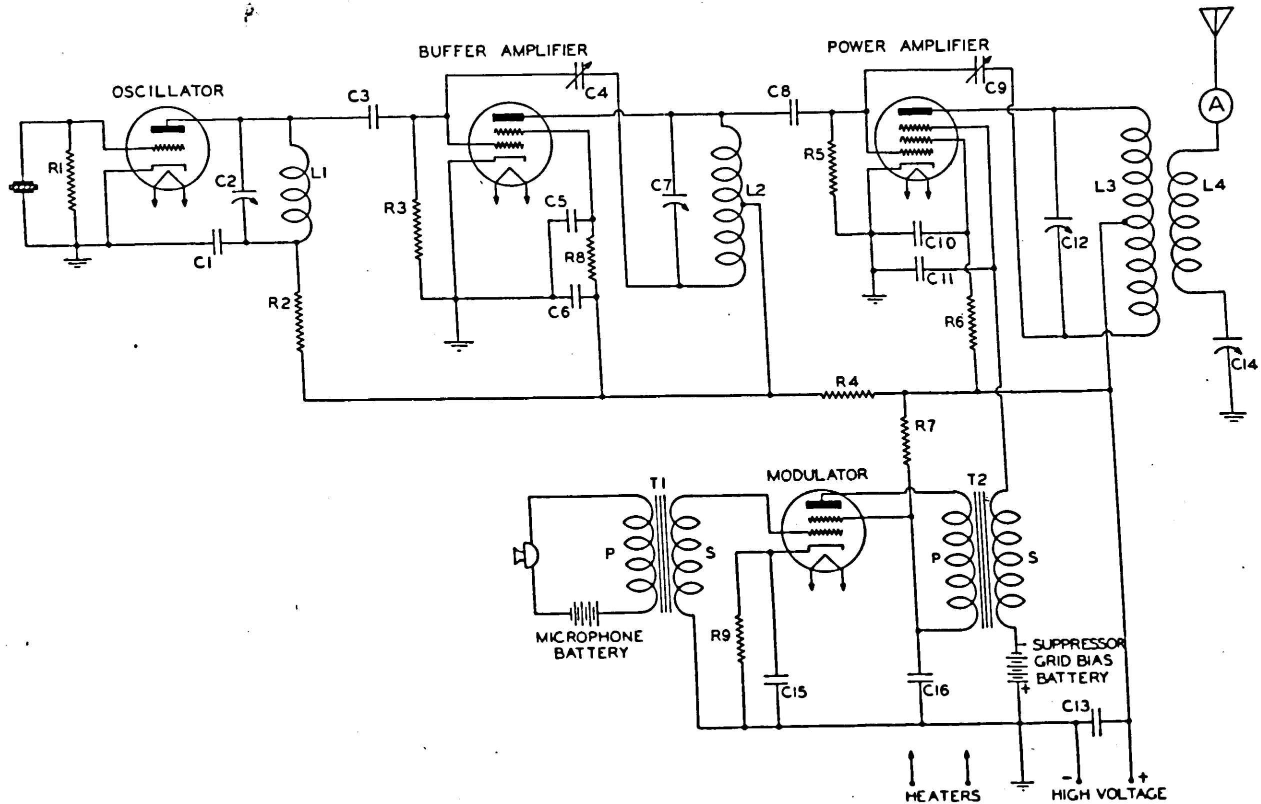


FIGURE 44. Crystal controlled AM transmitter—schematic diagram.

139. BUFFER AMPLIFIER. If the buffer amplifier stage is functioning properly, a voltage drop, measured with a VTVM should appear across R5 (if the power amplifier is also operating), and all tube element voltages should be normal. If abnormal operation is found, check C5, C6, R3, C4, C7, and L2.

140. POWER AMPLIFIER AND ANTENNA. Check the continuity of the antenna system, and determine if all tube element voltages are normal. If a trouble seems to be present, check R5, C8, R6, C9, C10, C11, C13, C12, L3, T2 and the suppressor grid bias battery.

141. AUDIO SECTION. Test methods outlined in chapter 6 for audio sections of receivers will be satisfactory for the audio section of the transmitter. The entire modulator including the microphone may be tested by connecting headphones across the secondary of T2 and listening for an audio signal while talking into the microphone. Measure tube element voltages, and check C15, R9, C16, R7, and T1. Check the microphone circuits and the microphone battery.

CHAPTER 8

REPLACEMENT REPAIR AND MAINTENANCE

142. GENERAL. Replacement, repair, and maintenance of radio parts and equipment require considerable technical skill, and the extent of such work accomplished by field artillery repairmen will depend largely upon individual ingenuity and skill. Repairmen should start *only* those jobs which can be accomplished with certainty. When a defective part is discovered, it should be replaced with an identical part, and located and connected in an identical manner as before. If unable to comply with this rule, repairmen should be guided by the information contained in the following paragraphs.

143. CLEANING. Radio equipment must be cleaned frequently and thoroughly. Failure to do so will inevitably result in corroded parts and connections, defective contacts, worn mechanisms, and, eventually, failure of the set. Clean, *dry* air under moderate or low pressure may be used to clean cabinets, chassis, and parts. A clean, dry cloth may also be used for this purpose. Switch contacts, plugs, jacks, sockets, and connectors must be periodically burnished with a noncorrosive cleaner to maintain a bright appearance. Moving mechanisms should be cleaned and lubricated only in accordance with the manufacturer's specifications. Moisture (especially moisture containing salt) must be removed from equipment immediately and thoroughly. Corrosion must be removed from coils and other parts.

144. EXPOSURE TO SALT WATER.

a. General. In amphibious operations, special precautions must be observed to protect radio equipment from exposure to salt water due to submerging, spray, or dampness.

b. Preventive measures. To prevent damage to equipment, perform the following:

(1) Seal all seams in lids and all plugs, jacks, sockets, and connectors using scotch or adhesive tape.

(2) Cover sliding joints with vaseline or other neutral grease.

(3) Enclose all equipment in water repellant fabric and uncover only when necessary.

(4) When operating on a beach, select a dry position protected from surf spray.

(5) Use deflectors of water repellant material to prevent spray or rain from reaching equipment.

(6) After setting up for operation, retape plugs, jacks, sockets, connectors, and seams to prevent salt laden sand from entering equipment.

c. **Remedial measures.** As soon as possible after exposure of equipment to salt water, treat as follows:

(1) Do not apply power until all foreign matter has been removed and parts are dry.

(2) Remove all traces of salt by washing or flushing with fresh water and scraping surfaces lightly.

(3) Apply rust preventive compound to metallic parts which may rust.

(4) After parts are clean, dry by wiping with a clean cloth and heating in an oven. Field kitchen ovens may be used, but the temperature must not exceed 135° F and, if possible, air should be circulated through the oven. If no other means is available, the equipment may be placed beneath a cover and electric lamps or other heat sources used to raise the temperature to about 135° F.

(5) Apply power for short intervals initially and watch for flashovers or emission of smoke, which will indicate parts requiring additional treatment.

(6) As soon as time permits, after equipment has been exposed, thoroughly inspect and test as indicated in chapter 9.

145. ELECTRICAL CONNECTIONS. Electrical connections must have mechanical strength as well as electrical conductivity. This may be obtained by twisting wires together and tying wires to socket connections before soldering. Soldering irons must be kept hot while in use and must be correctly applied to the part being soldered to avoid resin joints. Soldered connections must be neat, and must not have large quantities of excess solder adhering to the connection.

146. LEAD WIRES. When repairing or replacing wires, they should not be moved from their original positions in the set. Failure to observe this precaution may result in undesired feedback or inductive and capacitive effects. Wires should be as short as possible, particularly in ultrahigh frequency sets. High voltage leads should never be cabled with other leads unless adequate insulation is used to prevent shorting. Wires should never have sharp bends or other peculiarities, which might injure the insulation or otherwise subject the wire to unusual strain.

147. RESISTORS. Defective resistors must be replaced by resistors with the same ohmic resistance and the same or higher wattage rating. When resistors burn out, the cause is excessive voltage or reduced resistance in the circuit. The immediate cause of the defective resistor must be discovered and corrected before replacing a part. If a particular resistor frequently burns out and no unusual circumstances are present, a resistor with a higher wattage rating should be used..

148. COILS AND TRANSFORMERS. Replacement coils must have the same inductance as the part replaced. Transformers must have the same turns ratio and the same primary and secondary impedance. An expedient repair of an open receiver transformer primary is indicated in figure 45. The RF choke coil may be replaced by a resistor of 50,000 to 150,000 ohms for the primary or .1 to .2 megohms for the secondary. The coupling condenser should be .0001 to .005 microfarad for an RF stage or .01 to .1 microfarad for an AF stage.

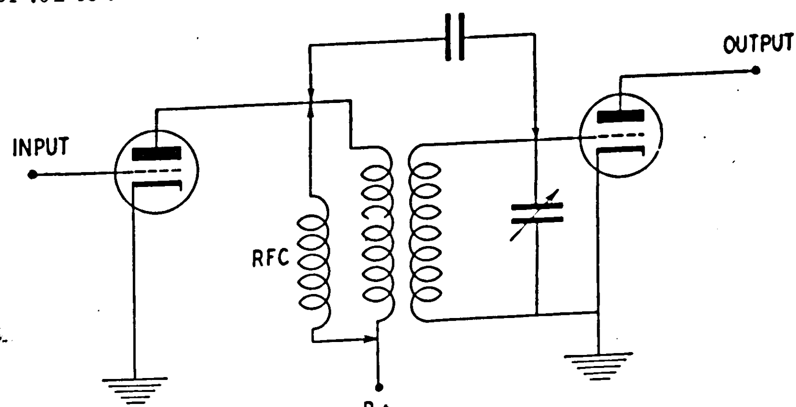


FIGURE 45. Expedient repair of transformer primary.

149. CONDENSERS. Replacement condensers must have the same capacity and at least as great working voltage as the part they replace. Electrolytic condensers must never be used where AC voltages may be applied to them. An expedient whereby a coupling condenser may be replaced is indicated in figure 46. A few turns of insulated wire connected to the primary and wrapped around the grid lead of the secondary provide the desired coupling when a condenser is not available.

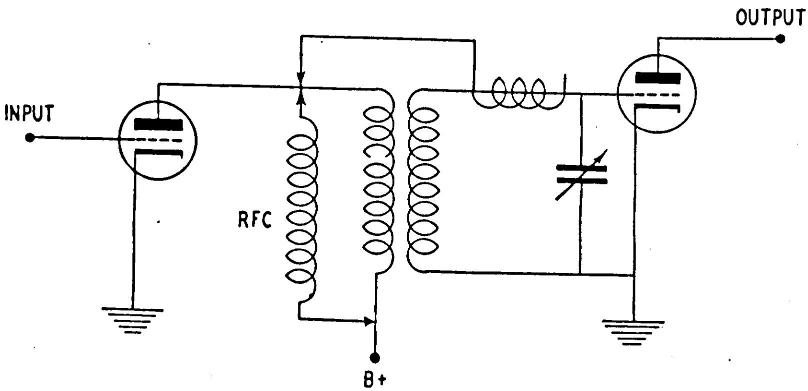


FIGURE 46. Improvised coupling condenser.

150. TUBES. Vacuum tubes must be replaced by tubes of identical types. When used in calibrated instruments or balanced circuits, the replacement tube must be matched with the old tube or recalibration and reneutralization will be necessary.

151. FUZES. Replacement fuzes must have an identical current-carrying capacity as the fuze replaced. When fuzes burn out, the cause of high current must be discovered and remedied before replacement. Circuits should never be overfuzed.

152. RELAYS. Relays may require readjustment of air gap, adjustment of armature tension, or cleaning of points. The air gap should be changed only when an adjustment is available and then should be set to the manufacturer's specification. Spring tension on the armature may be adjusted when defective, but should not be changed unless definitely required. Relay points should be burnished when sticking or arcing; however, only a special relay point burnishing tool or a riffler file should be used. A flat file, sandpaper, or emery cloth must never be used.

153. ANTENNAS. Special antennas and transmission lines require special knowledge and equipment to construct and tune and should be avoided except when special applications require their use. Manufacturer's specifications regarding the antenna and lead-in must be rigidly followed.

154. GENERATORS AND DYNAMOTORS.

a. **Lubrication.** Bearings must be kept well lubricated, but only in accordance with manufacturer's specifications. Grease and oil must never be allowed to get on the commutator or brushes.

b. **Commutator.** The commutator should be smooth and bright. If the commutator becomes rough or pitted, it may be smoothed by using No. 000 or finer sandpaper. Emery or carborundum cloth must never be used because particles of these abrasives become embedded in the bars or brushes and continue a lapping action that greatly reduces brush and commutator life. Insulating mica must be undercut slightly to prevent contact between the mica and the brushes. If required to undercut the mica, use a hacksaw blade which has been ground to the proper width and proceed very carefully to prevent damage to the commutator bars. After dressing the commutator, remove all particles of abrasive by blowing out with air.

c. **Brushes.** Worn or defective brushes must be replaced immediately. A tight brush can be relieved by sanding or filing the sides of the brush until proper clearance is obtained. When new brushes are installed they must be seated by placing a strip of No. 000 or finer sandpaper between the brush and the commutator with the abrasive surface facing the brush and pulling the sandpaper back and forth. The sandpaper must be held in close contact with the commutator on both sides of the brush so that the corners of the brush will not be rounded. If the brushes are improperly seated, arcing will occur which will reduce the life of brushes, pit the commutator, and cause interference with radio reception. Never use emery or carborundum cloth. Clean thoroughly after seating the brushes.

d. **Generator adjustment.** The output voltage of generators may be adjusted to the correct and steady value. Manufacturer's specifications should be followed in making this adjustment.

155. VIBRATORS. Vibrator units should be replaced, when defective, with an identical type. Repairs should not be attempted.

156. REPRODUCERS. When replacing headphones or loudspeakers, the impedance of the replacement unit must be the same as that of the unit replaced.

157. FILTER CIRCUITS. In constructing or replacing filter circuits, the impedance of the condenser at the lowest frequency encountered should not be more than one-fifth of the impedance of the filter choke or resistor at that frequency. Resistors should be used in filter circuits only when the current flowing is very small.

158. BRIDGING STAGES. Certain receiver stages may be bridged or eliminated if the circuits are changed to compensate for the stages eliminated. RF and IF amplifier stages may be bridged by connecting the plate of the preceding stage to the grid of the following stage through a .005 microfarad condenser, and connecting the cathodes together if not already grounded to a common point. For AF stages, use a .01 microfarad condenser. A typical bridged stage is indicated in figure 47.

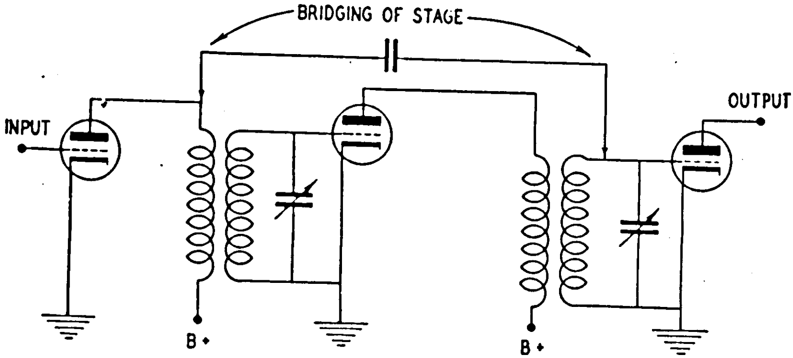


FIGURE 47. Bridging a stage.

159. BRIDGING AM DETECTOR. The AM detector stage may be eliminated by bridging from the plate of the last IF amplifier to the grid of the first AF amplifier and providing sufficient negative bias for the AF amplifier to cause it to operate as a plate detector.

CHAPTER 9
SERVICE METHODS

SECTION I
GENERAL

160. GENERAL. Radio sets normally reach the repairman under one of three circumstances: preset channels may have to be changed due to a change in frequency assignment; a routine service check may be required by the commanding officer at periodic intervals (preferably, once each month or after 300 hours of operation, whichever is least); trouble may develop in the set. When frequency assignments are changed, time may not permit a complete service check; the repairman however, should inspect each set visually and check its operation as completely as possible. Routine service checks or trouble shooting should be as complete and thorough as time permits, and should be used to disclose impending troubles as well as present troubles. An historical record should be maintained for each radio set in an organization. This record should contain information of all inspections, repairs, maintenance, etc., performed during the life of the set.

161. SERVICE ROUTINE. A definite service routine for both receivers and transmitters is required. This routine should include: a preliminary inspection; trouble shooting, where necessary; replacement, repair, or maintenance, where necessary; and a final operating check. Sections II and III indicate a general form to be followed for receivers and transmitters respectively. This must be varied in detail to be applicable to each individual type of radio equipment. When defective equipment is encountered, the repairman should always be able to discover the defect. If the trouble cannot be successfully repaired, the set should be sent to the proper echelon of signal maintenance with a report on the trouble found. If the radio set is used for vehicular operation, the vehicular installation must also be inspected.

SECTION II
RECEIVER

162. PRELIMINARY INSPECTION.

a. **Purpose.** The purpose of the preliminary inspection is to obtain information which will indicate the performance of the equipment, the physical condition of the equipment, and, possibly, symptoms of trouble which will simplify the process of trouble shooting.

b. **Procedure.**

(1) Obtain a report on performance.

(2) Inspect for surface defects, such as, loose or misplaced wires, bent or broken parts, broken tube caps, defective wires or cables, odors, and cleanliness.

(3) Check the lubrication of parts requiring lubrication.

(4) Turn the receiver on and note whether the tubes glow or get warm, or whether unusual noises or odors develop.

(5) Tune the receiver across the band. Check the operation of manual controls and the operation of the receiver. Tune in signals at all points on the band.

(6) Item (5) above should indicate a good receiver or one of following faults: dead, distorted, noisy, hum, oscillation, broad tuning, weak, fades, or operates intermittently.

(7) Proceed as indicated in paragraphs 163 to 172 according to the type of operation noted. If symptoms of trouble are present, use the common trouble charts in paragraphs 173 to 183 inclusive, to assist in isolating the trouble.

163. GOOD RECEIVER. A good receiver receives signals on all frequencies without distortion. It has adequate sensitivity and selectivity, and all mechanical devices operate smoothly. Operation is checked by tuning in signals as in paragraph 162 above. Adequate sensitivity and selectivity can be discovered by comparison with a receiver known to be good, by comparison with previous experience with receivers of the same type, or by readjustment to maximum. If the receiver is apparently good proceed to the final operating check (par. 184).

164. DEAD.

a. Isolate the defective stage or circuit by the circuit disturbance method (par. 132) or by the signal tracer method (par. 127–130), if possible.

b. Isolate the defective stage or circuit by voltage and resistance measurements (par. 113–126), if unable to do so in a above.

c. Test the defective stage and isolate circuit (par. 91–102).

d. Test the defective circuit and isolate part (par. 69–90).

e. Replace or repair the defective part (par. 142–159).

165. DISTORTED.

a. Determine whether the defective stage is before or after the detector by the signal tracer method (par. 127–130), and isolate the stage, if possible.

b. Isolate the defective stage or circuit by voltage and resistance measurements (par. 113–126) if unable to do so in a above.

c. Test the defective stage and isolate circuit (par. 91–102).

d. Test the defective circuit and isolate part (par. 69–90).

e. Replace or repair the defective part (par. 142–159).

166. NOISY.

a. Determine if the noise originates outside the set by shorting the antenna to ground. If the noise is external, it should cease.

b. If the noise is internal, isolate the defective stage by the stage muting method (par. 133), or signal tracer method (par. 127–130).

c. Check the individual circuits (par. 69-90) and parts (42-68).

d. Check for loose connections by wiggling wires or parts using a screwdriver of insulating material.

e. Repair or replace the defective part (par. 142–159).

167. HUM.

a. Isolate the defective stage by the stage muting method (par. 133).

b. Check the defective stage for imperfect filtering in the power supply (par. 77 and 90).

c. Check the defective stage for imperfect shielding (par. 52).

d. Test parts by substitution. Electrical tests are not reliable.

e. Check the power supply by replacing with dry cell batteries.

f. Correct the trouble.

168. OSCILLATION.

a. Isolate the defective stage by the stage muting method (par. 133).

b. Check the defective stage for poor grounds, open grids, open bypass condensers, or open filter condensers.

c. Check the tubes by substitution.

d. Correct the trouble.

169. BROAD TUNING.

a. Check the alignment of the RF and IF sections (par. 111).

b. Check voltages in the RF and IF stages (par. 120–133).

c. Check the tubes by substitution.

d. Check for high resistance in signal circuits (par. 69–74).

e. Replace or repair the defective part, if required (par. 142–159).

170. WEAK.

a. Check tubes, by substitution or with tube checker.

b. Check the AF stages using the signal tracer method (par. 127–130).

c. Check operating voltages (par. 113–126).

d. Check for opens in signal circuits (par. 69–74).

e. Check alignment (par. 111).

f. Correct the trouble.

171. FADING.

a. Check for loose wires or corroded connections (par. 48).

b. Check for leaking or shorting condensers (par. 44).

c. If the volume drops but distant stations can still be heard, check the detector and AF stages (par. 98–100).

d. If a distant station cannot be heard, check the RF and IF stages (par. 92–97).

e. Check the tubes by substitution.

f. Correct the trouble.

172. INTERMITTENT OPERATION.

a. Check for mechanical defects, such as loose connections, rubbing tuning condensers, poor contacts, and resin joints.

b. If jarring starts or stops the trouble, check connections carefully.

c. Locate whether the trouble is before or after the detector by the signal tracer method (par. 127–130) and isolate the stage, if possible.

d. The oscillator padder condenser may cause trouble at the low end of the band.

e. High converter bias may cause trouble at the high end of of the band.

f. AF oscillation (motorboating) causes a "putt-putt" sound in the reproducer. Check the AF section for open bypass condensers, open grid circuits, or leads moved from their usual place.

g. If the defect occurs within three minutes after the set is turned on, check the tubes and power supply (par. 47 and 83-90).

h. If the defect occurs in three to five minutes, check resistors (par. 43).

i. If the defect occurs after five minutes, check transformers (par. 46).

j. To make thermal troubles appear sooner, wrap the set in heavy paper.

173. COMMON TROUBLES. Paragraphs 174 to 183, inclusive, list common troubles in various components of receivers which may cause symptoms as indicated. These troubles are listed only as a guide to be used in connection with standard methods of trouble shooting.

	Dead	Distorted	Noisy	Hum	Oscillation	Broad tuning	Weak	Fades	Intermittent
174. POWER SUPPLY.									
Battery defective	X	X	X	X	X	X	X	----	X
Input voltage high	----	X	----	----	X				
Input voltage low	----	X	----	----	----	X	X		
Input voltage fluctuates	----	----	----	----	----	----	----	X	
Dynamotor defective	X	X	----	----	----	----	X	X	X
Generator defective	X	X	----	----	----	----	X	X	X
Generator poorly adjusted	----	----	----	----	----	----	X		
Vibrator defective	X	X	X	X	X	----	X	X	X
Transformer defective	----	X	X	X	----	----	X		
Transformer secondary open	X								
Transformer secondary shorting	X								
Transformer secondary half open	----	----	----	X					
Shielding defective	----	----	----	X					
Rectifier defective	X	----	----	X	----	----	----	----	X
Rectifier weak	----	X	----	----	----	----	X	----	X
Buffer condenser defective	----	----	----	X	----	----	X	----	X
Buffer condenser shorted	X								
Buffer condenser leaking	----	----	X						
Filter condenser defective	----	X	X	X	----	----	----	X	X
Filter condenser open	----	----	----	X	X				
Filter condenser shorted	----	----	----	----	----	----	X		
Filter choke defective	----	----	----	X	----	----	----	----	X
Filter choke open	X								
Filter choke shorted	----	----	----	X					
Filter choke grounded	X	X	----	----	----	----	X		
Fuze defective	X								
Fuze holder loose	----	X	----	----	----	----	----	X	X
Voltage divider open	X								
Voltage divider resistor defective	----	----	X	----	X	----	----	----	X
Wires or connections grounded	X								
Wires or connections loose	----	----	X	----	----	----	----	X	
Wires or connections intermittent	----	----	----	----	----	----	----	----	X
Wires arcing to ground	----	----	X						
Power cord defective	X	----	----	----	----	----	----	----	X
Power cord connector defective	X	----	----	----	----	----	X	X	X

	Dead	Distorted	Noisy	Hum	Oscillation	Broad tuning	Weak	Fades	Intermittent
175. REPRODUCER.									
Headphones defective									X
Headphone magnet weak							X		
Headphone diaphram bent							X		
Headphone diaphram tight							X		
Voice coil defective					X				X
Voice coil open	X								
Voice coil partially shorted							X		
Voice coil rubbing		X	X					X	
Field coil defective									X
Field coil intermittent								X	
Cone improperly adjusted							X		
Cone loose at rim		X							
Cone torn		X							
Cord open	X								
Cord short	X								
Cord intermittent								X	X
Connections loose			X					X	X
Connections high resistance		X		X			X		
Plug contact loose			X						X
Transformer defective	X	X	X				X		X
Transformer open				X					
Humbucking coil shorted				X					
Overloaded		X							
Feedback high					X				
176. TUBES.									
Burned out	X								
Gassy		X			X		X	X	
Weak							X		
Cathode leakage		X		X			X	X	
Microphonic		X							
Element open				X		X			
Element shorted				X					
Element loose			X					X	X
Oscillator not functioning							X		X
Oscillator bias high								X	
Shield loose or missing		X			X				
Shield shorting grid cap	X						X		X

	Dead	Distorted	Noisy	Hum	Oscillation	Broad tuning	Weak	Fades	Intermittent
Prong contact open	×	×	×						×
Socket connection open	×	×	×				×		
Socket connection loose								×	×
Socket connection high resistant						×	×	×	
177. FILAMENT CIRCUIT.									
Power supply defective	×						×	×	
Voltage high		×			×	×			
Voltage low		×					×		
Rheostat defective			×						×
Connection defective	×		×					×	×
Connection high resistance		×		×			×	×	
Connection loose			×						×
Wire shorted or grounded	×			×			×		
Wire open	×								
Wire partially open			×						×
178. GRID CIRCUIT.									
Bias incorrect	×				×				
Bias high		×							
Bias low		×							
Bias resistor defective				×			×		
Resistor open		×					×		
Resistor intermittent			×					×	×
Resistor shorting									×
Coil open		×					×		
Coil grounded		×					×		
Coil intermittent			×					×	×
Bypass condenser open		×				×			
Trimmer condenser defective							×	×	×
Tuning condenser shorting			×						×
Tuning condenser rotor poor contact							×	×	×
Shielding defective				×					
Leads too close to plate leads					×				
Alignment incorrect	×					×	×		
Circuit open				×	×		×	×	
Circuit grounded	×						×		
Connection defective			×		×	×		×	×

	Dead	Distorted	Noisy	Hum	Oscillation	Broad tuning	Weak	Fades	Intermittent
179. PLATE CIRCUIT.									
Voltage high		X			X				
Voltage low		X					X		
Resistor open	X								
Resistor intermittent			X					X	X
Resistor grounded	X	X					X		
Coil open	X								
Coil intermittent			X					X	X
Coil shorted							X		
Choke coil open								X	
Bypass condenser open				X	X	X			
Bypass condenser shorted	X								
Trimmer condenser defective							X	X	X
Tuning condenser shorting			X						X
Alignment incorrect	X					X	X		
Filtering defective				X					
Circuit open	X								
Circuit grounded	X						X		
Connections defective	X						X	X	X
Connections loose			X					X	X
180. COUPLING CIRCUITS.									
Coupling condenser open	X	X		X	X	X	X		X
Coupling condenser shorted							X		X
Coupling condenser leaking		X	X				X		X
Coupling condenser intermittent								X	X
AF transformer secondary open				X					
Insulation defective									X
Circuits tuned to wrong frequency					X				
Circuits tuned too sharply					X				
181. DECOUPLING CIRCUIT.									
Decoupling condenser open				X	X	X	X		X
Decoupling condenser shorted	X						X		X
Decoupling condenser leaky		X	X				X		X
Decoupling condenser intermittent								X	X
Decoupling resistor open	X								
Decoupling resistor value changed		X							
Decoupling resistor intermittent								X	X

	Dead	Distorted	Noisy	Hum	Oscillation	Broad tuning	Weak	Fades	Intermittent
182. ANTENNA CIRCUIT.									
Grounded	X		X	X			X		X
Coil open	X								
Lead-in open	X	X					X		
Lead-in grounded				X					
Lead-in coupled to coil					X				
Lead-in intermittent			X					X	X
Counterpoise open							X		
Switch defective	X						X		X
No ground connection				X	X		X		
Connections loose or dirty		X							X
Antenna strikes trees, etc									X
Antenna near source of noise			X						
Antenna too long						X			
183. MISCELLANEOUS.									
Screen grid circuit open	X				X				
Screen grid bypass shorted	X								
Volume control defective		X	X					X	
AVC resistor open or changed		X						X	
AVC condenser defective								X	
Regeneration		X							
Shielding defective			X	X					
Intermittent contacts			X						
Wires misplaced				X					
Excessive signal strength						X			
Oscillator aligned improperly							X		
Switch contacts defective	X						X	X	
Leads shorting to chassis							X		X

184. FINAL OPERATING CHECK.

a. **Purpose.** The purpose of the final operating check is to demonstrate that the receiver is performing satisfactorily and is ready to be returned to service.

b. **Procedure.**

(1) Turn the receiver on and tune across the band, noting the absence of unusual noises and squeals.

(2) Tune in a signal and check the operation of the manual volume control.

(3) Check the operation of the AVC on strong signals where the receiver has this feature.

(4) Check the calibration of the dial at both ends of the band.

(5) Check the sensitivity by tuning in a weak signal and comparing the performance to that of a receiver known to be good.

(6) Check the selectivity by noting the ability of the receiver to differentiate between signals on adjacent channels. Manufacturer's specifications must be consulted regarding the strength of signals which can be separated when on adjacent channels.

(7) Check the selectivity by noting that the channel is wide enough to assure passage of all intelligence through the receiver (see par. 163).

(8) Perform *all* final operating checks with the installation and the antenna with which the receiver is to be used.

SECTION III

TRANSMITTER

185. PRELIMINARY INSPECTION.

a. Purpose. The purpose of the preliminary inspection is to obtain information which will indicate the performance of the equipment, the physical condition of the equipment, and, possibly, symptoms of trouble which will simplify the process of trouble shooting.

b. Procedure.

(1) Obtain a report on performance.

(2) Inspect for surface defects, such as loose or misplaced wires, bent or broken parts, broken tube caps, defective wires or cables, odors and cleanliness.

(3) Check the lubrication of parts requiring lubrication.

(4) Turn the transmitter on and note whether the tubes glow or get warm.

(5) Operate the transmitter across the band, tuning the antenna when necessary. Check the operation of manual controls, microphone, and meter readings.

(6) Compare all meter readings with normal values.

(7) Items (5) and (6) should indicate a good transmitter or symptoms of a defective transmitter. Proceed as indicated in paragraph 186 to 187 according to the type of operation noted.

186. GOOD TRANSMITTER. A good transmitter transmits signals on all frequencies without distortion. It has adequate power output, and all mechanical devices operate smoothly. Operation is checked by tuning in signals on a receiver known to be good and noting operation. Relative power output is checked by measuring the effect of the transmitter on a good receiver and comparing with standards previously established, or by readjustment of the transmitter for maximum. If the transmitter appears to be good proceed to the final operating check (par. 188).

187. DEFECTIVE TRANSMITTER.

a. Meter readings, manner of operation, or visual inspection may indicate the nature of the trouble (par. 135). If so, proceed directly to the defective stage or circuit and remedy the trouble. If not, proceed as indicated below.

b. Check the power supply (par. 137).

c. Check the operation and tuning of the oscillator stage (par. 104, 135, 138).

d. Check the operation, alignment, and neutralization of each amplifier stage, in turn (par. 103-107, 135, 137-140).

e. Check the operation of the AF section (par. 141).

f. Check the modulation system (par. 109–110, 141).

g. Check the antenna (par. 60).

h. Check individual parts as required (par. 42–68).

188. FINAL OPERATING CHECK.

a. **Purpose.** The purpose of the final operating check is to demonstrate that the transmitter is performing satisfactorily and is ready to be returned to service.

b. **Procedure.**

(1) Turn the transmitter on and operate on all preset channels or at the high and low end of the band when the frequency range is continuous.

(2) Note that all meter readings are normal.

(3) Set up a good receiver and separate it from the transmitter being checked by the rated range of the transmitter.

(4) Connect a VTVM to measure limiter grid voltage if an FM receiver is used or AVC voltage if an AM receiver is used.

(5) Tune the receiver and transmitter to the same frequency and operate the transmitter. Note clear reception without distortion of modulated signal, or clear reception of CW signals.

(6) Record the limiter grid voltage or AVC voltage measured on the receiver. This voltage is a relative indication but not an exact measurement of the transmitter power output.

(7) Compare the voltage measured in (6) above with standards established by experience with good transmitters of this type.

(8) Perform *all* final operating checks with installation and antenna with which the transmitter is to be used.

CHAPTER 10
VEHICULAR INTERFERENCE

SECTION I
CAUSES AND LOCATION OF INTERFERENCE

189. GENERAL.

a. High voltage surges or sparks set up by automotive electrical equipment may produce radio interference. Energy radiated from high tension leads may be picked up by the radio antenna, or high current surges may be conducted to the vehicular storage battery and from there to the radio receiver. Capacitive effects in the vehicle wiring system may cause the radiated energy to be very pronounced at certain frequencies. However, most interference is quite broad in frequency.

b. Figure 48 shows a simple schematic diagram of a vehicle electrical system.

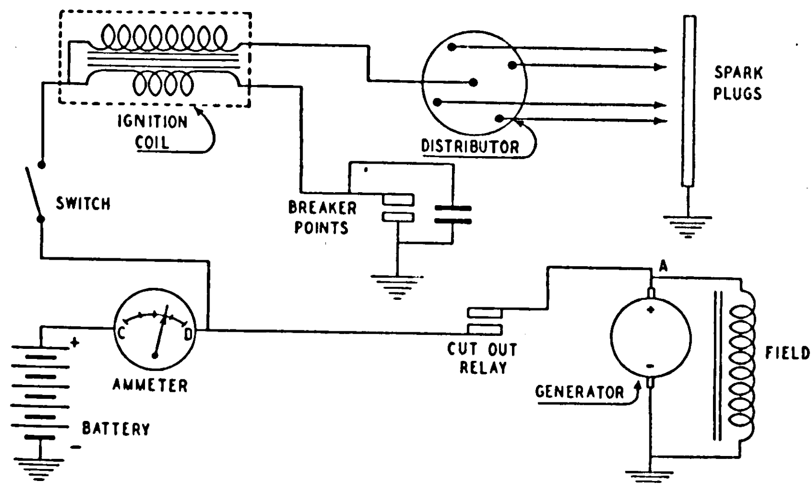


FIGURE 48. Simplified vehicle electrical system.

190. IGNITION NOISES. The ignition system is the chief cause of radio interference. Damped RF waves varying in frequency with the engine speed are radiated from sparks created at the distributor rotor, distributor breaker points, and spark plugs. Large current surges are also transmitted to the vehicle storage battery by the ignition system. Interference from these sources is recognized by clicking sounds in the receiver which vary in frequency with the engine speed.

191. GENERATOR NOISES. The generator and regulator of the vehicle electrical system may cause interference due to sparks between commutator bars and brushes and between relay points. This type of interference causes a roaring noise in the receiver similar to alternating current hum. The amount of sparking at the brushes will increase under the following conditions:

a. Brushes do not fit the commutator.

b. Worn brushes.

c. Weak spring tension on the brushes.

d. Oil or carbon on the commutator.

e. Commutator worn irregularly (egg shaped).

f. Excessive load on the generator.

192. BODY NOISES. Body noises in the receiver are caused by sparks resulting from static charges built up on poorly grounded body sections by friction or induction. This type of interference is noticed only when the vehicle is in motion and is recognized by its intermittent "frying" sound. Loose hoods, fenders, brackets, and bolts are common causes of body noises.

193. LOCATION OF NOISES.

a. The type of interference should be determined by listening to the noises in a receiver. To isolate a particular piece of equipment at fault, use the probe type antenna shown in figure 49. "A" is a 15-foot length of shielded conductor (stranded) and "B" is a probe coil consisting of four to eight turns of No. 14 and No. 18 copper wire on a nonmagnetic form 1½ inches in diameter. One end of the probe coil is connected to the conductor and other end is open. The entire length of shielded conductor and coil should be covered with friction tape. A short piece of wood fastened to the coil end of the cable facilitates handling.

b. To isolate the trouble, connect the probe antenna to an amplitude modulated receiver as indicated in figure 49, and place the

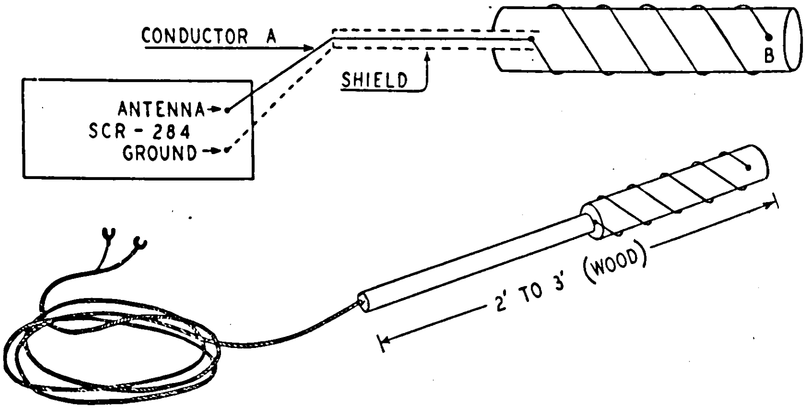


FIGURE 49. Probe type antenna.

probe near the suspected wire, apparatus, or part. As the probe approaches the source of trouble, the noise will increase. To detect body noises, place the probe near the suspected part and then ground the part with bonding cable—the noise should decrease.

SECTION II
NOISE SUPPRESSION

194. SHIELDING. Interference due to waves radiated from wiring may be prevented by shielding. Battery, generator, distributor, and ignition coil wiring is enclosed in a metallic sheath which is grounded so that interfering radiation can not reach the receiver antenna. Shielding should be used only with electrical equipment for which it was designed and which was designed to be used with shielding.

195. SUPPRESSORS. Suppressors (inductive resistors) may be placed in distributor circuits as indicated in figure 50. One suppressor is in the distributor high tension lead and one in each spark plug lead. All suppressors must be carefully matched and should have approximately 10,000 ohms resistance.

196. FILTERS. Inductive-capacitive filters may be placed in circuits as indicated in figure 50. Nomenclature used indicates standard signal corps filters.

197. BYPASS CONDENSERS. Bypass condensers may be used to eliminate noises when other methods are impossible, or may be used to improve other installations. Recommended capacities and locations appear below.

a. Ammeter to instrument panel	.5 mfd.
b. Regulator armature terminal to firewall	.01 mfd.
c. Regulator battery terminal to firewall	.5 mfd.
d. Generator armature terminal to generator frame	.5 mfd.
e. Horn line, at bottom of steering column, to column	.5 mfd.
f. Battery side of starter switch to firewall	.1 mfd.

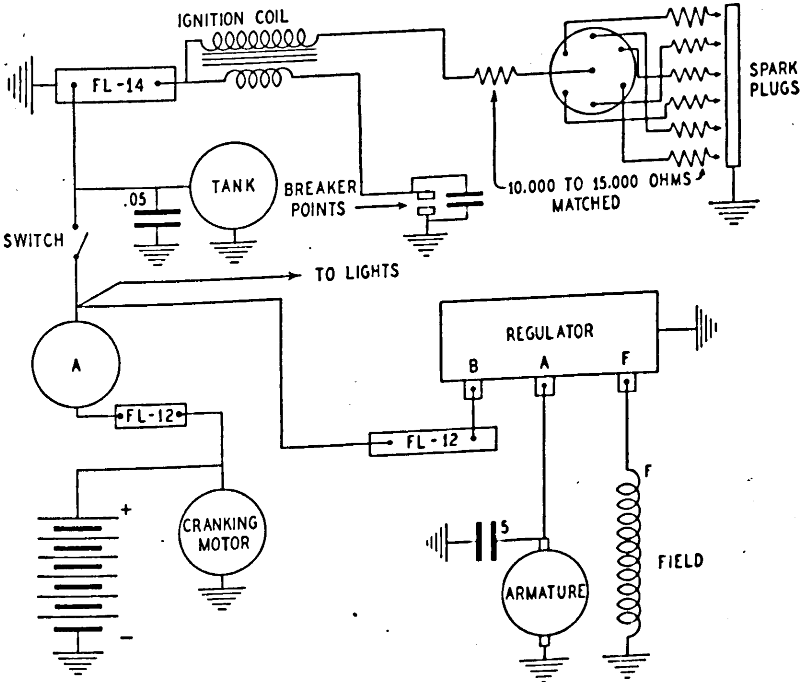


FIGURE 50. Suppressed electrical system.

198. BONDING. Bonding braid is used to insure that all parts of the vehicle are at ground potential. A check list for bonding points on ½-ton or ¾-ton trucks is as follows:

a. Front fenders to rear of splash apron.
b. Headlights to frame.
c. Radiator to cradle and cradle to frame.
d. Hood, across center hinge and to firewall.
e. Steering column to firewall.

f. Left and right splash aprons to frame.

g. Both sides of firewall to frame.

h. Throttle rod, thermostat cable, speedometer cable and choke rod to firewall.

i. Oil gauge line to firewall.

j. Rear of cylinder head to firewall.

k. Right and left rear of motor support bracket to frame.

l. Left front of motor block to frame.

m. Both sides of cab to frame.

n. Both sides in rear of body to chassis.

o. Rear of fenders to body.

199. SERVICE METHOD. To isolate and eliminate vehicular interference, proceed as follows:

a. Perform following operations:

(1) Check the bonding, making sure that connections are clean and tight.

(2) Clean the spark plugs and adjust their gap according to manufacturer's specifications.

(3) Clean the breaker points and adjust the gap according to manufacturer's specifications.

(4) Clean and check the generator commutator and brush assembly.

(5) Clean plug-in and slip-on connections at the distributor, coil, and spark plugs.

b. If steps in a above did not clear the trouble, isolate the nature of the trouble (par. 193).

c. Add ignition suppressors, bypass condensers, filters or bonding according to the nature of the trouble until eliminated.

d. All work done on motor vehicles should be done by the motor mechanic and not by the radio repairman.

e. Since some vehicle manuals contain information on suppression, these manuals should be consulted before attempting to test an installation or repair a defect.

CHAPTER 11

RADIO SETS SCR-609 AND SCR-610

SECTION I

GENERAL

200. GENERAL.

a. Radio Sets SCR-609 and SCR-610 are frequency modulated transmitting and receiving sets which differ only in that Radio Set SCR-610 includes additional components required for vehicular operation.

b. Details concerning the functioning of parts, method of installation and operation, and maintenance data are contained in TM 11–615. These notes are intended to supplement TM 11–615 on considerations of particular interest to field artillery repairmen.

c. Refer to figure 51 for identification of all parts and test points. Since more than one model of this set is in use, this schematic diagram may differ in details from that which accompanies any particular set.

SECTION II

PRESETTING CHANNELS

201. PREPARATION.

a. Remove the chassis from its case by removing ten screws from the front panel and pulling the chassis forward.

b. Place the chassis on a metal shelf such as the top of the power supply case.

c. Set switches SW-1 and SW-2 OFF.

d. Insert the proper crystals in the crystal sockets with name plates facing away from the center of the socket.

e. Check the internal battery BA-41 by inserting the DC volts probe of a VTVM in pin jack No. 4 of the metering socket (with common lead grounded). A reading of less than +20 volts indicates that the BA–41 is weak or has not been installed.

f. Connect the power and control cable plug on the chassis to the receptacle of a good power supply. The cable must not be twisted during this operation. If dry cell batteries are used, place Adapter RS–259 in series with BA–39.

g. Set the panel meter switch to CHECK.

h. Tighten lock nuts on the tuning condensers until a snug fit is obtained, but not tight enough to make adjustments difficult.

i. Set all tuning condenser indexes to appropriate setting shown in the chart below. If the index is difficult to read, set the condenser to maximum capacity and the end of the slot pointing toward zero will be the index end.

APPROXIMATE TUNING CONDENSER SETTINGS

Channel	A1-B1 Rec. Osc.	A2-B2 Mixer	A3-B3 R-F Grid	A4-B4 Trans. Osc.	A5-B5 Buffer	A6-B6 P-A Grid	A7-B7 P-A Plate
270	0.0	1.0	0.8	0.2	0.4	0.0	1.0
280	0.6	1.9	1.4	1.1	1.2	0.7	1.8
290	1.4	2.4	2.0	1.7	1.7	1.3	2.4
300	2.2	3.0	2.4	2.3	2.2	1.8	2.8
310	2.9	3.6	3.1	2.8	2.7	2.3	3.1
320	3.6	4.1	3.8	3.5	3.3	3.0	3.8
330	4.0	4.2	4.2	3.9	3.7	3.4	3.9
340	4.1	4.6	4.5	4.2	3.9	3.7	4.0
350	4.6	5.0	4.7	4.5	4.0	3.9	4.1
360	4.9	5.2	4.8	4.8	4.5	4.2	4.2
370	5.4	5.5	5.2	5.2	4.9	4.6	4.7
380	5.6	5.6	5.3	5.5	5.0	4.8	4.8
389	5.8	5.8	5.4	5.9	5.1	5.0	5.0

j. In adjusting tuning condensers in paragraphs 186 and 187, if it is necessary to move far from the approximate setting, check previous operations and examine the condensers for misalignment of plates or other defects.

k. Plug in the microphone and turn the volume control to its maximum clockwise position.

l. Preset both channels at the same time, setting the CHAN switch to A or B as appropriate for the condenser being adjusted.

m. Proceed with the precise presetting operation if a VTVM is available or with the field method if a VTVM is not available.

202. PRECISE METHOD.

a. Set up a VTVM in accordance with its operating instructions for measuring DC voltages and connect the common lead to the chassis of the set. Note that the panel is insulated from the chassis of the set.

b. Insert the VTVM probe in pin jack No. 1 of the metering socket (300 volt range). The VTVM should indicate −30 volts or more. If not, the crystal or crystal oscillator tube is defective.

c. Insert the VTVM probe in pin jack No. 2 of the metering socket (30 volt range). Adjust A1 and B1 for maximum indication on the VTVM (−4 volts or more).

d. Insert the VTVM probe in pin jack No. 8 (10 volt range). Adjust A2 and B2 for maximum indication on the VTVM.

e. With the VTVM probe in pin jack No. 8, adjust A3 and B3 for maximum indication on the VTVM.

f. With the VTVM probe in pin jack No. 8, adjust A7 and B7 for maximum indication on the VTVM.

g. Repeat **d**, **e**, and **f**. Make sure that maximum reading is obtained after the aligning tool is removed.

h. Remove the first RF amplifier tube (V5) and insert the VTVM probe in pin jack No. 3 (30 volt range). Press the microphone switch and adjust A4 and B4 for maximum indication on the VTVM. If more than one peak is found, use the highest peak near the approximate setting. Blow gently into the microphone during this adjustment and listen for the rushing sound as the top of the peak is approached. If the clearest sound is not at the top of the peak, the discriminator probably needs to be realigned.

i. Insert the VTVM probe in pin jack No. 4 (10 volt range). Press the microphone switch and adjust A4 and B4 for −5.0 to −6.0 volts on the VTVM.

j. Insert the VTVM probe in pin jack No. 5 (30 volt range). Press the microphone switch and adjust A5 and B5 for maximum indication on the VTVM (−15 volts or more).

k. Reinsert the VTVM probe in pin jack No. 4 and press the microphone switch. If the reading is not between −5.0 and −6.0 volts, readjust **h**, **i**, **j** above.

l. Replace the RF amplifier tube (V5), turn SW–1 ON, press the microphone switch, and adjust A6 and B6 for maximum *panel* meter reading (1.5 or more). Panel meter switch must be at CHECK.

m. The following adjustment must be made quickly to avoid damage to the tube. Turn the panel meter switch to OPER, turn

SW–2 ON, press the microphone switch, and adjust A7 and B7 for minimum panel meter reading (1.0 or less).

n. Repeat **l** and **m** above. Make sure that maximum and minimum readings are obtained after the aligning tool is removed.

o. Recheck all condenser settings visually. If they are not close to the correct approximate settings, the set is improperly tuned.

p. Replace the chassis in its case and readjust A7 and B7 for minimum panel meter reading.

q. Extend the antenna and assemble it to the set. Press the microphone switch and note the panel meter reading. If less than 1.8, check the antenna spring contact. If more than 2.5, recheck the adjustment of A7 and B7.

203. FIELD METHOD. The field method for presetting channels is not as good as the precise method and should not be used if a VTVM is available. Proceed as follows:

a. Prepare the set as indicated in paragraph 201.

b. If an approximate setting chart is not available, adjust the tuning condensers by estimation (near 1 for 280, near 3 for 335, near 6 for 385, etc.).

c. Adjust A1 and B1 for maximum rushing sound in the reproducer.

d. Adjust A2 and B2, A3 and B3, and A7 and B7, in turn, for maximum rushing sound in the reproducer.

e. Repeat **c** and **d** above.

f. Remove the first RF amplifier tube (V5), press the microphone switch, and *carefully* adjust A4 and B4 for loudest and *clearest* sidetone while blowing gently into the microphone.

g. Replace the RF amplifier tube (V5), turn SW–1 ON, press the microphone switch, and adjust A5 and B5, and A6 and B6 for maximum panel meter reading. Panel meter switch must be in CHECK position.

h. Repeat **g** above.

i. Turn the panel meter switch to OPER, turn SW–2 ON, press the microphone switch, and adjust A7 and B7 for minimum panel meter reading. This operation must be done quickly to avoid damage to the tube.

j. Repeat **h** and **i** above. Make sure that maximum and minimum readings are obtained after the aligning tool is removed.

k. Recheck all condenser settings visually. If they are not close to the correct approximate settings, the set is improperly tuned.

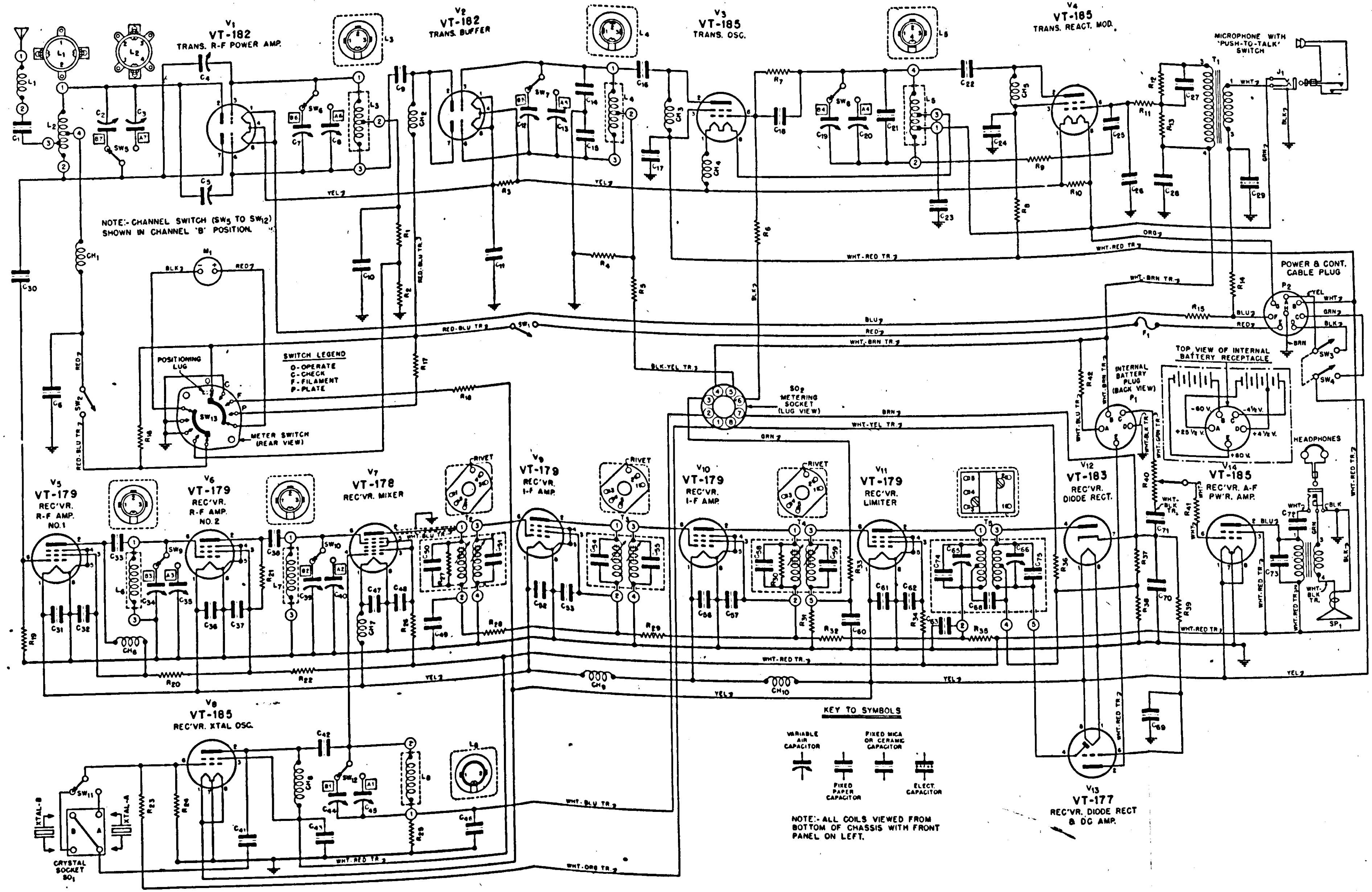


FIGURE 51. BC-659-A Transmitter and Receiver—Schematic Diagram.

l. Replace the chassis in its case and readjust A7 and B7 for minimum panel meter reading.

m. Extend the antenna and assemble it to the case. Do not readjust A7 and B7 unless the panel meter reads more than 2.5.

SECTION III
ALIGNMENT AND NEUTRALIZATION

204. GENERAL.

a. Alignment of the IF section or discriminator stage should not be required each time channels are preset. When improper adjustment of either is indicated by operation or by the presetting procedure, remedial action should be taken at once.

b. The signal source for alignment may be any signal generator which will produce 4.3 mc or a 4.3 mc crystal which will fit the crystal socket of the set. If oscillator VO–4–B is used, it should be coupled directly to the appropriate set terminal. If Frequency Meter SCR–211 is used, it must be coupled by twisting one end of insulated wire around the antenna post of the frequency meter and connecting the other end (stripped of insulation) to the appropriate set terminal.

c. Neutralization of the transmitter power amplifiers should not be necessary unless the original settings of the neutralizing condensers are changed.

205. ALIGNMENT OF IF SECTION.

a. Remove the chassis from its case and connect to a good power supply.

b. Plug in the microphone and turn the volume control to its maximum clockwise position.

c. Turn SW–1 and SW–2 OFF.

d. Couple the output of the signal generator between terminal No. 3 on transformer T2 and ground, insert the DC probe of a VTVM in pin jack No. 3 of the metering socket (30 volt range), ground the common lead of the VTVM to the chassis, and adjust the output of signal generator until the VTVM indicates between –10 and –20 volts.

e. Adjust the adjustment screws on transformer T4 primary and secondary, and transformer T3 primary and secondary, in that order for maximum VTVM reading. Primaries are on top of the cans and secondaries are on the bottom underneath the chassis. Reduce the output of the signal generator as each stage is aligned to assure sharp peaks.

f. Remove both crystals and couple the signal generator to the terminal leading from SW–10 to the control grid of the mixer tube (prong 6 of V7).

g. Adjust the screws on transformer T2 primary and secondary for maximum VTVM reading.

h. Disconnect the VTVM and signal generator, replace the crystals, turn SW–1 and SW–2 ON, and reassemble the chassis in its case.

i. If the output of the signal generator can not be reduced sufficiently in above procedure, remove the crystals from the set and connect the signal generator to the lower contact of SW–10 and ground. When the CHAN switch is in B position, the generator will be coupled directly to the mixer grid. As stages are aligned, switch to A position to prevent overloading and consequent broad tuning.

206. ALIGNMENT OF DISCRIMINATOR.

a. Proceed as in paragraph 205 **a**, **b**, **c**, and **i** above.

b. Insert the DC probe of the VTVM pin jack No. 8 (10 volt range). Adjust the primary trimmer of the discriminator transformer (T5) for maximum negative reading.

c. Adjust the VTVM for false zero on the 3 volt range (par. 21c).

d. Insert the DC probe of the VTVM in pin jack No. 7 and adjust the secondary trimmer of the discriminator transformer (T5) for zero voltage within ±.25 volts (meter will read false zero).

e. To be sure that the secondary is not adjusted to one side of the correct frequency, tune the secondary slightly above and below the supposed correct adjustment and note that the meter swings both directions from false zero.

207. ALIGNMENT OF IF AMPLIFIERS AND DISCRIMINATOR USING 4.3 MC CRYSTAL.

a. Remove the chassis from its case and connect to a good power supply.

b. Plug in the microphone, turn the volume control to its maximum clockwise position, and allow the set to reach normal operating temperature.

c. Turn SW–1 and SW–2 OFF, remove both crystals from their sockets, and remove the first RF amplifier tube (V5) from its socket.

d. Plug a 4.3 mc crystal into one crystal socket and turn the CHAN switch to its corresponding position.

e. Insert the DC probe of the VTVM in pin jack No. 3 of the metering socket (10 volt range) and ground the common lead of the VTVM to the chassis.

f. Adjust the screws on transformer T4 primary and secondary, T3 primary and secondary, and T2 primary and secondary, in that order for maximum VTVM reading.

g. Insert the DC probe of the VTVM in pin jack No. 8 and adjust transformer T5 primary trimmer for maximum VTVM reading.

h. Adjust the VTVM for false zero (par. 21c).

i. Insert the DC probe of the VTVM in pin jack No. 7 and adjust transformer T5 secondary trimmer for zero voltage with ±.25 volts (meter will read false zero).

j. Disconnect the VTVM, replace the proper crystals, and reassemble the chassis in its case.

208. NEUTRALIZATION.

a. Remove the chassis from its case and connect to a good power supply.

b. Plug in the microphone, turn the CHAN switch to the channel with the highest frequency, turn SW-2 OFF, and turn the panel meter switch to CHECK.

c. Press the microphone switch and turn A7 or B7 (depending on the position of the CHAN switch) through its entire range.

d. If the panel meter reading dips more than one division during **c** above, neutralization is necessary. To neutralize, continue.

e. Press the microphone switch and tune A7 or B7 for minimum meter reading.

f. Press the microphone switch and tune the neutralizing condensers C4 and C5 (found on either side of V1 below the chassis) for maximum meter reading. The settings of C4 and C5 should be approximately the same at all times.

g. Repeat **e** and **f** until the dip obtained with A7 or B7 is less than one division.

SECTION IV
SERVICING

209. GENERAL. Radio sets SCR-609 and SCR-610 should be inspected once each month, or after 300 hours of operation, or whenever defective performance occurs, whichever is earliest.

This inspection must include all auxiliary equipment, spare parts, and vehicular installations. In addition to this inspection, every opportunity should be taken to check the condition of the set when presetting channels. An historical record of all inspections and all maintenance work should be kept.

210. PRELIMINARY INSPECTION.

a. Obtain a report on performance.

b. **Vehicular inspection.** Inspect the vehicular installation and perform the following operations:

(1) Inspect the vehicle storage battery and note loose or corroded connections at the battery terminals. Check the state of charge of the battery.

(2) Inspect the power unit supply cable. Connections must be tight, proper polarity of the cable must be observed in making the connections, the cable insulation must not be damaged, and the cable must be adequately anchored to the body of the vehicle to prevent strain due to unnecessary vibration.

(3) Inspect Mounting FT–250. It should be firmly fastened to the body of the vehicle and the shock absorber device must be free from defects.

(4) Inspect Plate Supply Unit PE–117–C. It should show no evidence of physical abuse, link connections should be properly made according to the voltage of the vehicle electrical system, and all spart parts should be good and mounted in their proper place.

(5) Clean the power supply unit.

(6) Inspect the antenna system. Three section mast antenna with a three foot lead-in of wire W–126 may be used. Connections must be firm and not corroded or rusted. The mast base must be firmly mounted on the vehicle so that the antenna may assume a verticle position, and the mast base insulator must not be painted. The antenna must not be tied down with wire, either insulated or uninsulated. If a coaxial cable feed system is not used, the coxial lead should be removed from the mast base.

(7) Measure the voltage at link connector No. 18 of the power unit. For proper radio operation, this should not exceed 7.1 volts with the radio set operating and the vehicle engine running at a speed equivalent to 30 miles per hour on level highway.

c. **Receiver and transmitter.** Inspect the receiver and transmitter unit and perform the following operations:

(1) Inspect the set case for possible damage to fasteners and antenna terminal binding post.

(2) Remove the set from its case and inspect switches, meter, jacks, rubber gasket, desiccator, and loudspeaker.

(3) Inspect the radio chassis for surface defects such as: loose or misplaced wires; damaged coils; variable condensers binding, shorted or with loose rotors; defective fuze; defective switch contacts; defective tube socket contacts; incorrect tube type or tubes improperly inserted in the sockets; defective or missing shields; bent or broken parts; or unusual odors.

(4) Clean the receiver and transmitter unit.

d. Other equipment. Inspect microphone, headset, remote control unit, collapsible antenna, battery case, and all the auxiliary or spare parts for evidence of physical damage or poor general condition. Clean when necessary and replace defective or missing parts.

e. Operation. With the receiver and transmitter out of its case, connect it to the vehicular power supply, operate the vehicle engine so that the input to the power supply is a maximum, and check the following:

(1) With the meter switch at FIL and the receiver ON, the panel meter should read 2 or more.

(2) With the meter switch at PLATE and the microphone switch presed, the panel meter should read 2 or more.

(3) With the meter switch at CHECK and the microphone switch pressed, the panel meter should read 1½ or more.

(4) With the meter switch at OPER and the microphone switch pressed, the panel meter should read 1 or less.

(5) With the microphone switch pressed, a clear and loud sidetone should be heard in the loudspeaker or headphones when the repairman blows into the microphone.

(6) With the set in receive position, check the followng volttages at the meterng socket with a VTVM:

Pin jack No. 1	—15 volts or more
Pin jack No. 2	— 4 volts or more

(7) With the microphone switch pressed, check the following voltages at the metering socket with a VTVM:

Pin jack No. 3	—15 volts or more
Pin jack No. 4	—5.0 to —6.0 volts
Pin jack No. 5	—15 to —30 volts
Pin jack No. 6	—8 to —15 volts

(8) Replace the receiver and transmitter in its case, connect the vehicular antenna, and continue.

(9) With the meter switch at OPER and the microphone switch pressed, the panel meter should read between 2 and 3.

(10) A loud hissing sound should be heard in the loudspeaker or the headphones when no signal is being received.

(11) An incoming signal should be received without distortion.

(12) With the microphone switch pressed, an undistorted signal should be transmitted.

f. Alignment. Defective presetting or alignment may not always be discovered in these tests, but will be in the final operating check. If the presetting or alignment is known or suspected to be defective proceed at once to a complete alignment of the set (par. 201–207).

g. Neutralization. Check the neutralization of the power amplifier and reneutralize if necessary (par. 208).

h. The preceding steps should indicate whether the set is good or defective. If apparently good, proceed directly to the final operating check. If symptoms of trouble have been discovered, locate and remedy the trouble before performing the final operating check. Do not attempt repairs where successful completion is doubtful.

211. COMMON TROUBLES.

a. General. Common troubles of the SCR–610 are indicated below according to the symptom or indication they produce. This is not a complete detailed list and is to be used only in conjunction with standard service methods (chap. 9).

b. FIL meter does not register.

(1) Dead BA–40 or storage battery.
(2) Defective connector plug contacts.
(3) Open or shorted lead-in cable.
(4) Defective meter or meter switch.
(5) Defective PE–117–C.

c. FIL meter registers low.

(1) Weak BA–40 or storage battery.
(2) Defective connector plug contacts.
(3) High resistance contacts at meter switch.

d. FIL meter registers full scale.

(1) Shorted wires in cable.
(2) Defective meter.
(3) Four or more burned out tubes.

e. FIL meter registers in reverse. Battery connections reversed.

f. PLATE meter does not register.

(1) Defective fuze.
(2) Dead BA–39 or storage battery.
(3) Defective PE–117–C.
(4) Defective connector plug contacts.
(5) Shorted wires in cable.
(6) Switch SW–1 open.

g. PLATE meter registers low.

(1) Weak BA–39 or storage battery.
(2) Defective PE–117–C.
(3) High resistance contact at connector plugs or meter switch.

h. CHECK meter does not register.

(1) Tube V1 filament burned out.
(2) Tube V1 or V2 defective.
(3) Switch SW–1 open.

i. CHECK meter registers low.

(1) Transmitter improperly aligned.
(2) One half of tube V2 filament burned out.
(3) Tube V3 defective.

j. CHECK meter registers high.

(1) Defective resistor R1.
(2) Defective meter.

k. OPER meter does not register.

(1) Tube V1 defective.
(2) Switch SW–1 or SW–2 open.

l. OPER meter registers low.

(1) Tube V1 defective.
(2) Defective antenna system.
(3) Antenna contactor not making contact.

m. OPER meter registers high. Transmitter aligned improperly

n. Voltage at pin jack No. 1 low (receiver ON).

(1) Crystal defective.
(2) Tube V8 defective.

o. Voltage at pin jack No. 2 low (receiver ON).

(1) Crystal defective.
(2) Tube V8 defective.
(3) Receiver RF oscillator stage defective.

p. Voltage at pin jack No. 3 low (transmitter ON).

(1) Receiver improperly aligned.
(2) Transmitter improperly aligned.

q. **Voltage at pin jack No. 4 less than 20 volts (receiver OFF).**

(1) Battery BA–41 defective.

(2) Battery BA–41 not installed.

r. **Voltage at pin jack No. 4 not 5.0 to 6.0 volts (transmitter ON).**

(1) Transmitter improperly aligned.

(2) Battery BA–41 defective.

(3) Tube V4 defective.

(4) Reactance modulator stage or DC amplifier stage defective.

s. **Voltage at pin jack No. 5 low (transmitter ON).**

(1) Tube V3 defective.

(2) Transmitter improperly aligned.

(3) Transmitter oscillator stage defective.

t. **Voltage at pin jack No. 6 low (transmitter ON).**

(1) Tube V2 defective.

(2) Transmitter improperly aligned.

(3) Transmitter buffer amplifier stage defective.

u. **Unable to hear other stations.**

(1) Defective reproducer.

(2) Defective power supply.

(3) Receiver improperly aligned.

(4) Defective receiver tube or tubes.

v. **Unable to modulate transmitter.**

(1) Defective microphone or cord.

(2) Defective tube V4 or reactance modulator stage.

w. **Unable to align transmitter.**

(1) Battery BA–41 defective.

(2) Tube V4 or V13 defective.

(3) Power amplifier improperly neutralized.

(4) Defective discriminator adjustment.

212. FINAL OPERATING CHECK.

a. **General.** The final operating check must be a rigid test of the set's performance under conditions which will indicate its ability to receive and transmit satisfactorily at extreme ranges. Two methods are outlined in **b** and **c** below for this check. Either will be satisfactory if performed by experienced personnel who are thoroughly acquainted with the set's specifications and characteristics.

b. **Readability test.** Install the radio set to be tested in the manner in which it is to be used. Set up a test set, which is known to be good, on the same channels as the set to be tested. Move the test set to a point seven miles from the set being tested and with average intervening terrain. Have each set transmit, in turn, on each of its preset channels and note the reception on each receiver. It should be undistorted and loud enough to be easily understood. If the intervening terrain is such that it would reduce signal strength, good results can not be expected at maximum range. Reduce the distance between stations to compensate for this variation from standard conditions and repeat the test.

c. Voltage test. Install the radio set to be tested in the manner in which it is to be used. Set up an SCR-608 test set, which is known to be good, on the same channels as the set to be tested. (The SCR-608 test set must be modified as indicated in paragraph 234 so that limiter grid voltage may be measured.) Move the test set to a point seven miles from the set being tested (with average intervening terrain) and continue test as follows:

(1) Have the SCR-610 transmit its mean frequency and tune the test set receiver manually to zero beat.

(2) Measure the limiter grid voltage on the test set while the SCR-610 is transmitting.

(3) Compare the reading obtained in (2) above with readings obtained under similar conditions with SCR-610 transmitters which are known to be good. This comparison will give a relative indication of transmitter power output. Reading should not vary more than 50% from standard reading.

(4) Have the SCR-610 transmit a modulated signal and check for lack of distortion at the test set.

(5) Move the test set to a point where the noise level in the SCR-610 receiver being tested is just strong enough to be heard while the test set is transmitting.

(6) Have the test set transmit a modulated signal and check for readability at the SCR-610 receiver. It should be readable despite the noise level. This tests receiver sensitivity.

(7) Repeat (1) to (6) above on the other preset channel.

(8) Since the nature of the intervening terrain may effect results to a large degree, excellent performance at maximum range can not always be expected. Unfavorable terrain must be considered when interpreting results.

CHAPTER 12

RADIO SETS SCR-608 AND SCR-628

SECTION I

GENERAL

213. GENERAL.

a. Radio sets SCR–608 and SCR–628 are frequency modulated transmitting and receiving sets which differ only in that Radio Set SCR–608 includes two receivers and Radio Set SCR–628 includes only one receiver.

b. Details concerning the functioning of parts, method of installation and operation, and maintenance data are contained in TM 11–620. These notes are intended to supplement TM 11–620 and to provide field artillery repairmen with certain items of information of value to him in maintaining equipment.

c. Refer to figures 52 and 53 for identification of all parts and test points. Since more than one model of this set is in use, these schematic diagrams may differ in details from those which accompany any particular set.

SECTION II

PRESETTING CHANNELS

214. PREPARATION OF RECEIVER.

a. Remove the left hand receiver from its mounting.

b. Release all push buttons by partially depressing any one of them.

c. Turn the power switch ON and allow the receiver to stabilize for 15 minutes.

d. Turn the SQUELCH switch ON, SENSITIVITY control to minimum (counterclockwise), SPEAKER switch ON, and TUNE-OPERATE switch to TUNE.

e. Hold down the PUSH-TO-TUNE button and rotate the TUNING control manually to the high end of the dial until the word LOCK appears on the CHANNEL dial.

f. Turn the selector locking screw, located above push buttons, as far as possible in a counterclockwise direction, then clockwise one half turn.

215. PREPARATION OF TRANSMITTER.

a. Release all push buttons.

b. Select desired crystals and insert them in the crystal compartment.

c. Plug in the microphone.

d. Turn the transmitter power switch ON, TUNE-ANT CUR switch to TUNE, METER switch to No. 1, and RECEIVER-TUNE OPERATE switch to OPERATE.

e. Adjust the antenna coupling control clockwise to reduce coupling about one half.

f. Turn the gang condenser tuning control, located on the right end of the transmitter near its base, to the front position, loosen the selector locking screw, and return the control to the rear position.

216. PRECAUTIONS.

a. Run the transmitter dynamotor for short periods only to prevent overheating.

b. Always depress a transmitter push button before pressing the microphone switch.

c. Antenna tuning and coupling adjustments must be made with the set mounted in the vehicle and connected to the antenna which is to be used in later operation.

d. When depressing or releasing push buttons, do not allow the mechanism to jar condenser settings.

e. Presetting cannot be accomplished correctly if equipment is not in proper working order.

f. Do not depress or release any receiver push buttons while the mechanism is unlocked unless the PUSH-TO-TUNE button is depressed.

217. PRESETTING TRANSMITTER AND RECEIVER.

a. Depress the transmitter push button for the highest frequency to be preset.

b. Hold down the PUSH-TO-TUNE button and rotate the receiver TUNING control manually to the highest frequency to be preset.

c. Turn the RECEIVER TUNE-OPERATE switch to RECEIVER TUNE.

d. Adjust the transmitter gang tuning control until the receiver CALL SIGNAL lamp glows.

e. Adjust the transmitter gang tuning control for maximum meter reading. Receiver CALL SIGNAL lamp must still glow when adjustment is completed.

f. Hold down the PUSH-TO-TUNE button and depress the corresponding receiver push button.

g. Adjust the receiver TUNING control manually to zero beat with the transmitter.

h. Release the receiver push button while gently holding the PUSH-TO-TUNE button.

i. Repeat a to h inclusive for each channel in decreasing order of frequency.

j. Turn the transmitter RECEIVER TUNE-OPERATE switch to OPERATE and release the last push button.

k. Rotate the transmitter and receiver push button assemblies to lock position and lock.

l. Turn the transmitter TUNE-ANT CUR switch to ANT CUR and the METER switch to No. 6.

m. Depress successive transmitter push buttons, press the microphone switch, and adjust the corresponding antenna trimmers for maximum meter reading. If the meter reads off scale, reduce the thermocouple voltage adjustment as indicated in the technical manual.

n. If a three section antenna is used, depress the push button for the highest frequency used, press the microphone switch, and adjust the antenna coupling for maximum meter reading.

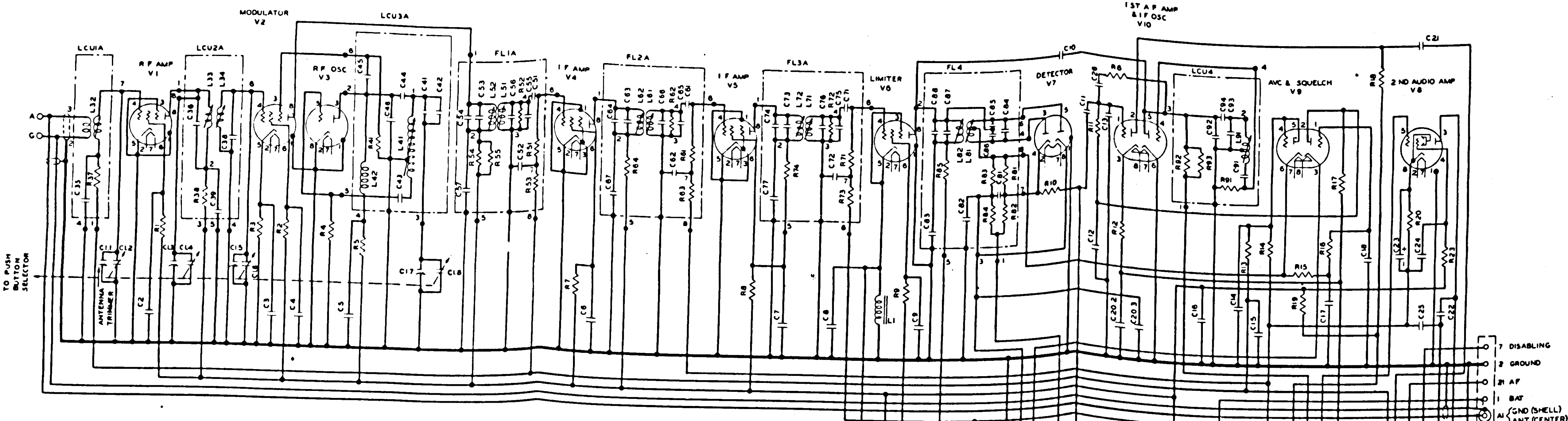
o. Readjust all transmitter antenna trimmers.

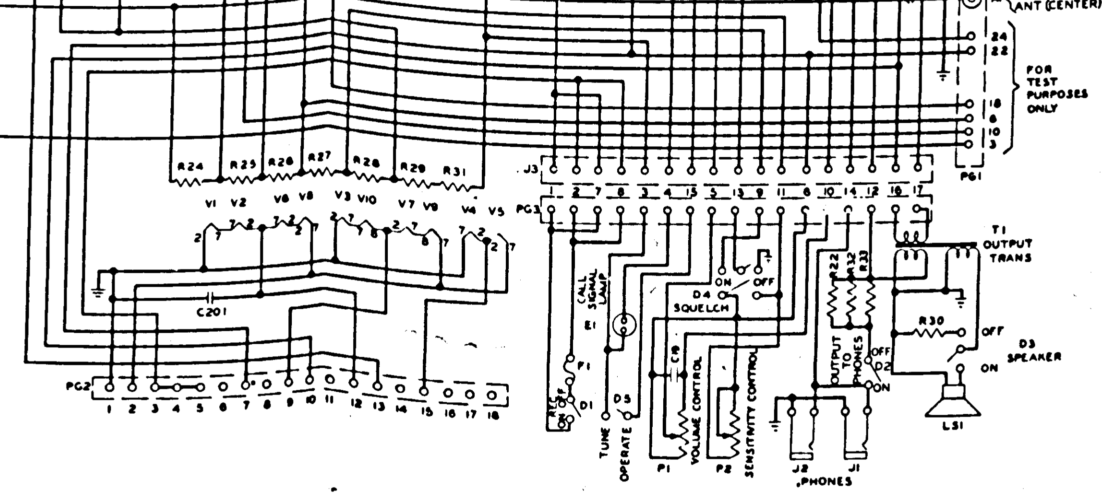
p. Turn the transmitter RECEIVER TUNE-OPERATE switch to RECEIVER TUNE position and depress corresponding push buttons for transmitter and receiver and note zero beat. Retune any receiver push button with a beat note over 1000 cycles per second.

r. Turn the transmitter RECEIVER TUNE-OPERATE switch to OPERATE.

s. Turn the receiver TUNE-OPERATE switch to OPERATE and adjust the SENSITIVITY control to the noise threshold or SQUELCH switch OFF.

t. Adjust the receiver antenna trimmer for greatest noise in the receiver at the high frequency end of the band. Use a screw-





RADIO RECEIVER BC-683-A

APPARATUS LEGEND

CAPACITORS

C1.1	16 UUF	MAX
C1.3	16 UUF	MAX
C1.5	16 UUF	MAX
C1.7	16 UUF	MAX
C1.2	62 UUF	MAX
C1.4	62 UUF	MAX
C1.6	62 UUF	MAX
C1.8	62 UUF	MAX
C2	0.006 UF	300 V
C3	0.006 UF	300 V
C4	0.006 UF	300 V
C5	0.006 UF	300 V
C6	0.006 UF	300 V
C7	0.006 UF	300 V
C8	500 UUF	500 V
C9	0.006 UF	300 V
C10	0.75 UUF	500 V
C11	0.006 UF	300 V
C12	0.01 UF	300 V
C13	500 UUF	500 V
C14	0.006 UF	300 V
C15	0.5 UF	600 V
C16	2 UF	600 V
C17	0.01 UF	300 V
C18	0.01 UF	300 V
C19	0.002 UF	500 V
C20.1	0.1 UF	800 V
C20.2	0.1 UF	800 V
C20.3	0.1 UF	800 V
C21	0.01 UF	300 V
C22	0.005 UF	300 V
C23	40 UF	25 V
C24	1 UF	600 V
C25	2 UF	600 V
C26	0.001 UF	500 V
C35	0.006 UF	300 V
C36	10 UUF	500 V
C38	5 UUF	500 V
C39	0.006 UF	300 V
C41	700 UUF	500 V
C42	200 UUF	500 V
C43	100 UUF	500 V
C44	30 UUF	500 V
C45	100 UUF	500 V
C46	20 UUF	500 V
C51	100 UUF	500 V
C52	0.001 UF	500 V
C53	50 UUF	500 V
C54	10 UUF	500 V
C55	10 UUF	500 V
C56	50 UUF	500 V
C57	0.006 UF	300 V
C61	100 UUF	500 V
C62	0.001 UF	500 V
C63	50 UUF	500 V
C64	10 UUF	500 V
C65	10 UUF	500 V
C66	50 UUF	500 V
C67	0.006 UF	300 V
C71	100 UUF	500 V
C72	0.001 UF	500 V
C73	50 UUF	500 V
C74	10 UUF	500 V
C75	10 UUF	500 V
C76	50 UUF	500 V
C77	0.006 UF	300 V
C81	250 UUF	500 V
C82	0.006 UF	300 V
C83	0.006 UF	300 V
C84	5 UUF	500 V
C85	50 UUF	500 V
C86	50 UUF	500 V
C87	25 UUF	500 V
C88	10 UUF	500 V
C91	50 UUF	500 V
C92	50 UUF	500 V
C93	100 UUF	500 V
C94	50 UUF	500 V

SWITCHES

D1	REC ON-OFF
D2	RADIO & EXT-EXT ONLY
D3	ON-OFF SPEAKER
D4	ON-OFF SQUELCH
D5	TUNE-OPERATE

LAMP

E1 CALL SIGNAL (NEON)

FUSE

F1 FUSE 15 AMP

JACKS

J1	PHONES
J2	PHONES
J3	FRONT PANEL JACK

LOUD SPEAKER

LS1 LOUD SPEAKER

COILS

L1	LIMITER CATHODE CHOKE
L32	ANTENNA COUPLING
L33	RF PLATE
L34	MOD GRID
L41	RF OSCILLATOR
L42	OSC SHUNT FEED
L51	1ST IF GRID
L52	MODULATOR PLATE
L61	2ND IF GRID
L62	1ST IF PLATE
L71	LIMITER GRID
L72	2ND IF PLATE
L81	DETECTOR INPUT
L82	LIMITER PLATE
L91	IF OSCILLATOR

POTENTIOMETERS

P1	100,000 Ω
P2	200 Ω

PLUGS

PG1	RECEIVER PLUG
PG2	DYNAMOTOR PLUG
PG3	FRONT PANEL PLUG

RESISTORS

R1	20,000 Ω 1/2 W
R2	250,000 Ω 1/2 W
R3	500 Ω 1/2 W
R4	50,000 Ω 1/2 W
R5	5,000 Ω 1 W
R6	100,000 Ω 1/2 W
R7	30,000 Ω 1 W
R8	20,000 Ω 2 W
R9	1,000 Ω 1/2 W
R10	250,000 Ω 1/2 W
R11	1,000,000 Ω 1/2 W
R12	2,000 Ω 1/2 W
R13	10,000 Ω 1/2 W
R14	250,000 Ω 1/2 W
R15	1,000,000 Ω 1/2 W
R16	1,000,000 Ω 1/2 W
R17	250,000 Ω 1/2 W
R18	100,000 Ω 1/2 W
R19	2,000,000 Ω 1/2 W
R20	300 Ω 1 W
R22	30,000 Ω 1/2 W
R23	5,000 Ω 1/2 W
R24	50 Ω 1/2 W
R25	2,500 Ω 1/2 W
R26	1,200 Ω 1/2 W
R27	2,500 Ω 1/2 W
R28	2,500 Ω 1/2 W
R29	13,000 Ω 2 W
R30	5 Ω 4 W
R31	6,800 Ω 1 W
R32	30,000 Ω 1/2 W
R33	30,000 Ω 1/2 W
R37	250,000 Ω 1/2 W
R38	1,000 Ω 1/2 W
R41	100,000 Ω 1/2 W
R51	100,000 Ω 1/2 W
R52	43,000 Ω 1/2 W
R53	100,000 Ω 1/2 W
R54	100,000 Ω 1/2 W
R55	100,000 Ω 1/2 W
R61	100,000 Ω 1/2 W
R62	43,000 Ω 1/2 W
R63	10,000 Ω 1/2 W
R64	1,000 Ω 1/2 W
R71	100,000 Ω 1/2 W
R72	43,000 Ω 1/2 W
R73	10,000 Ω 1/2 W
R74	10,000 Ω 1/2 W
R81	70,000 Ω 1/2 W
R82	250,000 Ω 1/2 W
R83	70,000 Ω 1/2 W
R84	250,000 Ω 1/2 W
R85	1,000 Ω 1/2 W
R91	100,000 Ω 1/2 W
R92	40,000 Ω 1/2 W
R93	40,000 Ω 1/2 W

TRANSFORMER

T1 OUTPUT TRANSFORMER

VACUUM TUBES

V1	VT-112 (6AC7)
V2	VT-112 (6AC7)
V3	VT-94 (6J5)
V4	VT-209 (12SG7)
V5	VT-209 (12SG7)
V6	VT-112 (6AC7)
V7	VT-90 (6H6)
V8	VT-107A (6V6GT)
V9	VT-229 (6SL7GT)
V10	VT-229 (6SL7GT)

DYNAMOTOR DM-34-D 12 V

CAPACITORS

C701	0.005 UF 800 V
C702	0.005 UF 800 V
C703	0.005 UF 800 V
C704	0.005 UF 800 V
C705	0.005 UF 800 V
C706	0.005 UF 800 V

COILS

L701	HV AF FILTER
L702	LV RF FILTER
L703	HV RF FILTER
L704	HV RF FILTER

JACK

J701 DYNAMOTOR JACK

DYNAMOTOR

MG 701 12 V DYNAMOTOR

DYNAMOTOR DM-36-( ) 24 V

CAPACITORS

C801	0.005 UF 800 V
C802	0.005 UF 800 V
C803	0.005 UF 800 V
C804	0.005 UF 800 V
C805	0.005 UF 800 V
C806	0.005 UF 800 V

COILS

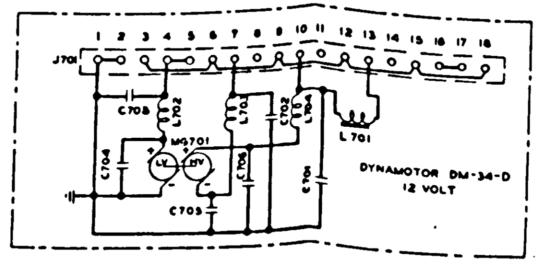
L801	HV AF FILTER
L802	LV RF FILTER
L803	HV RF FILTER
L804	HV RF FILTER

JACK

J801 DYNAMOTOR JACK

DYNAMOTOR

MG 801 24 V DYNAMOTOR



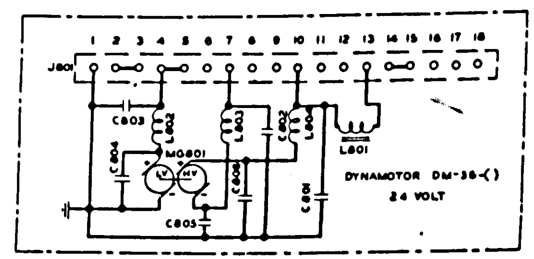


FIGURE 52. BC-683 Receiver-Schematic Diagram. Extract From Fig. 4, TM11-620

driver of *insulating* material through a hole in the left side of the receiver dust cover.

u. Tune the other receiver as above, but do not make any transmitter changes.

SECTION III

RECEIVER ALIGNMENT

218. GENERAL. Alignment of the SCR–608 receiver should not be necessary each time channels are preset. However, alignment should be checked each time a set is inspected and adjustments made wherever the inspection indicates that they are necessary. In succeeding paragraphs a method is outlined using an SCR–608 transmitter to provide a signal of correct frequency when a standard signal source is not available.

219. IF ALIGNMENT.

a. Mount a good SCR–608 transmitter on Mounting FT–237, remove the top plate and set up the crystal for chanel 318. The fundamental frequency for this crystal is 441.666 kc and its sixth harmonic is 2.65 mc which corresponds to the correct IF of the receiver.

b. Remove the cover from the receiver to be aligned and mount the receiver on Mounting FT–237.

c. Set up a VTVM in accordance with its instructions for measuring negative DC voltages (30 volt range) and connect its DC volts probe to the receiver limiter grid (prong 4 of V6) and its common lead to ground.

d. Ground the grid of the receiver RF oscillator stage (prong 5 of V3).

e. Remove the transmitter rectifier tube (V102) from its socket and connect the rectifier grid (prong 5 V102) to the receiver mixer grid (prong 4 of V2) through a series condenser. If a condenser is not available, use two insulated wires and twist together to obtain the effect of a condenser.

f. Turn the receiver power switch ON, SQUELCH switch OFF, and TUNE-OPERATE switch to OPERATE.

g. Turn the transmitter power switch ON, depress the push button for channel 318, and turn the RECEIVER TUNE-OPERATE switch to RECEIVER TUNE.

h. After the receiver has warmed up, adjust the primary and secondary adjustment of FL3A, FL2A, and FL1A, in turn, for maximum meter reading.

i. Repeat h above two or three times, if necessary, to obtain maximum meter reading.

j. If the meter reading exceeds 18 volts, the tuning of the stage will be quite broad. The set's response can be lowered by turning the SQUELCH switch ON and adjusting the SENSITIVITY control. However, do not allow the response to fall below 6 volts.

220. DISCRIMINATOR ALIGNMENT.

a. Set up the receiver to be aligned and a good transmitter as in paragraph 219.

b. Connect a VTVM to measure negative voltage at terminal No. 8 of FL4 with respect to terminal No. 7 (30 volt range).

c. Adjust the primary of FL4 for maximum meter reading. This should be about 20 volts. Turn receiver OFF.

d. Adjust the VTVM to false zero at 1.2 volts on 3 volt range (par. 21c). Connect the VTVM to measure negative voltage at terminal No. 3 of FL4, with respect to terminal No. 7.

e. Turn the receiver ON, allow time to warm up, and adjust the secondary of FL4 until false zero is obtained when the alignment tool is removed. Vary the secondary adjustment above and below resonance and note that the meter reading changes in both directions from false zero.

221. IF OSCILLATOR ALIGNMENT. After the alignment of the discriminator is completed, turn the TUNE-OPERATE switch to TUNE and adjust the trimmer of LCU4 to obtain zero beat.

222. RF ALIGNMENT.

a. Mount a good SCR–608 transmitter on Mounting FT–237 and set up two crystals for channels near the high and low end of the band.

b. Remove the cover from the receiver to be aligned and mount the receiver on Mounting FT–237.

c. Set up a VTVM in accordance with its instructions for measuring negative DC voltages (30 volt range), and connect its DC volts probe to the receiver limiter grid (prong 4 of V6) and its common lead to ground.

d. Press the receiver PUSH-TO-TUNE button and rotate the TUNING control manually to the channel corresponding to the transmitter crystal near the high end of the band. Turn the receiver ON.

e. Depress the transmitter push button for the channel near the high end of the band, turn the RECEIVER-TUNE-OPERATE switch to RECEIVER TUNE.

f. Adjust the receiver RF oscillator trimmer (C1.7) and then the RF amplifier trimmers (C1.4 and C1.5) for maximum meter reading.

g. Tune the receiver and transmitter to the channel near the low end of the band as in **d** and **e** above.

h. Adjust LCU2A and LCU1A for maximum meter reading. Adjust LCU3A *only* if tracking is off on the low end of the band.

i. Repeat **d** to **h** above until meter readings are stabilized. If meter readings exceed 18 volts, the tuning will be quite broad and false peaks may be obtained. To reduce readings, operate the receiver from a separate mounting somewhat removed from the transmitter.

j. After adjustments are completed, note that zero beat is obtained when the TUNE-OPERATE switch is turned to TUNE.

SECTION IV

TRANSMITTER ALIGNMENT

223. GENERAL. Alignment of the SCR–608 transmitter should not be necessary each time channels are preset. However, alignment should be checked each time a set is inspected and adjustments made whenever the inspection indicates that they are necessary.

224. PRECAUTIONS.

a. Operate the transmitter dynamotor for short periods only.

b. Do not touch high voltage circuits, for voltages present are dangerous.

225. OSCILLATOR AND 1st AMPLIFIER ALIGNMENT.

a. Mount the transmitter to be aligned on Mounting FT-237, remove the top plate, and unlock the push button selector mechanism.

b. Set the METER switch to No. 2 and the TUNE-ANT CUR switch to TUNE.

c. Set the condenser C107 to minimum capacity. Open end of slot should be to the left.

d. Turn the power switch ON and the RECEIVER TUNE-OPERATE switch to RECEIVER TUNE.

e. Depress the push button for a channel near the high end of the band and tune the ganged tuning condensers across the entire band. A meter reading should be obtained in all positions of the ganged tuning condensers.

f. Depress the push button for a channel near the low end of the band and tune the ganged tuning condensers across the entire band. A meter reading should be obtained in all positions of the ganged tuning condensers.

g. Turn the METER switch to No. 3, depress the push button for the channel near the high end of the band, and tune the ganged tuning condensers for maximum meter reading.

h. Depress the push button for the channel near the low end of the band, and tune the ganged tuning condensers for maximum meter reading.

i. Release the push buttons and lock the selector mechanism.

226. RECTIFIER ALIGNMENT.

a. Turn the METER switch to No. 4.

b. Adjust the tuning slugs in the coils L118 and L119 to approximately one inch from the end of the coils.

c. Set the condensers C153 and C157 to mid-capacity. Open end of slot should be to the rear.

d. Depress the push button for the channel near the high end of the band and adjust C153 and C157 for maximum meter reading on the 12th harmonic of the fundamental crystal frequency or one sixth of the output frequency. The correct harmonic may be distinguished by use of an absorption type wavemeter of the proper range.

e. Depress the push button for the channel near the low end of the band and adjust the tuning slugs in L118 and L119 for maximum meter reading.

f. Repeat **d** and **e** above until the meter reads about 35 for **d** and 30 for **e**.

227. TRIPLER ALIGNMENT.

a. Turn the METER switch to No. 1.

b. Set the condensers C114 and C116 to mid-capacity and the tuning slugs in coils L106 and L107 to approximately one inch from the end of the coils.

c. Depress the push button for the channel near the high end of the band and adjust C114 and C116 for maximum meter reading.

d. Depress the push button for the channel near the low end of the band and adjust the tuning slugs in coils L106 and L107 for maximum meter reading.

e. Repeat **c** and **d** above until the meter readings stabilize.

228. **DOUBLER ALIGNMENT.**

a. Turn the METER switch to No. 5.

b. Set the condenser C120 to mid-capacity and the tuning slugs in coil L108 to approximately one inch from the end of the coils.

c. Depress the push button for the channel near the high end of the band and adjust C120 for maximum meter reading.

d. Depress the push button for the channel near the low end of the band and adjust the tuning slug in L108 for maximum meter reading.

e. Repeat **c** and **d** above until the meter readings stabilize.

229. **POWER AMPLIFIER ALIGNMENT.**

a. Turn the METER switch to No. 6 and turn the RECEIVER TUNE-OPERATE switch to OPERATE.

b. Reduce the antenna coupling to minimum, set the antenna trimmer condenser corresponding to the channel near the high end of the band to maximum capacity (white dot up) and set the antenna trimmer condenser corresponding to the channel near the low end of the band to minimum capacity (white dot down).

c. Depress the push button for the channel near the high end of the band, press the microphone switch, and adjust condenser C126 for minimum meter reading.

d. Depress the push button for the channel near the low end of the band, press the microphone switch and adjust coil L110 for minimum meter reading. Coil L110 can be adjusted by using a screwdriver to move the toothed wheel at the bottom of the coil.

e. Repeat **c** and **d** above until meter readings stabilize.

SECTION V
SERVICING

230. **GENERAL.** Radio Sets SCR-608 and SCR-628 should be inspected once each month, or after 300 hours of operation, or whenever defective performance occurs, whichever is earliest. This inspection must include all auxiliary equipment, spare parts, and vehicular installations. In addition to this inspection, every opportunity should be taken to check the condition of the set when presetting channels. An historical record of all inspections and all maintenance work should be kept.

231. PRELIMINARY INSPECTION.

a. Obtain a report on performance.

b. Vehicular Inspection. Inspect the vehicular installation and perform the following operations:

(1) Inspect the vehicle storage battery and note loose or corroded connections. Check the state of charge of the battery.

(2) Inspect the power supply cable from the vehicle ignition system to the terminal box. Connections must be tight, the cable insulation must not be damaged, and the cable must be adequately anchored to the body of the vehicle.

(3) Inspect the power supply cable from the terminal box to Mounting FT–237. Connections must be tight, the cable insulation must not be damaged, proper polarity must be observed, and the cable must be adequately anchored and protected where it enters Mounting FT–237.

(4) Inspect the mounting frame and cabinet for physical damage and make sure it is mounted firmly to the vehicle body.

(5) Inspect Mounting FT–237. It should be well grounded to the mounting frame and cabinet, the fuze should be good, a spare fuze should be provided, antenna terminals should be undamaged, and cannon sockets should be free from defects.

(6) Inspect the antenna system. Three sections of antenna must be used. If the lead-in wire is more than 40 inches in length, coaxial cable should be used. Connections must be firm and not corroded or rusted. The mast base must be firmly mounted on the vehicle so that the antenna may assume a vertical position, and insulator must not be painted. Wire must not be used to tie down the antenna. If a coaxial cable feed system is not used, the coaxial lead should be removed from the mast base.

(7) Measure the voltage at the fuze in Mounting FT–237. For proper radio operation this should not exceed 14 volts with respect to ground with the radio set operating and the vehicle engine running at a speed equivalent to 30 miles per hour on level highway.

c. Receivers. Inspect both receiver units and perform the following operations:

(1) Inspect and clean cannon plugs, check for play, and burnish if necessary.

(2) Inspect receiver front panel switches, controls, jacks, and binding posts for physical damage.

(3) Remove the receiver dust cover and inspect the chassis for surface defects, such as: loose or misplaced wires; damaged

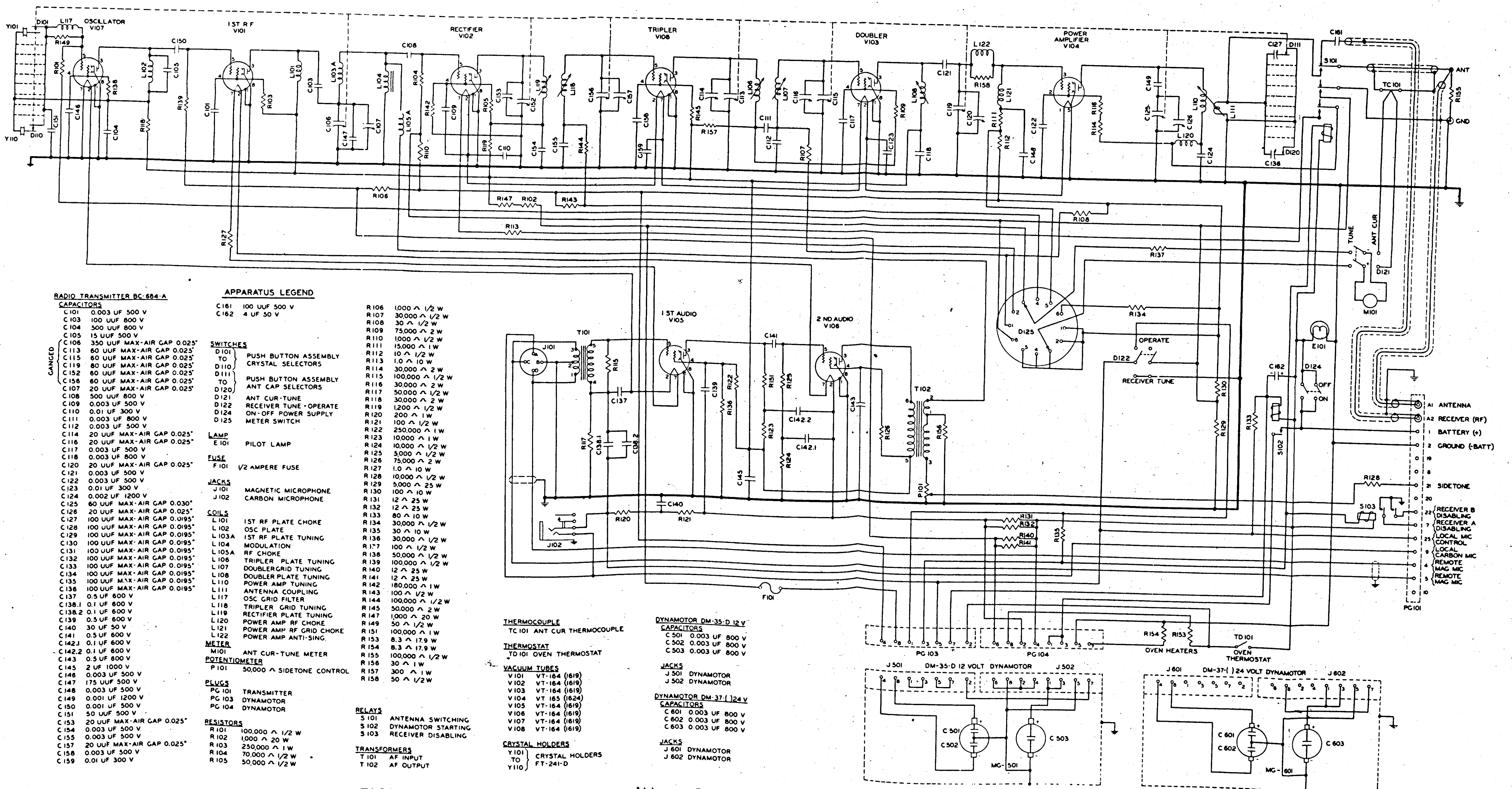


FIGURE 53. BC-684 Transmitter-Schematic Diagram. Extract From Fig. 6, TM11-620

filter units; damaged tuning units; damaged variable condensers; defective or missing fuze or spare; defective switch contacts; defective tube socket contacts; incorrect tube types or tubes improperly inserted in the sockets; defective or missing shields; bent or broken parts; or unusual odors.

(4) Clean chassis and parts.

(5) Clean push button assembly with dry, clean air (do not use carbon tetrachloride). Lubricate as specified in the technical manual, if required. Do not allow lubricant to get on the locking wedge.

(6) Remove the dynamotor and inspect plug connections, brushes, brush holders, commutators, and bearings.

(7) Replace brushes, clean commutator, and lubricate bearings as specified in the technical manual, if necessary. Do not allow lubricant to get on the commutator or brushes. Clean thoroughly with dry, clean air.

d. Transmitter. Inspect the transmitter unit and perform the following operations:

(1) Inspect and clean cannon plugs, check for play, and burnish if necessary.

(2) Inspect transmitter front panel and right end panel switches, controls, meter, jacks, and binding posts for physical damage.

(3) Check crystal compartment and spare crystal tray.

(4) Remove the dust cover and inspect chassis for surface defects, such as: loose or misplaced wires; damaged coils; loose, shorted, or damaged trimmer and tuning condensers; defective or missing fuze and spare; defective switch contacts; defective tube socket contacts; incorrect tube types or tubes improperly inserted in the sockets; defective or missing shields; bent or broken parts; or unusual odors.

(5) Clean chassis and parts.

(6) Clean the push button assembly with clean, dry air (do not use carbon tetrachloride). Lubricate as specified in the technical manual, if required.

(7) Remove the dynamotor and inspect and treat as in **c** above.

(8) Inspect relays, and burnish points when necessary. Use burnishing tool only. Do not use abrasive papers or cloth. Make sure that the points close when the relay operates.

e. Other equipment. Inspect microphone, headset, remote control unit, and all other auxiliary equipment or spare parts for evidence of physical damage or poor general condition. Clean when necessary and replace defective or missing parts.

f. Operation. With the transmitter and receivers mounted in the vehicle and connected to the antenna and power supply with which it is to be used, perform the following operations:

(1) Turn the receiver power switch ON. Dynamotor should start.

(2) Turn the SPEAKER switch ON and turn the VOLUME control to its maximum clockwise position. After 20-30 seconds, operation should be indicated by noise from the speaker when the SQUELCH switch is OFF. The CALL SIGNAL LAMP should light.

(3) Turn the SQUELCH switch ON and extinguish lamp with the SENSITIVITY control. Noise from the speaker should cease.

(4) Plug in the microphone and turn the transmitter power switch ON. Indicator lamp should light.

(5) Depress a transmitter push button, turn the RECEIVER TUNE-OPERATE switch to OPERATE, and press the microphone switch. Dynamotor should start and meter should indicate antenna current.

(6) Check the push button set up by depressing corresponding buttons on receiver and transmitter, turning the receiver TUNE-OPERATE switch to TUNE, pressing the microphone switch and noting a beat note under 1000 cycles per second on each channel.

(7) Turn the OUTPUT-TO-PHONES switch ON, TUNE-OPERATE switch to OPERATE, and SPEAKER switch OFF, and check headphone operation.

(8) Turn the TUNE-ANT CUR switch to TUNE and check panel meter readings with the transmitter operating on each

Switch Position	1	2	3	4	5	6
Circuit	Doubler Grid Current	1st RF Grid Current	Rect. Grid Current	Tripler Grid Current	PA Grid Current	Tot. Plate & Screen Current
27.0	35	40	15	30	20	70
38.9	50	10	15	35	30	70

push button for each position of the METER switch. Readings obtained should be as indicated in the table below for channels 270 and 389. Readings for other channels may be obtained by interpolation.

(9) An incoming signal should be received without distortion.

(10) With the microphone switch pressed, an undistorted signal should be transmitted.

g. Alignment. Defective presetting or alignment may not always be discovered in these tests, but will be in the final operating check. If the receiver is properly aligned, dial readings will correspond to the channel marked on the corresponding crystal in the transmitter, reception will not be weak or distorted, and zero beat of the receiver will be in the exact center of the range through which the CALL SIGNAL lamp is lighted. If the transmitter is properly aligned, peak panel meter readings for METER switch positions 3, 4, and 1 will occur at the same setting of the gang tuning control for each channel. If the presetting or alignment is known or suspected to be defective, proceed at once to a complete retuning or realignment of the set (par. 214–229).

h. The preceding steps should indicate whether the set is good or defective. If apparently good, proceed directly to the final operating check. If symptoms of trouble have been discovered, locate and remedy the trouble before performing the final operating check. Do not attempt repairs where successful completion is uncertain.

232. COMMON TROUBLES.

a. General. Common troubles of the SCR–608 are indicated below according to the symptoms or indication they produce. This is not a complete detailed list and is to be used only in conjunction with standard service methods (chapter 9).

b. Dynamotor does not operate.

(1) Defective fuze. (Check for shorts in dynamotor and tube heater circuits before replacing.)

(2) Weak battery or defective battery connection.

(3) Defective switch or connections.

(4) Defective dynamotor.

c. Dead receiver.

(1) SENSITIVITY control improperly adjusted.

(2) Defective speaker or headphones.

(3) Defective tube or tubes.

(4) Defective dynamotor connections.

(5) Internal short. (If smoke appears, turn off the receiver and check for shorts using an ohmmeter.)

d. Weak or distorted reception.

(1) Dynamotor defective.

(2) Weak battery or defective battery connections.

(3) Receiver improperly aligned.

(4) Defective speaker or headphones.

(5) Defective antenna system.

(6) Defective antenna relay. (Connect antenna lead-in to REC binding post on FT–237 to check relay.)

(7) Defective cables or connections in Mounting FT–237. (Remove receiver from its mounting, connect a power supply directly to the connections on the cannon plug, and connect the antenna lead-in to "A" binding post of the receiver.)

e. Transmitter dynamotor runs but pilot lamp does not light.

(1) Defective lamp.

f. Pilot lamp lights but dynamotor does not run.

(1) Weak battery.

(2) Defective connection(high resistance contact).

(3) Defective microphone control circuit. (Check by turning RECEIVER TUNE-OPERATE switch to RECEIVER TUNE position.)

(4) Defective dynamotor relay contacts.

(5) Defective dynamotor.

g. Pilot lamp does not light and dynamotor does not run.

(1) Fuze in FT–237 defective.

(2) Wires or connections in FT–237 or power circuits defective.

(3) Defective battery.

(4) Defective transmitter power switch.

h. No antenna current.

(1) Defective meter thermocouple.

(2) Defective transmitter fuze. (Check sidetone in headphones — if OK, fuze is good.)

(3) Defective crystal.

(4) Defective tube or tubes.

i. No antenna current and no current in No. 6 METER switch position.

(1) Defective fuze.

(2) Defective dynamotor.

j. No antenna current, ½ normal current in No. 6, and no current in No. 2. Defective front bank of tubes.

k. **No antenna current, 2/3 normal current in No. 6, and high current in No. 2.** Defective rear bank of tubes.

l. **No antenna current, nearly normal current in No. 6, and low to normal current in No. 2.**

(1) Circuit improperly aligned.

(2) Defective crystal.

(3) Defective tube.

m. **No antenna current and normal current in all meter positions.**

(1) Defective thermocouple.

(2) Defective antenna system.

n. **Lower than normal current in all meter positions.**

(1) Weak battery.

(2) Weak tube (especially 1st RF amplifier stage).

(3) Circuits not tracking.

(4) Defective condensers or resistors.

o. **Low antenna current, low current in No. 6, and weak transmissions.**

(1) Defective power amplifier tube.

(2) Power amplifier aligned improperly.

p. **High antenna current.**

(1) Defective antenna system.

(2) Defective thermocouple.

q. **Normal antenna current, but unable to contact other stations.**

(1) Defective microphone.

(2) Defective transmitter audio amplifier (check sidetone).

(3) Defective antenna circuit.

(4) Transmitter tuned on wrong harmonic.

r. **Peaks obtained when METER switch is at No. 3, 4, and 1 with different setting of gang tuning control.** Transmitter improperly aligned.

233. FINAL OPERATING CHECK.

a. **General.** The final operating check must be a rigid test of the set's performance under conditions which will indicate its ability to receive and transmit satisfactorily at extreme ranges. Two methods are outlined in **b** and **c** below for this check. Either will be satisfactory if performed by experienced personnel who are thoroughly acquainted with the set's specifications and characteristics.

b. **Readability test.** Install the radio set to be tested in the manner in which it is to be used. Set up a test set, which is known to be good, on the same channels as the set to be tested. Move the set to a point fifteen miles from the set being tested and with favorable intervening terrain. Have each set transmit, in turn, on each of its preset channels and note the reception on each receiver. It should be undistorted and loud enough to be understood. Squelch circuits should be inoperative during this test since they reduce receiver sensitivity at extreme ranges. If the intervening terrain is such that it would reduce signal strength, good results can not be expected at maximum range. Reduce the distance between stations to compensate for this variation from standard conditions and repeat the test.

c. Voltage test. Install the radio set to be tested in the manner in which it is to be used. Set up an SCR–608 test set, which is known to be good, on the same channels as the set being tested. (The test set must be modified as indicated in paragraph 234 so that limiter grid voltage may be measured.) Move the test set to a point 10–15 miles from the set being tested (with average intervening terrain) and continue test as follows:

(1) Have set being tested transmit its mean frequency and tune test set receiver manually to zero beat.

(2) Measure the limiter grid voltage on the test receiver while the set being tested is transmitting.

(3) Compare the reading obtained in (2) above with readings obtained under similar conditions with SCR–608 transmitters known to be good. This comparison will give a relative indication of transmitter power output. Reading should not vary more than 50% from standard reading.

(4) Have the set being tested transmit a modulated signal and check for absence of distortion at the test set.

(5) Move the test set to a point where the noise level in the receiver being tested is just strong enough to be heard while the test set is transmitting.

(6) Have the test set transmit a modulated signal and check for readability at the receiver being tested. It should be readable despite the noise level.

(7) Repeat (5) and (6) above using the other receiver of the set being tested.

(8) Repeat (1) to (7) above on the other preset channels.

(9) If the intervening terrain is unfavorable, this fact must be considered in interpreting results.

234. SCR–608 TEST SET. In order to conduct the final operating check in paragraph 233c, one SCR–608 receiver in each organization should be modified to facilitate measuring limiter grid voltage. This modification in no way impairs the efficiency of the set for other purposes. Proceed as follows:

(1) Remove the dust cover from the receiver to be modified.

(2) Solder one end of the lead wire of a 1-3 megohm resistor to terminal No. 6 of Filter Unit FL3A (limiter grid). This lead wire should be as short as practicable.

(3) Remove the spare fuze from its receptacle.

(4) Terminate the other lead wire of the resistor at a terminal pin or jack which can be mounted in place of the spare fuze. It must be insulated from ground.

(5) Replace dust cover.

(6) To measure limiter grid voltage insert the DC volts probe of a VTVM in the spare fuze receptacle to contact the terminal of the limiter grid lead wire, and ground the common lead at the TUNE-OPERATE switch.

CHAPTER 13
RADIO SET SCR-284

SECTION I
GENERAL

235. GENERAL.

a. Radio Set SCR–284 is a transmitting and receiving set capable of CW or amplitude modulated voice operation.

b. Details concerning the functioning of parts, method of installation and operation, and maintenance data are contained in TM 11–275. These notes are intended to supplement TM 11–275 and to provide field artillery repairmen with certain items of information of value to him in maintaining equipment.

c. Refer to figures 54 and 55 for identification of all parts and test points. Since more than one model of this set is in use, these schematic diagrams may differ in details from those which accompany any particular set.

SECTION II
ALIGNMENT AND NEUTRALIZATION

236. RECEIVER ALIGNMENT, GENERAL.

a. Alignment of the SCR–284 receiver should not be necessary at frequent intervals. However, alignment should be checked each time a set is inspected, and adjustments made whenever the inspection indicates that they are necessary.

b. The self contained crystal oscillator is used in the receiver alignment procedures outlined below to obtain signals near the high and low end of the band. However, any signal generator could be used for this purpose. If the IF stages are badly out of alignment, a frequency meter or a good receiver should be used as the signal source.

237. RECEIVER IF AND BFO ALIGNMENT.

a. Remove the set from its case and connect to a good receiver power supply so that the receiver and the crystal oscillator are operative.

b. Connect the bare end of an insulated wire to the antenna terminal of the receiver (No. 12 of plug 2-K-1) and couple the other end of the wire to the crystal oscillator by wrapping one or more turns around the CRYSTAL holder.

c. Set up a VTVM in accordance with its instructions for measuring DC voltage and connect it to measure a minus voltage (3 volt range) at the common terminal of 2-R-12, 2-R-19 and 2-R-18 with respect to prong 7 of the mixer tube (2-V-2).

d. Turn the main switch to VOICE and the AVC switch OFF.

e. Pull the CRYSTAL switch OUT.

f. Tune the receiver to a crystal check-point near 3800 kc as indicated by maximum reading on the VTVM when the receiver tuning dial is near 3800.

g. Loosen the lock nut on the slotted shaft on the under side of the chassis and adjust coil 2–L–10 for maximum reading on the VTVM.

h. Repeat procedure in g above for coils 2–L–9, 2–L–7, 2–L–6, 2–L–5, and 2–L–4, in turn.

i. Repeat g and **h** above.

j. Turn MAIN switch to CW and adjust coil 2–L–8 to obtain zero beat. Refasten all lock nuts.

238. RECEIVER RF ALIGNMENT.

a. Make connections indicated in paragraph 237 **a** to **e** inclusive.

b. Tune the receiver to a crystal check-point near 5800 kc as indicated by maximum reading on the VTVM when the receiver tuning dial is near 5800.

c. Adjust the oscillator trimmer condenser 2–C–22 and the receiver dial until maximum reading on the VTVM is exactly on 5800 kc.

d. Adjust the antenna trimmer 2–C–2 for maximum reading on the VTVM.

e. Adjust the RF trimmer 2–C–8 for maximum reading on the VTVM.

f. Tune the receiver to a crystal check-point near 3800 kc as indicated by maximum reading on the VTVM.

g. Adjust the antenna coil 2–L–1 and then the RF coil 2–L–2 for maximum reading on the VTVM. A lock nut must be loosened and then retightened in each case.

h. Repeat **b, d, e, f,** and **g.**

i. Retighten all lock nuts carefully and check receiver operation over the entire frequency band.

239. TRANSMITTER OSCILLATOR ALIGNMENT.

a. Connect the transmitter to a good Power Unit PE–103–A using a well charged 6 volt battery. Do not use a 12 volt battery.

b. Leave the receiver connected to the transmitter, but place it to one side. Close switches 1–S–5 and 1–S–6 on the receiver shelf.

c. Turn the STANDBY switch to LOW and the MAIN switch to CW.

d. Pull the CRYSTAL switch OUT.

e. Tune the receiver exactly to zero beat with the crystal oscillator at 5800 kc.

f. Tune the transmitter to the setting corresponding to 5800 kc as obtained from the CALIBRATION CHART.

g. Turn the screwdriver adjustment labeled CALIBRATION to obtain zero beat with the crystal oscillator and the receiver.

240. BUFFER AND POWER AMPLIFIER ALIGNMENT.

a. Continue as in paragraph 239.

b. Push the CRYSTAL switch IN.

c. Hold down the key and vary the ANTENNA COUPLING and ANTENNA TUNING controls to obtain maximum reading on the ANTENNA CURRENT meter.

d. Adjust the buffer trimmer condenser 1–C–32 for maximum reading on the ANTENNA CURRENT meter.

e. Adjust the power amplifier trimmer condenser 1–C–40 for maximum reading on the ANTENNA CURRENT meter.

f. Repeat **c, d,** and **e** above.

241. NEUTRALIZATION. Neutralizing condensers are provided to prevent oscillation of transmitter amplifiers; however, this is seldom or never necessary. For the procedure in neutralization consult TM 11–275.

SECTION III
SERVICING

242. GENERAL. Radio Set SCR–284 should be inspected once each month, or after 300 hours of operation, or whenever defective performance occurs, whichever is earliest. The inspection

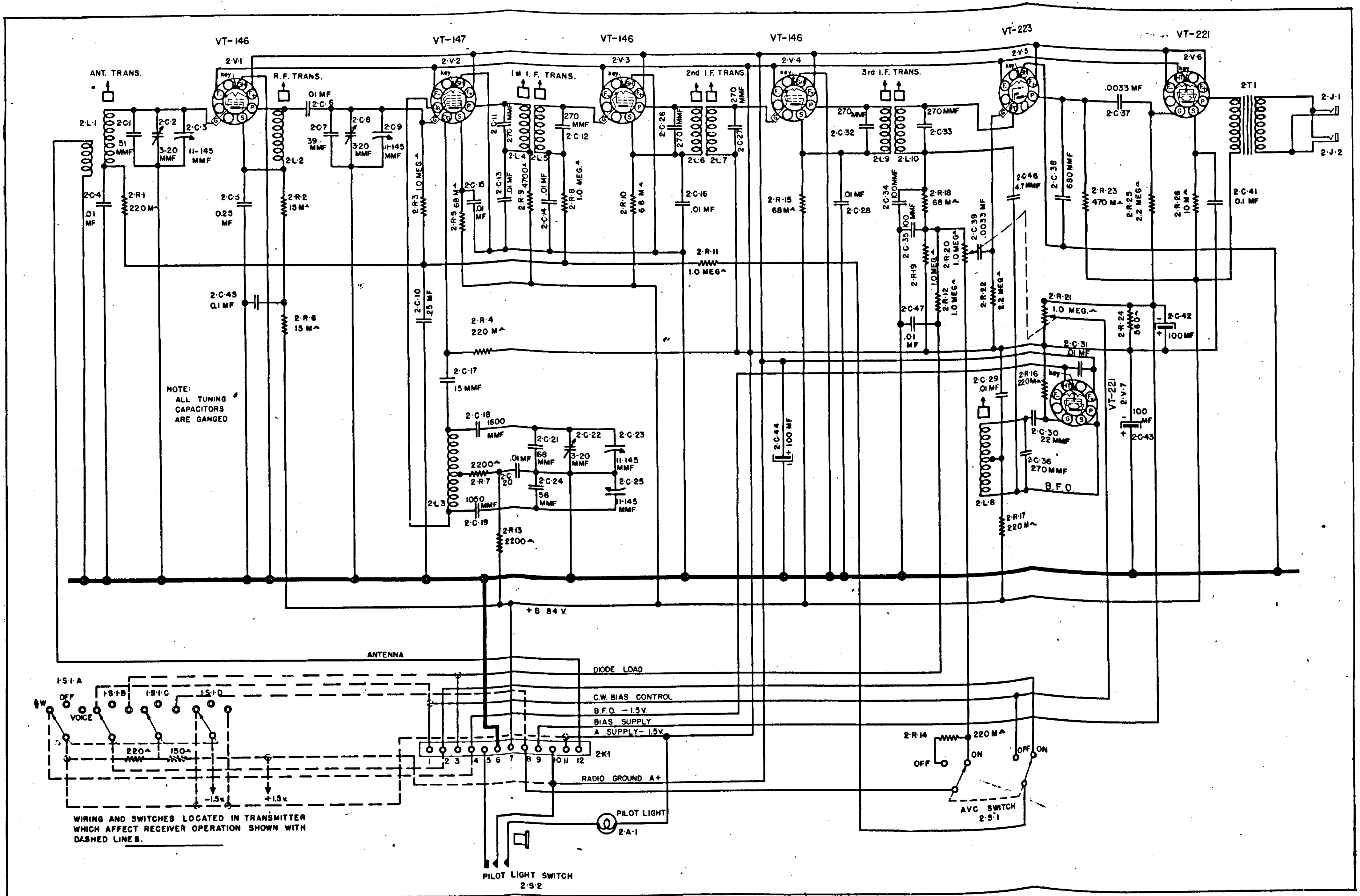


FIGURE 54. BC-654 Receiver-Schematic Diagram. Extract From Fig. 42, TM11-275

must include all auxiliary equipment, spare parts and vehicular installations. An historical record of all inspections and all maintenance work should be kept.

243. PRELIMINARY INSPECTION.

a. Obtain a report on performance.

b. Vehicular inspection. Inspect the vehicular installation and perform the following operations:

(1) Inspect the vehicular storage battery and note loose or corroded connections. Check the state of charge of the battery.

(2) Inspect the power supply cable from the vehicle ignition system to Power Unit PE–103–A. Connections must be tight, the cable insulation must not be damaged, the cable must be adequately anchored to the body of the vehicle, and proper polarity must be observed.

(3) Inspect Frame FM–41–A. It should be firmly fastened to the body of the vehicle and the shock absorber device must be free from defects.

(4) Remove Power Unit PE–103–A from the mounting frame and inspect plug connections, brushes, brush holders, commutators, bearings, circuit breakers, relay, and switch.

(5) Replace brushes, clean commutator, dress relay, and lubricate bearings as specified in the technical manual if necessary.

(6) Inspect the antenna system. Connections must be firm and not corroded or rusted. The mast base must be firmly mounted on the vehicle so that the antenna may assume a vertical position, and the mast base insulator must not be painted. The antenna must not be tied down with wire, either insulated or uninsulated. If a coaxial cable feed system is not used, the coaxial lead should be removed from the mast base.

(7) Measure the voltage at terminal No. 5 of plug 3–K–1 (PE–103–A). For proper radio operation, this should not exceed 7.1 volts for a six volt system or 14 volts for a twelve volt system with respect to ground with the vehicle engine running at a speed equivalent to 30 miles per hour on level highway.

(8) Inspect the power cord for damaged insulation and defective plugs. Test for continuity if necessary.

(9) Inspect the Power Converter PE–104–A for surface defects.

c. Receiver and transmitter. Inspect the receiver and transmitter unit and perform the following operations:

(1) Inspect the set case for possible damage to fasteners and antenna mounting.

(2) Inspect front panel switches, controls, jacks, meter, lights, and binding posts for physical damage and mechanical operation.

(3) Remove the receiver and transmitter unit from its case and inspect chassis for surface defects, such as: loose or misplaced wires; defective switch contacts or operation; defective tube socket contacts; incorrect tube types or tubes improperly inserted in the sockets; defective or missing spare tubes; defective or missing spare panel lamps; defective or missing shields; bent or broken parts; defective antenna loading coil; or unusual odors.

(4) Clean chassis and parts.

(5) Inspect relay and burnish points when necessary. Use burnishing tool only.

d. Other equipment. Inspect microphone, headsets, remote control unit, hand generator, counterpoise, guys, antenna insulator, and all other auxiliary equipment or spare parts for evidence of physical damage or poor general condition. Clean when necessary and replace defective or missing parts.

e. Operation. With the radio set mounted in the vehicle and connected to the antenna and power supply with which it is to be used, perform the following operations:

(1) Turn the MAIN switch to CW.

(2) Pull crystal switch out and rotate the receiver TUNING control and listen for beat notes at all even hundred frequencies (3800, 4000, 4200, etc.).

(3) Check operation of manual volume control.

(4) Turn MAIN switch to VOICE.

(5) Tune in amplitude modulated signal and check for quality of reception.

(6) Turn AVC switch ON and check operation of automatic volume control circuit on strong signals.

(7) Zero beat transmitter to receiver near the high and low end of the band (CRYSTAL switch OUT) and check calibration of transmitter.

(8) Load antenna at each end of the band (CRYSTAL switch IN).

(9) Check CW and voice operation in both HIGH and LOW positions of the STANDBY switch.

(10) Substitute ground power supply and antenna and repeat (7) to (9), inclusive.

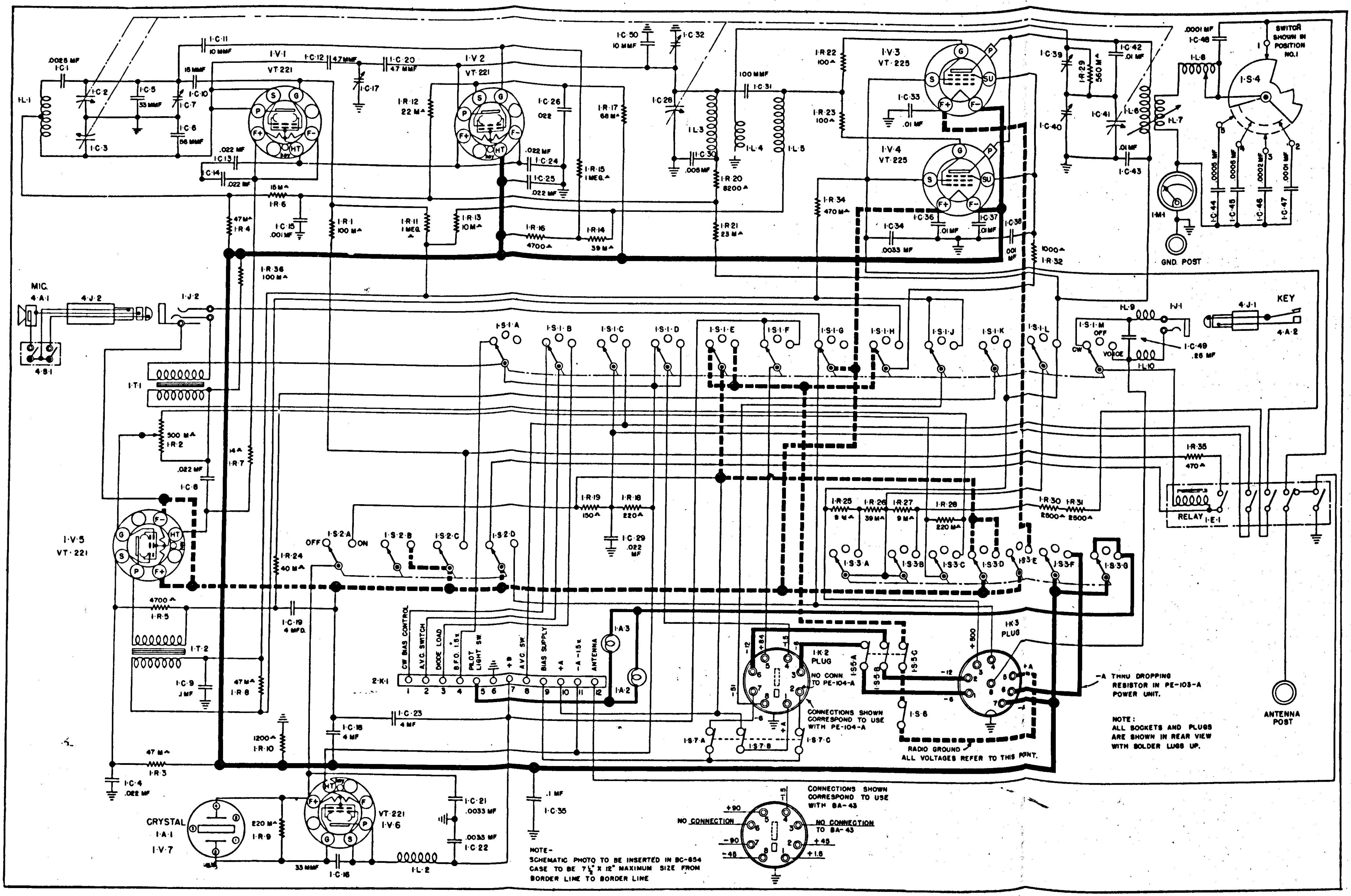


FIGURE 55. BC-654 Transmitter-Schematic Diagram. Extract From Fig. 44, TM11-275

f. Alignment. Calibration of the transmitter oscillator and the receiver may be checked by comparison with the crystal oscillator (par. e(2)and(7) above). However, defective alignment of circuits may not always be discovered in these tests, but will be in the final operating check. If alignment of either receiver or transmitter is known or suspected to be defective, proceed at once to a complete alignment of the set (par. 236–240).

g. The preceding steps should indicate whether the set is good or defective. If apparently good, proceed directly to the final operating check. If symptoms of trouble have been discovered, locate and remedy the trouble before performing the final operating check.

244. COMMON TROUBLES.

a. General. Common troubles of the SCR–284 are indicated below according to the symptoms or indication they produce. This is not a complete or detailed list and is to be used only in conjunction with standard service methods (chapter 9).

b. Dead receiver.

(1) PE–103–A switch set for 12 volts and should be 6 volts.
(2) PE–104–A switch set for 12 volts and should be 6 volts.
(3) Defective vibrator in PE–104–A.
(4) Defective copper oxide rectifier in PE–104–A (deteriorates in salt laden air).
(5) Switch 1–S–6 (door of battery compartment) open.
(6) Switch 1–S–5 (rear of battery compartment) open.
(7) Dead storage battery.
(8) Defective BA–43.
(9) Defective tube or tubes.
(10) Receiver improperly aligned.

c. Weak receiver.

(1) Defective PE–104–A.
(2) Weak storage battery.
(3) Weak BA–43.
(4) Receiver improperly aligned.
(5) Weak tube or tubes.
(6) Antenna grounded.
(7) Headset shorted.
(8) Counterpoise open.

d. Receives voice but not CW.

(1) Defective BFO tube.
(2) BFO improperly aligned.

e. Unable to zero beat receiver to crystal oscillator.

(1) Defective BFO tube.
(2) Defective crystal oscillator tube.
(3) Defective or missing crystal.
(4) Defective crystal switch.

f. Receiver howls. Defective contacts at terminals No. 1 and 2 of 2–K–2. (May be possible to stop howl by grounding No. 4 of AF transformer.)

g. PE–103–A does not run.

(1) Circuit breakers not ON.
(2) 6–12 volt switch in wrong position.
(3) Defective connections to battery.
(4) Dead storage battery.
(5) Defective power cord.
(6) Defective microphone.
(7) Switch 1–S–5 open.
(8) Defective relay.

h. Unable to zero beat transmitter to receiver.

(1) Defective crystal switch.
(2) Defective transmitter tube.
(3) Defective power supply.

i. No antenna current.

(1) Defective meter.
(2) Defective PE–103–A or GN–45.
(3) Defective key leads.
(4) Defective keying relay.
(5) Defective tube or tubes.
(6) Antenna open or grounded.
(7) Defective contact wheel on antenna tuning coil.
(8) Defective power cord.

j. Low antenna current.

(1) Defective power supply.
(2) Defective tube or tubes.
(3) Transmitter improperly aligned.
(4) Defective antenna system.

k. Transmits CW but not voice.

(1) Defective microphone.
(2) Defective modulator tube.

l. Transmitter skips dots. Keying relay improperly adjusted.

245. FINAL OPERATING CHECK.

a. General. The final operating check must be a rigid test of the set's performance under conditions which will indicate its ability to receive and transmit satisfactorily with both CW and voice at extreme ranges. This method will be satisfactory if performed by experienced personnel who are thoroughly acquainted with the set's specifications and characteristics.

b. Readability test. Install the radio set to be tested in the manner in which it is to be used. Set up a test set, which is known to be good, and move it to a point fifteen miles from the set being tested and with favorable intervening terrain. Have each set transmit with voice, in turn, on frequencies near the high and low ends of the band, if possible, or on their assigned frequencies. Note the reception on each receiver. It should be undistorted and loud enough to be easily understood. Change to CW and repeat test. If atmospheric conditions and intervening terrain are such that they would reduce signal strength, good results cannot be expected at maximum range. Reduce the distance between stations to compensate for this variation from standard conditions and repeat the test.

c. Voltage test. To obtain a more precise test of relative transmitter power output proceed as follows:

(1) Set up an SCR–284 test set, which is known to be good, on the frequency assigned for testing. Preferably two frequencies should be used, one near the high end of the band and the other near the low end of the band.

(2) Remove the soft rubber grommet from the center of the battery compartment door on the test set. Pass two test leads through the hole in the door and connect to terminals No. 3 and 11 of the receiver terminal strip 2–K–1.

(3) Set up a VTVM in accordance with its operating instructions and connect it to the test leads to measure negative rectified voltages at No. 3 with respect to No. 11. This is AVC voltage.

(4) Install the radio set to be tested in the manner in which it is to be used.

(5) Move the test set to a point fifteen miles from the set being tested and with favorable intervening terrain.

(6) Have the set being tested transmit an unmodulated signal.

(7) Tune the receiver of the test set for maximum AVC voltage.

(8) Record the maximum AVC voltage and compare with readings obtained under similar conditions with SCR–284 transmitters known to be good. This comparison will give a relative

indication of transmitter power output. Readings should not vary more than 50% from standard reading.

(9) If the intervening terrain is very unfavorable, this fact must be considered in interpreting results.

APPENDIX I

ABBREVIATIONS

1. ABBREVIATIONS. Abbreviations commonly used by radio technicians and used in this manual are listed below with their respective meanings:

Audio frequency	AF
Alternating current	AC
Amplitude modulated	AM
Automatic volume control	AVC
Beat frequency oscillator	BFO
Continuous wave	CW
Delayed automatic volume control	DAVC
Direct current	DC
Fahrenheit	F
Frequency modulated	FM
Intermediate frequency	IF
Kilocycles (per second)	kc
Megacycles (per second)	mc
Microfarad	mfd
Radio frequency	RF
Vacuum tube voltmeter	VTVM

APPENDIX II

PARTS COLOR CODING

1. GENERAL. Values of standard radio components may frequently be identified by a color code system.

2. RESISTORS.

a. Numbers. Numbers are represented by the following colors:

0—black	5—green
1—brown	6—blue
2—red	7—violet
3—orange	8—gray
4—yellow	9—white

b. Body, tip, and dot system. Three colors are used on each resistor. The body color represents the first figure of the resistance value; the tip or end color represents the second figure; and, the dot color near the center of the resistor represents the number of zeros following the first two figures. For example, a resistor with green body, orange tip, and red dot has a value of 5300 ohms.

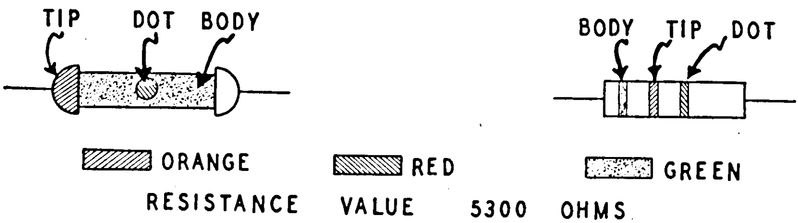


FIGURE 56. Resistor code.

c. Band system. Resistors may also be marked by three colored bands. The band nearest the end of the resistor is the body color, the next band is the tip color, and the third band is the dot color. A fourth band may be added to indicate tolerance as follows:

5%—gold
10%—silver
20%—no color

3. CONDENSERS.

a. Three dot system. Small mica condensers are sometimes marked with dots using the same color code as in paragraph 2 above. Capacity is indicated in micro-micro-farads. The first two dots are significant figures and the third dot indicates the number of zeros after the second significant figure. An arrow or other appropriate symbol indicates the proper direction to read. Tolerance is sometimes indicated by a single dot on the reverse side of the condenser according to the following code:

2½%—white
5 %—green
10 %—blue
15%—yellow
20%—red

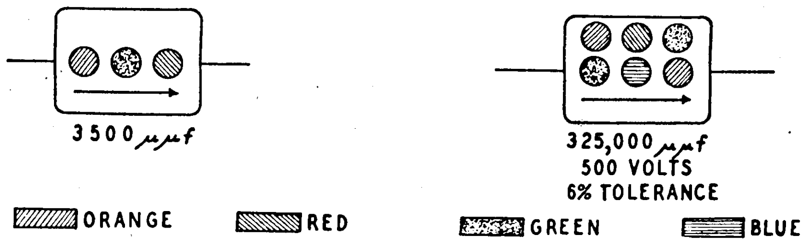


FIGURE 57. Condenser code.

b. Six dot system. If more than two significant figures are required, a six dot system may be used. The three upper dots are significant figures and the three lower dots represent voltage, tolerance, and multiplier reading, respectively, from left to right. Colors are as follows:

Color	Significant Figure	Voltage	Tolerance	Multiplier
black	0	—	—	1
brown	1	100	1%	10
red	2	200	2%	100
orange	3	300	3%	1,000
yellow	4	400	4%	10,000
green	5	500	5%	100,000
blue	6	600	6%	1,000,000
violet	7	700	7%	10,000,000
gray	8	800	8%	100,000,000
white	9	900	9%	1,000,000,000
gold	—	1000	—	.1
silver	—	—	10%	.01
no color	—	500	20%	—

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