RADIO RECEIVER TROUBLES

THEIR CAUSE AND REMEDY

REFERENCE TEXT 14X-1

PIONEER HOME STUDY RADIO SCHOOL

NATIONAL RADIO INSTITUTE

WASHINGTON, D. C.

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IMPORTANT

Instructions in How to Use This Reference Book

This reference book is divided into four parts: **A**, an index of radio receiver troubles under the usual symptoms (effects), under which are listed the probable causes; **B**, a discussion of general defects and tests; **C**, a section devoted to general troubles of receivers, their cause and remedy; and **D**, a section on receiver alignment and balancing.

In using this text as a means of shooting trouble, refer to the index. The main headings give the symptoms or other obvious results of a defect. For example: Receiver squeals, howls, or putputs; hums, smokes, etc. After you locate the proper section according to the defects you observe, you will find a list of probable causes. The causes listed should indicate to you some part or connection to check. In the beginning all the references given should be studied. In trouble shooting, select first the causes you think most likely to give the trouble in the receiver you are servicing. After most of the probable causes you will see a number followed by a letter. The number refers you to the section; the letter to the paragraph in that section.

If incorrect alignment or an unbalance is given as the cause of trouble the proper procedure for realigning or balancing a receiver is given in the section on alignment.

You should carefully read the sections on general defects and tests, general receiver troubles, and alignment and balancing, so you will be familiar with the contents. Select any section that interests you. Read especially section 22, "Voltage and current measurements as an aid in locating the defect."

When reference is not made in the index to an explanation in the following selections, the information in the index is sufficient to indicate what is to be done. For example: The customer complains that: "Stations are not received at the proper points on the dial." Referring to the index the probable cause "Dial slipped on condenser's shaft" fits this case. No further instructions are needed, as the cause itself is an indication of what you should do—reset the dial and tighten the set screw.

Remember, this reference text will be more and more helpful as you study and learn more about radio and radio receivers.

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A: INDEX OF RADIO RECEIVER TROUBLES BY EFFECTS OBSERVED, FOLLOWED BY PROBABLE CAUSE

BALLAST GETS TOO HOT OR BURNS OUT

Shows White Heat or is Too Hot to Touch

Natural Condition; *24b*
Ground or Short in Filter System; *31a*
Filter Condenser Shorted; *13a, 14f, 14h*
Choke Coil Grounded; *17c, 31a*
Shorted Rectifier Tube; *6b, 43e, 43g*
Power Transformer Defective; *17d*
Shorted Line Filter Condenser in Power Transformer Primary Circuit; *13a, 36b*
Selecting the Proper Ballast; *9a, 9c*
Incorrect Ballast; *9b*
Burned out pilot lamp; *7d*
Short-circuited filament circuit; *4a, 4b*

BROAD TUNING

Several Conditions Arise. *Condition A.* Receiver Tunes Broad on Local or Semi-Local Stations; But is normal in other respects; *Condition B.* Receiver Broader Than Usual and "Pep" of Receiver Gone; Finally, *Condition C,* Tunes Broad and Only Local and Semi-Local Stations Received.

The Ability of the Receiver Must Be Carefully Borne in Mind in Judging a Condition of Broad Tuning. Read *28n.* When the Defect Causing Broad Tuning is Not Readily Fixed, or Has no Appreciable Effect When Fixed, the Worst Offender May Be Suppressed With a Wave Trap.

Condition A: Usually a Natural Condition:

Inexpensive Receiver, Broad Tuning Normal; *23d, 23e*
Too Close to Local Stations; *28e*
Antenna Too Long; *29d*
Station Tuning Broad is Unusually Powerful; *28c*
Grid Leak-Grid Condenser Type Detector; *28n*

Condition B: Generally Due to High Resistance in Signal Circuit or Abnormal Tube Operation:

Loose and High Resistance Connections; *3a, 3d, 5a to 5f*
High Resistance in Grid Circuit; *5a to 5f*
Poor Tube Prong to Socket Contact; *3f*
Improper R.F. Alignment; *45f, 45i*
I.F. Stage Improperly Aligned; *45g to 45k*
Return Signal Circuit Leads Not Grounded; *1f, 1d*
Grid and Plate Leads Out of Place; *do not try to correct, pep up receiver*
No Ground to Receiver; *check*
Variable Condensers Dirty; *15b*
Ineffective or Defective Volume Control; *10a*
Storage Battery Charge Low; *21c*
"B" Batteries Run Down; *21i*
Low Line Voltage; *30c*
Open or Shorted Bypass Condenser; *12a, 12b, 12c, 13a*
Weak Tubes; *6b*
Shields Not Firmly in Place, or a Good Chassis to Shield Contact Does Not Exist; *19a, 3f, 20d*

Condition C: Usually Due to no Supply Voltage to Some Stage, or an Open Circuit:

Dead or Defective Tube; *6f, 6a*
No Plate Voltage on an R. F. Tube; *study section 22*
Open Grid Circuit; *1d*
Variable Condensers Partially or Totally Shorted in Some Section; *15g*
Control Grid Clip Loose, Corroded or Grounded; *3f, 5c*
See Causes Creating Condition B.

CONDENSERS LEAK WAX

Poor Ventilation; *26g*
Condensers Leaky; *13a, 12c*
Defective Condenser; *13a, 12c*
Voltage Rating of Condenser Used Too Low; *11c, 26g*
Excessive Wax Used in Manufacture; *No Harm Done*

CONDENSERS HISS OR SIZZLE

Sound Coming Directly From Electrolytic Condenser

Loudspeaker Cable Not Plugged or Connected to the Main Chassis; *14j*
Excessive Voltage Across Electrolytic Condenser. (Producible by Any Defect or Open in the Receiver Which Will Cause Excessive Voltage at This Filter Condenser). *14j*
Condenser Defective or Not Used for Some Time; *14k*
Electrolytic Condenser Improperly Connected; *14i*
Electrolytic Condenser Incompletely Formed; *14k*

DEAD SPOTS SHORT WAVE CONVERTER

Reception Peculiar to Short Wave Bands: *25a to 25k*
Incorrect Receiver Adjustment; *25c*
Oscillator Not Working; *section 40*
Shorted Tuning Condenser; *15g*
Incorrect Coil Plugged in (plug-in coils used).

NOISE INTERNAL, WHEN RECEIVER IS ADJUSTED

NOISE, INTERNAL

Station Tuned In, No Part Touched or Adjusted, and Hiss, Scratches, Rattles and Racket Noises Heard.

NOISE, EXTERNAL

Noise Comes Through Loudspeaker And is Not in The Chassis

NOISE, MECHANICAL

Noise is Not Emitted From Loudspeaker and Heard Only With Set Playing

NOISE, INTERNAL; AUTO RADIO

The Defects Listed Below Are Only Peculiar to Auto Radios. But an Auto Radio Also is Subject to Defects Producing Noise Like Other Receivers. Hence See "NOISE INTERNAL."

OSCILLATIONS

See Sections on "Squeals"

PILOT LIGHT BURNS OUT TOO OFTEN

PILOT LIGHT FLICKERS OR TOO DIM

RECTIFIER TUBE PLATES GET RED

RESISTOR OVERHEATS OR EMITS SMOKE

RESISTORS GET WARM

RECEIVER SMOKES

RECEIVER UNSATISFACTORY (INEXPENSIVE MIDGET)

POOR SELECTIVITY

See Broad Tuning

SHOCK WHEN AERIAL IS TOUCHED

SHOCK WHEN CHASSIS IS TOUCHED

SIGNAL DISTORTED OR MUFFLED

Several General Conditions Arise. *Condition A:* Signal is Distorted All The Time; *Condition B:* Signals Distorted at High Sound Levels; *Condition C:* Signals Distorted at Low Sound Levels—Otherwise Normal.

CONDITION A: Signal Distorted or Muffled Regardless of Receiver Adjustment

Located in R.F. System

Located in Detector or A.V.C. System

Located in Audio System

Located in Loudspeaker Unit

Located in Power Supply System

SQUEALS, HOWLS, PUT-PUTS

Often Referred to as Regeneration, Oscillation, Whistling, Spilling Over, Instability, Growling, Motor-Boating, Feed-Back and Parasitic Coupling. In the Following Cause List We Refer to the Condition Where This Disturbance is Continuous or While Receiver is Tuned or Playing. These Squeals Are Not a Feature of a Regular Receiver, as it Would Be in Regenerative Receivers and Beat Frequency Locaters in Short Wave Receivers. In the Latter Case The Squeals May Be Stopped at Will. Squealing, Howling and Put-Puts Are an Indication That Undesirable Audible Frequencies Are Present. Squeals and Howls are Generally an R.F., I.F., and Detector Defect; While Put-Puts Referred to as Motor-Boating, Indicates Audio Stage Trouble. This Type of Interference Arises From Several Basic Conditions: *Condition A,* Open, Short or Undesirable High Resistance Causing One Stage to be Coupled to Another Producing Feed Back; *Condition B,* Change in Setting, or Defect in the Oscillation Suppression System, or Change in Voltages; *Condition C,* a Defect in the Receiver; and *Condition D,* Mechanical or Acoustical Feed Back, Detected By a Gradual Rising Whining Sound.

Condition A: Electrical Feed Back Due To Part or Circuit Defect

Condition B: Change in Adjustment or Incorrect Receiver Operation

Condition C: Receiver or Tube Defect

Condition D: Mechanical Resonance and Coupling

SQUEALS, HOWLS, PUT-PUTS; ONLY WHILE SET WARMS UP

SQUEALS, HOWLS; DISTORTION ON SOME DISTANT STATIONS

SIGNALS WEAK, AT ONE END OF DIAL

STATIONS NOT RECEIVED AT PROPER POINTS

TONE CONTROL, INOPERATIVE MANUAL

TONE CONTROL ADJUSTMENT MAKES SET DEAD

TUBE OR TUBES DO NOT LIGHT

TUBES GO BAD OR BURN OUT TOO OFTEN

Tubes Have a Limited Life and They Terminate Their Useful Service Generally By Losing Emission or Becoming Gassy. Often After Hard Use the Filament Burns Out. Defects or Improper Operation of a Receiver Shorten its Useful Life, Often Roughly Figured as One Year of Fairly Constant Use.

TUBES GET BLUE ON GLASS

TUBES GET BLUE INSIDE AMONG ELEMENTS

More Often Due To:

Less Often Due To:

TUNE, CANNOT

Defect Clearly Mechanical and Easily Located by The Action Observed

VIBRATOR DOES NOT LAST

Typical of Auto Radios and 6, 32, and 110 volt Vibrator "B" Eliminators Continuous Operating With Excessive Sparking Causes Burning of Contacts.

Condition A: Overload

Condition B: Underload

Condition C: Improper Adjustment of Contacts; 44b

VISUAL TUNING INDICATOR, NO ACTION OF

When a Strong Broadcaster is Tuned in The Needle (Meter Indicator) or The Shadow Width (Shadowgraph Indicator) Neon or Blinker Lamp Shows No Change, It is Understood That The Receiver Has A.V.C. and Reception is Normal Except for A.V.C. Indicator Defects.

Case A: Meter and Shadowgraph

Case B: Neon Indicator

Case C: Blinker Lamp System

VOLUME GREATER WITH GROUND WIRE DISCONNECTED

VOLUME, LOWER WITH ALL WAVE ANTENNA

B: GENERAL DEFECTS AND TESTS

1. OPEN CIRCUITS. (*a*) In testing a radio circuit an "open circuit" is taken to mean a break in the path of D.C. supply currents or signal currents.

(*b*) As any path for a D.C. current must be continuous over a conductor, an open or break is tested with an ohmmeter. This device is indispensable and no serviceman would think of tackling a job without it. Between any two points or terminals of a D.C. path there must be a definite value of ohmic resistance. If you test between these two points and merely observe that the ohmmeter reads a resistance value, you have proved that the path is continuous—you have tested for continuity; if you get no resistance reading the circuit is open and defective; if you get a varying reading, a make and break connection exists; if you compare the resistance value with what it should be, you have gone a step farther and may be able to tell if some part is shorted.

(*c*) An ohmmeter is essential to prove that a circuit is continuous, shorted or open. A circuit diagram of the receiver you are working on is of great help, as you may trace each circuit for continuity or for exact resistance by referring to the diagram.

(*d*) When a circuit diagram is not available it is possible to check a D.C. path for continuity if the following rules are remembered. Continuity in any tube circuit should exist between: *1*, a plate and the filament (or cathode) of the rectifier tube; *2*, a screen grid and the cathode of the rectifier tube; *3*, a control grid and the chassis; *4*, a suppressor grid and the chassis; *5*, a cathode and the chassis. Continuity may or may not exist between the chassis and the filament (or cathode) of the rectifier tube, depending on whether a power pack bleeder resistor is or is not used (check the circuit diagram).

(*e*) As the electrodes of most tubes in a radio receiver are series fed (through the signal circuit parts) in general a continuity check for D.C. supply will be a check on signal circuits. The exception is inductive and capacitive coupling between stages or sections.

(*f*) As a rule a break in a D.C. supply circuit destroys reception, a break in a signal circuit may create many forms of troubles, which are pointed out in the index on receiver troubles. A circuit disturbance test will indicate the defective stage of a dead receiver.

(*g*) Any part in a circuit may be checked for an open by merely connecting an ohmmeter to its terminals. Coils, resistors, and transformers may be checked for continuity and exact resistance, if you know what its value should be. Usually the circuit diagram gives the ohmic value. Condensers should test open (see section on condensers).

(*h*) An absolute check on any part with an ohmmeter should be made with one of its terminals disconnected from the chassis, for if that part is shunted by some other part or circuit which conducts a D.C. current a true reading will not be obtained. A circuit diagram will help you decide whether this procedure will be necessary. If no diagram is available, and you question the reading you get while the part is in the circuit, disconnect it for the test.

(*i*) Several ohmmeters which you can construct will be mentioned in the Course. You can build one from the parts supplied with your Experimental Outfits.

2. THE CIRCUIT DISTURBANCE TEST. (*a*) When a receiver is dead—does not play, then there are no symptoms to help you locate the trouble. A test should be conducted to find out which stage is defective. Realizing that a radio receiver is nothing more than a chain of stages (R.F., Detector, A.F., Loudspeaker sections in cascade), a simple test is possible. It is called the circuit disturbance test, and is based on the principle, that if any stage is disturbed or shocked, the current change in that stage will be relayed on towards and through the loudspeaker, coming out as a click—if the stages following the one disturbed are in working order. You can create a disturbance by *1*, pulling out and returning a tube from its socket; *2*, touching the control grid of a screen grid tube; *3*, in the case of tuned R.F. stages touch the stator section of the variable condenser in the stage being tested; or *4*, remove and return the control grid cap of the screen grid tube. Any one of these should produce a click or squeal, and as the test proceeds from the loudspeaker to the antenna the clicks should, in general, become louder.

(*b*) In locating the defective stage by means of the circuit disturbance test, start with the power output stage. Pull out the tube, and immediately insert it back into its socket. A click means: a normal section from the power tube through the loudspeaker; no click means: lack of power supply, defective loudspeaker, defective tube, or an open circuit—tests you will find in this reference book. Repeat this test for the other power tube, if one is used. If the output stage is working according to this click test, proceed to test the A.F. Detector, and T.R.F. stages for a tuned radio frequency receiver; test the second detector, I.F., oscillator, first detector, and preselector stages in the case of a super. Use any of the four methods of getting a disturbance, previously mentioned. When you go from a click to no click, the defective stage is isolated. Test the tube, and check the continuity of that stage.

(*c*) Checking the oscillator in a superheterodyne receiver by the click method may be a little confusing. A sure test is made as follows. If pulling out the first detector tube produces a click, and connecting the antenna to the grid of the first detector (set normally tuned to a local station) doesn't produce signals in the loudspeaker, the oscillator is defective. Test the oscillator tube and the continuity of its circuits.

3. LOOSE CONNECTIONS. (*a*) By a loose connection we usually mean, a connection that appears to be properly made, but actually is not a solid one. All connections must either be soldered, or securely clamped together. Only antenna and ground connections should be made through a binding post. Power supply loudspeaker and isolated sections (R.F. and detector chassis separated from the A.F. and power supply) are connected by prong and receptacle connections.

(*b*) Any connection which is insecure, that is, its contact resistance varies, is a loose connection. When the connection opens electrically it may be considered an open connection, and a physical jar or a vibration will often restore the connection.

(*c*) When noise is emitted from a receiver, and still exists when the antenna and ground leads are disconnected, and the noise will change when the chassis is violently slapped with the palm of your hand, a loose connection probably exists—a connection whose contact resistance is varying.

(*d*) Loose or improperly soldered connections can usually be located by touching the various joints in the receiver with a wooden stick. Of course, the receiver chassis and loudspeaker are removed from the cabinet, the chassis set on one of its ends so all parts are easily seen and touched, and the receiver is turned on. An orange wood stick can be used as they are very durable and can be bought at any drug store. Press firmly on each joint. Very often joints that appear to be well soldered are held only by rosin. If the receiver is properly connected for operation, the pressure on a suspected joint will usually produce a crackling sound in the loudspeaker. Another frequent cause of trouble is broken wiring under the insulation of flexible wire. Manipulation of the wire from side to side will usually indicate where the trouble occurs.

(*e*) Wiggle all cable plug connections, the A.C. plug, antenna and ground binding posts and leads, and battery lead connections; if the receiver is of the battery type.

(*f*) When the loose connection is disturbed the noise will be more violent, or may be produced at will. Quite often the loose connection may be inside the part, particularly fixed condensers. Be sure to wiggle and snap with your fingers: all tubes; tube top caps; and those parts covered with a can, case or shield; and all controls. A loose connection may be internal. If the loose connection is inside some part and the connection cannot be rectified, a new part should be used. Check socket contacts and connections.

(*g*) If with the noise, definite receiver troubles are observed (hum, oscillation, weak signals, improper control, etc.), the symptom will very likely indicate the probable cause and location of the defect. Refer to the probable causes in the index under the symptom observed.

(*h*) A total break in a connection which cannot be seen, hence called a loose connection, will not produce noise. Usually by pulling on the various leads the connection will break or noise will be heard. These loose connections can be traced with a continuity test. Furthermore, the symptom will often lead you to the probable location of the defect.

(*i*) Quite often the heat of the chassis will cause a connection to open and close. This difficulty is handled in the same way, although actual tracing of the defect may be difficult because the connection may, while testing, become secure.

4. (*a*) **SHORT CIRCUITS** may or may not destroy reception, depending of course on where the short exists. When a short destroys reception, the defective stage may be isolated by the circuit disturbance test. Read section 2. Then an ohmmeter check on each part in that stage will show up the shorted part; the ohmmeter will read zero or abnormally low resistance. If the short cannot be rectified, use a new part. Where you suspect a partial short in a high-voltage tube filament which is in series with other tube filaments, measure the filament voltage. Low voltage on this one filament indicates it is partially shorted.

(*b*) In a number of cases a part will be grounded to the chassis and in this way becomes shorted. This is often caused by a part being pushed from its correct position, or the insulation of its lead through the chassis becoming worn, thus creating the short. Repositioning the part or replacing the defective insulation removes the short.

(*c*) If the short does not destroy reception, only ruins it, the symptoms observed will help localize the short, and then the parts in the circuit can be checked with an ohmmeter.

5. HIGH RESISTANCE AND CORRODED CONNECTIONS. (*a*) A connection or joint of only a few ohms is not wanted as it produces many undesirable effects. Anything above a near zero ohm connection is referred to as a high resistance connection. Although a low range ohmmeter (0 to 10 ohm range) will allow you to check such joints, it is easier to spot these poor connections and make new ones. Here are a few hints in spotting high resistance joints.

(*b*) Joints that have an excessive amount of rosin, are likely to become poor joints. Resolder such connections.

(*c*) A greenish covering on a joint indicates corrosion and eventually a high resistance connection. Resolder such connections, or clean corrosion off if only a pressure contact is used.

(*d*) A connection made with excessive solder may have a high resistance if the two parts or wires to be connected are separated by a lump of solder instead of being soldered close together. Such joints are particularly objectionable in short wave circuits.

(*e*) A good solder joint may be made if the two surfaces to be connected are cleaned, tinned and physically clamped together before being soldered. Acid or acid core solder must not be used.

(*f*) High resistance and corroded connections will result in feed back, poor selectivity, lack of sensitivity and many other defects indicated in the index of receiver troubles.

6. TUBES. (*a*) It is safe to say that a majority of receiver troubles are caused by tubes which are bad in one way or another. The filaments of tubes may burn out, may lose their emission, their elements may short, the tube may become gassy, its characteristics may change and poor connections inside the tube may develop.

(*b*) The most satisfactory test of a tube is to try a new one in its place. A test in a tube tester is not always sufficient because although the tester may indicate that the tube is good it may not be satisfactory for certain purposes.

(*c*) For example, a tube may have a slight amount of gas. It would be entirely unsatisfactory for use in an automatic volume controlled or oscillator stage, as the output volume would vary. (It might work fine in another stage of the receiver.) Power tubes should show no glow between elements and they will if gas is present. A blue glow on the glass is natural, a condition of fluorescence.

(*d*) In many service shops the first thing which is done to a set coming in for repairs is to remove the old tubes and try an entire new set. Should the trouble clear up, the old tubes are reinserted one at a time until the bad one is located by recurrence of the difficulty.

(*e*) Elsewhere in the Course, we show how tubes may be tested in regulation tube testers and if you have such a tube tester you need only follow the manufacturer's instructions. Also, we show how short checkers can be made and operated. An ohmmeter, however, will enable you to check a tube for shorts. The only two prongs which should show continuity are the filament prongs.

(*f*) By placing your hand on a tube while the receiver is operating, you can often-times tell whether it is working. If the tube is cool it has no plate current and a new one should be tried. Excessive heat may indicate the presence of improper control grid voltage or circuit defects which would result in excessive plate or screen voltage and this would lead you to make actual voltage and current measurements on that stage.

(*g*) Noisy tubes can be tested by snapping them with your finger when the set is operating. If this causes the noise to show up, a new tube should be tried.

(*h*) When choosing a tube for use in an automatic volume stage, tune in a weak signal and then try a number of tubes. Use the one which reduces the volume the least but cuts the volume down on powerful stations.

(*i*) When several similar type tubes are used in the same receiver (for example, three type 58 tubes) interchange the tubes for the best results.

(*j*) Whenever tubes are used in pairs (push-pull, push-push), it is important that two tubes each with the same characteristics be used, otherwise hum and distortion may result. Full-wave rectifier tubes should have equal emission per plate. Balanced tubes are best checked in a tube tester, but they must also be checked in the receiver as a receiver short or ground may exist.

7. (*a*) **PILOT LIGHTS** are a source of nuisance and trouble. They burn out or cause receiver troubles. Their voltage rating should be equal to the voltage of the filament line to which they are connected, if a shunt connection is used; or their current rating equal to the line current if a series connection is used. Check the voltage with a low range A.C. voltmeter, if a large number of burn outs occur; or check the circuit diagram and determine by referring to a tube table what the filament current should be of the tubes with which the lamp is in series.

(*b*) A pilot lamp with higher voltage rating than the source voltage may be used, if sufficient light is obtained; but a low voltage lamp must not be used on high voltage source. For example; a 6.3 volt pilot lamp may be connected to a 5 volt source, but a 5 volt lamp must not be connected to a 6.3 volt source. A lamp with higher voltage rating than its source will burn dim.

(*c*) Loose connections in the pilot lamp circuit or failure to screw the lamp tightly into its socket will cause a flicker. It is possible to solder these lamps in place, if they get loose too often. A loose connection in the pilot light circuit will often times cause noise. You should be sure that the pilot lamp leads cannot be hit by the tuning condenser mechanism as it revolves.

(*d*) In some universal sets, the pilot lamp is used as a fuse, in series with the filaments. In others, the lamp is shunted across a resistor, tube filament or a section of the ballast tube. If the lamp burns out, excessive voltage will exist across the part shunted.

If the pilot lamp is shunted across a section of the rectifier tube filament and the rectifier plate is fed from the filament tap, be on the lookout for broken-down filter condensers as they would cause the rectifier plate current to be excessive and this would burn out the pilot lamp.

Always replace any burned-out pilot lamps found in universal sets. Use an exact duplicate type as the voltage and current rating is very important in such a set.

(*e*) In receivers using a center tap filament circuit care must be taken that the pilot lamp does not become grounded as this would unbalance the center tap and hum would be heard.

(*f*) To be on the safe side always use high quality pilot lamps for replacements.

8. (*a*) **RESISTORS** are made in three general forms: *1*, wire wound on a tube (porcelain or bakelite) and often coated with baked vitreous enamel; 2, resistance material like carbon mixed with a binder (bakelite resin or a ceramic), extruded into rods, cut and baked; *3*, glass or porcelain coated with a resistive material. Of course, these elements are capped with terminals, coated with enamel and labeled to improve their appearance, and to help identify their value. A resistor is rated as to resistance and power dissipation. For ordinary radio receiver use, wire wound resistors are accurate to 5 percent, ceramic and coated (metallized) resistors are accurate to 10 percent. These facts are important in checking their ohmic value. The exact value is dictated by the use to which a resistor is put. For replacement be governed by the service diagram, or label or color code on the resistor found defective

(*b*) Power rating is important if you want the resistor to stand up. Grid resistors may be 1 or 2 watt types, plate resistors 2 watts, bleeder resistor 5 watts and power pack resistors must be calculated or manufacturer's specifications followed. In the final analysis the watts dissipated in a resistor is the current through it in amperes, times the voltage drop. If the resistor is under the chassis or covered, the resistor should have a rating 4 times this computed value; if the resistor is well exposed to air a safety factor of 1.5 to 2 times, will suffice. It is a good idea to never use a resistor less than 1 watt rating where space will permit.

(*c*) There are other ways of judging a resistor: voltage, temperature, and age tests; but if a reliable make of resistor is used, these items may be ignored.

(*d*) There is only one simple way of testing a resistor—with a multi-range ohmmeter (one part of a multimeter). It should be able to test as low as one ohm and at least as high as 2 megohms. When a good ohmmeter is not available, you may use a 0-50 voltmeter connected in series with a 45 B Battery block. Of course, only continuity may be checked. The free end of the voltmeter and the battery are connected to two probe leads. Bring the two probe points together and note the deflection; it should be about 45 volts. Now when you connect the probes to a resistor and get maximum reading the resistor is either shorted or has a very low resistance; if no reading is obtained the resistor is open; any in-between reading indicates continuity and the resistor is *probably* o. k. If you use an ohmmeter (calibrated to read directly in ohms) there is no guessing about the resistor value. Now for a few hints.

(*e*) In testing any resistance, always be sure that it is not connected to other apparatus, such as a coil; as this would give an apparent short-circuit reading. If the resistance is in a receiving set this can be determined by very carefully checking over the entire circuit to which the resistor is connected, using the schematic diagram if one is available. In case of doubt on this subject, it is the best policy to disconnect one lead of the resistor from the circuit for test purposes.

(*f*) In the case of tapped resistors such as those used in many power packs and also the **hum** adjustors on many sets, it is necessary to test each individual section of the resistance.

(*g*) It sometimes happens that a resistance may not burn out, but may change in value, either increasing or decreasing. Occasionally an incorrect resistor may accidentally be placed in a circuit. In such cases it is necessary to use an ohmmeter in order to check the resistor with the value specified in the manufacturer's service data.

9. BALLAST RESISTORS. (*a*) Unless the ballast has been chosen correctly, either the ballast itself or the tubes will burn out too often. Ballasts are rated as to their current carrying capacity and average voltage drop. The latter means that if you set the primary of a power transformer to 100 volts, the ballast takes up the voltage difference in the line supply. Receivers using 5, 6, 7, 8, etc. tubes require ballasts of different current capacity. Be sure to order and use a ballast for:

A: the wattage or number of tubes in the receiver, and

B: for either 100 volt or 85 volt primary transformer voltages.

Buy from a distributor or manufacturer willing to give you help in selecting the proper size ballast.

(*b*) The ballast will burn out if it was designed for a receiver of less wattage or tubes —or for a lower primary voltage. If the ballast was designed for a set with more tubes, the ballast action will be less and more chances for tube burn outs exist.

(*c*) A number of line voltage controls are either variable resistors or resistors of fixed ohmic value. They do not have any ballast action. A ballast of reliable make is preferred on a line of varying voltage.

(*d*) Modern battery receivers employ filament supply ballast resistors. In some receivers, the filament system is divided into two sections each controlled by a ballast; both ballast resistors in the same ballast tube. If one burns out the tubes in that section do not heat up. Check the radio tubes, if found o. k. check the ballast. A check consists of a continuity test and inspection of the part value used in the receiver. A ballast resistor of the glass envelope type should burn a deep cherry red.

(*e*) If the ballast resistor has been shorted accidentally or intentionally because the latter has to be replaced too often, the radio tubes will quickly burn out. If the correct ballast is used and burns out too often, the receiver is defective (see index for probable causes).

10. VOLUME CONTROLS OR VARIABLE RESISTORS. (*a*) Volume controls usually are some form of variable resistance. They are either of the wire wound or coated type. First inspect the volume control for mechanical perfection. No wire should be loose and the resistor coating should not be flaky. The movable contact should be firm against the resistor element, and make a good contact. The arm should turn freely. Then connect an ohmmeter to it and see that as the movable arm is rotated the resistance varies without sudden changes. If the resistance element is broken or worn it should be considered as defective and the entire volume control replaced.

(*b*) A popping, cracking noise heard in the receiver only when the volume control is adjusted is positive indication that the device is defective. (An exception—a good volume control in the c bias or grid circuit of a gassy tube will give this action—try a new tube.) Generally speaking, it is not practicable to attempt to repair a volume control. It should be replaced with a new one which can be obtained from the distributor of the receiving set in your locality or from any large radio supply house, if you give them the exact name and model number of the receiver.

(*c*) Before removing the old control prior to replacement draw a picture diagram of the connections—then it will be easy to connect the new control.

11. CONDENSER, FIXED. (*a*) Most fixed condensers used in radio receivers either use wax paper or mica as the dielectric and are therefore referred to as paper or mica condensers. Paper condensers are either housed in aluminum, tinned sheet steel, moulded bakelite or paper containers with suitable lugs protruding as the terminals; mica condensers are moulded inside of bakelite forms. Moulded condensers are usually small capacity devices, rarely over .05 microfarads; the paper condenser values range from .05 to 10 microfarads.

(*b*) Condensers are first rated as to their capacity—in microfarads. A variation of 10 percent (except padding condensers used in the oscillator circuit of a superheterodyne receiver) is of no importance. Although a capacity checker is used by a few servicemen, it is not an essential service device. Be governed by the service diagram for the correct value to use; the capacity on the condenser label or case put on by the condenser maker is a sufficient guide. If no service diagram is available use: .1 to .25 mfd. for R.F. and I.F. bypasses; .25 to 1 mfd. for A.F. bypass; 1 to 10 mfd. for C bias resistor shunt capacitors in A.F. circuits; .00025 for grid leak detectors; .0001 for R.F. coupling condensers; .01 to .25 for A.F. coupling condensers.

(*c*) The voltage rating of a fixed condenser is important. The voltage across the terminals to which the condenser is connected is your guide. Its rating should be greater than this value. Many servicemen never use a fixed (paper or mica) condenser with less than a 600 volt rating even if the condenser is to be used in a low-voltage circuit. The increase in cost is only a few cents and this is excellent insurance against a call-back. Buffer condensers in vibrator power supplies should be rated at 1600 volts or more. Filter condensers of the paper type should have a 600 volt rating. These are good replacement rules to use.

12. OPENS AND LEAKS. (*a*) The easiest way to locate an open condenser in a receiver is to place the receiver in such a position that the connections to the various condensers can be easily reached. Turn the receiver on and then connect a condenser of approximately the same size and known to be

in good condition across the connections to the condenser which you are testing. If normal reception is obtained when making the connection it is an indication that the condenser under test is defective.

(*b*) Another method of testing a condenser is to entirely disconnect the condenser from the receiver and to then charge the condenser by momentarily touching the connections of a 45 volt "B" battery across the condenser terminals. A condenser, not of the electrolytic type, should hold a charge for several minutes, which can be checked by shorting it and observing the spark. If the charged condenser being tested is of small capacity, the cord tips of a head-set can then be touched to its terminal, care being exercised not to touch the cord tips or the condenser terminals with the fingers. A sharp click in the phones when the contact is made indicates that the condenser is in good condition and has held the charge. In the case of paper condensers having a capacity of .5 mfd. or larger, merely short circuiting the terminals after the condenser has been charged should produce a bright spark accompanied with a loud snap. Such a condenser should be able to hold a charge three or four minutes between the time it is charged and discharged.

(*c*) If the condenser does not hold its charge and no spark or a very feeble spark is obtained it indicates that the condenser is leaky or open and it should be replaced with a new condenser. If a high voltage, high range ohmmeter is available, capable of measuring up to 50 megohms, a good 1 mfd. condenser should show not more than 50 megohms leakage resistance.

(*d*) If the leak in a fixed condenser varies, noise will result. After prying parts and connections with an orangewood stick to be sure they are not at fault, then unsolder each fixed condenser and listen if the noise has disappeared (set turned on). Resolder connections before testing another condenser. If reception stops, a temporary perfect condenser should be used. Defective resistors causing noise may be located in the same way provided opening the circuit does not stop the receiver. Don't solder or unsolder with the set turned on.

13. SHORTS. (*a*) Condensers, not of the electrolytic type, can best be tested for shorts and leaks by connecting an ohmmeter, or a voltmeter in series with a battery, across their terminals. A steady reading should not be obtained. A momentary deflection of the pointer of the meter, which then returns to zero, indicates that the condenser is neither open nor shorted. If a steady deflection is obtained it indicates that the condenser is defective and it should, of course, be replaced.

14. (*a*) **ELECTROLYTIC CONDENSERS** are made in two forms for use in radio receivers: the wet type in a long cylindrical aluminum can; or the dry (paste electrolyte) in a paper container. Although some are made with 2, 3 and 4 units in one container, the usual form is a single unit electrolytic condenser. An electrolytic condenser has polarity. In the metal container unit the can is invariably negative, the insulated electrode the positive terminal; in the case of paper wrapped electrolytics the container near each lead or lug is marked + or −. If no marking is to be seen the red lead is invariably +.

(*b*) Electrolytic condensers are rated as to capacity and working voltage. For filter use the most common sizes are 4 and 8 microfarads, although small and larger capacities are readily obtained. Use only condensers with a rating of 450 to 475 D.C. working volts.

(*c*) A.F. bypass condensers are often of the dry electrolytic type. As the required voltage rating is low, and the capacity high, a small compact unit is available. Units of 10, 25 or 50 microfarads with 25 to 75 volt ratings are used. For filtering rectified A supplies 15 volt-1000 or 2000 microfarad dry electrolytics are employed.

(*d*) In replacing an electrolytic be guided by the specifications given on the service circuit diagram, wherever possible; otherwise be guided by the information given elsewhere in this book.

(*e*) Electrolytic condensers develop shorts and opens and may also develop trouble which is not made evident by tests the ordinary serviceman has facilities to make. For this reason, it is recommended that, if a large amount of service work is done, a 4 and 8 mfd. electrolytic condenser with a high voltage rating be carried with you on all jobs for test purposes. The leads of the condenser suspected of being defective can be unsoldered and the one you know to be in good condition can be connected in the circuit in its place. This will give you a check on the original condenser.

(*f*) To test for short circuits or excessive leakage through an electrolytic condenser, a 0-100 milliammeter should be connected in series with the condenser while the receiver is in operation. However, before turning on the power a 6 or 10 ohm rheostat should be connected across the terminals of the milliammeter. The rheostat should be of the type that has an open end; in other words, so that the rotating arm can slide off of the resistance winding which, in effect, means the rheostat is not connected across the milliammeter. The rheostat shunts the meter and increases its range, which will prevent burn-out of the meter if the condenser is entirely shorted or while the film of the condenser is building up.

(*g*) The receiver is then turned on. At first the current through the condenser is likely to be as high as 85 or 90 milliamperes. However, this high value of current should only be evident momentarily and after three or four minutes of operation, the current through the condenser should reduce to less than ¼ milliampere per microfarad. In other words, if the condenser under test is an 8 mfd. electrolytic condenser, the total current flow as measured by the milliammeter after five minutes of operation should not be more than eight times ¼ or 2 milliamperes. If more than 2 milliamperes is measured after a few minutes of operation, then the electrolytic condenser has excessive leakage and another one should be used in its place. Unless the condenser is completely shorted, the rheostat should be turned to the off position so as to ge the true value of current through the condenser.

(*h*) Many servicemen test an electrolytic condenser by shunting it with an 0-1 megohm ohmmeter (an ohmmeter with a 45 battery is preferred). Connect the ohmmeter so the ohm indication increases, showing that the film is building up. As an average value the reading should exceed 1 megohm. You should check several good electrolytics to obtain an idea of what this value should be with your ohmmeter.

(*i*) Electrolytic condensers, it has been mentioned, have positive and negative terminals and if they are connected into a circuit incorrectly they will pass too much current. This may cause them to make a hissing or frying noise, and if kept up for any length of time, ruin the condenser, rectifier tube, and filter chokes.

(*j*) A voltage applied to a condenser higher than its rated working voltage will cause it to hiss and fry and eventually break down. This happens quite often, when the loudspeaker cable has not been connected to the chassis. Any defect in the power stage or loudspeaker that removes the load on the power pack, increases the rectified output voltage, will have the same effect.

(*k*) Electrolytic condensers that have not been used for a long time, especially in cold weather, may hiss and fry when voltage is applied to them due to the fact that they are improperly formed. Usually this will not last over a few minutes after which they will be in good condition. But if they hiss, watch the rectifier tube. If the space between the elements starts to turn blue shut the power on the receiver off at once. Use a new electrolytic.

(*l*) In checking an electrolytic condenser by the substitution method, listen to the receiver play so you can tell whether the new one makes an improvement in results.

15. TUNING OR ADJUSTING CONDENSERS. (*a*) *Variable condensers* are usually rated as to maximum capacity. Their minimum capacity and high frequency resistance are important factors but these factors are not easily checked by a serviceman. Always consider the maker, and when a replacement is required insist on an exact duplicate. In general a good variable condenser may be judged by its mechanical construction. The plates should be large gauge sheet aluminum, alignment of plates exact, and the frame of solid appearance. Sliding or pigtail connections should exist at each rotor section.

(*b*) Many service calls may be traced to defects in the tuning condensers. The plates of the condensers sometimes touch each other. They should be carefully bent so that this does not occur. Dust or dirt between the plates may be removed with a pipe cleaner. A metallic fuzz sometimes gets between the plates causing shorts to occur at some points of the dial setting. A pipe cleaner will not remove this. It may be removed by burning it off by the application of a high voltage across the condenser plates. Unsolder the lead to the stator plate and apply the high voltage directly across the condenser, turning the tuning knob so that all shorts will be burned out. Dirt may be removed and leaks between plates may be eliminated by the same process. This voltage may be obtained from the high voltage winding of a power transformer, not the one in the set; and to protect the transformer a 100 watt lamp should be placed in series with the primary.

(*c*) The connections between the rotors of the tuning condensers and the chassis are very important. Should a poor connection occur, the ground will have to be through one of the other tuning condensers and this may result in feedback and consequent oscillation. When spring wiping contacts are used bend them to get a good contact and if necessary sandpaper all points of contact. Sometimes a pigtail (flexible) wire may be used to ground the rotors. If the wire cannot be readily soldered to the condenser shaft a small hole may be drilled in the shaft and a screw used to connect the wire and the shaft. Enough slack must be left so that the pigtail can wrap around the shaft when the condenser is turned.

(*d*) In some poorly designed receivers the condenser plates are so thin that they will vibrate. Naturally this change in capacity will cause very unstable reception. In most cases a new condenser gang is about the only remedy although some servicemen float the condenser on soft sponge rubber to reduce the vibrational pickup.

(*e*) If you find that it is impossible to tune a receiver over its entire range examine the tuning condensers as they may hit a wire or other stationary object which prevents them from turning.

(*f*) *Trimmer Condensers* sometimes short and they should be tested for continuity. Remember when testing any condenser to disconnect one of its leads otherwise you will obtain a reading through some object shunting it. If the mica in a trimmer condenser appears cracked it may be removed and a new piece installed.

(*g*) To check a section of a ganged condenser or a trimmer, unsolder the lead from one end of the condenser so the coil shunting it is disconnected, and check the condenser with an ohmmeter. No reading should be observed.

16. (*a*) **COILS, R.F. CHOKES AND A.F. TRANSFORMERS** are an important part of a radio receiver and naturally are used for their inductance. We will consider: *1*, the R.F. coils wound single layer on an insulating tube; *2*, the multi-layer coil used extensively in I. F. transformers, primary of R.F. transformers, secondaries of coils in midget receivers, and R.F. and I.F. choke coils; and *3*, the audio transformer.

(*b*) R.F. coils are fundamentally designed to have a definite inductance, a minimum amount of distributed capacity, and low high frequency resistance (or Q factor). The high frequency resistance cannot be judged from its D. C. resistance (measured with an ohmmeter) and is generally much greater. Audio transformers are designed for a definite frequency range, definite D.C. primary current, turn ratio and minimum distributed capacity, and maximum watt handling power. Tests for these properties are not made by the serviceman, unless a great deal of original designing is done.

(*c*) The usual tests are for continuity, opens, shorts, grounds and D.C. resistance of the windings. In the case of coils used in a tuning section the coils must match: have equal inductance and distributed capacity, best accomplished by using identically constructed coils.

(*d*) In connecting an R.F. or A.F. choke remember that they are so designed that the inside turn (nearest the core or form) is the ground or a low potential connection, the last outside turn is the high voltage (R.F. or A.F.) terminal. In connecting R.F. or A.F. transformers the inside turn of the primary (one nearest the core) is the plate connection; the outside primary turn, the +B connection. In transformers the outside turn of the secondary is the grid terminal, the inside turn (nearest the core) is the ground connection. In tracing the coils from the plate, to +B, to ground, to grid, a continuous winding, all in the same direction, should exist. Most servicemen merely reverse primary or secondary connections, and observe whether an improvement exists. In the case of split primary or secondaries, the center tap is ground, +B or −C, and the outer two terminals are the plate or grid connections.

(*e*) To test for continuity or winding resistance use an ohmmeter, the probes connected to the two terminals of the winding you wish to measure. Be governed by the values given on the circuit diagram. Shorts between a few turns are not easily detected by this test. Shorts in R.F. transformers can be judged by inability to line up the stage with another, broad tuning and lack of selectivity; in audio transformers no easy means of detecting a short between a few turns are possible. Of course, a replacement test will quickly show up any short; the action of the receiver will indicate its presence. Opens are easily detected by a continuity test. By unsoldering the terminals of a coil, choke or transformer, grounds or shorts to the frame or core are easily detected with an ohmmeter. Connect the ohmmeter to one terminal of each winding (the receiver leads unsoldered), and the core, or chassis of the device. No reading should be observed. Leaks are detected by employing a high range ohmmeter (at least 2 megohms).

(f) *Opens* occur because of poor soldering, corrosion at joints, and a physical tear; *shorts* are produced by high voltage arc overs, atmospheric conditions (moisture and fumes in the air), and tampering; *leaks* occur because of accumulation of dust and dirt plus moisture, breakdown of insulation; and *change in inductance* because the windings get loose, are crushed physically, or the shield has been disturbed.

(*g*) A physical inspection of coils is imperative. If the coil is moist be sure to bake it under a lamp. Go over joints and connections. Be sure the windings and shields are intact. Test for opens, shorts, leads and resistance of windings.

(*h*) If an R.F. or I.F. coil is damaged beyond repair (one or two turns may safely be removed) use a new coil. Do not try to replace a secondary or a primary. Get a whole new part and an *exact* duplicate preferably made by the maker of the receiver you are servicing. If the new (or old) coil will not align with the others, either the other coils must be adjusted for turns, or a whole new set of coils procured and used.

17. POWER TRANSFORMERS AND IRON CORE CHOKES. (*a*) *Power Transformers* are designed to operate from a line of a definite frequency and voltage; to supply definite voltages from the secondaries when definite currents are drawn; and to handle a definite total ampere × volts—the apparent watts rating. *Iron Core Chokes* are designed to have a definite inductance (usually measured in henries) when a definite D.C. component flows through it. It must be able to handle this current with negligible temperature rise. The serviceman in making a replacement must assume that the new device is correct in these respects because reliable makers rate their devices correctly. Other than this the usual tests are for opens, shorts (continuity), resistance of windings and leakage. A number of special tests will now be considered.

(*b*) In testing a power transformer or iron core choke in the chassis with an ohmmeter make sure that there are no resistors or other parts capable of passing a D.C. current connected across it; otherwise the readings will be incorrect. When in doubt unsolder the connections, so the terminals of the device are free.

(*c*) A test should be made between the transformer taps or terminals and the core and shield of the transformer. No reading should be obtained. If the ohmmeter shows a reading, it indicates that the winding is grounded or leaky to the core or shield and the trouble should be repaired at once. No reading should be obtained when testing between any secondary winding and the primary winding. As the center tap on the secondary of the power transformer is usually grounded —unsolder the connection for a ground or leak test.

(*d*) Shorted turns in some cases can be checked with an ohmmeter, comparing the resistance you read with the value given in the circuit diagram. A short in the primary turns may increase the secondary voltage and overheat the transformer; a short in the secondary turns of a transformer will reduce the secondary voltage of the section shorted and overheat the device. The best test for a transformer or iron core choke is to connect it to a source of correct voltage and frequency (secondaries open in the case of transformers) and measure the A.C. primary or coil current. In the case of transformers the current should be less than .25 ampere; if more than that value a short exists. Even lower values should be indicated in checking a choke. Considerable experience is required to interpret the readings.

(e) Secondary filament windings on power transformers sometimes have center taps to which the grid returns are connected. If these taps are not exactly in the center of the winding, then A.C. hum is apt to be present. This trouble is seldom encountered in transformers manufactured by reliable companies. In such cases it is, of course, impractical to reconstruct the transformer. It is possible, however, to use small center-tapped resistances especially built for the purpose. The two ends of the resistance are connected directly across the filament taps on the transformer and the center tap of the resistance is used in place of the center tap on the winding, which is not used and should be disconnected. It is impossible to center tap the high voltage winding in this manner.

(f) Loose Laminations in a replacement part are usually due to faulty construction and the defective piece of apparatus should be returned to the manufacturer. In some cases the laminations can be tightened by tightening the bolts holding the apparatus together or by driving a small wooden wedge between the laminations.

18. SWITCHES. (a) The power off and on switch may become defective. This is easily indicated by the lack of light from the pilot lamp or the other tubes in the receiver. Of course, a careful check must be made to determine definitely whether or not the radio receiver obtains its power from the wall outlet. The power cord and plug, and fuses if used, must be in good condition. If the switch is defective (always open) then there will be no continuity when testing the plug tap terminals with an ohmmeter; if always closed it will be impossible to turn the set off. These conditions will occur with the switch in the closed or open position.

(b) The inductance switches used in all-wave sets may cause noise if they are dirty. Dirt will also cause certain bands on an all-wave receiver to be dead. Clean the contacts of the switches with a clean cloth (free of oil) using a little carbon tetrachloride (Carbona). This will remove all grease and dirt from the switch contacts.

(c) The rotating arms of all of the sections of an inductance switch must rotate when changed from one band position to another. Any switch arm failing to make contact should be repaired. Bend the switch arm into the proper position if it is damaged.

19. (a) **SHIELDING** in receivers is employed to prevent undesired coupling between circuits. Lack of shielding will result in oscillations and broad tuning. Not only lack of shielding will cause this but also poor or inefficient shielding. Dirty connections between shields and the chassis make them ineffective and you should be sure that the connections are tight and clean. A little sandpaper rubbed over the points of contact between the shield and chassis will eliminate this cause of trouble. Loose shielding will result in mechanical noises when set into vibration by sound waves from the speaker. Also, loose shielding will cause noises to arise in the receiver circuits and this noise will be heard from the loud speaker. Bending the shields so that they tightly grip their supports will prevent this. Be sure that the shields are in place, and not pushed out of line or to one side.

20. MECHANICAL TROUBLES. (a) Once the source of a mechanical trouble is located the repair is obvious. If a dial cord slips, the tension on the cord should be increased. The manner in which this should be done will be clear after an examination of the particular system in use. Perhaps a spring has slipped off its hook or a screw needs tightening.

(b) If a bearing is frozen (jammed) "3 in 1 oil" should be worked into the housing; if the bearing does not turn freely, remove it and rub it down with a fine sandpaper, return it and use a lubricant with a graphite base. The turning condenser gang must turn easily, particularly where a rubber friction drive is used—oil bearings and if there are any tension screws at the end of the shaft, loosen them until the gang moves freely.

(c) Where the dial cord has broken it is necessary to install a new cord, which should be obtained from the manufacturer or his distributor. Oftentimes you will be able to obtain, on request, specific instructions on restringing the cord along with the new cord you order. It is possible to get along nicely without such instructions but then one must pay careful attention to the system, figuring out in one's mind just how the cord must go on if the system is to work properly. You may have to try two or three times before you get it just right.

(d) In any mechanical trouble, personal observation is the key to success. In radio receivers all mechanical systems have been made as simply as possible although hardly any two are alike.

(e) You must be the judge of when replacement of parts will be necessary. When new parts may be easily obtained and the originals seem badly worn, don't waste time trying to patch them up—put in new ones.

21. (a) **BATTERIES** are used extensively on receivers where socket power is not available. These battery receivers are to be found in camps, farms, rural and unwired homes. Then, too, there are obsolete battery operated receivers in homes where a modern all-electric receiver has not been installed. In all these cases, the batteries must be carefully inspected and tested as they are a constant source of trouble.

(b) *"A" Batteries* furnish power to heat the tube filaments, and if they run down (voltage drops) they no longer serve their intended purpose.

(c) Storage Batteries generally consist of three 2 volt cells in series, a total of 6 volts. Checking the voltage of each cell is only an approximate means of testing the cell. A true voltage check should consist of loading the battery (the set turned on) and checking each cell for voltage at the start of the test run and 10 to 20 minutes later. The voltage should not be less than 1.9 volts per cell. A better

and quicker test is to check the *specific gravity* of the electrolyte (liquid) in each cell, with a hydrometer. When the reading drops below 1.150 the battery should be recharged. The electrolyte in a fully charged cell should have a specific gravity of about 1.300. Connect the battery to a charger with the vents of each cell open. Charge until the electrolyte in each cell bubbles. Check the specific gravity of each cell, which should be about 1.300. If one cell shows a low density electrolyte, try charging this cell for a couple more hours and if the density of the electrolyte does not come up, have the cell repaired at a reliable battery repair station. If at the start of the charge, the liquid in any cell is low, add distilled water only, to about one-half inch above the plates.

(d) Confusion sometimes arises in determining the polarity of the terminals. The plus terminal may be marked +; or it may be painted red; or if you connect a D.C. voltmeter to the terminals of the battery so the meter needle reads up-scale, the + terminal of the voltmeter (always marked) connects to the + terminal of the battery. The latter is a good test for any D.C. source of power.

(e) All battery terminals should be kept clean and tight. Connections to storage batteries should be carefully watched as they corrode quite easily. If the terminals are corroded they can be cleaned by scrubbing vigorously with hot water, being careful not to let the water get into the cells of the battery. After the terminals are cleaned the connecting wires should be attached by means of battery clamps which also have been carefully scraped until they are clean and bright. A liberal application of vaseline applied over the storage battery terminals and connections will tend to eliminate corrosion.

(f) *Air Cells* are best tested with a voltmeter. To be sure that the battery will not be drained too much, use a high resistance voltmeter (any radio voltmeter will suffice). The voltage should not be below 2 volts. The best test is to check the battery voltage before and after a 10 minute test run. A radical change would be at least .1 volt. Then if the voltage is below 2 volts get a new air cell battery. Follow the instructions in filling it with water, and be sure that the cellophane on the breathing electrodes is taken off.

(g) *Dry "A" Cells* are extensively used for filament supply on modern 2 volt tube receivers. Two in series are required and sets of two all in parallel help to get greater life between battery changes. Dry cells are tested with an ammeter connected across the terminals. When new, about 35 amperes is normal. When the combination can no longer supply more than 2.5 volts, the cells should be discarded. A load test should be made. If the voltage drops rapidly while used, the life of the battery is exhausted. If a line variable resistor is used be sure to caution the customer not to reduce its value too often. A change of once a month is normal. Always replace the entire set of cells, for one bad cell will throw the load on the good ones.

(h) *"B" and "C" Batteries* must furnish current to the various electrodes of the tubes. Follow the markings on the cable tabs or the receiver instructions.

(i) "B" and "C" batteries should be replaced with new ones just as soon as the voltage has dropped 20 per cent. That is, any 45 volt battery should be replaced as soon as the voltmeter reading shows a voltage as low as 36 volts under load.

(j) It occasionally happens that a defective connection or a defective cell *inside* a battery will develop and cause trouble. The only remedy is to replace the entire battery with a new one.

(k) Reception frequently can be improved by placing a bypass condenser across the "B" and "C" batteries. Connect one terminal of a condenser having a value between .1 mfd. and 1 mfd. to minus B and the other terminal of the condenser to the highest voltage terminal of the "B" batteries—that is, 90, 135 or 180 volts as the case may be. The connection should be in the set if it is found that the condenser improves the results.

(l) It is actually more economical to use large "B" blocks instead of small capacity "B" batteries. The initial cost is greater, but the over-all cost is less.

22. VOLTAGE AND CURRENT MEASUREMENTS AS AN AID IN LOCATING THE DEFECT. (a) Voltage measurements afford a quick check on the voltage supply circuits but usually are of no use when a signal circuit defect exists. For example, an open coupling condenser or a shorted tuning condenser will have no effect on the operating voltages.

(b) You must be "on your toes" when making voltage measurements. The actual measurements are simple but the proper interpretation of the results is a more difficult matter. You must remember that the voltmeter is not only a measuring device but that it is also a resistor. Many a serviceman has been puzzled by the fact that on measuring the voltage across some part of the set started to play. The part was burned out but the meter when connected across the part completed the circuit.

(c) For the experienced man as well as the beginner, good equipment is necessary if satisfactory results are to be obtained. The best outfit to own is a good high resistance multimeter which will enable you to measure currents, resistance values, and A.C. or D.C. voltages.

(d) Now suppose you have something with which to check voltages, whether it be a multimeter or the parts in your experimental outfits. The chassis is turned upside down and with the negative test probe from the meter on the cathode of one of the tubes touch the positive lead to the other elctrode prongs one at a time. Write down your readings so they may be compared to those furnished by the manufacturer. If the grid return is made to the chassis a check from cathode to chassis will give the control grid voltage, otherwise a test must be made from the control grid to chassis. If the control grid bias voltage is correct, the plate current is in all probability of the right value. To measure the plate current the set is turned off, the lead to the

...e disconnected and the milliammeter leads connected to it and the plate. This places the milliammeter in series with the plate and on turning on the set the plate current will gradually come up to normal if everything is all right. A socket plug in adapter simplifies current and voltage measurements.

(*e*) In checking the rectifier, a test with the D.C. voltmeter connected from the filament or cathode to chassis will check the general condition of the tube and power transformer high voltage winding. The power transformer may be checked by itself with an A.C. voltmeter. The high voltage winding has about 700 or 750 volts A.C. across it and the winding is center tapped in the case of full-wave rectifiers. Each half may be measured separately from a rectifier plate to the center tap which may or may not be directly grounded. The entire A.C. voltage is measured by connecting the A.C. voltmeter to both plates.

(*f*) In making measurements always use the highest range of the meter. This will protect the meter if the voltage is higher than normal and will show if a lower range may be used. Never use the milliammeter to measure voltage as this will burn out the meter. If the meter reads backwards, reverse the test probes. Use the A.C. range for A.C. measurements and the D.C. range for D.C. measurements.

(*g*) The internal resistance of your meter will affect the reading you obtain when testing voltages in high resistance circuits, such as plate and control grid circuits of resistance coupled systems. The lower the resistance of your meter the lower will be the measured voltage. The meters used by manufacturers when making up their voltage charts generally have a resistance of 1000 ohms per volt. A 1000 ohm per volt voltmeter will be satisfactory for you, although you may use a 20,000 ohm per volt meter, if you wish.

(*h*) Remember that slight differences in line voltage will change your readings and that manufacturers' tolerances in resistor values will introduce another cause for variation from specified voltage values. As long as the measured values are within 20% of the specified values they are to be accepted as normal, if you use a 1000 ohm per volt meter. Where recommended voltage charts are not available, tube manufacturers' charts will give you *some* idea of what to expect although you must not follow them too closely. After you have done some service work you will know without charts whether the voltages are approximately correct.

(*i*) The following index is to help you interpret voltage and current readings. Study the index carefully.

COMMON CAUSES OF INCORRECT VOLTAGES AND CURRENTS

High Plate Potential

Insufficient load upon power pack due to weak tubes.
Open high current load in receiver.
Short circuited voltage reducing resistance.
High line voltage.
High grid bias voltage.
Incorrect tap upon power pack divider.
Open bleeder resistance between circuits.
Open bleeder resistance in divider.
Shorted filter choke or loud speaker field in power pack.

HIGH PLATE VOLTAGE ON ALL TUBES

(Output Tube Plate Current Low)

Excessive grid bias resistor (output stage).
Defective output tube or tubes.

LOW PLATE POTENTIAL

Excessive current drain upon power supply.
Open or leaky filter condenser.
Insufficient grid bias.
Shorted bleeder resistance.
Low line voltage.
Defective operation of line ballast, replace with a new one.
Leak through bypass condenser.
Shorted or defective section of voltage divider
Defect in power transformer.
Defective rectifier.
Defective filter choke or loud speaker field.

LOW PLATE VOLTAGE ON ALL TUBES

(High Plate Current in Rectifier)

Defective filter condenser.
Short circuit in voltage divider system.
High resistance short in output tube plate circuit.
Resistance short in eliminator filter chokes.
Gassy tube in output system.

LOW PLATE VOLTAGE

(High Plate Current in Output Tube)

Shorted or grounded grid bias resistor.
Shorted or grounded grid bias resistor bypass condenser.
Ground connection to input push-pull secondary winding open.
Open grid bias resistance.
Open grid circuit.
Gassy output tube or tubes.
Shorted output tube.

NO PLATE VOLTAGE ON ALL TUBES

Shorted power transformer winding.
Shorted filter condenser.
Defective rectifier tube.
Open filter choke.
Open in − B circuit.
Ground in output tube plate circuit.
Open loud speaker field.

NO PLATE VOLTAGE UPON ONE TUBE AND REDUCED PLATE VOLTAGE UPON OTHER TUBES

Open R.F. choke in plate circuit which does not secure plate voltage.

Shorted bypass condenser.
Grounded plate circuit.
Shorted voltage divider bleeder section if it is the detector stage.
Grounded plate coupling unit in plate circuit.
Shorted plate element in tube.

NO PLATE VOLTAGE ON OUTPUT TUBES

(Plate Voltage Available on Other Tubes)

Open in plate circuit.
Open in output unit.
Open in − B connection to grid bias resistance.
Open in grid bias resistor.
Defective tone control.
Plate to chassis condenser broken down.

EXCESSIVE PLATE CURRENT

Gassy tube.
Insufficient grid bias.
Excessive plate voltage.
Excessive positive bias upon screen grid.
Open grid circuit.
Leaky or broken down grid coupling condenser.
Defective AVC system.

NO PLATE CURRENT

Open plate circuit.
No plate voltage.
Open filament circuit cathode circuit.
Defective tube.
Very high negative bias.

INSUFFICIENT PLATE CURRENT

(Normal or High Plate Voltages)

Defective tube.
Low filament voltage.
High grid bias.
Low screen grid voltage.
Defective AVC system.

HIGH GRID BIAS

High plate current.
High value of bias resistance use correct value.
Defective bias resistance.
Defective bleeder resistor.
Defective condenser or resistor in grid return.

LOW GRID BIAS

Low plate current.
Shorted bias resistance or bypass condenser.
Defective resistance or incorrect value.
Measurement made incorrectly.

NO GRID BIAS

(High Plate Current)

Shorted grid bias bypass condenser.
Grounded cathode.
Grounded filament.
Open grid circuit.

LOW OR NO SCREEN VOLTAGE

Open variable control for screen grid voltage.
Open screen grid circuit.
Open resistance in screen grid circuit.
Broken down screen bypass condenser.

NO SCREEN VOLTAGE UPON ONE TUBE

(Low Plate Voltage Upon Other Tubes)

Grounded variable control.
Shorted screen grid bypass condenser.
Short in voltage divider across bleeder or screen grid control resistance.
Shorted screen grid in tube.

EXCESSIVE FILAMENT OR HEATER POTENTIAL

Incorrect adjustment of voltage reducing resistance.
High line voltage to power pack.
Insufficient load upon filament or heater winding; open filament circuit, or defective tubes.
Wrong tube; use correct tube.
Short circuit in power transformer primary.
Hi-lo switch in lo position.

INSUFFICIENT FILAMENT OR HEATER VOLTAGE

Too great load on heater or filament winding.
Low line voltage.
Wrong tube in socket causing excessive current drain.
Incorrect line voltage reducing resistance.
Defective operation of ballast; replace.
Short circuit in transformer.
Short circuit in filament circuit.
Hi-lo switch in hi position.

C: GENERAL TROUBLES, CAUSE AND REMEDY

23. CUSTOMER'S OPINION—NATURAL EFFECTS (*a*) Of course, you want the customer's opinion of what is wrong—because your job is to service that complaint. But you must know when a complaint is just or unreasonable. If you find that the opinion is unreasonable, explain the situation as carefully as you can without offending the customer. Experience is an important factor in judging the performance of a receiver. Receivers are frequently weak in one or more ways. A receiver may be loud and clear but have poor selectivity; or it may be selective but poor in quality.

(*b*) If the receiver is of a reliable make (not necessarily the most advertised or the product of the largest manufacturer) and was not designed to sell for a low price, reasonable performance should be expected. But don't expect the receiver built three or four years ago to be as good as the one made recently. Improvements are constantly being made and each year the higher priced receivers are better all around.

(*c*) In general, the more tubes used in a receiver the better it should perform. Do not include AVC tubes, squelch tubes, automatic tone control tubes, tuning monitors, as they are merely aids to simple operation. A superheterodyne receiver is generally better than a tuned R.F. receiver. Selectivity and sensitivity are improved as more R.F. and I.F. stages are employed, and this should be used as a guide. Tone and volume are greatly governed by the size of the cabinet, type of power output tubes and cost of the receiver (including good workmanship and design, good material).

(*d*) When inexpensive receivers are encountered, such as midget, universal, some D. C. receivers, too much should not be expected. These receivers were made to sell at a low cost and naturally only a limited performance may be expected. These receivers neither have sensitivity, selectivity, volume, nor fidelity comparable with a higher priced receiver. Here too the number of tubes and the size of the cabinet are used roughly to judge their worth.

(*e*) Some of the shortcomings of an inexpensive receiver which cannot be readily changed are: Only local stations are strong, distant stations weak or absent (try a longer aerial); distorts on high volume (try adjusting loudspeaker if of the magnetic type and if voltages are correct nothing can be done); distorts on low volume (nothing can be done); only local stations during the day (natural); tunes broad (natural).

(*f*) Customers expect too much from all-wave receivers. They must be told that only local and semi-local powerful broadcasts are reliable and free from noise. Foreign and distant shortwave reception is quite irregular, varying from day to day, hour to hour, and every minute. The same receiver will perform differently in various locations. An all-wave antenna should be used as it will generally give greater signal strength, but quite often only a reduction in noise will be obtained—in itself a very good reason for using one. Certain bands of the all-wave receiver work best during the day (ultra short-wave), while other bands work best at night. This is a natural condition. For more information on short-waves read section 25.

(*g*) Chance will have it that tubes burn out one after the other without any defect in the chassis. The whole set of tubes may be old and weak, and instead of replacing all at once, they are replaced as they burn out. Naturally they seem to require constant service. Tubes are normally rated for 1000 hours, approximately one year, and no one should expect longer life. A chassis and power line voltage check will quickly tell if the frequent burning out is normal. If the line voltage fluctuates use a line ballast.

(*h*) Very sensitive receivers are naturally noisy except on local and powerful stations. Circuit and tube noises exist and cannot be remedied. The customer must be told to expect this on distant stations.

(*i*) Receivers with AVC will be noisy when tuned between stations, as the receiver is operating in its most sensitive condition. Receivers with squelch or automatic noise gates eliminate this trouble to a considerable extent.

24. NATURAL CONDITIONS WHICH ARE NOT DEFECTS. (*a*) A resistor is supposed to get hot, but it is only when it gets unusually hot that a defect is indicated. Of course the position and use of the resistor that you question must be considered. A grid, or AVC, or plate resistor should not get hot; but a bleeder resistor or power pack voltage divider, or line voltage regulating resistor is supposed to get hot. Only when it gets so hot that it is red (O.K. for line ballast resistor), smokes, melts or chars surrounding parts is a defect indicated. Check with an ammeter to determine if the current through it is normal.

(*b*) Ballast tubes get hot, in fact they work because the resistance elements are working at high temperatures. The radio tubes get hot even to the point where it is impossible to touch them. The rectifier and power tubes heat up the most. Only when the plates turn cherry red is a defect indicated. Check voltages and currents if in doubt.

(*c*) Certain tubes, especially the rectifier and power tubes, have a purple blue glow *at the glass envelope*. This is a natural condition and should not be confused with a blue glow in the space between the cathode and the plate which indicates a defective tube or its operation. In the case of rectifier tubes do not condemn mercury vapor tubes as defective. Usually you can see little balls or a film of mercury, on the glass. Glow in a mercury vapor tube is natural.

(*d*) Quite often radio men observe a spark when connecting the ground lead to the ground binding post of the receiver. This is natural in a receiver where a condenser is connected from the ungrounded supply line to the chassis. If you reverse the power line plug in the outlet the sparking will probably stop. You should insert the power plug so that the sparking is observed when the ground is connected. When this condenser is used and the ground is left off, touching the antenna or even the chassis may result in a shock. Connecting the ground will stop this.

(*e*) Some all-wave receivers tune broad on the broadcast band. A certain amount of broadness cannot be helped if the short-wave bands are to be designed to operate with minimum frequency drift (signal fading due to oscillator frequency shift). The I.F. stages are broadly band-passed so when the oscillator frequency shifts, amplification will still exist. A sacrifice of selectivity for better S-W results.

25. ALL-WAVE RECEIVING CONDITIONS. (*a*) It may appear very difficult to determine a natural from an unnatural short-wave receiving condition. However, the following discussion plus a little experience will greatly help:

(b) It will be necessary to classify radio receivers in two groups: *1*, the inexpensive and *2*, the more expensive receivers. The inexpensive receivers do not have the sensitivity or the selectivity usually obtained from a more expensive receiver. Greater volume and less interference will be received from the expensive set. Consequently the inexpensive receiver will tune broadly, give weak signals in the day-time, give weaker signals at one end of dial, have dead spots, have fading due to lack of or inadequate AVC, have dead spots in one band of the all-wave receiver, dead spots in several bands of the all-wave receiver and lack of clear signals due to an inefficient antenna system.

(*c*) The receiver employing a short-wave converter may also be considered in the inexpensive class, as it is a make-shift assembly. On such an arrangement we may hear noises and yet no signals. This may be due to improper connections from the converter to the broadcast receiver. Check them. Is the antenna connected to the antenna posts of the converter? Is the broadcast receiver set to the correct dial position?

(*d*) The inability to get reception may be due to the wrong band setting or wrong time of day for the particular band. It is, therefore, important that you check the time when best reception can be expected and also when programs are actually on the air. Only those familiar with the general characteristics of the transmission and reception of short-wave signals can realize the full possibilities of the use of an all-wave receiver. Therefore, the following information regarding the nature and general characteristics of short waves will be helpful, especially to you and your customers interested in short-wave reception.

(*e*) It is interesting to know that there are four major short-wave broadcast bands. Each band has its own characteristics. For instance, the 19 meter band (16 megacycles) is best adapted for reception during daylight hours and will be rarely useful after nightfall. Furthermore, signals at distances of over 1500 miles from the receiver are heard best on this band.

(*f*) The 25 meter band (12 megacycles) works quite well during both day and night; however, only very distant stations, especially those located over 2000 miles away, can be heard after darkness. During the day signals approximately 1000 miles or more away will be heard.

(*g*) Just above the 25 meter band will be found a 31 meter (10 megacycles) broadcast band. This band has the general characteristics of the 25 meter band. However, very good reception of the distant stations is possible both day and night.

(*h*) Probably the most reliable short-wave band is the 49 meter band (6 megacycles). Very good daylight reception is obtained when the transmitter and receiver are but 300 miles apart, although very good distant reception is obtained when a large portion of the path taken by the signal lies in complete darkness.

(*i*) The reason for a difference in radio reception is explained as follows: Radio signals transmitted into the ether and on any wave length are known to divide into two parts, known as the *"ground"* and the *"sky"* waves. The former remain close to the earth's surface, thus providing reliable signals for short distances near the transmitter. The other wave, called the sky wave, is reflected back to earth at great distances from the transmitter. It is interesting to know that there is usually a point where the ground and sky waves exist together and the signal will distort, fade out and fade in again if the receiver is located here. Then there is an area following in which neither ground nor sky waves exist. This is known as a dead spot region, within which reception does not exist. The area or length of the dead spot region is commonly termed "skip distance," which varies with seasonal changes and with weather conditions and the time of day. Actually the reflecting layer for the sky waves changes its effective height, thus changing the angle of its route, giving a large variation in reception conditions. And it is known that reception may change radically in a very few minutes, especially in a region which borders on a dead area.

(*j*) The general characteristics of short waves must be considered in connection with frequency bands upon which reception is desired, as well as the time of the day. For instance, 6 P.M. is the best time in the eastern part of the United States to hear European broadcasting stations operating on high frequencies. Early afternoon broadcasts of European programs may be heard on frequencies above 25 meters.

(*k*) In order to check the operation of a radio receiver we should listen to a number of stations and if we receive only one station clearly in each band we know that the set is working properly and that the distortion, if any, is due to weather conditions or improper spacing between the transmitter and receiver. These conditions are, of course, beyond the control of the listener. These are natural conditions. The unnatural conditions can then be very easily weeded out from the natural. Such a case would be when an expensive receiver has poor sensitivity and broad tuning, as well as rapid fading.

26. PART INCORRECTLY CHOSEN OR REDUCED IN VALUE BY USE. (*a*) A reliable make of receiver should generally give reception at least acceptable to the customer at the time of purchase. Otherwise the customer would not purchase it. Of course, it is not improbable that an incorrect value of a condenser, choke or resistor may have been used in the original design or that the value of some part will change after the receiver has been in use some time; yet the greatest chance of changing the characteristics of the receiver will come in making an improper replacement while servicing. A few examples will be helpful.

(*b*) When a decoupling condenser (connected from cathode to + B) is too small regeneration and squeals may arise. For A.F. use .5 to 2 mfd., for R.F. use .1 to .25 mfd.

(*c*) If a bias resistor bypass condenser is too small, regeneration, degeneration, distortion or hum may be introduced. For A.F. use 2 to 8 mfd.; for R.F. use .1 to .25 mfd.

(*d*) **If the condenser across a variable resistor** is too small, the volume control will be noisy. Try a higher capacity value.

(*e*) Incorrect resistor value may result in improper electrode voltages. Even if the resistor used is according to the circuit diagram it is always safer to check voltages after a replacement, with a voltmeter.

(*f*) A resistor may be correct as far as ohmic value is concerned, but have inadequate heat dissipating properties. Its wattage rating is too low. If the resistor gets too hot, use one with a higher rating, or see that the air circulation is not blocked. If in doubt figure watts dissipated by the formula; watts equals volts dropped times current carried, or watts equals current times current times the resistance of the resistor. For under chassis use, select a resistor with about four times the power rating. For above chassis use, select one with about twice the power rating. High watts dissipation (50 watts and above) use resistors with equal watts rating and be sure there is a good circulation of air.

(*g*) The fixed condenser should have a working voltage at least equal to twice the voltage it is to be used on. There are two exceptions to this, solely for economical reasons. Filter condensers should be selected so their rating about equals the peak voltage and A.F. "C" bias resistor condensers should have at least the voltage rating of the terminals to which they connect. Whenever possible use as high a voltage rating as you can without running up the cost. For ordinary use accept nothing under 200 volts rating. Melting wax running from a condenser which is not near a hot spot, or is properly ventilated, indicates the necessity for a higher voltage condenser.

(*h*) Chokes, coils, transformers and variable condensers should be exact replacements, preferably of the same make.

(*i*) Substitute a new grid leak for the old one if you think it is defective. It is practically impossible to test grid leaks with any degree of accuracy. Try various grid leaks ranging in value from 2 to 6 megohms until you find the one giving strongest and clearest signals. If the set is used for distant reception, a high resistance leak gives best results. If for local or nearby stations, a low value resistance should be used.

(*j*) Always check the tubes in a receiver, as to proper type. It is not uncommon to find incorrect types used, for example, a 24 in place of a 51. Replacing a tube with the wrong filament voltage rating may cause it to burn out.

27. OUTSIDE INTERFERENCE (STATIC). (*a*) Noises originating outside the receiver can usually be determined by removing the aerial and ground wires. If the noise still persists, it is an indication that the noise originates IN the receiver or accessories (batteries, tubes, power unit or loose connections). Natural interference (static) presents itself as varying sounds, usually loud crackling or crashes. Static is a natural phenomenon, and up to the present time no means of successfully overcoming it has been devised.

(*b*) Static interference is much more noticeable during the hot, summer months and **makes it impossible to receive distant stations** with any degree of regularity. In fact, it is sometimes so bad that it is impossible to obtain satisfactory results, except possibly on the very strong local stations. Accumulations of static electricity on the aerial wires sometimes become so great as to severely shock a person touching the antenna system or antenna binding post of the receiver. Instances have been known when the charge is so great that the electricity will arc across to the antenna post to the receiver if a lead connection is broken.

(*c*) The ignition systems of automobiles and trucks passing along the road or street will cause static-like interference in short-wave reception. This is especially true in the 15 megacycle band. There is no remedy for this type of interference other than placing the antenna and lead-in as far as possible from the highway along which the automobiles pass.

(*d*) On some types of receivers it is natural to receive a large amount of static and other noises when tuning from one station to another, or when switching from one band to another in an all-wave receiver. The only remedy for this type of trouble is to turn down the volume control on the receiver before making the change.

28. STATION INTERFERENCE AND BROAD TUNING. (*a*) There is no receiver made with reasonable sensitivity, selectivity and fidelity which will not suffer from station interference. The designer recognized the fact that one good quality works to spoil another desirable feature and strikes a balance. It is your duty to acquire by experience, the ability to judge what performance should be expected from the receiver you are servicing.

(*b*) Before proclaiming that interference cannot be eliminated, check for broad tuning (see in this section "Judging Broad Tuning"). If the customer prefers selectivity to fidelity peak the tuning stages. If this does not reduce interference to a satisfactory amount, the only logical step to take is to install a wave trap. Contrary to the general opinion, any coil and condenser will not make a good wave trap. Use a good variable condenser of small size and a regular R.F. receiver transformer. The trap should be designed for the broadcast or the short-wave band in which interference is present.

(*c*) Connect the wave trap in series with the antenna lead wire, when the trap's coil and condenser are in parallel or has a primary winding; for all-wave antenna systems connect the coil and condenser in series and connect the trap across the two leads to the receiver. Tune the receiver to the station desired and adjust the wave trap to eliminate the undesired station. Retune the receiver for desired station and the trap for undesired station.

(*d*) The types of interference you will encounter are as follows:

(*e*) If the receiver is located too near a local broadcasting station, the station may be received over a wide range of the station selector scale. This is referred to as broad tuning. Assuming the receiver alignment is satisfactory, a wave trap should be used, tuned to the powerful local so stations to either side may be tuned in.

(*f*) Often the customer will complain that the local station can be tuned in with distant stations, but when a station is not tuned in, this station interference is not obtained. This difficulty is referred to as "cross-modulation" and is due to the fact that the local station is causing, usually the first tube to act as a detector, and not allowing the tuned stages following a chance to tune it out. Be sure to use variable mu screen grid or super R.F. pentode tubes if specified for the receiver, as these tubes help reduce cross modulation (also hum). A high C bias or low plate voltage on the first R.F. tube may produce this interference; check voltages with manufacturer's recommended values. Try a wave trap tuned to the local station riding in on distant broadcasts.

(*g*) If the local station radiates harmonics, interference will be obtained on higher frequencies. A 610 K.C. broadcast may be heard at 1220, 1830, 2440, etc. This is no fault of the receiver, and not a thing can be done to the receiver to eliminate these undesired signals. If you are sure that the station is radiating harmonics (check this fact on several receivers in various localities) call the station engineer. He will gladly make a check.

(*h*) In some supers a station having a frequency equal to the dial setting ***plus*** or ***minus*** twice the I.F. frequency may ride in on the desired signal. This is called image interference. A coil and condenser trap (both parts in series connected across the antenna and ground) tuned to the interfering signal will help eliminate this interference.

(*i*) Should you find that a local code or broadcast short-wave station interferes on a **lower frequency range of a receiver** (for example, the broadcast band) tune the local out with a short-wave trap. The receiver is a superheterodyne and harmonics of its oscillator are beating with the frequency of the offending station.

(*j*) If long-wave code stations (above 550 meters) are interfering with reception of a superheterodyne receiver, the station is probably of the same frequency as that of the I.F. section. A long-wave wave trap may be inserted in the antenna lead-in. Use an I.F. transformer similar to the one in the receiver. Use only one coil and its condenser; open other circuits. You may also set the I.F. to a slightly higher or lower frequency. Realign the receiver completely. This may throw the station dial calibration off.

(*k*) It is worth remembering that many customers report that they hear the same station at different positions of the tuning dial. What they are really hearing is the same program coming from different stations, and have not bothered to check up that they are listening to a chain program.

(*l*) When we stop to realize that there are a few hundred stations on at the same time in the broadcast band, it is reasonable to expect some interference. First, several stations may be on the same frequency and a sensitive receiver, regardless of its selectivity will pick **up both or several of the stations.** Nothing can be done to eliminate this interference which is often recognized by one fading in while the other fades out, one after the other; or all coming at one time creating a hash of words or music; or a chopping up of the more powerful broadcast. On the other hand, if one station is off its assigned frequency by more than 50 c.p.s., a low pitch hum or squeal may be heard.

(*m*) If two stations are 10 k.c. apart as they should be and modulate a 5 k.c. sound, and the customer's receiver is band-passed to at least 10 k.c.—garbled reproduction is heard. Because it sounds so much like "monkey chatter" it is referred to by this expression. Nothing can be done with an ordinary receiver unless you wish to reduce fidelity by peaking the tuning systems. In a high fidelity receiver with variable band width, reduce or compress the band width of reception.

(*n*) In *judging broad tuning* do not estimate the number of divisions on the tuning dial over which the station may be received and then express an opinion. Figure out the actual number of kilocycles. Tuning is broad if on local stations the band width exceeds 30 kilocycles, on distance if it exceeds 20 kilocycles for powerful broadcasters, on distance if it exceeds 10 kilocycles for normal power radio stations. Sharp 10 kilocycle cut-off for all stations is ideal and making a receiver sharper than this value only tends to destroy tonal qualities. If in your opinion tuning is broad, and the receiver is capable of better selectivity, realign the tuning stages. See section 45, on Receiver Alignment. A 4 to 5 stage tuned R.F. receiver should give acceptable selectivity; a superheterodyne with one pre-selector stage and 2 I.F. transformers (tuned plate—tuned grid) should give satisfactory selectivity. Receivers with more tuned stages should be band-passed for higher fidelity. Receivers with less tuned stages should be peaked sharply. Receivers in which the detector is of the grid leak-grid condenser type are generally broader than if a bias type detector is used. A change-over may help.

29. ANTENNA SYSTEM TROUBLES. (*a*) *Short Aerial.* The aerial on any receiving set should have a length approximating that suggested by the manufacturer of the receiver. Generally speaking, for the broadcast band, an aerial 60 to 80 ft. long will give excellent results. Indoor aerials and light socket antennas never give the same results as good outdoor antennas. Such installations usually give good results on local or nearby stations, but are not of much value for distant reception. If possible, always use an outdoor straight-away.

(*b*) *Poor or High Resistance Joints.* The ends of all wires to be joined should be scraped clean and then soldered and taped. The ground wire should be connected by means of an approved ground clamp to the cold water pipe, or a pipe driven into the damp ground. Scrape the surface of the pipe under the clamp so as to form a good electrical connection. The ground wire should be soldered to the ground clamp. In all wave antennas a poor connection can exist at the coupling transformer, especially in the types having adjustments. Examine all taps, connections and switches carefully for loose, dirty or corroded connections.

(*c*) *Antennas that are too short* generally reduce volume and since some sets are more sensitive at one end of the dial than the other, this effect is more noticeable at the less sensitive end. In some cases, the aerial resonates at the end with good reception and falls off in efficiency at the other end of the band. A change in length, generally, an increase, is a remedy for this. Then, too, a short antenna may cause a receiver to oscillate; lengthening the straight-away helps.

(*d*) *When an antenna is too long,* the receiver may not be selective, the volume of local stations may be uncontrollable, or station interference may exist. Cut the length of the aerial to the size suggested by the manufacturer of the receiver or insert a condenser in series with the aerial. A small fixed condenser of approximately .0025 mfd. or .0001 mfd. is usually helpful. A variable condenser permits finer adjustment.

(*e*) An antenna system that is poorly designed and erected will not give the receiver a chance to show its ability. Be especially sure that an all-wave antenna is erected properly, following the antenna kit manufacturer's instructions carefully. Keep well away from trees, power lines, metal roofs, etc. Be sure that the antenna is correctly matched (coupled) to the set input. The types with adjustable or tapped transformers should be adjusted for maximum results. Be sure that the antenna is of a type that will work satisfactorily with the set.

(*f*) Keep antenna wires free from contact with other objects. Do not let the wire touch trees or sides of buildings. Use stand-off insulators to hold wires away from the building, and be sure to take the lead-in wire into the house through a porcelain tube or by way of an approved "lead-in strip" provided especially for that purpose. Remember, the better the antenna installation, the better the antenna insulation, the stronger and clearer will be the reception. It pays to take time to erect the antenna system in a workmanlike manner.

(*g*) Keep the *aerial* and lead-in wire pulled tight so it cannot *sway* excessively in the wind. By using an aerial spring or pulley and weight, the antenna may be kept tight. Avoid anchoring the antenna to objects like trees which sway with the wind.

(*h*) If you touch an *aerial* or its lead-in which is *touching a power line* you will get a shock. Aerials should be erected as far from them as possible. If the lead-in must come close to a power line, be sure that both are fastened so securely that no contact can be made. If the power line is loose, inform the power company; they will quickly rectify the defect. As a matter of course, you should keep the antenna system away from power and telephone lines; as this will minimize interference. It is advisable to install the aerial so that the wires are at right angles to any power lines and as far away as possible. Any power line passing through branches of trees should be thoroughly taped to prevent current leakage. This work can only be done by the power company. Whenever a large number of power and telephone wires are seen, always recommend a noise-reducing antenna, the straight-away in the noise free zone.

(*i*) Quite often you run across an installation where the receiver works equally well when the ground lead is disconnected. The *power line is a better ground* than the one used. The power line has a grounded side and is generally connected to the set chassis through a condenser; and by disconnecting the original ground, the power line then acts as the ground.

(*j*) A short, straight wire connected to the cold water pipe makes the most practical ground connection. Avoid the use of steam or gas pipes.

(*k*) An *arrester* having poor or corroded connections and leaks due to collections of dirt or soot will naturally cause noise. A shorted arrester will stop reception of distant stations. The arrester could be defective due to age or a lightning surge. The simplest test of this is to temporarily disconnect the suspected arrester or try a new one.

(*l*) *Select the Correct All-Wave Antenna.* There are many types of all-wave antennas, and there are certain types that will work satisfactorily only with receivers having definite input impedances for which they are designed. The older radio receivers may have low or high impedance inputs and special variable impedance transformers should be used so a correct match is possible. This should be considered before the purchase of the aerial. Types having variable impedances are on the market which can be made to work with most all-wave sets. An all-wave receiver requires an all-wave antenna for best results, and they should be properly connected to the receiver. Read the instructions with the antenna kit.

(*m*) *A Choke or Resistor Receiver Input* provides an untuned antenna input. Of course, no tuning action exists, thus permitting strong locals to "ride in" on weaker stations, an effect known as cross-modulation. A tuned input may be substituted or a wave trap used, adjusted to the offending local station.

(*n*) *Two receivers should not be used on the same antenna,* unless a system especially designed for this use is installed. Shocks can be obtained where two sets are connected to the same aerial. Noises, squeals and whistles often occur. Feedback takes place between the sets which are so coupled. Sets should be on separate ordinary aerials if they are to be used at the same time. However, if a shock is the only objection to the multiple use of an antenna, a small mica condenser should be placed in series with each lead-in, thus preventing shocks.

(*o*) *Testing an Antenna System.* A broadcast antenna should not be difficult to test. Disconnect the antenna and ground leads from the receiver. Connect an ohmmeter to ANT and GND receiver posts; a low ohm reading indicates normal continuity. Connect the ohmmeter to antenna and ground leads, set the ohmmeter to its highest range. The reading should be infinite resistance, showing no shorts or leaks. If a reading is obtained inspect the lead-in and antenna for poor insulation or possible shorts to conductors on the house, and disconnect and test the lightning arrester—no reading should be obtained. To check antenna lead wire for opens, connect one end to a metal gutter or pipe, test with the ohmmeter from the free end to the metal gutter or pipe. A low ohmic reading should be obtained for normal continuity.

(*p*) Checking an all-wave transmission line system calls for a little more deliberation. Disconnect the transmission line from the receiver transformer, and check the latter for continuity, just as you would any R.F. transformer. In general, continuity should exist between primary terminals and between secondary terminals. If in doubt, connect the transmission cable directly to ANT and GND receiver posts. If reception is now obtained, to get a new transformer.

(*q*) To check the transmission cable, connect an ohmmeter to the ends disconnected from the transformer. If the antenna end starts with a transformer, the reading obtained should be low (resistance); if the antenna is a doublet with no transformer, a high resistance should be obtained. Due to breakdown of insulation in the cable, collection of soot and dirt, some reading will be observed in an installation that has been up some time. If it is less than 10,000 ohms, install a new cable, identical with the original. It is a good plan to disconnect the cable from the antenna coupler, if one is used and check the cable itself for leakage. Always check between the leads or shield to ground. No short or leak should exist.

(*r*) The antenna coupler is checked in the same manner as the receiver transformer. A schematic wiring diagram of the antenna system if followed will, of course, eliminate any guessing in the tests.

(*s*) If a poor connection is suspected, shake the antenna, lead wires, or cable when making an ohmmeter test.

30. POWER SUPPLY DEFECTS. (*a*) *Improper Line Power Supply.* Always be on the lookout for D.C. receivers in A.C. sections, as the receiver will not operate; and A.C. receivers in D.C. sections of a community as the line fuses will blow out. On the other hand, the receiver may begin to smoke due to excessive current of the improper type flowing through it and, the transformer may burn out. Universal receivers, however, will operate on either A.C. or D.C. In some Universal receivers it is necessary to throw a switch at the rear of the chassis to work it on A.C. or D.C., that is, to convert its operation. Also determine definitely the correct operating line voltage to be applied to the receiver if there is any question at all about the proper power supply.

(*b*) *High or Low Line Voltage.* The tubes in a radio receiver will go bad if the power supplied to them is above or below their specified working values, particularly if the voltage is above normal. It is therefore extremely important to check the line voltage.

(*c*) Low line voltage during the day time may cause weak signals to be received. On the other hand, we may experience broad tuning. High line voltage may cause **squeals, howls or put-puts.**

(*d*) **Distorted or muffled signals may be reproduced if the line voltage is abnormally high or low.** Again check the line voltage.

(*e*) When low or high voltage line supplies are suspected the first thing naturally to do, is to find out by an A.C. voltmeter test whether the voltage is above or below the recommended input for the receiver. If the receiver has any means of adjusting the primary of the power transformer to the line voltage (usually taps or a variable position fuse is provided), an adjustment is made. The taps or fuse positions are marked; set them to a position that is nearest to the line voltage. It is always safer to set the receiver for a high line voltage. If you set it to a low line voltage there is no immediate way of telling whether the line voltage will go up during the day. A line voltage check during the afternoon and early evening will give more definite information. Then set the power transformer primary for the highest voltage; or preferably install a line ballast. A ballast is always preferred when line voltage variation exists. When no receiver adjustment is provided and the line voltage stays constant but high, install a variable line regulator (variable resistor) although a ballast will work as well and insure against sudden line voltage rises. If a number of complaints of this nature are found in the same district, report the condition to the power company. In most cases the condition will be rectified. Don't expect the power company to build an entire feeder system; cooperate with them by using a line ballast.

(*f*) *No Power When Switch is Turned On.* The tubes in a radio receiver may not light for many reasons. However, a careful check should always be made of the power line voltage. A burned out house or receiver fuse, or an open in the power cord will make it impossible for the receiver to operate. Fuses in the receiver circuit should likewise be renewed if damaged accidentally.

(*g*) *A defective line switch* may cause the line fuse to blow whenever the receiver power plug is inserted into the wall outlet. When such condition occurs, install a new fuse and then proceed to test the continuity of the switch terminals with respect to the chassis and the power cord lead as well. With the receiver switch in the off position we should not have continuity between the prongs of the receiver power plug.

(*h*) *Reversed Power Plug.* When operating Universal A.C.-D.C. receivers as well as D.C. receivers from D.C. lines, it is extremely important that the line plug be inserted in the outlet with the proper polarity. Often times all tubes will light and yet no signals will be heard due to the fact that the line plug is reversed. Hum may exist in an A.C. receiver because of a reversed plug. These conditions may be easily corrected by merely removing the plug and inserting it again in reverse, thus reversing the polarity of the power supplied to the receiver.

(*i*) *Shock When Chassis is Touched.* Most of the inexpensive universal and D.C. sets have what is known as a hot chassis. That is, the chassis is above ground and usually a voltage equal to the line voltage is supplied to the receiver. When touching such a receiver chassis we may become shocked. If it is necessary to handle such a chassis with the line plug plugged in, wear a pair of rubber or dry canvas gloves. Be careful and do not touch the chassis with a ground wire or set the chassis on a sheet of metal which is grounded. The main line fuse may blow if you do!

(*j*) *Filament Circuit Troubles.* Whenever several tubes in a receiver do not light, look for a poorly soldered filament connection, or an open filament resistor, a poor socket prong, or a poor soldered joint at the tube prong. A break in a filament cord resistor may be found in some of the inexpensive Universal receivers. This condition will prevent the tubes from lighting. The resistor cord should be replaced if the break is found to be more than 6 inches from the ends of the cord.

(*k*) A short circuit between a filament circuit and a ground may cause hum in an A.C receiver. This will usually be due to poor insulation or insufficient spacing between the leads carrying the filament supply.

(*l*) Distortion or muffled signals may be received by the application of excessive filament voltage or having a broken ground wire or lead. Check the filament voltage and also the ground to the filament circuit. Refer to the schematic wiring diagram of the receiver for exact connections.

(*m*) It is important to have the proper center tap to the filament source of the R.F. tubes in a high gain receiver in order to reduce resonant or tunable hum to the lowest value.

(*n*) Some receivers use fixed as well as variable midtap resistors. Hum will be heard if these are defective, when the receiver is A.C. operated. The resistance of the resistors may be checked by removing the connecting leads and using an ohmmeter If the resistor is found to be open and should it be impossible to repair, then insert a new one.

31. DEFECTIVE FILTER SYSTEM. (*a*) A defective filter system of a radio receiver, regardless of the type, will cause serious trouble unless corrected at once. Naturally the defect will be in a choke coil or a filter condenser. A grounded filter choke coil, or a leaky or shorted filter condenser will throw an unusually large load on the rectifier tube and the power transformer. If the latter is adequately protected by a fuse, the set fuse will blow. If the fuse has too high a current rating the transformer may overheat and eventually break down; or the rectifier tube elements, particularly the plate will get red hot, emit gasses and a blue glow will arise between the elements; or the line ballast resistor will overheat and eventually burn out. A blue glow between elements is a definite indication of a filter defect, except in the case of a mercury vapor rectifier tube. Shut the power off at once and check chokes and condensers, as explained elsewhere in this reference text.

(*b*) Mercury vapor rectifier tubes oftentimes employ small radio frequency chokes at their plate lead terminals. When these chokes become defective due to improper installation, or are accidentally damaged, we may hear noise. This noise may be heard from the receiver chassis or loudspeaker.

(*c*) A filter choke or loudspeaker field which is shorted may cause hum, squeals, howls, and put-puts. This is due to the fact that there is insufficient reactance inserted in the circuit. A shorted radio frequency choke may also result in squeals.

(*d*) All receivers using a metal chassis generally have the chassis grounded. For this reason a careful inspection should be made to see that no piece of apparatus or bare wire is touching the chassis that is intended to carry power to points other than the chassis itself. This can be determined quite definitely by comparing all connections with a schematic wiring diagram and making continuity tests.

32. REGENERATION AND OSCILLATION. (*a*) *Regeneration* in a radio receiver is generally recognized by a swishing or rushing sound as you tune in a station; *oscillation* which is generally excessive regeneration makes itself known by squeals and howls, either with set tuned to any dial position or when tuning through a station. Oscillation is, of course, quite objectionable and must be removed, although some individuals may be willing to have regeneration if it is controllable. Oscillation in beat signal generators for signal finding is quite essential, and regeneration under control allows greater signal strength to be obtained. Regeneration is only objectionable if it distorts or muffles signals, or reduces the fidelity of reception.

(*b*) A check for internal and external squeals and howls or swishing should first be made. If any of these symptoms are heard when the station selector or receiver is not adjusted, some one in the neighborhood is producing the interference. Nothing can be done unless the offender is tracked down with a directional loop antenna receiver and that receiver corrected or the owner shown how to operate his receiver. All other conditions of interference are due to set defects or unbalance.

(*c*) Superheterodyne receivers often produce a squeal or howl when tuned, the harmonics of the I.F. or local generator beating with the incoming signal or some other signal passing through the preselector even when the signal itself is not audible. Lowering the oscillator grid bias or plate voltages, checking up on misplaced wires in the I.F. section often corrects this defect.

(*d*) Regeneration and oscillation is generally a radio frequency system defect. R.F. systems using triode tubes as amplifiers will oscillate unless suppressed or neutralized. Hence, when such a system is found which oscillates always reneutralize the receiver (see section 45 on Receiver Alignment) or check the grid suppression. They may be shorted. Usually grid suppressor resistors of large value may be required, but before this is done be sure that a defect is not causing an undue amount of feed back. For example: a grid lead may be too close to a plate lead. Try changing the position of the grid lead.

(*e*) R.F. systems using tetrode and pentode tubes when properly designed do not oscillate. Only a defect can produce undesirable feed back, as is often the case for systems with triode tubes. Whenever a defect exists which

feeds the output into a previous stage or grid, regeneration will take place. Some of these possibilities are:

(*f*) Open or defective last filter condensers in the power pack. This is the common supply to all stages, and an open condenser will present a high resistance coupling, causing hum, regeneration and oscillation.

(*g*) An open grid bias condenser couples the plate to the grid often producing this interference.

(*h*) An open cathode to plate supply bypass condenser will allow R.F. signals from the plate to pass into the supply circuits and then to a grid circuit causing squeals and howls. An open in a cathode to —C terminal, or a short in the resistor to a plate or grid supply terminal will cause closer coupling through the supply system.

(*i*) Most servicemen usually track down a defective condenser by connecting two leads with probes to a 1 mfd. condenser and connecting the probes across various bypass, and filter condensers. If a defective condenser or its lead is open or poorly soldered (usually in its container) shunting the good condenser across it will stop the trouble. Install a new condenser of recommended size.

(*j*) Any high resistance connection may be a source of plate to grid feed back, and a good soldered connection should be made. Improper wiping contacts at the rotors of variable condensers, or their absence often result in regeneration and oscillation.

(*k*) Undesirable inductive coupling is, of course, a major source of feed-back. But all such possibilities are eliminated in the original design of the receiver. If the receiver is of reliable make, it is best to consider the other sources of trouble. If undesirable coupling is found it should be reduced (less turns) or eliminated entirely.

(*l*) A large number of possible defects are given in the index under "Squeals, Howls and Put-Puts." Study this part of the index if you have a job involving regeneration and oscillation.

33. (*a*) **MOTORBOATING** is a term describing the sound produced in some receivers, resembling the put-put-put of a single cylinder gas engine. It is in reality a low frequency oscillation produced by high common impedance in the plate circuit of the audio amplifier. However, any combination decoupling and filter system defect may result in motorboating.

(*b*) Defective tubes are to be suspected and new ones should be tried. Bypass and filter condensers should be checked for opens by shunting them with others. If an automatic volume control system is used, pay particular attention to the decoupling condensers—trying others. Check the connections between the rotors of the tuning condensers and the chassis. Sometimes, a 100.000 ohm resistor shunted across the signal input circuit of the first audio tube will prevent motorboating.

(*c*) Test for shorts between the primaries and secondaries of audio, R.F. and I.F. transformers. Open grid returns will result in a sound quite similar to motorboating and such circuits should be checked with an ohmmeter, using a circuit diagram as a guide.

(*d*) Push-pull and push-push stages may oscillate or motorboat. The simplest cure is to insert a 200 or 300 ohm resistor in series with each grid; and if this does not completely solve the trouble connect similar resistors in series with each plate; in each case, next to the socket terminals.

34. MECHANICAL FEED BACK. (*a*) Sound emitted from the loudspeaker is to a more or less degree, acoustically (through the air) or mechanically (through the cabinet and chassis), fed back to the signal circuits. This may result in a howl which rises from zero intensity to a loud amplitude. Naturally, such interference will not be tolerated by the customer. Recognizing the means of coupling indicates at once the solution of the trouble.

(*b*) Microphonic tubes are a common source of trouble. Tapping each tube with the receiver volume turned up and tuned to a station will quickly identify the microphonic tube. Try the latter in a different position (where the same type tube is used) or replace with another tube.

(*c*) Another very common trouble is at the clamps which hold the chassis to the cabinet. In some receivers the machine floats on sponge rubber or springs. If they harden or lose their elasticity, microphonic noises arise. Adjust springs and replace hardened sponge rubber. Such machines are shipped with chassis temporarily bolted down. Before the machine is placed in operation free the chassis so it will float.

(*d*) If the felt rim on the loudspeaker has hardened or has been omitted or the loudspeaker is too tightly bolted to the baffle mechanical feed-back will be strong. Be sure the rim is used, that it is soft and only moderately snug to the baffle board.

35. HUM. (*a*) When an appreciable amount of raw A.C. gets to the loudspeaker a low pitched hum will be heard. Theoretically, there is always some A.C. in the output, but for a receiver of good fidelity it should be one-millionth of the maximum output. As expense is involved in getting hum out of the output, only moderate and high-priced receivers will be found free of hum. Objectionable hum should never exist, in any receiver of reliable manufacture. Receivers with a small baffle have plenty of hum current in the loudspeaker but the hum is not reproduced by the loudspeaker due to the small baffle area. For high fidelity receivers hum output must be kept to a very low value, and the least power supply defect may result in hum.

(*b*) A procedure to identify and isolate the source of hum trouble is highly important. Hum is generally of three forms: *1,* hum existing at all times whether on or off a station, *general hum; 2,* hum existing only when set is tuned to a station, particularly a powerful station, called *tunable or resonant hum; 3, direct hum* coming from a part and not through the loudspeaker, called *mechanical hum.*

(c) General hum is easily identified. You will hear it coming from the loudspeaker soon after the power switch is turned on. A strong hum louder than the broadcasts that you can tune in indicates, as a rule, a total break down; a mild hum, not heard in a normal receiver of the same make, indicates inadequate filtering or some minor circuit disturbance.

(d) Tunable hum is generally produced by a defect which throws raw A.C. into the R.F. section causing some R.F. tube to be modulated by this interference. Before considering the receiver to be at fault, check for transmitter hum. A battery operated unmodulated oscillator is connected to the receiver input and the set tuned to this oscillator. A strong signal may be necessary. If hum is not tuned in, the station is radiating a hum. It will probably be removed in a few days by the station engineer. Signals entering the receiver via the power line may become modulated with A.C. Try two 0.1 mfd. 600 volt condensers across line, center tap grounded; if line filter is not used.

(e) When hum is heard and placing your ear next to the grill of the loudspeaker shows that it is not coming through the loudspeaker, you are reasonably sure that some part, usually laminations of an audio or power transformer or iron core choke are vibrating. Wedging the laminations or tightening the core bolts or rivets will help to reduce this trouble.

(f) In tracing hum first disconnect the aerial and ground and move the power supply cord around to be sure that induction from it does not exist. If the symptoms or experience do not indicate the probable cause (study the index on hum), isolating the stage where hum originates is a time saving procedure.

(g) Of course, tunable hum indicates a defect in the R.F. systems, and the index suggests locations and defects. Next if any hum adjusters are used they should be reset for minimum hum output. Unless you are familiar with the receiver you should refer to a circuit diagram, particularly one which gives the location of the various adjustments. If the receiver works normally except for too much hum output, a stage isolation test is made.

(h) For an isolation test use a head-set with a series 1 mfd. condenser. This is probably the most sensitive as well as the most practical hum indicator. The tests to be described should be tried on various receivers without abnormal hum, in order to acquaint yourself with the amount of hum that ordinarily is heard in a receiver which is in good shape. Check the input of the loudspeaker (plate to chassis or plate to plate of the last stage). If hum is heard and the loudspeaker has no hum bucking device, check the rectifier and filter system. Defective rectifier tubes, shorted or leaky filter condenser, shorted or grounded filter chokes may be causing the hum. A serious defect in the power pack may cause the rectifier tube to glow between elements, and this will be observed even before an isolation test is made.

(i) If the rectifier-filter delivers normal hum output (some will always be heard) isolate the stage it is entering. Connect the head set between plates and chassis (or cathode of each tube) or preferably in series with the plate (in which case the 1 mfd. condenser is omitted), starting from the loudspeaker and working towards the antenna ground. When you pass through a stage of abnormal hum (equal to that received across the filter output) that section is allowing hum currents to pass from the power pack to the signal circuits. Poor connections, shorted isolating resistors from the supply terminal to the electrode or the electrode supply to cathode bypass condenser, defective or weak tubes, operating voltages and open circuits should be checked. Study the troubles peculiar to each section, as given in the index on hum.

(j) Quite often hum is accompanied by other defects; no volume, smoking parts, regeneration, oscillation, motorboating, etc. By isolating the primary defect and correcting the trouble, hum too will be eliminated. If inadequate filtering exists in the power supply system, replacing the condensers for others of less leakage, or adding more filter condensers (to increase the filter capacity) may eliminate the hum.

(k) Power pack filters with tuned circuits are often contributors to hum. If the choke and resonating condenser (a fixed condenser) are tested as normal, probably a shift in the air gap of the choke has thrown the circuit out of resonance. Try various small condensers in steps of .0001 mfd. across the choke. If this fails to tune out the hum adjust the choke's air gap. Loosen the laminations of the choke and insert various thicknesses of paper in the air gap. When least hum is heard clamp the lamination tightly.

(l) Some servicemen as a "make-shift" move the loudspeaker away from its baffle one or two inches. This will reduce low frequency response and hum as well.

36. EXTERNAL NOISE. (a) The test for external or internal noise is to disconnect the antenna and ground leads from the receiver, short ANT to GND, and listen for the original noise. Slap or shake the receiver chassis to check for loose connections. Now if the noise is not coming through the power line connection and no noise is heard we have definite proof that noise is coming from an external source.

(b) Most modern radio receivers have built in, a line noise filter. In some cases it is merely a condenser across the line input; in better receivers two condensers in series are connected to the line, the mid-condenser connection grounded; or in other receivers a shield is wound between the primary and secondary of the power transformer. The only sure way of determining whether a receiver has a line noise eliminator is to refer to a service circuit diagram. In your case it is wise to buy or build a portable line filter. Insert the line noise filter. If the antenna input is shorted and the insertion of the filter eliminates the noise, install a permanent line filter; if the filter does not eliminate the noise, the cause is internal; if after the filter has eliminated the noise, but restoring the antenna-ground connections bring back the noise the elimination procedure is as follows:

(c) In every case where external noise is experienced and a line filter does not help, ***install a noise-reducing antenna.*** There are

many approved types on the market. Select one of reliable make, one which gives you good results and stick to it. Get the straight-away as far up in the air as you can, as far away from metal objects and power, telephone and trolley wires. Always run, if possible, the straight-away at right angles to lines. The length of transmission line is immaterial in a well designed noise-reducing antenna. Use an all-wave antenna for all-wave receivers.

(d) In 95 percent of the cases a well installed noise-reducing antenna will eliminate external noise. In the other cases, the offending device in the locality must be traced and noise filters installed, a subject studied in the regular course. A few hints will help.

(e) The power plugs connected to radio receivers are oftentimes connected to the power cord by means of small machine screws. When the cord is continually pulled in and out, we find that the screws become loose. Therefore, we will have a small break in the current or circuit, thus causing interference or external noise.

(f) Poor connections to electrical units within the house, such as fans, small motors, sewing machines and other electrically operated devices will cause external interference to be heard. Such conditions may be corrected by tracing all connections to lamps, and other power cord connections. Defective switches and power outlets cause interference and should be corrected or replaced.

(g) House line fuses may have been blown and replaced with tinfoil or a copper penny. Such fuses are loose and often will provide very poor contact. Poor contacts cause an arcing of the current and consequently, a radiation of interference. Install the proper fuse when such conditions are found.

(h) Line filters should be purchased, and for large electrical machines one designed particularly for the device used. A simple filter can be made by placing two 2 mfd. condensers in series across a line and grounding their midpoint. These condensers should have a working voltage of 600 volts. A short direct ground lead should be made from the midpoint between the two condensers.

37. SIGNAL CIRCUITS OVERLOADED. (a) Radio receivers can easily be fed with too much signal, which is in many cases no fault of the receiver. Each receiver is rated to handle a definite output without distortion and if this is exceeded by tuning to a local station or some other powerful broadcaster with the volume control wide open, distortion is inevitable. The customer must be instructed to reduce the output to a reasonable amount. Of course, there is some stage in the receiver which first shows signs of being overloaded, and if distortion at this point can be reduced the volume range of the receiver can be extended. Naturally, a receiver must first be correctly tuned, otherwise cutting of the side-band frequencies will cause distortion.

(b) Detectors very often overload. Before anything is done to this part of the circuit, check the tube in a tester or try several new tubes. Next check the tube's operating voltages. If the tube is defective the distortion will disappear, if the voltages are incorrect, the correction will be obvious by a stage voltage analysis. Grid leak—grid condenser detectors overload quickly on strong signals. Besides distortion, the detector may block stopping reception momentarily. If the customer prefers to listen to strong broadcasters, try leaks of lower ohmic values, about ½ to 1 megohms. This will reduce sensitivity. If the detector has an automatic C bias voltage drop, vary the cathode to − B resistor for best results; or, if readily done, increase the detector's plate voltage.

(c) Improper plate load filtering of R.F. current may cause distortion. Try a larger load filter bypass condenser, only large enough to keep R.F. out of the audio system, otherwise the tone of the output will be lowered to an apparent degree. Try a 10 to 30 millihenry R.F. choke in series with the plate load.

(d) Audio tubes are easily overloaded by too much signal. The tubes and voltages should be checked. With the exception of a push-pull (Class B) audio amplifier, a plate milliammeter in the plate supply of each suspected stage should show no or very little current change. If the stage is fed with a signal above the value it was designed to handle (loudspeaker output high) a current change will be observed. This indicates the limit of the handling ability of the receivers. Although the output handling ability of tube may be increased by running up the plate and grid voltages, such a procedure is not recommended for normal service work.

(e) Loudspeakers are often overloaded or at least distortion comes from this point. Overloading is quickly spotted by the fact that rattles are mixed with false reproduction. The cone, the cone soft leather rim, or the spider may be weak or hardened. Replacement cones should be used after the voice coil or armature has been centralized and found not to cure distortion. If the voice coil hits against the stops on large signals, ask the customer to reduce the volume to a reasonable amount.

(f) The defective stage can be located by connecting a pair of 2000 ohm ear phones across the plate cathode of each tube working from the detector to the output. A 1 mfd. condenser should be in series with the phone. When distortion appears the immediate stage ahead of the connection is causing the trouble.

(g) Overloading in the R.F. section produces distortion, as well as hum modulation and cross modulation. Check: for correct type of tubes, the tubes themselves, and electrode voltages. A plate milliammeter check is often helpful. A pair of earphones in series with the plate of an R.F. tube should produce no or a minimum of audio signal; the current change with a signal tuned in should not be observed.

(h) It is worth recommending a shorter antenna (broadcast type only) if distortion due to overloading appears with broad tuning.

38. LOUDSPEAKER TROUBLES. (a) Loudspeaker *fields* which are suspected of being open or shorted may be checked with an ohmmeter. To test for a shorted field place the ohmmeter leads directly across the field coil. This will also enable you to check for an open in the field. A test from either of the field leads to its frame will enable you to show up a ground. In making the latter test have a wiring diagram handy as some fields are naturally grounded. When a field is open or shorted remove the field and take off the insulating paper. Sometimes the trouble is right on the surface of the coil and can be repaired. If repair is not possible purchase and install a new field.

(*b*) Lack of excitation on the field may be due to a defective rectifier or a filter condenser ahead of the field being broken down. If the field is open or shorted there will be no excitation. A quick check for this condition is to hold a metal (steel) screw-driver about a quarter of an inch away from the pole piece. It should be strongly attracted if the field is being properly excited.

(*c*) A frequent trouble encountered in dynamic loudspeakers is *opening* of the *voice coil*. Generally the flexible lead from the cone to the output transformer breaks. Usually resoldering this lead will complete the repair job. A partial open sometimes occurs and on strong signals when the cone moves quite a distance, distortion and partial intermittent reception will occur. Loose turns on the voice coil will cause a peculiar rattle which, once heard, can always be identified again. Remove the cone and coat the voice coil with a good loudspeaker cone cement, obtainable from the large radio supply firms, allowing it to dry thoroughly. This will hold the wire on the voice coil form.

(*d*) The voice coil sometimes becomes off centered and in such a case will rub against the pole pieces. You can check up on this by moving the cone in and out with your hand, pushing as nearly as possible on the center. If you feel the voice coil rubbing, loosen the screws holding the coil in place and move the cone around until no rubbing occurs. Then tighten the holding screws. A better way of doing this is to cut thin strips from a business card and insert these along side of the voice coil, between it and the pole pieces. This will center the voice coil and the holding screws may then be tightened and the strips removed. Iron filings in the pole pieces or openings of the loudspeaker are a frequent source of trouble. A pair of hand bellows is useful for removing them and it is seldom necessary to take off the cone to do this job.

(*e*) After being in use for several years a loudspeaker cone is liable to become stiff and the supporting ring may harden. It is advisable to install a new cone, as they are inexpensive. When a leather ring is used to hold the cone to the metal edge of the loudspeaker, "Neatsfoot" oil may be worked into the leather to soften it. When the spider loses its flexibility, replace with a new cone unit.

(*f*) Never operate a receiver with the loudspeaker disconnected. In the case of receivers using electrolytic condensers an overload on the first condenser will occur if the loudspeaker is not plugged in. If the condenser is of the wet variety, a hissing sound will be heard indicating that the condenser is breaking down.

(*g*) A.C. dynamic loudspeakers using dry disc rectifiers will in time emit considerable hum. If hum is heard when the receiver is turned off but the field excited you know that it is time to install a new rectifier unit.

(*h*) Defective loudspeaker cords, particularly on magnetic loudspeakers, are a source of trouble. They may be checked for continuity with an ohmmeter and if bad must be replaced. Do not neglect to shake and move the cords when making this test. An intermittent reading, of course, indicates a bad connection.

(*i*) Weak magnets in magnetic and permanent dynamic loudspeakers are a frequent source of trouble. In the latter case the loudspeaker must be replaced and in the former case you should try reversing the loudspeaker leads. If the loudspeaker is directly in the plate circuit of a tube, the polarity of the loudspeaker leads is important because current flowing through the loudspeaker windings in the wrong direction will tend to demagnetize the permanent magnet. The loudspeaker wire having the most red in it connects to plus B.

39. RESONANT EFFECTS IN CABINET AND ROOM. (*a*) Although there may be only a small amount of hum present at the output of a loudspeaker and this hum may be natural, it may be heard with sufficient intensity to cause a complaint from the customer. Resonant effects in the room or cabinet are often responsible. The hum is emitted from several different directions and on striking a hard surface may rebound and add to the hum at another point in the room. If a hum is heard only in particular spots in the room, experiment with the position of the cabinet. Drapes on the walls and a sufficiency of furniture in the room will usually eliminate hum. Placing a rug under the receiver is often helpful. In some cases, it may be advisable to bore holes in the bottom of the loudspeaker compartment or to line the inside of this compartment with some sound absorbing material such as celotex.

(*b*) Resonant effects in the room and cabinet will not only result in hum but also in noise. Loose parts in the cabinet may be caused to dance up and down under certain sounds from the loudspeaker giving rise to a rattling noise. To clear up the trouble, fasten the parts down so they cannot vibrate. Reflectors behind radiators are a common source of mechanical noise. Directing the loudspeaker away from such objects is the usual cure. Pictures and mirrors hung on the wall have also been known to vibrate when struck by certain sound frequencies.

(*c*) The more critical broadcast listener will complain that the receiver sounds too boomy, caused very often by cabinet resonance. Lining the loudspeaker compartment with celotex, sound absorbing wool, or heavy soft cloth helps. Keep the cabinet at least 2 to 3 inches away from the wall, and preferably in a corner—"katty-corner."

40. OSCILLATOR CIRCUIT TROUBLES. (*a*) When the oscillator circuit of a receiver is suspected of being defective, one of the simplest tests is to touch the ungrounded side of the oscillatory circuit with a moist finger. A click in the loudspeaker should result when the terminal is touched and also when the finger is removed; if only one click is heard, the tube is not oscillating. Another test is to tune in a station and pull out the oscillator tube. If the signal can still be heard, the oscillator tube is not functioning.

(*b*) When in doubt, try a new oscillator tube. Go over the connections in the oscillator circuit with a hot soldering iron as a high resistance connection will prevent the oscillator from functioning—possibly only over a section of its range. Test the continuity of the oscillator circuit and compare it with that of a schematic diagram of the receiver. All resistors should be tested for proper value and condensers should be checked for opens by trying new ones. Improper alignment of the oscillator stage will cause the set to be dead over a portion of the dial. This may also be caused, particularly in combination detector-oscillator stages using a pentode tube such as a 6C6, by excessive control grid voltages. You may try reducing the value of the bias resistor by about one-third of its present size. In circuits using a pentagrid tube such as the 6A8, try increasing the value of the oscillator grid resistor by about one-third of its rated value. In battery sets look for low filament voltage on the oscillator.

(*c*) If the mica spacing in any of the oscillator trimmer adjustments appears to be split or dirty, try a new piece of mica. Do not neglect the fact that the plates of the tuning condensers may rub at some portion of the dial setting. If everything seems to be in good condition as far as you can determine, the installation of a new exact duplicate oscillator coil would be worth while.

(*d*) When adjusting the oscillator of a receiver, you may find at the very high frequency adjustment, two points at which a signal can be received. Use that adjustment which results in least capacity of the trimmer condenser. If you select the other position, the receiver will be dead at mid-scale. If the oscillator is equipped with a grid leak, it may be necessary to experiment with other values of resistors for best results.

41. A.V.C. TROUBLES. (*a*) When an A.V.C. trouble is indicated, you should, first of all, try new tubes in the A.V.C. stage and in the stages controlled by it. Then, the continuity of the circuit should be tested with an ohmmeter, using a wiring diagram of the receiver. Improper value resistors should be replaced with others of the right size and bypass and coupling condensers should be checked for opens by shunting them with others of about the same size and known to be in good condition.

(*b*) There are some peculiarities in A.V.C. receivers worth mentioning. When tuning from a strong station, the receiver sensitivity will be automatically increased. If you are in a noisy location the noise between stations may be terrific but it may cut down to nothing on strong signals. Where the A.V.C. tube serves only the purpose of automatically controlling the volume, you will oftentimes note an increase in volume when the A.V.C. tube is removed. This is quite natural and does not indicate a defect.

42. TUNING INDICATORS. (*a*) Whenever a tuning indicator is found, it is quite safe to assume that the receiver embodies automatic volume control (A.V.C.). Should no change in indication be observed first check the A.V.C. action. Tune through local and distant stations. Watch for elimination of blasting on locals, noise off station (if the receiver does not incorporate a squelch system) and reduction of fading. If the A.V.C. action is normal then the defect is definitely in the indicator.

(*b*) You should be able to tell when a reasonable correct action is taking place. The greatest indication is obtained on local or powerful stations. Distant stations and particularly those on the short wave band produce little change in indication when tuned in—perhaps only a "quiver"—because there is insufficient signal pick-up. When insufficient indication is obtained on local stations, and the receiver is otherwise normal, check antenna for grounds, or leaks, causing low pick-up. Try a longer aerial.

(*c*) The meter (needle indicator), the moving vane system (shadowgraph), the neon glow tube (glow indicator) may be defective. The moving vane instrument may be tested by applying a small C battery; the glow lamp checked by placing it in series with a 10,000 ohm resistor and connecting to a 110 volt A.C. or D.C. source. Or a new neon glow indicator may be tried. The shadowgraph or blinker type may not operate because the lamp is burned out, or not securely in the socket. After turning the lamp securely in the socket and no indication is observed, try a new lamp.

(*d*) There is always the possibility that the indicator is shorted. The moving vane unit should show continuity, a glow lamp no circuit resistance, when the proper test connections are made.

(*e*) Be sure the voltage supplied the neon indicator is correct. Usually an adjustment is provided. Try various positions and especially when a new neon indicator is used. It should be set so it barely lights on no signals.

(*f*) In the blinker system the three coil transformer and the input filter condenser often become defective. Check and replace if necessary. In replacing watch color code on leads for a proper reconnection.

(*g*) Remember, any defects in the A.V.C. system will affect the action of the visual indicator, so be sure to check the A.V.C. before blaming the indicator.

43. ASSOCIATED DEFECTS. (*a*) A part may be overheated, destroyed or made defective because some other associated part is defective. For example:

(*b*) A "C" bias resistor connected between the cathode of the tube and − B may become overheated, burn out, stop reception because the bypass condenser between + B and cathode is leaky or shorted. Even if the condenser is only leaky sufficient extra current will be bled to the bias resistor to send the C bias up to a value that will either distort or stop reception.

(*c*) A leaky coupling condenser between the plate and grid of two stages, will if the grid input has a high ohmic resistor destroy the tube. Current is bled from + B through the leaky coupling condenser, through the grid resistor. The grid is made positive, causing excessive distortion and eventually ruining the emission of the tube which becomes weak and useless. When such a stage is checked to have normal + B supply, high plate current and cathode to — B voltage, check for leaky coupling condenser.

(*d*) A rectifier tube becomes gassy emitting a blue glow between elements; or the plates get red hot due to an overload. The line fuse or ballast may burn out. The cause may be a shorted or leaky filter condenser, or a grounded filter choke, or a short in the load (signal circuits drawing too much current). Check D.C. drop across suspected parts or circuits.

(*e*) A socket or internal tube short between cathode and screen grid or plate, screen grid and control grid suppressor grid and plate, etc., may cause large current to flow in the associated circuits, destroying tubes, resistors, and even coils. A socket voltage analysis and comparison to the manufacturer's voltage table will reveal the defect.

(*f*) To check for abnormal current measure the voltage across the resistor through which the abnormal current is flowing. If higher than rated and the resistor itself is not shorted, high current is indicated. Or break the circuit, with an adapter if possible, and measure the current directly.

(*g*) ***Moral:*** When a defective part is located, be sure that some other defect did not cause the trouble. Always make sure of this fact or the trouble will reappear.

44. AUTO RADIO TROUBLES. (*a*) An automobile radio receiver may develop practically any trouble common to other radio receivers. Special conditions of use and special design of the power pack create troubles peculiar to auto radios. These will now be considered.

(*b*) ***Vibrator Trouble.*** The Vibrator B eliminator is a delicate instrument and must be operated without excessive sparking, otherwise continuous operation will burn the contacts. The burning of the contacts will cause improper operation of the unit. Adjusting screws may also become loose due to continuous vibration. Vibrators that do not have adjusting screws may be adjusted by bending the spring levers themselves to the proper spacing. Filing the contacts when they have become worn is sometimes desirable. This is especially necessary when the fuses in the vibrator leads blow continuously. Pitted or dirty vibrator points are therefore to be reconditioned by filing and proper spacing. Internal noise is oftentimes heard on an auto radio due to dirty contacts.

(*c*) Due to the continuous vibration within the vibrator unit itself, we may experience broken or loose connections. Such connections may cause the vibrator to be intermittent and **also to produce excessive noise when the automobile is in movement.**

(*d*) It is wise for the beginner and even a busy, experienced serviceman to replace defective vibrators with new ones. Fortunately these units are plug-in devices and therefore are quickly replaced. Use a recommended duplicate replacement unit.

(*e*) ***Ignition Interference.*** The following suggestions for the suppression of Ignition Noise Interference are given through the courtesy of the Galvin Manufacturing Company. These hints are given in the order of their importance, and if any have been overlooked on the job you service, make the necessary changes or additions.

1. Apply suppressors to spark plugs and distributor.

2. Apply generator condenser.

3. Reroute primary wire from coil to distributor, keeping it as far away as possible from high tension wires.

4. Connect dome-light filter to dome-light wire at point where it enters front corner post.

5. Shield high tension wire if coil is mounted on instrument panel.

6. Shield antenna lead-in wire from radio set to top of front corner post. Ground shield at both ends.

7. Shield primary wire from coil to distributor.

8. Connect a .002 to .006 mfd. high grade mica condenser directly across the primary breaker points of the distributor.

9. Bond (connect) the upper metal parts of the car body to one another and return a heavy copper bond (connector) from these points down to the bulkhead of the car. (This is usually necessary in cars using composite wood and metal body construction.)

10. Bond to bulkhead where necessary all control rods and pipes passing through the bulkhead.

11. Shield head of coil when mounted on instrument panel.

12. Cover floor boards of car with copper screening, bonded to car frame.

13. Adjust spark plug points to approximately .028 of an inch.

14. Clean and adjust primary distributor breaker points.

15. In cars having rubber motor mountings, connect heavy bond from grounded side of battery directly to frame of car.

16. Connect a .5 to 1 mfd. condenser from hot primary side of ignition coil to ground.

17. If ignition coil is mounted on driver's side of bulkhead, move it to the motor compartment side, using the same holes for mounting.

18. Clean ignition system wiring. Clean and brighten all connections. Replace any high tension wiring having imperfect insulation.

19. Ground metal sun visor and rain troughs if necessary.

20. Make sure hood of car is well grounded. Clean hold-down hasps on both sides.

21. Bond instrument panel and steering column to bulkhead.

22. When under-car aerial is used, connect a .5 mfd. condenser to tail and stop-light wires.

And special hints:

(*f*) ***Static Noise.*** Tail light, stop light, head light or horn wires sometimes pick up static charges from the tires and cause interference. To determine if these are at fault, drive the car from a dry pavement onto a wet one. If the wet pavement eliminates the noise, then the light wire should be shielded and the shield grounded. Noise is sometimes caused by the antenna being too close to body metal of car. Antenna should be checked for this condition whether the car manufacturer or an individual has installed it. There must be a space of at least 3 inches between the metal car body and the antenna. (Courtesy: Mallory.)

(*g*) ***Wheel Brake Noise.*** The front brakes sometimes accumulate static and cause interference due to a poor ground in the front wheels and a peculiarly constructed lining. If this condition is suspected, set the car in motion, then with the motor shut off and the clutch disengaged, apply the brakes. If the interference is eliminated then the front wheels are the cause. To overcome this condition, use graphite grease or insert grounding springs in the internal hub cups. In the case of external brakes, it is necessary to ground the brake bands to the chassis. (Courtesy: Mallory.)

(*h*) ***Antenna Touching Car Frame.*** The antenna in an auto radio must be carefully insulated from the frame. If allowed to touch, signals will be shorted out and noises introduced. The roof types must be carefully installed, at least 3 inches of space being between the aerial and any grounded metal. Be sure that the insulating bushings and washers are correctly used and in good condition in the under-car and bumper types of antennas.

(*i*) ***Internal Auto Radio Noise.*** Auto radios that reproduce noise with the antenna disconnected, may be experiencing interference due to dirty brushes on the generator which charges the battery. The brushes are usually dirty when excess oil has been applied to the generator commutator. In such cases, the cover over the generator brushes should be removed. Then, with the car idling, you should rub the commutator down with a canvas cloth dipped in carbon tetrachloride. Whenever the cloth becomes black you should move it along and try again. Eventually, the commutator of the generator will become shiny. Then you should add a very small quantity of vaseline thereby preventing oxidation. Incidentally, the brushes should be in good condition and held against the commutator by the springs provided. If the brushes are entirely too short to operate properly, they should be replaced. Sometimes it is necessary to apply very fine sandpaper in order to remove all of the carbonized surfaces of the commutator. When finishing such an operation, commutators should be covered with a thin coat of vaseline.

D: RECEIVER ALIGNMENT AND BALANCING

45. (*a*) In radio receivers there are two kinds of adjustments which you as a service man will be called upon to make. These are alignment (often called synchronizing) and neutralization (often called balancing). The first has to do with the tuning of circuits while the latter is a method used to prevent oscillations (squeals and howls).

(*b*) Sets having single tuning dials (the tuning condensers work on a common shaft) will be equipped with aligning or trimming condensers. Modern receivers using screen grid tubes employ no neutralizing condensers and therefore if such a set squeals or howls there are no adjustments to prevent this. The set has developed a defect. It is absolutely incorrect to try to stop howls and squeals by adjusting aligning condensers. (If 3 and 4 I.F. stages are employed and they are peaked when they should be band passed, the receiver may squeal. It is proper to band pass, adjust trimmers, only in this case.) This requires a close examination of every trimmer or padding condenser and its purpose.

(*c*) The following information is of a general nature. Exact details are given by the manufacturer for each of their receivers. Follow them. This subject is taken up in greater detail elsewhere in the course.

(*d*) ***Neutralizing.*** Bear in mind that not all sets using triode tubes have a neutralizing system. To check for neutralizing condensers first locate the aligning condensers (commonly called trimmers). These will be found on the tuning condenser gang frame. Then if there are any more similar condensers on the chassis they are probably there for neutralizing purposes. Check service diagram for a regeneration control. This should always be adjusted first.

(*e*) The method of adjustment is as follows: Open the filament circuit of the tube in the stage to be neutralized by slipping a soda water straw over one of the filament prongs—you can unsolder one of the filament leads if you wish—then tune to a station between 1000 and 1500 k.c. and turn volume all way on. Adjust the neutralizing condenser with an insulated screw driver for least signal output. The filament circuit is then closed and the same procedure carried out on the remaining neutrodyne stages.

(*f*) ***Aligning T.R.F. Receivers.*** To align a T.R.F. set, tune in a weak broadcast station at about 1400 k.c. Adjust the trimmers on the condenser gang for maximum signal output. For any other position, bend the end rotor plates in each condenser section. As many adjustments as there are segments in the split rotor plate should be made, one with each segment in full mesh with the stator. Start with the condenser set so the first segment meshes with the stator.

(*g*) ***Aligning Superheterodyne Receivers.*** To align a superheterodyne a service oscillator is really necessary. Connect the output of the oscillator, tuned to the I.F. of the set to the control grid of the first detector and the chassis. Turn back the attenuator (volume control) on the signal generator so that the signal can barely be heard. Adjust the I.F. trimmers for maximum output. An output meter is the best instrument with which to measure output level. Connecting a copper oxide rectifier type A.C. voltmeter, having a series condenser, to the plate and chassis or plate and plate of the output tubes will indicate output levels. If the receiver is an inexpensive one or has only two I.F. transformers, the adjustments must be made very sharply. That is, adjusted for the greatest signal output.

(*h*) If the receiver has three or more I.F. transformers the stages should not be adjusted too sharply, as this may cause oscillation (squeals), circuit noise (rushing or hissing noise), or distort the signals. If in this case each I.F. transformer has been peaked each one should be band passed. On each transformer, tighten one adjustment slightly (one-quarter turn) and loosen the other slightly by the same amount. If the gain is too much, repeat the band pass adjustment for all the transformers.

(*i*) Connect the output of the oscillator to the aerial and ground posts of the set. Tune both the receiver station selector dial and the oscillator to 1400 k.c. Adjust the trimmers on the condenser gang for maximum output (the oscillator trimmer first) keeping the test oscillator attenuator set so the signal is always just audible or a low output meter reading is obtained. If the set oscillator is equipped with a low frequency padding condenser (will be shown in diagram by an adjustable condenser in series with oscillator tuning condenser and coil) tune receiver and test oscillator to 600 k.c. Tune set back and forth about 600 k.c. while you adjust the padder. You may hear the signal at more than one point. Adjust the low frequency padder at the point where signals are strongest.

(*j*) All-wave receivers have an I.F. amplifier to be adjusted as described above. They must be adjusted at the recommended I.F. They have tuning condenser trimmers and padding condensers for the broadcast band which are also adjusted as described above. For each short wave band covered by the receiver there will be a set of trimmers and padders. The trimmers are to be adjusted at the high frequency end of the band and the padder at the low frequency end of the band. Manufacturer's instructions which will give the location and purpose of the various adjustments should be obtained from the manufacturer or from his local distributor.

(*k*) *Antenna Compensator Condenser.* A few receivers have a special antenna compensating or trimmer condenser for adjusting the receiver to the antenna with which it is used. It is only necessary to tune in a broadcast station operating on a medium frequency (approximately 1000 k.c.) and then adjust this condenser for greatest volume. Instructions on making this adjustment are generally given in the operating instructions received with the radio receiver. After this adjustment is made it will not be necessary to change it unless a different antenna is used with the receiver.

(*l*) *Points to Remember.* Use an oscillator for aligning and neutralizing if you have one —otherwise use a broadcast signal. Don't try to neutralize if the set does not squeal. Don't try to align a superheterodyne without an oscillator. Always use an insulated screw driver for all of the above adjustments. In aligning an R.F., I.F., or Neutrodyne amplifier, the stage to be adjusted first does not matter greatly; however, in a super first adjust the I.F., then the trimmers, and finally the padders.

(*m*) Whether you align or neutralize first depends on the operation of the receiver. If the receiver squeals, neutralize first; if the R.F. stages are so far off alignment that it cannot squeal, then you should align first. For a better job, after the first neutralization, realign and neutralize the second time.

(*n*) Procure and follow when possible manufacturer's instructions especially for all wave receivers.

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