Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

How Vibrations and Microphonic Noises Are Eliminated

LOOSE parts in a radio receiver chassis can cause three different types of annoying sounds: *1,* microphonic noise; *2,* rattling sounds; *3,* mechanical hum. The Radio-trician must be able to recognize each of these sounds, know how they are caused, and know how to correct the trouble.

Microphonic Noise. Older radio receiving tubes have a rather flimsy internal construction, with the result that tube elements vibrate at the slightest provocation. This vibration causes tube electrode currents to fluctuate at a corresponding rate, and the loudspeaker reproduces these current variations as a howl or "ping" which lasts until the tube stops vibrating; such a tube is said to be *microphonic.*

If sound waves from a loudspeaker hit a microphonic tube directly and are strong enough to keep it in vibration, the howl will continue until the vibration is stopped by turning off the set temporarily or by touching the tube. A loud sound produced by the loudspeaker will often start vibrations in a microphonic tube. At first the vibrations are weak, but the small current fluctuations are amplified by the receiver and react upon the tube to produce a louder and louder howl. The process builds up rapidly, with the tube serving as a sort of microphone which picks up sound waves from the loudspeaker. The pitch of the howl will depend upon the natural period of vibration of the microphonic tube.

You can recognize a microphonic howl by the fact that it builds up gradually in loudness when the set is turned off for an instant and then turned on again. The cone of the loudspeaker will be vibrating violently when this howl is the loudest. Touching the microphonic tube with your hand will dampen the vibrations and stop the howl temporarily, but it will usually start up again the next time an unusually loud sound comes from the loudspeaker.

Microphonic noises are quite rare in modern receivers, because tubes today are rugged in construction and consequently are little affected by sound waves coming from the loudspeaker. Only in highly sensitive receivers and in high-gain public address amplifiers are you likely to have microphonic tube trouble. When this occurs, tune the receiver off a station or stop using the microphone, then snap or jar each tube until you locate the one which will produce a howl. Try a new tube of the same type in its position; if one brand of tube will not remedy the trouble, try tubes of different makes.

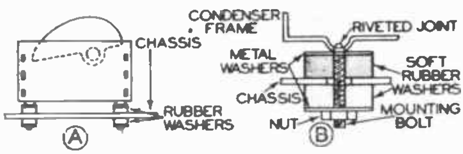

FIG. 1. How variable condensers are mounted on rubber to eliminate microphonic noises.

A more likely cause of microphonic noise in a modern receiver is the gang tuning condenser. Loud sounds from the loudspeaker can set the rotor plates of this unit into vibration; this sets up a varying current in the receiver circuit in much the same way as for a microphonic tube. To prevent this, condenser rotor plates are made from soft aluminum, which has less tendency to vibrate than other common metals; oftentimes the outer edges of the rotor plates are held together by a metal or fiber strip. In addition, the entire variable condenser unit is often mounted on soft rubber washers in the manner indicated in Fig. *1A,* to prevent chassis vibrations from being transmitted to the condenser frame and the rotor plates.

To determine if microphonic noises are originating in the tuning condenser, turn on the set and tune to a point where no stations are heard. Turn up the receiver

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volume control to its loudest position, then make the rotor plates vibrate by rubbing them with a small stick of wood or with your fingernail. If howling occurs now, the condenser unit is microphonic.

If the rubber washers which support a microphonic tuning condenser have hardened, replace them. If the condenser mounting bolts have been tightened so much that the washers can no longer absorb vibration, loosen the nuts. If the tuning condenser shaft is rubbing against the receiver cabinet, provide sufficient clearance at this point. If any leads to the tuning condenser are stiff enough to transmit vibration, replace them with flexible stranded wire leads. If no rubber washers are used at the tuning condenser supports, it may be necessary to enlarge the mounting holes and insert rubber washers as shown in Fig. *1B*; after this is done, connect each corner of the condenser frame to the chassis with braided copper wire, using soldered connections. (If the condenser frame is orginally insulated from the chassis as it is in many universal A.C.-D.C. receivers, the frame should not be grounded.)

In the average receiver, the loudspeaker is fastened directly to the cabinet. The loudspeaker sets into vibration the entire air inside the cabinet, and this vibration is transmitted through the wood cabinet to the chassis unless precautions are taken to "float" the entire chassis on rubber and make all holes for control shafts large enough so that no part of the chassis is in contact with the wood cabinet. It is for this reason that you find rubber feet like those shown in Fig. *2A* at each corner of a chassis; another method of securing a

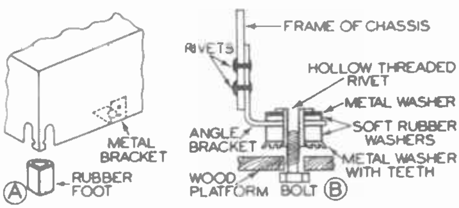

FIG. 2. Two ways in which the chassis of a radio set can be mounted on rubber to prevent transmission of vibrations from the cabinet to the chassis.

floating chassis, by means of rubber washers, is shown in Fig. *2B*.

Before radio receivers are shipped from the factory, the chassis is tightly bolted to its supporting platform. These mounting bolts must be loosened when the receiver is installed in a home. With a chassis of the type shown in Fig. *2A*, there will generally be a metal bracket riveted or welded to the inside of the chassis near each corner, with a bolt going upward through the wood supporting platform into the threads on this metal bracket; this bolt should be loose while the receiver is in operation. With the arrangement shown in Fig. *2B*, however, the bolts can be tightened with-

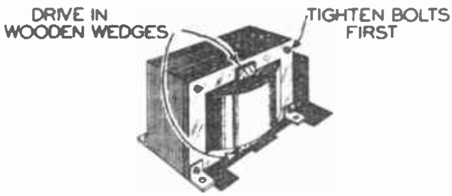

FIG. 3. This sketch illustrates how wood wedges can be used to prevent the coil and laminations of a transformer from vibrating.

out affecting the rubber mounting. In an old receiver the rubber supports may be hard and in need of replacement, or some one may have tightened chassis bolts which should normally be loose enough to allow the chassis to float.

Rattles. Loose elements in tubes, loose shields around tubes and coils, or loose parts of any kind often vibrate violently or rattle for a short interval of time when loud sounds come from the loudspeaker. The rattle is somewhat annoying even though it has no appreciable effect upon the receiver circuit. The first thing to do when eliminating a rattle is to make sure that the chassis is floating properly on its rubber feet. Next, make sure that tube shields are tight and seated properly around the tubes. Look for loose parts above the chassis; in most cases the trouble will be due to a loose bolt or rivet, and the method of tightening the part will be obvious.

Sometimes a radio receiver will cause rattles in other objects which have a large surface in the direct path of sound waves coming from the loudspeaker. The metal covers sometimes used on radiators are frequent offenders; the large metal surface actually vibrates when sound waves from the loudspeaker hit it. Loose windowpanes or large ornaments may also rattle. Suggest that the customer change either the position of the radio or that of the object which rattles.

Mechanical Hum. A power transformer or a filter choke will sometimes develop a loud humming noise, which is heard even when the loudspeaker is silent; this is due to looseness of the sheet metal laminations which make up the core. Tighten the bolts which hold the core together; if the hum still is heard, make two hardwood wedges and drive them in opposite directions between the coil and the core of the transformer, as indicated in Fig. *3*.

Interference Which Can Be Eliminated With a Wave Trap

If an *undesired* station is heard when a receiver is tuned to a particular *desired* station, we have what is known as *interference*. The larger modern receivers are so designed that interference troubles are practically negligible, but there are countless thousands of obsolete receivers and inexpensive new receivers in use today which do not have sufficient selectivity to eliminate the types of interference now to be discussed.

Radio servicemen are constantly receiving interference complaints from set owners who do not realize that the trouble is due to inadequate receiver design rather than to failure of the receiver. Fortunately, the installation of a simple wave trap will in many cases eliminate or greatly reduce the trouble. Before I tell you how to connect and adjust wave traps, I will explain how you can recognize the various types of interference which are encountered.

Cross-Talk Interference. If a strong local station can be heard clearly in the background when a T. R. F. or superheterodyne receiver is tuned to a weaker local station or to a distant station, and yet the offending local station disappears when the set is tuned between stations, we have what is known as *cross-talk*. The signal of the powerful local station rides in on the signal of the weaker station. A wave trap which can be tuned to the frequency of the offending powerful station will usually eliminate cross-talk.

Code Interference. If an undesired signal is heard at all broadcast band settings of a superheterodyne receiver, we have what is known as *code interference*. The interfering signal may be in code, coming from a commercial code station, or it may be a voice signal from a weather bureau station. The interfering signal will be loudest when the receiver is tuned to the lower frequencies in the broadcast band. Code interference occurs chiefly in superheterodyne receivers, for in these sets there is one section (the intermediate frequency or I.F. amplifier) which is tuned to the lower frequencies on which these weather bureau and commercial code stations operate. If the frequency (known as the I.F. value of the receiver) to which this section is tuned coincides with the frequency of the interfering station and if the first stages of the receiver are not selective enough to keep out this interfering signal, it will get into the I.F. amplifier and there be amplified sufficiently to be heard in the loudspeaker regardless of how the receiver is tuned.

Code interference can generally be eliminated by trapping the offending signal before it can get into the receiver; a simple wave trap connection will do the trick. Determine the frequency of the offending station if possible, and select a wave trap which will tune to that frequency; otherwise, get a wave trap which will tune to the I.F. value of the receiver, then adjust the wave trap until the code interference is suppressed.

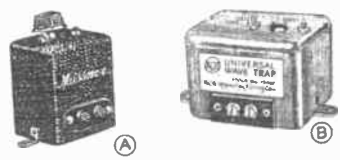

FIG. 4. Examples of commercial wave traps.

Image Interference. Another trouble which is quite common in superheterodyne receivers is known as *image interference*. You can recognize this by the fact that a powerful local station, which may be either a regular broadcast station, a police radio station, a commercial short-wave station or an amateur station, will be received not only at its regular setting on the receiver dial but also at a lower-frequency setting. If a desired station is at this second point, the undesired or image signal will interfere with the desired signal and cause a squeal. When you hear this squeal along with a desired station, you must make a simple calculation in order to identify it positively as image interference.

First of all, determine the I.F. value of the receiver; most circuit diagrams give this. If the squeal is heard when the receiver is tuned to a frequency which is *below* the frequency of the powerful local station *by twice the I.F. value*, you have image interference. For example, suppose the receiver has an I.F. value of *260* kc., and an annoying squeal is heard when you tune in a station at 630 kc. Multiplying this I.F. value by 2 gives 520 kc.; adding 520 to 630 gives you 1,150 kc. If there is a powerful local station broadcasting on 1,150 kc., you know that it is causing image interference. Identify the offending station by listening for its call letters, then determine its frequency and install a wave trap which will tune to that frequency; this will eliminate or greatly reduce image interference.

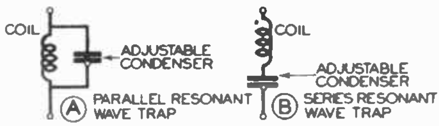

FIG. 5. Internal connections of wave traps.

Broad Tuning of Local Stations. When powerful local stations each cover from 40 to 100 kc. on the tuning dial, we have what is known as *broad tuning.* This trouble is particularly common in older receivers and in some of the inexpensive recent sets. Broad tuning is due essentially to inadequate receiver design rather than to failure of a part (assuming that the set has been properly aligned). The installation of a wave trap which will block the signal of the most annoying local station, to permit reception of distant stations which are fairly near it in frequency, is a possible remedy.

Blasting and Distortion. If the output of a radio receiver is excessively loud and is distorted when a strong local station is tuned in, the volume control being at its normal setting for distant reception, we have the condition known as *blasting.* Turning the volume control down will reduce the loudness of the sound but the distortion will still be present. Blasting will be noticeable only on powerful local stations; weak locals and distant stations will be received satisfactorily. Detuning of the local station will eliminate blasting, but at the same time it introduces another form of distortion which gradually becomes objectionable to the listener. Although blasting is not strictly a form of interference, it is brought up here because it can be eliminated by a wave trap which is tuned to the interfering station.

What Wave Traps Are. When a simple radio coil and an adjustable condenser are connected together and placed in a metal housing, we have a wave trap. There will be two terminals on it, and the general appearance of a commercial unit will be similar to that of the wave traps shown in Fig. 4. These wave traps can be purchased at such low prices that the Radiotrician does not bother to make them.

In general, there are two types of wave traps, which differ only in the manner in which the coil and condenser are connected. If these parts are connected together in parallel, as indicated in Fig. 5A, the unit is known as a *parallel resonant wave trap.* If the coil and condenser are connected together in series, as indicated in Fig. 5B, the unit is known as a *series resonant wave trap.* If you do not know which connection is used in a particular unit at hand, simply connect an ohmmeter to its two terminals. If you get continuity (a low-resistance reading), you have a parallel resonant wave trap. If there is no continuity between the terminals, you have a series resonant wave trap.

A parallel resonant wave trap should always be inserted *in the antenna lead,* as shown in Fig. 6. This is done by connecting the antenna lead to one terminal of the trap, then connecting the other terminal to the antenna terminal of the receiver. A series resonant wave trap, on the other hand, should always be connected *between the antenna and ground terminals* of the receiver itself, without disturbing the normal antenna or ground connections. Always order a wave trap which will tune to the frequency of the offending station. A wave trap may be mounted either on the chassis or on the inside of the cabinet.

To adjust a wave trap, tune in the desired station having interference, then adjust the screw or knob on the wave trap until the interference is a minimum or is entirely absent. If the use of a single wave trap will reduce the interference but not eliminate it sufficiently, you can use both types of wave traps at the same time, connecting them exactly as indicated in Fig. 6. When there are two interfering stations, you can use two parallel resonant wave traps inserted in the antenna lead-in in series with each other, tuning one to each of the interfering stations. If there are more than two interfering stations, it will usually be more advisable to recommend the purchase of a new and improved receiver.

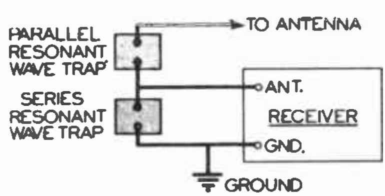

FIG. 6. Wave trap connections to a receiver.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

Setting Up Push-Buttons in Radio Receivers

A RAPIDLY increasing number of the radio receivers in use are provided with automatic tuning, whereby a desired station can be tuned in accurately and almost instantly simply by pressing a push-button.

With receivers having automatic tuning, individual adjustments must be made for each station-selecting button before the push-buttons can be used. These adjustments are rarely if ever made at the factory, and must therefore be made in the radio dealer's

Push-button adjustments for the majority of radio receivers are remarkably easy once you master the few simple rules presented in this job sheet. The work is pleasant, and paves the way for even more profitable radio repair jobs when you have progressed far enough with your studies to handle the work.

shop or in the home of the purchaser. When receivers are purchased from mail order radio supply houses or through wholesale channels, the push-buttons must be set up by the purchaser himself or by some one whom he calls in.

The process of setting up the push-buttons for a radio receiver is relatively simple in the majority of cases, so you should be able to handle many extra-money jobs of this nature once you master the basic principles of the different automatic tuning systems covered in this job sheet.

With some types of automatic tuning systems, the station-selecting buttons can get out of adjustment due to careless handling of the receiver, normal vibration resulting from the action of the push-button mechanism, or changes in the characteristics of tuning circuit parts due to temperature changes. The push-button adjustments then require resetting.

Whenever a broadcasting station changes its operating frequency, all receivers which have a push-button set up for that station will require resetting. Many people hesitate to attempt even simple adjustments like this, so again you have an opportunity for profitable business.

Types of Automatic Tuning Systems. The various systems employed by receiver manufacturers for automatic tuning purposes can be divided into three groups, according to the operating principles employed:

1. *Mechanical automatic tuning systems*, in which the regular gang tuning condenser of the receiver is rotated to the correct position for a desired station by mechanical action when the station-selecting button is pressed.

2. *Electrical automatic tuning systems*, in which pressing in of one button automatically switches into the tuning circuits of the receiver a preadjusted set of trimmer condensers or adjustable inductances (coils), and at the same time releases any button previously depressed.

Trimmer condenser.

3. *Electro-mechanical automatic systems*, in which a small electric motor automatically rotates the gang tuning condenser to the correct position for a desired station when a button is pressed.

Electrical systems and push-button type mechanical systems are the commonest now in use, and are likewise the simplest to adjust. The procedures for setting up the buttons for these types will be covered in

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this job sheet. Variations will undoubtedly be encountered, but your knowledge of the basic principles will allow you to figure out the correct procedure for the particular system at hand. It is almost impossible to do any serious damage even if you make mistakes at first in setting up buttons, so don't be afraid to tackle these jobs.

Telephone dial-type mechanical systems and electro-mechanical systems are somewhat more complicated, and ordinarily can be set up only by following detailed instructions provided by the manufacturer. Special adjusting tools are sometimes needed. If you have the manufacturers' instructions and the necessary tools at hand, and have a certain amount of mechanical ability and ingenuity, there is no reason why you should pass up jobs involving these more complicated systems. If you do not have the necessary information at hand for a particular set, however, it will be better for you to wait until you have progressed further with your N. R. I. course and have studied the advanced lesson which deals with automatic tuning control systems.

Important: Before tackling the job of setting up push-buttons on a receiver, be sure your customer understands that you are expected only to take care of the push-button adjustments. This is only fair, for you cannot be expected to do regular radio service work until you have progressed further with your N. R. I. course.

General Instructions

Allow Set to Warm Up. Any receiver having automatic tuning should be allowed to operate for at least twenty minutes, so that receiver parts will reach normal operating temperatures. If buttons are set up while the receiver is cold, stations may be appreciably off tune when circuit parts change slightly with heat.

Study Instructions If Available. Whenever button-setting instructions are available for the receiver being adjusted, these instructions should be studied carefully unless you have had previous experience with that particular type of tuning mechanism. The general instructions given here will ordinarily be adequate, but specific instructions will often describe short-cuts which speed up the job.

Assign Stations to Buttons. Determine the number of buttons which are available for station-selecting purposes. Extra buttons are sometimes provided for tuning the receiver on and off, for phonograph operation, for manual tuning, etc., and should not be included in your count.

Select a corresponding number of radio stations, giving preference to the customer's favorite local or powerful near-distant stations which can be received satisfactorily.

Determine the frequency of each selected station by referring to a radio log book or the radio program in your local newspaper, and make a list in which the stations are arranged in the order of increasing frequency (with the lowest-frequency station first on the list).

Make a rough sketch of the push-buttons as they appear from the front of the receiver, assign the stations in logical order to the available station-selecting buttons, and label each button accordingly *on your sketch.* (With mechanical systems, the buttons can be assigned in any order, but the usual procedure is to work from left to right, assigning the lowest-frequency station to the extreme left-hand button. With electrical systems, tuning ranges must be considered, as explained in the next paragraph.) The sketch which you make will serve as a guide during the adjusting procedure.

Adjustments for Electrical Systems

While the receiver is turned on and warming up, locate the trimmer adjustments on or above the chassis (or directly behind the push-buttons), note the frequency range printed on the chassis for each set of adjustments (an example of this appears in Fig. *1*), then assign a station to each station-selecting button in the order which makes each station fall within the frequency limits for its button, and label the buttons accordingly on your sketch. The trimmer adjustments will usually be accessible from the back of the cabinet; on some sets, a cover plate at the back of the set must be removed. On a few sets, the trimmer adjustments will be accessible from the front. In rare cases, the only button available for a desired station may not be tunable to the station frequency; you must either choose a new station for that button, or leave the button blank and advise the customer to use manual tuning for that station.

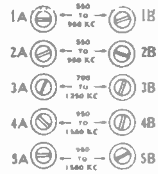

FIG. 1. Typical arrangement of adjusting screws for the electrical automatic tuning system of an auto radio receiver having vertically arranged buttons. The "A" screws are for oscillator trimmers, and the "B" screws are for antenna trimmers.

Tune in manually the first station on your list, and note the nature of the program. Now press in the button assigned to that station, and tune in the same station by adjusting the *oscillator* trimmer (sometimes called the tuning or station-selecting trimmer) for that button with a screwdriver. Now adjust the other trimmer for that button (usually called the *antenna* trimmer) so as to secure maximum volume. This adjustment will be quite broad. Carefully readjust the oscillator trimmer so the station comes in clearly and with maximum volume. This completes the set-up for this button.

When in doubt, you can identify the oscillator trimmer by the fact that a number of stations will usually be heard when its adjusting screw is rotated. Never turn a trimmer condenser screw more than a few turns out, for this is unnecessary and the screw may fall out. Never apply force to a screw. It is not necessary to remove the receiver chassis from its cabinet during this button set-up procedure. If the station cannot at first be tuned in with the oscillator trimmer,

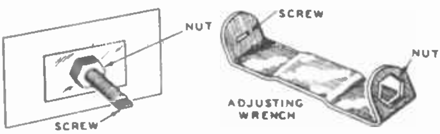

FIG. 2. Example of coaxial adjustments sometimes used for electrical automatic tuning systems, with special adjusting wrench. On Zenith sets, the screw adjustment controls the oscillator, while the nut controls the antenna circuit.

loosen the antenna trimmer screw one or two turns, then return to the oscillator adjustment. Coaxial (one inside the other) trimmer adjustments like that in Fig. *2* may be encountered; special wrenches are sometimes provided, but ordinary tools will usually serve just as well.

Restore manual tuning to make certain the same program, from the desired station, is heard equally well both on manual and automatic tuning. (Slightly greater volume will sometimes be obtained with automatic tuning, because two individual trimmers can be adjusted to resonance more accurately than can a two-gang tuning condenser).

There is always the possibility that the trimmers are tuned to a different station which is carrying the same network program as the desired station, so it is a good idea to check your work by pressing one button after another, during the regular intervals for station announcements. When the desired station is a local, background noise will be noticeably greater when trimmers are incorrectly set to a different station carrying the same network program.

Tune the receiver manually to the next station on your list, then set up the button for that station in the same manner. Repeat the entire procedure for each remaining button.

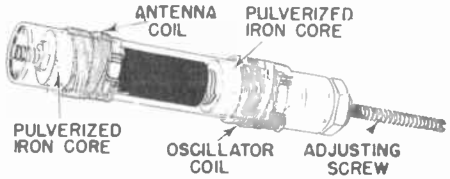

FIG. 3. Example of dual permeability tuned coil, which requires only a single screwdriver adjustment of the center screw when setting up a push-button. Rotation of the adjusting screw makes the pulverized iron cores slide in or out of the coils, thus changing the inductance of each coil. One coil like this is provided for each station-selecting button.

Adjustable inductances called *permeability tuned coils* are often used in place of trimmer condensers. A typical dual permeability tuned coil is shown in Fig. *3*. For the same change in frequency, permeability-tuned coils require many more complete turns of the adjusting screw than do trimmer condensers.

Adjustments for Mechanical Systems

Mechanical automatic tuning systems can be divided into two groups, as follows:

1. Rocker bar mechanisms, where each button has its own locking adjustment;

2. Cam-and-lever mechanisms, where one locking adjustment serves for all buttons.

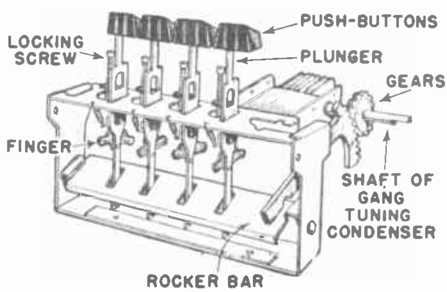

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FIG. 4. Typical rocker bar mechanism employed in mechanical automatic tuning systems.

Rocker Bar Mechanisms. A typical mechism of this type is illustrated in Fig. 4. A single pivoted rocker arm (flat metal piece) drives the gang tuning condenser through a gear system, so that the angle of the rocker arm determines the station which is tuned in. Each station button is on a flat metal plunger having a metal finger which can be locked in a desired angular position by means of an individual locking screw. Pressure on a button makes the rocker arm rotate to the same angle as that to which the finger on the plunger was set, thereby rotating the tuning condenser to the correct position for reception of the station assigned to that button.

The locking screws are always accessible from the front of the receiver, but are exposed in various ways depending upon the design of the mechanism. Thus, they may be exposed by removing the push-buttons, by removing the station call letter tabs from the buttons, by removing the station tabs from the push-button escutcheon (the ornamental trim plate surrounding the buttons on the panel), or by removing the push-button escutcheon. In a few sets, the push-buttons themselves can be rotated, and serve also as locking screws.

The set-up procedure is essentially the same for all rocker bar or similar mechanisms which have individual locking adjustments for each button. Set up one button at a time, as follows: Release its locking adjustment; press in the button and hold it there; carefully tune in manually the station assigned to that button; tighten the locking adjustment; release the button, completing its set-up.

Cam-and-Lever Mechanisms. A typical mechanism of this type is illustrated in Fig. 5. Each station button is on a pivoted lever having at its other end a roller which can be pressed against a heart-shaped cam (irregular-shaped metal disc) on an extension of the gang tuning condenser shaft. Pressure on the button forces the roller against the cam, making the cam rotate until the roller is at its lowest point (closest to the cam shaft). Somewhere on the mechanism is a locking adjustment which when tightened locks each cam to the shaft, by squeezing the cams between friction washers which are anchored to the shaft. Pressure on a button will thus cause rotation of the gang tuning condenser.

The set-up procedure is essentially the same for all cam-and-lever mechanisms. After assigning a station to each button, loosen the locking adjustment. Push in and hold down firmly the first button which is to be set up, then tune the receiver accurately to the desired station with the manual tuning knob. Release the button now, repeat this procedure for each other button, then tighten the locking adjustment.

In the mechanism shown in Fig. 5, the locking screw is in the center of the manual tuning knob. In other mechanisms, the locking adjustment may be a knurled screw on the side of the receiver, a wing nut on the side of the dial assembly, a screw accessible from the back of the receiver, a screw which is exposed by removing the push-button escutcheon or removing a snap-in button on the escutcheon, or a screw accessible

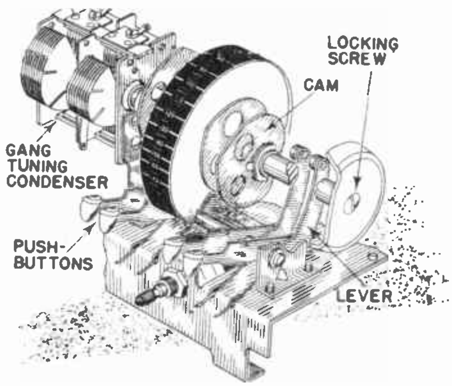

FIG. 5. Typical cam-and-lever mechanism used in mechanical automatic tuning systems.

The diagrams in Figs. 1, 2, 3 and 5 are reprinted from Supplement No. 8, "Automatic Tuning," to the Third Edition of the Mallory-Yaxley Radio Service Encyclopedia, copyrighted 1940 by P. R. Mallory & Co., Inc., Indianapolis, Indiana.

through a hole located below the tuning unit. Sometimes the tuning knob itself must be either pushed in or pulled out, then turned counter-clockwise, to unlock the cams.

Final Check. With all systems, it is highly desirable to make a final check of your work by comparing push-button and manual reception for each station. If reception is clearer on manual tuning for any station, repeat the adjustment procedure for that station button.

Insert Call Letter Tabs. Printed tabs containing the call letters of all broadcasting stations in this country are usually supplied with receivers having automatic tuning. When the button set-up job is completed, the tabs for the selected stations should be cut out of the printed sheet and placed on the buttons or in slots provided for this purpose in the escutcheon which surrounds the buttons.

Overhauling Radio Receivers

ONCE a year a radio receiver should be thoroughly overhauled, after which the tubes should be tested and the set tuned up. This job sheet will train you to do the actual overhaul, which simply involves removing accumulated dust and dirt, re-soldering poor connections and tightening loose parts.

The General Electric table model all-wave receiver shown in Fig. *1* will be used as our example in the illustrations, but the overhaul procedure applies to all radio sets. I suggest that you practice this overhaul job on your own receiver after studying this job sheet.

Check Performance. Place the receiver in operation and tune in several local and distant stations to see how well the set performs, then check the operation of the volume and tone controls. In later job sheets you will learn how to replace defective controls and how to test tubes.

Remove Chassis and Loudspeaker. Pull the power cord plug out of the wall outlet, and disconnect the antenna and ground leads to the receiver, as was done on the set shown in Fig. *2*. Using a midget screw-driver, loosen the set screws in the control knobs on the front of the set, after which you can pull off all knobs. Knobs with no screws are held by friction and can be removed by a strong, steady pull.

Remove the loudspeaker mounting screws or nuts, and carefully lift out the loudspeaker. Place it on the bench alongside the cabinet, leaving it connected to the chassis. Now remove the mounting bolts or screws (underneath the cabinet) which hold the chassis in place, and slide out the entire chassis. Replace the control knobs temporarily so they will not get lost. Undoubtedly there will be considerable dust on the chassis and on the various parts; use a soft cloth, a piece of cheese-cloth or a one-inch wide paint brush to remove as much of this as possible.

Now remove the tubes *one at a time,* wiping off all dirt with the cloth and polishing the prongs with fine sandpaper if they appear corroded. Wipe the top of the tube socket and the chassis in its vicinity, then replace the tube and repeat the process on each other tube in turn. *Never take out*

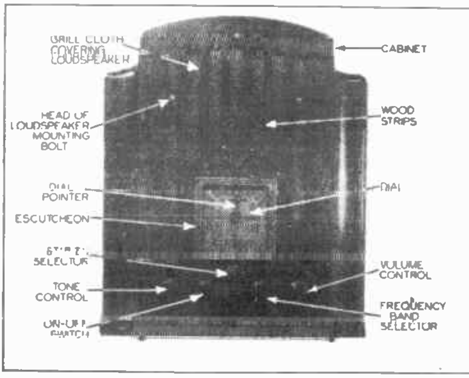

FIG. 1. This General Electric all-wave receiver will serve as our example for the overhaul procedure described here.

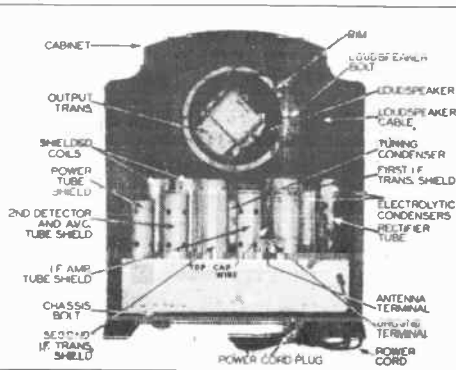

FIG. 2. An inspection of the rear of the set will show how the chassis and loudspeaker can be removed for a thorough overhaul.

more than one tube at a time, for you may get them mixed and replace them incorrectly.

Quite often a tube will be surrounded with a metal can known as a tube shield. One type of tube shield is removed by pulling upward (if there is a connection to a top cap on the tube, remove this first). Another type, made in two parts and known as a form-fitting shield, is held together by a spring steel ring. Pull out the tube and

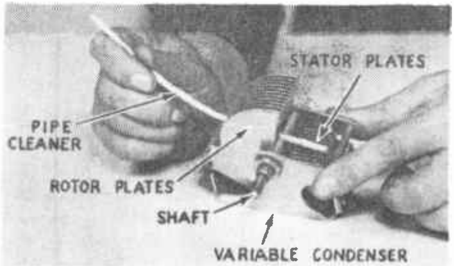

FIG. 3. From the earliest days of radio, pipe cleaners have been used to clean dust from between the plates of variable condensers, as shown above. This can be done without removing the condenser from the chassis

shield together, then push this ring out of its groove with a screw-driver; the shield will then fall apart and can easily be removed for cleaning.

Turn the chassis over and prop it up on wood blocks so that tubes or other delicate parts will not be crushed. Use a hand bellows, a tire pump, or a vacuum cleaner attachment to blow out dust around the many small parts and wires underneath the chassis; this should be done near an open window if possible. Finish cleaning the underside of the chassis with a brush or cloth. *Do not change the positions of any wires or apply force to any part while dusting.*

It is most important that all dirt be removed from the variable condensers. With the chassis in a normal position again, rotate the gang tuning condenser to its open or minimum-capacity position and run a pipe cleaner between each pair of plates to loosen the dirt, as illustrated in Fig. *3*, then blow out any dust which remains.

Any grease or dirt remaining on the chassis after the dusting procedure should be removed with a cloth dipped in a cleaning fluid such as naphtha. Clean the tuning dial window with a soft cloth.

A radio which has been exposed for a long period of time to moisture and particularly to a salty atmosphere, such as at the sea shore, may have lost its vitality due to dampness of the insulation on coils and various wires. The remedy is quite simple in a case like this; all you need is a small electric fan and a portable electric heater.

Set the chassis on end and direct the heater and fan towards it, as indicated in Fig. *4*. Change the position of the chassis or heater from time to time to insure that each part will be properly dried out. The fan serves to circulate the heat and to carry off water vapor. Do not bring the heater too close to the chassis, for this may melt the wax used in various parts. A 100-watt lamp in a desk lamp reflector will do in place of a heater, but more time must be allowed for drying. Remember that some coils are mounted on top of the chassis; apply heat to these also.

Inspect For Loose Parts: Carefully examine each of the parts above and below the chassis. Now that you are learning radio, try to identify all parts by name. The photographs in Figs. *5* and *6*, in which important parts are clearly labeled, may be of help to you in this respect. Do not expect to identify all parts, however, until you have studied them in your course.

Grasp each rigidly mounted part with your fingers and move it slightly; if the part ap-

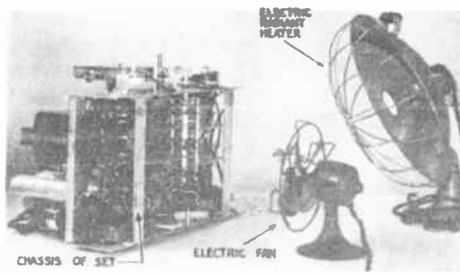

FIG. 4. A simple and effective way of drying out a chassis which has been exposed to moisture.

pears to be loose, tighten its mounting bolts or screws. The best way to do this is illustrated in Fig. *7*; set the chassis on one end, leaning it against a small box if necessary to prevent it from falling over. A set of socket wrenches like that shown in Fig. *8* is handy for this work.

If parts which are riveted to the chassis become loose, hold your claw hammer against the head of the rivet and gently tap the hollow or "curled-over" end of the rivet with another hammer.

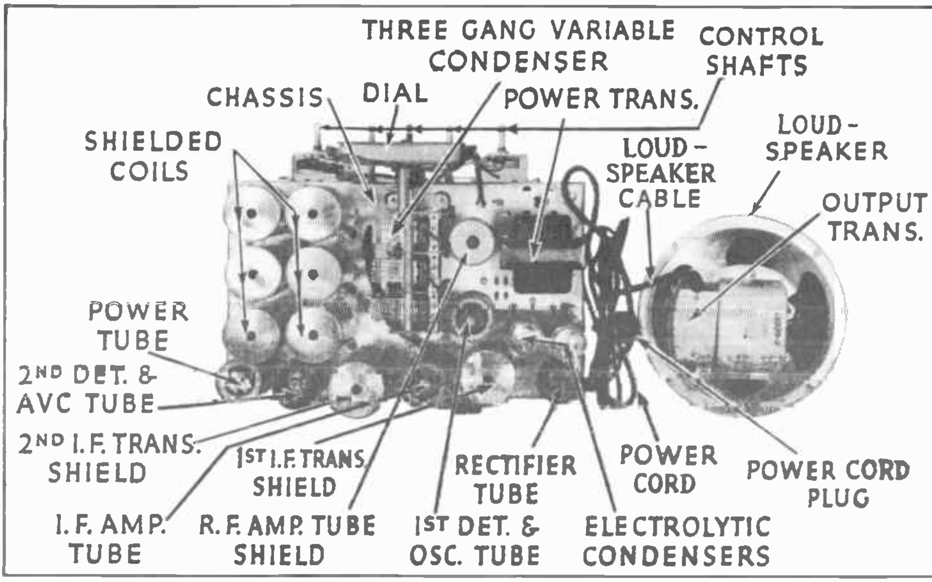

FIG. 5. Top view of the chassis of the General Electric receiver used as our example, with important parts clearly labeled to assist you in identifying similar parts on your own set.

Warning: Do not blindly tighten every screw head and nut which you see on a chassis; a great many of these screws and hexagonal-head bolts or nuts are for tune-up or alignment purposes, and will control the settings of trimmer condensers or adjustable coils. You can recognize these screws by the simple fact that they are mounted *on* a part, and do not serve to fasten that part to the chassis. A few typical alignment screws are shown in Fig. 9.

Check Connections. Inspect each soldered connection beneath the chassis in an orderly manner, section by section. Resolder each joint which appears to be defective; joints which have a green and corroded appearance, joints covered with excessive rosin, and joints in which the solder did not flow smoothly are often in need of resoldering. You can test joints for looseness by pulling on the wires with a pair of long-nosed pliers.

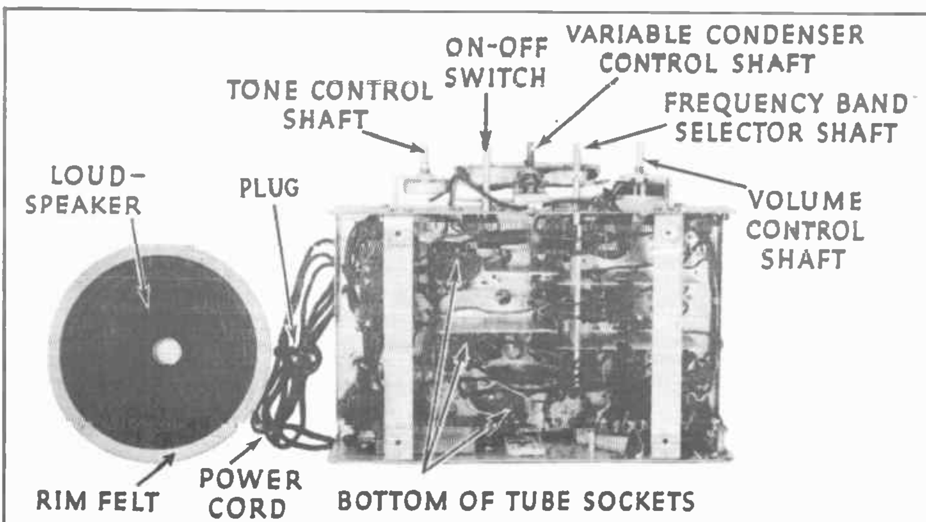

FIG. 6. The underside of a receiver will be unfamiliar to you for some time yet, but gradually, as you progress with your Course, you will become able to identify parts beneath a chassis like this.

Be on the lookout for insulation which is bruised or cut, particularly on wires which go through the chassis. If you find a lead with defective insulation, either replace with a new lead or unsolder one end and slip a piece of varnished cloth tubing (called "spaghetti" by radio men) over the wire so it will cover the break in the insulation, then resolder the lead.

Inspect the power cord for defective insulation, particularly at the point where it enters the chassis and at the wall plug. Give the same attention to the grid leads on top of the chassis. Polish the grid lead caps with sandpaper or scrape with a knife, and adjust so they make firm contact with the top caps of the tubes. Be sure that each tube shield makes good contact with the chassis, and be sure that the grid leads do not touch the shields.

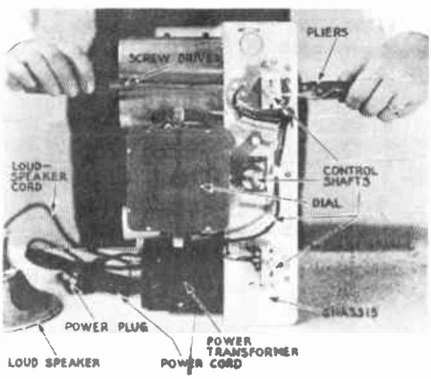

FIG. 7. Learn to handle a chassis in this manner when tightening loose bolts.

Check Performance. Plug in the power cord, re-connect antenna and ground wires, place the set in operation, and tune in various stations just as you did originally. The performance of the receiver should be as good as or better than that originally secured at that time of the day or night.

In an actual service job, this will be the time when the receiver is tuned up or aligned for the best possible performance. This alignment procedure will be taken up in a later job sheet.

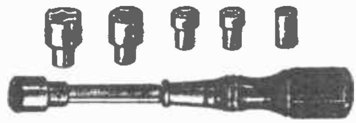

FIG. 8. A set of socket wrenches for the hexagonal nuts encountered in radio work is handy to have on your work-bench. Sockets are detachable in this set. Some servicemen prefer a set having an individual and permanent handle for each socket, as the small sockets are rather easily lost.

Replace Chassis and Loudspeaker In Cabinet. Remove the control knobs and slide the chassis back into its cabinet. Replace the loudspeaker next, then tighten its mounting bolts or screws. Now replace the chassis in its cabinet, and pull each corner of the cabinet in turn over the edge of your workbench so you can replace the mounting bolts or screws. Always pull out the power cord plug when handling the chassis, for otherwise there is a chance that you may get your fingers on terminals which are "hot," and receive a severe shock.

Replace the control knobs, and polish the outside of the cabinet carefully with a good grade of ordinary furniture polish. Now check over the aerial and ground systems carefully, cleaning and resoldering any poor connections. Be sure the lead-in wire does not make contact with the building or any other objects. Wipe off antenna insulators if they are accessible. A final check of receiver performance completes your overhaul and tune up job.

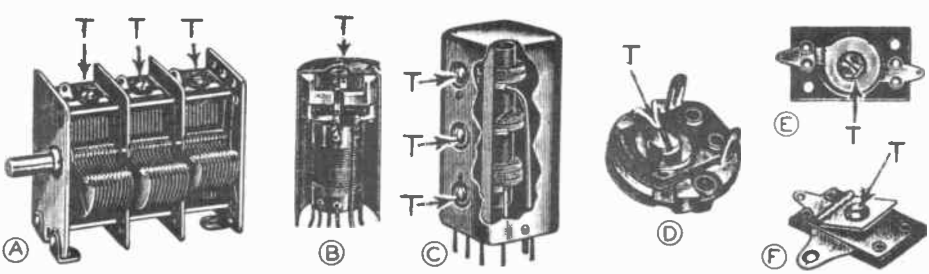

FIG. 9. Screw heads and hexagonal nuts like those marked *T* in this illustration are for alignment or *tune-up* purposes, and *must not be touched* while overhauling a chassis. You will find these alignment screws on gang tuning condensers as at *A*, on top of a metal coil shield as at *B*, at the side of a coil shield as at *C*, and on separate parts like those at *D*, *E*, and *F*, which are mounted directly on the chassis.

Common Causes For Receiver Failure

A RADIO receiver consists of many radio parts and tubes, skillfully mounted on a metal chassis and connected together with insulated wires. Failure of a receiver to operate satisfactorily may be due to one or more of the following causes: *1*, a defective tube; *2*, a defective part; *3*, a defective connection; *4*, a defect in the power source. The repair of a receiver involves locating the defective part or connection and making a repair or replacement; it is generally advisable to overhaul and tune up the set after the repair has been made.

The first step in a receiver repair job, the location of the defect, is a real challenge to the skill and ingenuity of a Radiotrician, for only rarely is one of these defects visible to the eye. Once the defect is located, the rest of the repair procedure is comparatively simple.

Although there are many different possible defects which can occur in a radio receiver, the problem of locating the trouble is greatly simplified by the fact that each defect has its own particular *effect* upon the performance of the receiver. One defect, for example, may cause the set to stop playing; another may cause howling, distortion, hum, or a loss in volume. Once you learn how each part works, and how the omission or failure of a part affects the operation of its circuit, you will find yourself making surprisingly accurate predictions as to the cause of a defect, simply by observing the performance of the receiver and making a few general tests.

Since tubes, resistors, coils, condensers and transformers are the only parts which ordinarily become defective in radio receivers, I will give you a number of general facts about these parts and then show you how to check each one for defects.

Checking Radio Tubes. The heart of a radio tube is the part known as the *cathode*, which emits electrons when heated. The majority of radio tube troubles are due to defective cathodes, so let us see just how a cathode can cause a tube to fail.

In a modern tube designed for A.C. receivers, the cathode is a metal sleeve coated with a special chemical material which emits (gives off) electrons freely when heated. The cathode is connected to one of the prongs on the tube base. Inside the cathode, but insulated from it, is a thin

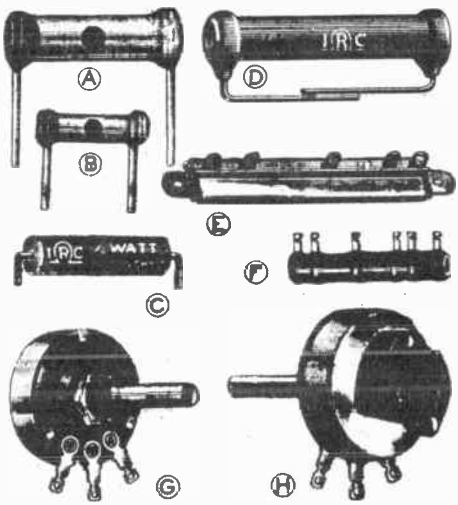

FIG. 1. Examples of resistors used in radio receivers; a defect in a resistor like one of these is one common cause of receiver failure. *A* and *B*—carbon resistors; *C*—metallized resistor; *D*, *E* and *F*—wire-wound resistors; *G*—front view of variable resistor often used as a volume control; *H*—rear view of variable resistor, showing on-off power switch mounted on cover plate.

wire or ribbon known as the filament; this becomes red-hot when alternating current is sent through, and thus serves to heat the cathode. In battery-type tubes, such as are used in portable or farm receivers (also in some power-rectifier tubes, of which the type 80 is most common), the cathode is omitted and the electron-emitting chemical coating is placed directly on the ribbon-shaped filament.

Burned-Out Filament. A break in the filament will naturally mean tube failure, for this prevents the filament current flow required to heat the cathode. Radiotricians say that the filament is open or *burned out.* The tube will feel cold when touched, and in the case of a glass tube, no reddish glow will be visible in the center of the tube.

Low Emission. Deterioration of the chemical material on the cathode, with a reduction in the number of electrons emitted, is the other common cathode trouble; Radiotricians say that the tube has *poor emission.* To identify this trouble you will either have to try a good tube of the same type in the receiver, or check the suspected tube with a tube checker.

Shorted Electrodes and Open Leads. Along with the cathode in a radio tube are a number of other electrodes, each connected to a prong on the tube base. A tube is defective when the electrodes touch each other (*an internal short*) or when there is a break (*open*) in a lead connecting an electrode to its prong.

Checking Resistors. Fixed resistors are made in many forms, a few of which are shown at *A, B, C, D, E,* and *F* in Fig. *1.* Usually there are only two terminal or leads, but some types have extra terminals or *taps,* as at *E* and *F.* A fixed resistor offers a definite amount of this resistance to current flow; the amount of this resistance is easily measured with the ohmmeter section of a multimeter.

When a fixed resistor becomes defective, its rated resistance changes. If the measured resistance differs considerably from that marked on the resistor or specified on the circuit diagram or parts list for the receiver, the Radiotrician knows that the resistor is defective. Often it is not even necessary to know the rated value of a fixed resistor; if the ohmmeter indicates an extremely high (infinite) resistance, there is obviously a break or open circuit somewhere in the resistor or in its leads. Likewise, if the ohmmeter indicates zero resistance, a short-circuit between the resistor terminal is indicated. In each case, the resistor should be replaced.

Variable resistors, also known as rheostats and potentiometers, usually resemble the units shown at *G* and *H* in Fig. *1.* They consist essentially of a fixed resistor and a rolling or sliding part which makes contact at various points along the resistor element as the shaft is rotated. There are usually three terminals, the outside two being for the ends of the fixed resistance element, and the middle terminal being connected internally to the movable contact.

If a crackling noise is heard when a variable resistor in a receiver (serving as a volume or tone control) is rotated, you can be pretty sure that there is poor contact between the fixed resistor and the moving arm. Failure to control loudness or tone uniformly and smoothly is another sign that a variable resistor is defective and in need of replacement. Finally, there may be a defect in the fixed resistor element itself or in its connections; this can be detected with an ohmmeter by using the same checking procedure as for fixed resistors.

Checking Coils and Transformers. A coil is simply a single length of insulated wire wound on bakelite or paper tubing or on special spools known as coil forms. Some coils, such as that in Fig. *2A,* have iron centers or cores; in others (like those at *B* and *C* in Fig. *2*), the center is open, or a solid wood rod is used as the coil form. Coils are rated according to their *inductance* in henrys (h.) or millihenrys (mh.); the larger the coil and the more turns of wire there are in it, the higher is its inductance.

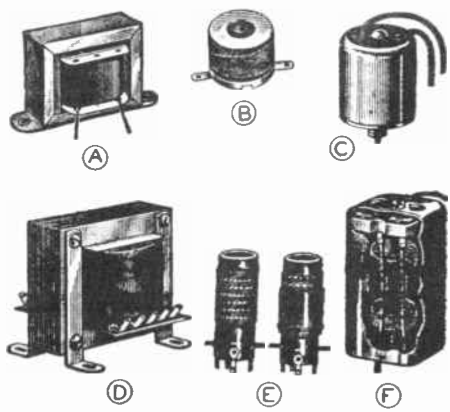

FIG. 2. Defects in coils and transformers like these are common causes of receiver failure. *A*—iron-core coil, also called a choke coil or filter choke; *B*—simple coil wound on wood core; *C*—same coil as at *B*, in metal housing; *D*—iron-core transformer; *E*—transformer made up of several coils wound on bakelite tubing; *F*—transformer in metal housing.

Coils offer very little resistance or opposition to the flow of direct current, but offer quite a high opposition (known as *reactance*) to the flow of alternating current; this reactance increases with the size of the coil (its inductance), and also with the frequency of the alternating current passing through the coil (the number of complete cycles of change in current per second). Coils are used primarily to control the flow of alternating currents.

Coil reactance or inductance can be checked with elaborate, costly equipment, but these tests take time and fortunately are not necessary in service work. The Radiotrician first checks the coil with an ohmmeter to determine if it is open (a broken wire) or shorted (a short circuit or undesirable connection across part or all of the coil), and to measure its direct current resistance. The correct D.C. resistance of a coil is generally specified on the circuit diagram of a receiver; any great deviation from this specified value indicates a defective coil. With iron-core coils there should be no electrical connection between the coil wire and the core; if the ohmmeter indicates a low-resistance connection, the coil is defective and is said to be *grounded* to its core.

An ohmmeter will not reveal all types of coil defects, but the Radiotrician can detect them by observing the performance of the receiver and making circuit tests based upon his knowledge of radio theory.

Two or more coils wound on a single coil form or on a single iron or steel core make up what is known as a *transformer.* A varying current in one coil produces a varying magnetic field which passes through the other coils, introducing or *inducing* in them a correspondingly varying voltage. Typical examples of radio transformers are shown at *D, E* and *F* in Fig. *2.*

The individual coils on a transformer can be checked with an ohmmeter for opens, shorts or grounds; the ohmmeter can also be used to make sure that there are no electrical connections between coils. Detection of other transformer defects depends upon a knowledge of how radio circuits which contain transformers should act.

Checking Condensers. Devices used in radio circuits primarily for storing electrons are known as *condensers.* They are rated according to their electron-storing ability or *capacity* in microfarads (mfd.) or micro-microfarads (mmfd.) A fixed condenser contains two groups of metal plates separated by an insulating material such as air, mica, waxed paper, oil, or a chemical; at *A, B, C* and *D* in Fig. *3* are examples of fixed condensers.

A condenser in good condition will not allow direct current to flow through it (because there is no direct electrical connection between its terminals), but it will allow alternating current to flow. The larger the *size* (capacity) of a condenser, the less will be its opposition (reactance) to alternating current; furthermore, this reactance is less at higher frequencies.

An ohmmeter connected across a good condenser should give a high-resistance or open-circuit reading (electrolytic condensers, shown at *C* and *D* in Fig. *3,* use a chemical as the insulating material and hence may give a medium-high resistance reading even when good). A condenser which gives a zero-resistance or short-circuit reading is obviously defective.

A good paper condenser will cause the ohmmeter needle to flicker or "kick" when the ohmmeter is first connected; absence of this flicker may indicate an open in the condenser terminal connections. Radiotricians often connect a good condenser of the correct size across a suspected condenser; if this restores correct receiver operation, they know that the original condenser is defective (open) and in need of replacement. There are capacity testers for determining exact capacity values of condensers, but the simple tests just described are generally sufficient to tell if a fixed condenser is defective.

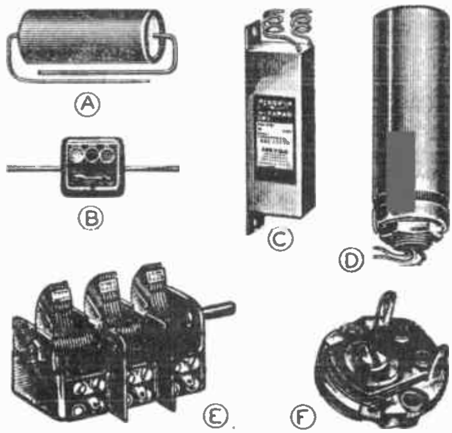

FIG. 3. Examples of condensers which may cause receiver failure. *A*—tubular paper condenser; *B*—mica condenser; *C* and *D*—electrolytic condensers; *E*—three-section variable tuning condenser; *F*—trimmer or semi-adjustable condenser.

Variable tuning condensers, the capacity of which can be varied by rotating the condenser shaft, are used extensively in radio sets; a typical unit is shown in Fig. *3E.* The metal plates may become bent enough so that opposite groups of plates are shorted. You can generally hear the plates scrape against each other if you listen carefully while rotating them, but you can also check for a short with an ohmmeter. The trouble can then be cured by straightening the rubbing plates with your long-nose pliers. With semi-adjustable variable condensers like that shown at *F* in Fig. *3,* an ohmmeter will reveal a short.

Checking Receiver Power Supplies

When a receiver does not play, one of the very first things you should do is check the power supply to the receiver. Turn on the receiver and watch the dial; if the pilot lamp does not light, check to see if it is burned out, then feel the tubes to see if they are heating. If all tubes are cold, you can be quite sure that there is trouble in the power supply to the receiver.

Check the wall outlet into which the receiver power cord has been plugged. If a table lamp or bridge lamp is conveniently near at hand, see if it works in its own outlet, then plug it into the suspected outlet. If the lamp works, you know that the outlet is okay. You could just as well measure the A.C. voltage at the outlet with the A.C. voltmeter in a multimeter, by inserting the test probes into the wall outlet slots; the meter should read somewhere between 105 and 125 volts in a normal location in this country. If the voltage reading is incorrect or zero, and a defect in house wiring (not simply a blown house fuse) is indicated, ask the customer to call in an electrician; in most localities only experienced electricians are allowed to repair permanent electrical wiring in homes.

Be on the lookout for a poor contact between the wall outlet and the prongs of the radio cord plug, as indicated by a flickering of the radio pilot lamp when you wiggle the plug. If the prongs are set into a bakelite or hard rubber cap, grasp the end of a prong with your combination pliers and twist slightly; repeat for the other prong, twisting in the opposite direction. In the case of a soft rubber cap, use one pair of pliers to hold a prong near its base, and use another pair of pliers to twist or bend the prong as much as is necessary for a good contact.

Having made sure that the plug and the wall outlet are in good order, you are ready to check the receiver supply circuit. Pull out the wall plug, and insert the two multimeter test probes in the holes in the two prongs of the plug. Using your multimeter as an ohmmeter, measure the resistance between the prongs when the receiver power switch is set to its *ON* position. The ohmmeter should read a low value, about 5 to 10 ohms for A.C. operated receivers. An open circuit, indicated by the ohmmeter's failure to give any needle movement, indicates a break in the power cord or in the receiver power supply circuit. A zero-resistance reading indicates a short somewhere between the power cord wires.

Before removing the chassis from its cabinet, look for a fuse in the chassis; some receivers have one. If broken or blown, replace with a standard radio fuse of the same size. If the defect has not yet been located, remove the chassis and turn it upside down so you can check the power supply leads and the power circuit parts.

In A.C. operated receivers, there are two wires in the power cord, and these separate as they pass into the chassis. In a typical arrangement such as that in Fig. *4*, one wire goes to the fuse, if used, and from it to one terminal of the power switch. From the other terminal of the switch a wire goes to

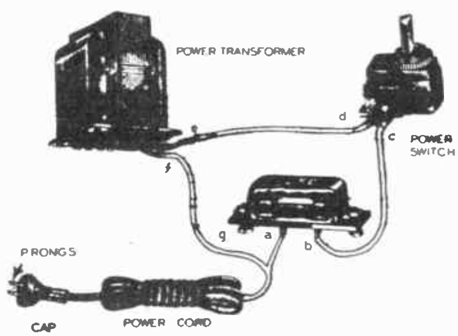

FIG. 4. Power circuit connections for a typical A. C. receiver. A 2-ampere fuse is generally used.

the power transformer; the other power cord wire goes directly to this transformer.

To check the circuit, place one multimeter probe on one cord wire (at *a* in Fig. *4*), and connect the other probe to the nearest exposed metal part in the circuit (such as at *b*). Continue advancing this second probe to other exposed parts in the circuit (to *c*, *d*, *e*, *f*) until you arrive at the other cord lead (at *g*). In each test the ohmmeter should show continuity (a low or zero-resistance reading); if no continuity is indicated for one probe position, you have located the break in the circuit. It may be a defective connection or it may be a defective part which requires replacement.

Radio Servicing Jobs and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

How To Test Tubes in the Receiver by the Comparison Method

The Comparison Method.—You should know that tubes may be tested with a checker, or right in the receiver, by the comparison method. Both procedures are widely used by radio service men. Some test tubes by a checker only; some, only by comparison in the receiver. But a wise technician knows both methods and knows when one is better to employ than the other.

You are familiar with the tube checker method, as it was taken up in a previous job. In order that you may understand the advantages and disadvantages of both systems you must know something of the comparison method.

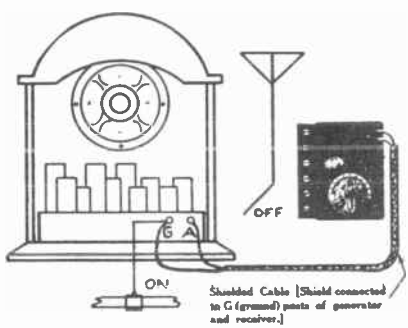

FIG. 1. *How to Connect Signal Generator.*

Instruments Required.—To test tubes by the comparison method, you need only two instruments. Fortunately, both are included in nearly all commercial testers made for service men—instruments which are absolutely essential for successful servicing.

A signal generator and an output indicator are required. The output indicator is usually a part of a multimeter. Both instruments were described in detail in previous jobs.

The Signal Generator.—Although for this job any signal generator which will produce a modulated radio signal within the tuning range of the receiver will be satisfactory, your money should be spent in procuring an all-wave signal generator, which can be used for any of the other needs in radio servicing. You should get a reliable all-wave signal generator whose output can be reduced to practically zero.

Connecting the Signal Generator.—There is only one way in which to connect a signal generator for this tube test. The lead from the signal generator's ground binding post must go to the ground post of the receiver, and the lead from the signal generator's antenna post must go to the antenna post of the receiver. Before making the test, be sure that the regular aerial lead to the receiver has been disconnected. The ground wire may be left attached. The proper connections are shown in Fig. *1*.

The Output Meter.—There are many different types of output meters on the market, but the one generally used to measure receiver output consists of a copper oxide rectifier voltmeter connected in series with a 1 mfd., 600 volt condenser. Such a device is to be found in most multimeters.

Be sure that the output indicator used has at least two or three sensitivity ranges and that you understand how the sensitivity may be reduced. In some instruments this is accomplished by changing the lead to a different binding post or pup jack, while in other instruments the sensitivity is increased or decreased by rotating the position of a main selector switch; in practically every case there is *one* common (to be used at all times) terminal, marked "output," or "plus and minus" (±). Since A.C. is to be measured there is no polarity to be observed; reversing the leads makes no difference.

Connecting the Output Meter.—An output meter, with a protective condenser (which prevents D.C. from flowing through the rectifier), may be connected anywhere in the audio system of a radio receiver. When a modulated radio frequency signal is fed to the input of the receiver the indicator will register the output. Inasmuch as you are interested in measuring the over-all audio output from the receiver, a connection to the output stage is recommended. The output meter, accordingly, is connected either across the voice coil of the loudspeaker, between the output tube plate and the chassis, or to the two plates in a push-pull output stage. These three connections are schematically shown in Figs. *2*, *3*, and *4*.

Preliminary Adjustments.—With signal generator and output meter connected and with the output meter set at its least sensitive range, the receiver and the signal generator are turned on, and tuned to some mid-scale frequency in the broadcast band, for example, 1,000 kilocycles. The

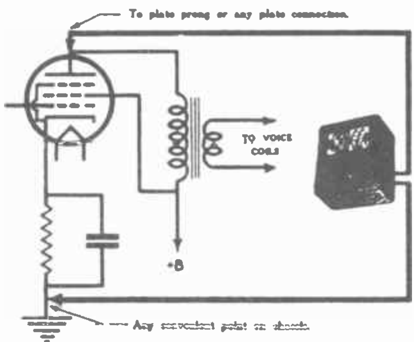

FIG. 2. *How to Connect the Output Indicator to a Single Tube Output Stage.*

output meter is now set at a sensitivity range that will give a reasonable meter needle deflection. The signal generator frequency is then adjusted to produce maximum reading of the output meter, which will occur when the signal generator is working at exactly the selected frequency.

As a general rule, the next step is to reduce the output of the signal generator to a value which will permit a one-third scale reading of the output indicator when the indicator is set to its most sensitive range. The reason for this adjustment will appear later.

The Comparison Test.—This completes the preliminary set-up. A tube in the receiver is now removed and a new one is tried in its place. If the tube change increases the output indication a reasonable amount, say up to half-scale deflection, the new tube is considered necessary and the original tube is discarded; if the deflection does not change or even goes down, the original tube is returned to the socket. This test is continued for the remaining tubes in a similar manner.* Of course, every time a new tube is retained the output indicator reading will be higher. It will then be necessary to reduce the output of the signal generator so that at the beginning of each test the output indicator needle will be at one-third scale.

An Earlier Comparison Method.—This comparison test is an improvement over the earlier method of tuning a radio receiver to some distant station, then replacing tubes with new ones, one at a time, and checking them by listening to the volume of the distant station. Although an acceptable emergency test for tubes, this older practice is not so scientific or accurate as the actual signal generator-output indicator method, for only relatively large variations in the volume of sound can be discerned by the human ear. Furthermore, the signal strength of the distant station may vary during the test.

Testing Tubes in AVC Receivers.—In connection with the use of the comparison method of checking tubes, there are a few important considerations for you to remember, if you desire to do a first-class job and justify your customer's confidence in you as a Radio-Trician.

Receivers equipped with automatic volume control (AVC) must be judiciously handled. As you will learn from your main course, the AVC system in a receiver controls the radio frequency system in such a way that as the signal received increases, the sensitivity of the R.F. system decreases. In an AVC receiver, if you replace a bad tube with a good one the R. F. amplification will increase, but, as the AVC will nullify this effect, you will probably think that the bad tube is good.

Fortunately, this AVC action starts only at a definite signal strength, referred to as the "threshold point." For signals below the threshold point the AVC has very little action; on such weak signals a change to a better tube increases output registered on the meter. In order to test tubes below this important threshold point, it is necessary that the output of the signal generator be very low and the output indicator extremely sensitive.

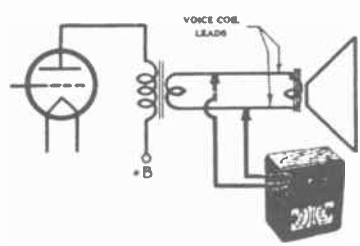

FIG. 3. *How to Connect an Output Indicator to a Dynamic Speaker. Use 0-10 volt or a Lower A.C. Range of Meter.*

You can easily tell when the threshold point is exceeded, because when you increase the output of the signal generator

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* Any order may be taken although it is a good plan to start with the rectifier tube, then test the first R.F. tube, proceeding from this stage to the output.

above the threshold point the output indicator will show very little increase.

The problem is accordingly solved by maintaining low signal generator output. If you have difficulty in getting sufficiently low output from your signal generator, connect the bare end of a piece of insulated wire to the antenna post of the receiver and wrap the other end around the antenna lead from the signal generator—the more turns the greater the coupling.

Gassy Tubes.—There are tests on tubes in AVC receivers which can be properly made only by the comparison method; namely, checking for gassy tubes in the R.F. amplifier or in the AVC. This check is always made after the tubes have been tested for output. The signal generator is left on but the receiver is turned off, to allow the tubes to become cold. Then the receiver is turned on and, as the tubes begin to heat, the signal from the generator will be indicated on the output meter.

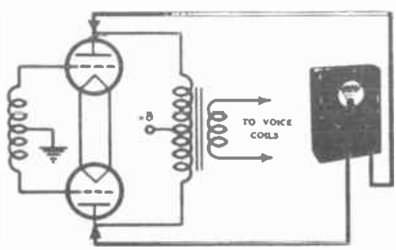


FIG. 4. *How to Connect an Output Indicator to Sets Having Push-Push or Push-Pull Output Stages.*

If, in a few minutes, you observe that the output indicator creeps up, you have a gassy tube in one of the R.F. stages; if the output indicator readings decrease gradually, it is probable that the AVC tube is gassy.

It is to be remembered that these are only general rules. Absolute proof can be obtained only by checking the circuit and understanding the function and working of every tube in the receiver. Obviously, the importance of radio knowledge is great.

Selecting the AVC Tube.—Selecting the AVC tube by tube checker test alone is not good practice. It must be chosen through actual test in the receiver. Many practical men tune the receiver to a distant, weak station and select the AVC tube which will not reduce the intensity of the distant program but which will reduce the volume when the receiver is tuned to a powerful local or semi-local station. The same test may be accomplished with a signal generator capable of operating at extremely low output values.

Tube Alignment.—Often there is something to be gained by interchanging tubes of identical types in a receiver. Even though tubes may check satisfactorily in a tube checker or by the comparison method, it is possible that these tubes may work better in one stage of the receiver than in another. One tube may be a better detector than an amplifier, or a better oscillator than an amplifier. Therefore, as a final bit of adjustment, which may aid remarkably the ability of the receiver to tune in the distant stations, you should include a tube alignment test.

The procedure is simple. With a signal generator feeding a weak signal to the receiver, interchange similar tubes. For example, if the receiver uses four type 24A tubes, interchange them until an arrangement is found at which the output is greatest. After such an alignment on a weak signal, you should tune in a strong station to make sure that the positions selected are such that no tube will be overloaded. You can judge this by the ability of the receiver to reproduce at normal volume without distortion.

Which Method Is Best?—Many busy, practical service men object to the additional labor involved in the comparison method, and insist that the tube checker serves their purpose adequately. But the old saying that "the proof of the pudding is in the eating" holds true here, for the most conclusive test of the worthiness of any tube is a test right in the receiver where it will be used.

Not to be overlooked is the use of the comparison method of tube testing for demonstrating the value of new tubes to the set user in his home. Such scientific proof is most convincing and will help you in the important business of selling tubes.

Testing Tubes in Homes.—The busy service man uses a tube checker on his outside jobs, that is, in servicing in the home. Each tube is removed from its receiver socket and tested in the checker. If found to be bad, it is replaced with a new tube. If, after this test, there is reason to believe that further improvement can be made by switching tubes of similar types in the receiver, the comparison method set-up is employed, and the tube alignment test, previously described, carried out.

Testing Tubes in the Shop.—At the service bench the expert invariably uses the comparison method, because the same connections are also used for alignment, neutralizing and other receiver adjustments, subjects which are to be considered in later radio servicing jobs. The comparison method is also preferred at the bench because the best tube for each position of the receiver can be selected, tubes can be properly interchanged, and the peak output of the receiver obtained. It is by so "squeezing" the last bit of performance out of a receiver that results are achieved which the customer cannot but appreciate.

The tube checker also has its place at the service bench. It is used for checking tubes which the service man may want to take on a service job, or to check old tubes which he may want to place in trade-in receivers so that they can be sold at low prices. He would also use it for checking new tubes bought from the parts jobber, to be sure that every tube received and paid for met his standards of a good radio tube.

Your Choice of Method.—You now know the two usual means of tube testing, and when and how each is most commonly employed. Equipped with such knowledge, you can decide for yourself, in any given circumstances, which of the methods should be used.

How To Align a Tuned R.F. Receiver

When Is Alignment Needed?—Tampering with the R.F. system, constant vibration and shock, effects of the weather, and general aging will throw the tuned circuits of a radio receiver out of line, resulting in poor selectivity and sensitivity. This applies to both superheterodyne and tuned radio frequency sets.

When a receiver is serviced for lack of volume or inability to separate stations, the alignment of the R.F. system should be checked and adjusted, after (and this is important) you are sure that the tubes are in normal condition, the tube voltages are correct, and there are no internal defects, which might produce the same trouble. Although service manuals of the receivers you are repairing will give you the correct operating voltages, a little experience will enable you to dispense with them, for operating voltage need only be approximately correct. The plate and grid voltages are about the same for similar types of tubes used for the same purpose. Refer to service manuals or radio tube charts until you are familiar with the different voltages used.

Alignment Creates Customer Satisfaction.—Then, too, there is the service job brought to your bench for general repairs. I stressed in earlier job sheets on radio servicing that the chassis should be tightened mechanically, that poor joints should be resoldered, that tubes should be checked and aligned, that the chassis and variable condensers should be thoroughly cleaned, and finally that the R.F. system should be aligned.

In this job I will consider the process for a tuned radio frequency receiver. The "super" will be considered in a later job.

Equipment Required—How Connected.—To align a receiver you need a signal generator and an output indicator. The signal generator is connected to the ANT and GND posts of the receiver; the output indicator is connected to the plate circuit of the power stage, just as I explained for the testing of tubes. In some cases the receiver may be tuned to the station most desired. All receiver adjustments are made to give maximum receiver output.

You Will Encounter Three Types of T.R.F. Receivers.—Alignment is required because the variable condensers in the tuning system are not adjusted so each stage tunes exactly to the signal. The procedure of aligning the R.F. system hinges around the construction of the ganged variable condenser. The three conditions one must consider are: *1*, Sets not equipped with trimmer condensers; *2*, sets using trimmer condensers; and *3*, sets with trimmer condensers as well as slotted rotor end plates.

Receivers with No Trimmers.—You may from time to time run across a few sets not equipped with trimmers. Don't spend too much time aligning such a receiver, for the customer really needs a new set, or a wave trap to give better station separation.

If you want to go to the trouble of aligning such a set—most service men don't—tune in a local station, loosen the set screws holding the rotors of the ganged condensers, move the condensers one at a time for greatest signal strength, then retighten the set screws. The adjustment need not be made at any particular frequency—make it where it will do the most good, at the part of the dial most used.

Sometimes in sets like this you can't move the condensers individually. Alignment is then made by bending the condenser leads away from or towards the chassis to secure best results.

Receivers with Trimmers.—Sets equipped with tuning circuit trimmers—adjusting condensers in parallel with the tuning condensers—are more modern and are capable of better performance. Alignment can be accomplished by increasing or decreasing the capacity of the trimmers, while the receiver is tuned to the customer's favorite station.

Receivers Having Trimmers and Split Rotors.—Finally there is the receiver which uses split rotor plates in addition to trimmers. The set is intended to be selective over the entire broadcast band and it is your job as a Radio-Trician to see that the full possibilities of the set are realized. While a signal generator and output meter are not an absolute necessity on the two previous cases, they are on this one.

Connect the oscillator and output meter to the set just as if you were going to align the tubes. Tune the set and signal generator to 1,400 k.c. and adjust the signal generator for maximum output. Next adjust the output of the generator for one-third deflection on the output meter, with the volume control on the set turned up to its normal setting. Adjust the trimmers (no special order) for a maximum reading on the output meter, reducing (whenever necessary) the generator output so the output meter needle does not read off-scale.

Now you may adjust the segments on the end rotor plates of each variable condenser section. Turn the tuning knob of the set until the first split section of the tuning condenser rotor meshes with the stator. Tune the generator to give maximum output, adjusting its output until the output meter reads one-third scale. Bend the first split section on the rotor of each condenser in or out for maximum deflection on the output meter. Turn in the next segment and repeat. When all the split segments have been adjusted for maximum results retune the set and generator to 1,400 k.c. and readjust the trimmers, as bending the plates may have thrown off the previous adjustment. The set is then correctly aligned.

Having aligned a receiver in the above manner we may find that the music and speech from a broadcast station do not sound natural. This is particularly noticeable in receivers using more than three tuned stages. It is due to the fact that the receiver is now too selective and is cutting off the higher audio frequencies—side-band cutting. Compensation for this is easily made. Adjust the trimmer condenser on one of the R.F. stages so the resonant point is slightly off. If adjusting one trimmer is insufficient, try another. If one is turned in, turn the other out, a little at a time, until the quality seems normal.

Some Helpful T.R.F. Don'ts.—Don't try to align an old receiver until you have given it a thorough overhauling, cleaning out dirt and grime from the R.F. coils and condensers.

Don't try to align a receiver which has a damaged, warped, or loose chassis. Where a one thirty-second inch change in a condenser plate is so important, how can you expect to align a receiver where the parts themselves are loose?

Don't adjust any trimmer condensers other than those which are in parallel with the tuning condenser.

Don't try to align a radio unless all shields and shield connections are tight. If at all possible, leave the receiver in its cabinet while aligning. Always connect ground wire to the receiver when aligning.

NATIONAL RADIO INSTITUTE

Washington D. C.

Radio-Trician

REG. U. S. PAT. OFF.

Service Manua

Compiled solely for Students & Graduates

ON

SERVICING A. C. RECEIVERS

A great deal has been written on the many troubles that arise in Radio broadcast receivers and what causes their failure and how to correct troubles when they occur. The Radio sections of our daily papers and Radio publications have devoted columns and pages in answering individual problems. These have been of invaluable assistance to the individual, but in nearly all cases have referred to specific conditions.

In this Service Manual on A. C. Receivers, we will endeavor to group service problems under general classifications, prescribe methods of diagnosing them, followed by a prescription for correcting them.

We believe that general methods may be applied in spite of the fact that there are so many different types of sets on the market, each one claiming individual distinction all its own. All Radio sets, no matter what type, which fail to give satisfaction do so for a number of reasons that are fundamental.

Any student who will carefully study the information given in this Service Manual will be able, in practically all cases, to locate and remedy the trouble encountered. This is especially true if the Radio-Trician has available a schematic wiring diagram of the receiver with which he is working. The value of wiring diagrams in Radio servicing cannot be over-estimated and you should make it a practice to collect and save as many as possible. Service information and diagrams on the most popular receivers will be sent to you from time to time during your Radio studies. You should always keep these and also the ones that are printed in various magazines and Radio publications. Many Radio manufacturers are glad to supply service information to Radio-Tricians, but they of course dislike giving this information out to the general public. Just as soon as you have worked up a nice service business, have a neat letterhead printed as this will be a big help in securing valuable service information.

The Radio-Trician, before he starts to make any adjustments other than turning on the set and trying the various controls, should question the customer as to how it happened, the time, place, and conditions surrounding the failure. Such questions as the following:

How long has the set been in operation?

Was the set operating satisfactorily up to the time of failure?

Were you tuning the set when the failure occurred?

If so, what control were you moving?

Did you make any changes in the connection of the aerial or loud-speaker, if so what were they?

Did it suddenly stop operating?

Was there any squeal or howling sound just prior to failure?

Did the loud-speaker fall?

Is the antenna OK?

In short, have the customer re-enact the conditions at the time of failure. Get all the symptoms and an astonishing amount of time may be saved in running down the difficulty. If sufficient questions are asked, the customer will generally give you the real cause of trouble or he will suggest something to you in the course of inquiry that will point out just what was the cause of the failure.

TROUBLES ENCOUNTERED IN A. C. RECEIVERS

The following are the main troubles which are encountered with electric receivers. To check the cause and correct any of these conditions, read the paragraphs in the following pages whose numbers correspond to the numbers under each of the headings listed below.

In order to economize on space, many references will be made to the Service Sheet Servicing Direct Current Operated Receivers which you have already received. The numbers which are in parenthesis refer to paragraphs which are numbered correspondingly on Pages 3, 4 and 5 of the Service Sheet just mentioned. Therefore, refer to the Service Sheet on battery operated receivers whenever a number is in parenthesis in the following paragraphs.

Tubes Do Not Light

(17), (33), (60), 101, 113, 129, 130, 162.

Tubes Light But No Signal

(5), (9), (19), (20), (24), (33), (43), (44), (54), (60), 113, 117, 172, 173, 174.

Weak Signals

(4), (5), (8), (9), (10), (16), (17), (18), (19), (21), (23), (27), (28), (29), (31), (32), (33), (34), (35), (36), (37), (38), (40), (42), (43), (44), (49), (51), (52), (53), (54), (55), (60), (61), 102, 104, 105, 109, 113, 114, 116, 132, 133, 136, 138, 139, 149, 151, 172.

Distorted or Muffled Signals

(4), (10), (17), (23), (29), (35), (36), (37), (44), (52), (53), (61), 102, 104, 105, 108, 110, 115, 170, 171.

Poor Distance Reception

(1), (2), (4), (5), (9), (10), (15), (16), (17), (19), (23), (24), (25), (29), (31), (33), (52), (60), 102, 104, 105, 109, 115, 136, 149, 172.

Howls and Oscillations

(5), (10), (16), (18), (23), (28), (29), (31), (32), (34), (35), (37), (51), (52), (53), (61), (65), 104, 134, 135, 136, 137, 168, 169.

Fading Signals

(1), (33), (58), 102, 104, 115, 125.

Noise

(2), (5), (17), (20), (23), (27), (28), (29), (32), (33), (35), (36), (42), (44), (51), (52), (53), (54), (60), (61), (62), 102, 104, 107, 115, 140, 141, 142, 143, 146, 152, 166, 167.

Hum

(17), (18), (25), (27), (41), (64), 102, 104, 105, 109, 118, 120, 121, 122, 123, 124 125, 126, 127, 129, 130, 136, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155 156, 157, 158, 159, 160, 161, 165.

Broad Tuning

(5), (10), (15), (29), (31), (33), (34), (35), (37), (50), (51), (52), (53), (60), 132, 164, 172.

101. LINE VOLTAGE D. C. INSTEAD OF A. C. Never connect an alternating current receiver to a Direct Current line; there is a great danger of burning out the power pack of the receiver. If in doubt as to the kind of current, call the local Power Company and ask them which kind of current is used.

102. DEFECTIVE RECTIFIER TUBE. If the various elements of a rectifier tube are loose, the tube may cause intermittent reception or a microphonic howl. Low output of the tube may cause weak signals and A. C. hum. A new tube should be substituted in place of the suspected tube in order to determine its condition.

103. RESISTANCES, DEFECTIVE. The most accurate method of testing resistances is by the use of the high resistance voltmeter and "B" battery test. The reading obtained when placing the test points on the resistor to be tested should be less than the voltage reading when the test points are connected together, the exact difference, of course, depending upon the value of resistance being tested. A small resistance will make little change in the reading, while a high resistance will reduce the voltage reading considerably. No voltage, of course, indicates an open circuit in the resistance.

If a high reading is obtained when testing a high resistance, it shows that the resistance is short-circuited. A short circuit on a low resistance is harder to determine since the difference in the voltage readings will be very small. After some experience in testing resistances, the Radio-Trician will have little trouble.

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.

It is not a good policy to use the lamp test method of testing resistances. There is danger of burning out resistances of small current carrying capacities such as grid resistances. Also this test is not nearly as accurate as the voltmeter test, especially in the case of a resistance.

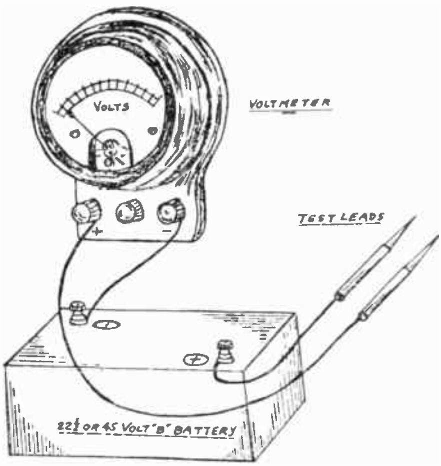


Fig. 1—Voltmeter Testing Outfit.

In testing any resistance, always be sure that it is not connected to any piece of apparatus, such as an inductance coil, which would give a 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 remove the resistance from the circuit and test it separately.

104. TUBES, DEFECTIVE. Tubes that are unsatisfactory in one part of a

receiver can oftentimes be placed in other sockets in the set and give good results. This is especially true in the case of the A. F. and R. F. tubes. Tubes that give poor results in the R. F. sockets will sometimes give good results as audio amplifiers. Occasionally a "soft" tube, that is, one that oscillates easily when used in a R. F. amplifier, will cause the amplifier to oscillate. In this case the tube should be replaced or possibly used in another socket. An extremely sensitive detector tube will cause an A. C. hum if the receiver is extremely critical.

Important: In changing tubes in a receiver, always be sure that the correct tube is placed in the correct socket. That is, never place a 226 type tube in a 171 type socket, or vice versa, as the tube will burn out. Also it is advisable to turn the power off when changing tubes because removing two or three tubes will result in overloading the tubes remaining in the circuit and may shorten their lives or change their characteristics.

105. INCORRECT VOLTAGES. This trouble in the correctly designed electric receiver is caused by incorrect A. C. line voltage or a defective rectifier tube (see paragraph 102). This is, of course, supposing that the receiver is in good condition. If the voltage is too high it can be reduced by inserting a resistance, capable of carrying the necessary current (approximately 1 ampere), in series with one side of the A. C. line, or by using a voltage regulator manufactured by a reliable company. If the A. C. line voltage is low, it will be necessary to take the matter up with the Power Company, as they will be very glad to remedy the condition.

Excessive plate voltage may be due to incorrect or defective grid bias resistor and plate resistors in the power pack; also an open in the voltage divider system between the detector and B— tap and to shorted filter chokes.

Insufficient plate voltages may be due to: Defective rectifier; excessive plate current; defective plate by-pass condenser.

Incorrect filament voltage may be due to wrong value of voltage reducing resistance (in modern sets such resistances are rarely used).

Incorrect grid voltage may be caused by incorrectly designed or defective grid bias resistors or defective grid bias resistance by-pass condenser.

106. TRANSFORMERS, DEFECTIVE. A high resistance voltmeter and "B" battery should be used for testing the continuity of the windings in any type of transformer, such as R. F., A. F. and Power transformers. In the case of A. F. transformers that winding which has the least resistance, that is, gives the highest voltage reading, is the primary winding. The various sections of push pull transformers should also be tested for continuity.

In testing power transformers, make sure that there are no resistors connected across the filament taps as otherwise the reading would indicate a complete winding, when in reality the winding might be open.

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 voltmeter shows a reading, it indicates that the winding is grounded to the core or shield and the trouble should be repaired at once. No voltage reading should be obtained when testing between any secondary winding and the primary winding.

As in the case of testing short circuits in resistances, considerable experience and the use of highly accurate voltmeter readings are necessary to determine if transformer windings are short circuited. This is especially true in the case of step-down secondary windings. Under actual operating conditions, a short circuit in the primary winding of a power transformer will increase the voltage output of the secondary windings. A short circuit in the secondary windings will reduce the voltage output of the transformer.

107. CONDENSER, DEFECTIVE. In order to find out whether or not a fixed condenser is defective, it is first necessary to remove it from the set and short circuit the two terminals together to discharge it. Then charge the condenser by connecting a "C" battery to its terminals, being careful not to touch either the condenser terminals or the ends of the leads while doing this. A condenser should be able to hold such a charge for a few minutes. The cord tips of a head-set are then touched to its terminals, care being exercised not to touch the cord tips or the condenser terminals with the fingers for this will discharge the condenser through the body, and then the test is incorrect. A soft click in the phones at the moment the condenser terminals are touched shows that it is in good condition as the condenser holds its charge. If no click is heard or the click

is very faint, the condenser is defective and should be replaced with a new one. To conduct this test, it is absolutely necessary that the condenser be disconnected from any other piece of apparatus to which it may be attached.

For small condensers, the above method is not very accurate and the ordinary voltmeter and battery continuity test should be used. No reading on the voltmeter should be obtained other than a momentary deflection when the test points are applied to the condenser terminals.

108. INCORRECT GRID VOLTAGE. See paragraph 105 and apply the tests outlined in paragraphs 103 and 107.

109. OPEN IN GROUND SYSTEM. Make the usual careful inspection for open circuits in the entire ground system. In many receivers using a metal chassis, many connections that are at ground potential are connected to the chassis and this is in turn connected to the ground binding post. Such connections should be carefully inspected to see that they are making good contact.

110. TOO GREAT SIGNAL STRENGTH. Too much volume from local stations will often overload the detector or audio tubes, thus causing distortion. The volume control should be inspected to see that it is functioning properly. The grid and plate potentials should be checked to see that they are correct. If the signal strength is still too great, the aerial can often be disconnected and satisfactory results secured on local stations.

111. WRONG CONNECTIONS TO TRANSFORMER SECONDARY. Check connections with a schematic diagram of the receiver. If necessary, check A.C. voltage output of transformer with an A. C. voltmeter capable of reading the highest voltage output of the transformer.

112. TUBES IN PUSH-PULL TRANSFORMER. For best results the tubes in push-pull amplifiers should be as nearly matched as possible. Do not use one exceptionally good tube and one that is not so good in the amplifier as it will probably cause distortion.

113. OPEN CIRCUITS. Test all circuits for continuity, using voltmeter and battery method. If possible check with schematic diagram of receiver.

114. VARIABLE CONDENSERS. Always keep the plates of variable condensers clean and free of dirt. The ordinary pipe cleaners, obtainable from any cigar store, can be used to clean the plates of the condensers.

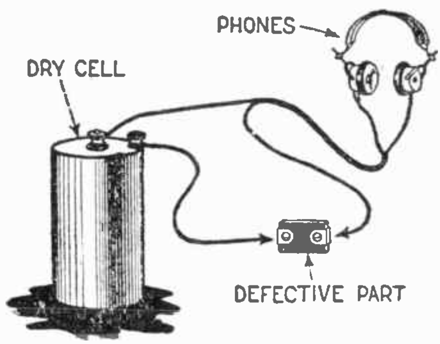


Fig. 2—Head-phones and Dry Cell Method of Testing Defective Apparatus.

Make sure that the rotor or movable plates are not bent and make contact with the stator plates.

115. VOLUME CONTROL, DEFECTIVE. Volume controls used on electric receivers almost always are some form of variable resistance. The ordinary test for the continuity of resistances should be used and also all variable contacts should be inspected. If the volume control is defective, it is generally the best policy to replace the control with a new one rather than to attempt to repair the old one.

116. GROUNDED CIRCUITS. 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 not supposed to be connected to the chassis. This can be determined by comparing all connections with the schematic diagram.

117. CHOKE COILS, DEFECTIVE. The method of testing choke coils is the same as that used for testing resistances and the same instructions as given in paragraph No. 103 can be used.

118. TRANSFORMER CENTER TAP INCORRECT. Secondary 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 this purpose. The two ends of the resistance are connected directly across the filament taps on the transformer and the grid-return is connected to the center-tap of the resistance. The center-tap on the transformer is not used.

119. GRID BIAS RESISTANCE BY-PASS CONDENSER. By-pass condensers connected across the grid bias resistors should be tested the same as any other condensers. (See paragraph No. 107.) An open condenser or one of incorrect value may cause an A. C. hum. These condensers are not always used and it is sometimes possible to eliminate A. C. hum by the addition of such a condenser.

120. LACK OF GROUND ON CORE AND CHASSIS. In many receivers A. C. hum is reduced by grounding the cores and shields of choke coils and transformers. If such connections are open or poorly made A. C. hum will result. Carefully inspect all connections and see that they are good and tight.

121. LOOSE LAMINATION IN POWER PACK OR AUDIO TRANSFORMERS. This is 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.

122. HUM IN DYNAMIC SPEAKERS. Many dynamic speakers require either high or low voltage direct current to excite the field coil. This produces the dynamic field necessary for the operation of the receiver. This current is supplied by either a battery, the power supply in the Radio receiver or by a rectifier operating directly from the light line. The two latter type of dynamic speakers have the disadvantage, however, in that they produce a slight amount of hum. Under normal conditions, this will not be objectionable but in localities where excessive hum is had, it is advisable to use the magnetic type of speaker in preference to the dynamic speaker.

123. RESONANT EFFECT IN ROOM. You will find that in some installations, the hum will sound very much louder than in others. This may be due entirely to a resonant effect in the room which tends to build up the low notes and make them sound loud in proportion to music or speech. By standing in various parts of the room, you will notice that the hum is louder in some places than others. The only remedy for this condition is to place the instrument in different positions in order to find the one where the best effect is had.

124. SENSITIVE DETECTOR TUBE. The UY-227 detector tube is extremely sensitive and will pick up hum from any lamp cord or wire carrying alternating current near it. It is extremely important that all wires be kept as far away from this tube as possible. This is especially true of the cords which supply the receiver.

125. VARIATIONS IN ELECTRIC LIGHT CURRENT. In a few localities light current is very unreliable and may cause excessive hum or fading. In a case of this nature similar results will be had in various installations in the neighborhood. It is obviously impossible to eliminate this trouble by any adjustment of the receiver or speaker when the cause of the trouble is defective current. When this trouble is experienced, get in touch with the Power Company and tell them of your experience. Whenever it is possible to correct these conditions the Power Companies are always glad to do so. Before you complain to the Power Company, however, be sure that the trouble is with the line. Find out whether or not your friends and neighbors have the same trouble and if they do you can be pretty sure the trouble is with the line.

126. RESONANT EFFECT IN CABINETS. A resonant condition may occur in a cabinet which will exaggerate hum. This is most apt to occur when the compartment in which the speaker is placed is entirely closed. When possible, it is therefore advisable to leave the back of the cabinet off entirely. If the speaker is placed on top of the cabinet, trouble is likely to be had, so it is best to place the speaker a short distance from the cabinet.

127. R. F. TUBE OSCILLATING. An objectionable hum can be caused by the R. F. circuit oscillating which is characterized by a loud, steady hum. Taking one of the R. F. tubes out or placing a finger on the tuning condenser plates will locate trouble in the R. F. circuits. See also paragraph No. 104 on tubes.

128. INDUCTION FROM NEARBY A. C. LINES. If the aerial or ground wires run close to or parallel with any wire carrying alternating current, an A. C. hum will be present. Run all such wires as far from the A. C. line as possible and perpendicular to the A. C. lines if possible.

Likewise, any wires carrying alternating current that are in close proximity to the receiver or speaker may cause interference. Keep such wires as far as possible from all radio circuits, especially the detector circuit.

129. Open Primary Power Transformer. See Par. 106.

130. Open Secondary of Power Transformer, Low Voltage. See Par. 106.

131. High Resistance in Grid Circuit. A high resistance joint in the grid circuit of any radio-frequency stage will tend to make that stage tune broad. Make sure that all joints are well made.

132. Open Bias Resistance. Par. 113.

133. Loose Connection in Power Unit. See Par. (60).

134. Grid Resistance Shorted. Par. 103.

135. Excessive R. F. Voltage. Par. 105.

136. Open Secondary R. F. Transformer. See Par. 106.

137. R. F. By-Pass Poorly Grounded. See Par. 116.

138. Shorted Primary Transformer. See Par. 106.

139. Shorted Secondary Power Transformer. See Par. 106.

140. A. C. Plug Elements Loose. See Par. 60.

141. Audio Transformer Defective. See Par. 106.

142. Condenser Plate Bent. Par. 114.

143. Leaky Condensers. See Par. 107.

144. Grounded Filament Circuits. See Par. 116.

145. Open Filament Mid-Tap Resistors. See Par. 103.

146. Defective Filter Condensers. See Par. 107.

147. Open Ground in Secondary. See Par. 109.

148. Shorted Filter Choke. Par. 117.

149. Open Grid Circuit. See Par. 113.

150. Grounded A. F. Transformer. See Par. 116.

151. Open Antenna Choke. Par. 117.

152. Ground Binding Post Not Making Good Contact With Chassis Frame. See Par. 109.

153. Grounded or Open Choke Coil. See Par. 116.

154. Grounded or Open Plate Circuit. See Par. 116.

155. Grounded or Open Resistor. See Par. 116.

156. Hum Adjuster Defective. See Par. 103.

157. Open or Shorted By-Pass Condenser. See Par. 107.

158. Open Grid Bias Resistance By-Pass Condenser. See Par. 119.

159. Lack of Grid Resistance By-Pass Condenser. See Par. 119.

160. Open Grid Circuit Filter By-Pass Condenser. See Par. 107.

161. Grid Bias Resistance By-Pass Condenser Capacity Too Low. See Par. 119.

162. Open Lead in A. C. Plug Cord. See Par. 113.

163. A. C. Plug Reversed. In some installations an A. C. hum may be reduced by reversing the plug that connects the receiver to the A. C. line.

164. Open Grid Circuit. An open circuit in any R. F. stage will cause that stage to tune broad. See Par. 113.

165. Pilot Lamp Grounded. Par. 116.

166. Noisy Resistors in Power Pack. This trouble can be generally located only by substituting a resistance known to be in good condition. Also see Par. 103.

167. Pilot Lamp Loose in Socket. Tighten lamp in socket.

168. Shorted R.F. Choke Coil. Par. 117.

169. Defective R.F. Tube. Par. 104.

170. Grounded or Open Biasing Resistance. See Paragraphs 103 and 116.

171. One-half of Push-Pull Transformer Secondary Open, Shorted or Grounded. See Paragraphs 106 and 116.

172. Variable Condenser Shorted or Stator Grounded. See Pars. 107 and 116.

173. Grid Condenser Shorted, Open or Grounded. See Paragraphs 107 and 116.

174. Grid Leak Grounded. Par. 116.

TESTING THE CONTINUITY OF ANY ELECTRIC RECEIVER

In testing any receiver, it is only necessary to remember that each tube has only three individual circuits. These circuits are the grid, filament and plate. Keeping this in mind, you can easily test the continuity of any receiver by using a high-resistance voltmeter and "B" battery. You can take any circuit, no matter how complicated it may seem to be, and trace out these three circuits for each tube. You can also start at any point of the circuit and trace the circuit back through resistors, condensers, and transformer windings until you finally arrive at the "B—" of the receiver. If an open circuit is encountered when making these tests, it is, of course, only necessary to then test each individual piece of apparatus in that circuit in order to find one that is defective.

In Figure 3 you will find a schematic diagram of a typical A. C. receiver including the power pack. This diagram is very similar to the majority of electric receivers on the market. It is advisable for the student to study this diagram in order that he may become familiar with the various circuits. It is not necessary to completely understand the use of the various pieces of apparatus used in this receiver as the theoretical discussion of electric receivers will be taken up in detail in advanced lessons. The purpose of the following descriptions of the various circuits is merely to enable the student to test the continuity of a receiver so that any defects may be located. These paragraphs contain a complete description of each individual circuit in the receiver.

Testing Grid Circuits

Starting at the grid terminal of the first radio-frequency tube, Figure 3, we find the grid resistor, and then the circuit goes to the tuning circuit, and aerial inductance. This inductance is connected to the metal chassis which in turn is grounded. The circuit then continues to the grounded side of the power pack, up through the 150-ohm resistance to the "B—" lead. From the "B—" lead the circuit continues up to the mid-point of the resistance connected across the 1.5 volt secondary winding of the power transformer and then back over the filament circuit to the filament of the first tube.

You will thus see that if you place one test point on the grid of the first R. F. tube and the other contact on one filament terminal, that you should receive a voltage reading since the circuit should be complete. If you do not obtain a reading it indicates that there is an open in the circuit and it will be necessary to test each individual part of the circuit until the trouble is found.

The grid circuits of the next two radio frequency tubes are practically the same as the circuit just described. That is, a circuit starts from the grid terminals, passes through the 600-ohm grid resistors, through the secondary windings of the radio-frequency transformers which are in turn connected to the metal chassis. The circuit then continues through the chassis and to the grounded side of the power pack which is connected to the metal chassis. The circuit then goes through the 150-ohm resistance to the negative "B" lead and then to the filament circuit, as described in the preceding paragraph.

In testing the grid circuit of any detector tube using the grid leak and grid condenser for detection, it is necessary to place one test point on the side of the grid condenser which is NOT connected to the grid of the tube. By studying the diagram, you will readily see that this circuit is then identical to the one just described, after passing through the secondary winding of the radio-frequency transformer.

The grid circuit of the first audio-frequency amplifier is the same as those described with the exception that the grid is connected to the secondary of the audio transformer. The other side of this transformer is connected to the metal chassis and the circuit continues as described in the above paragraphs.

The grid circuit of the last audio amplifier is slightly different. After passing through the secondary of the audio-frequency transformer, the circuit goes to the 650-ohm resistor, then to the 150-ohm resistor, and from there follows the circuit back to the negative "B" lead, and then to the mid-tap on the 5-volt secondary winding of the power transformer (not to the 1.5-volt center tap), and then through either side of this winding to the filament terminals of the last audio-frequency tube.

TESTING PLATE CIRCUITS. Starting at the plate terminal of the first radio-frequency amplifying tube, we see that the circuit passes through the primary winding of the radio-frequency

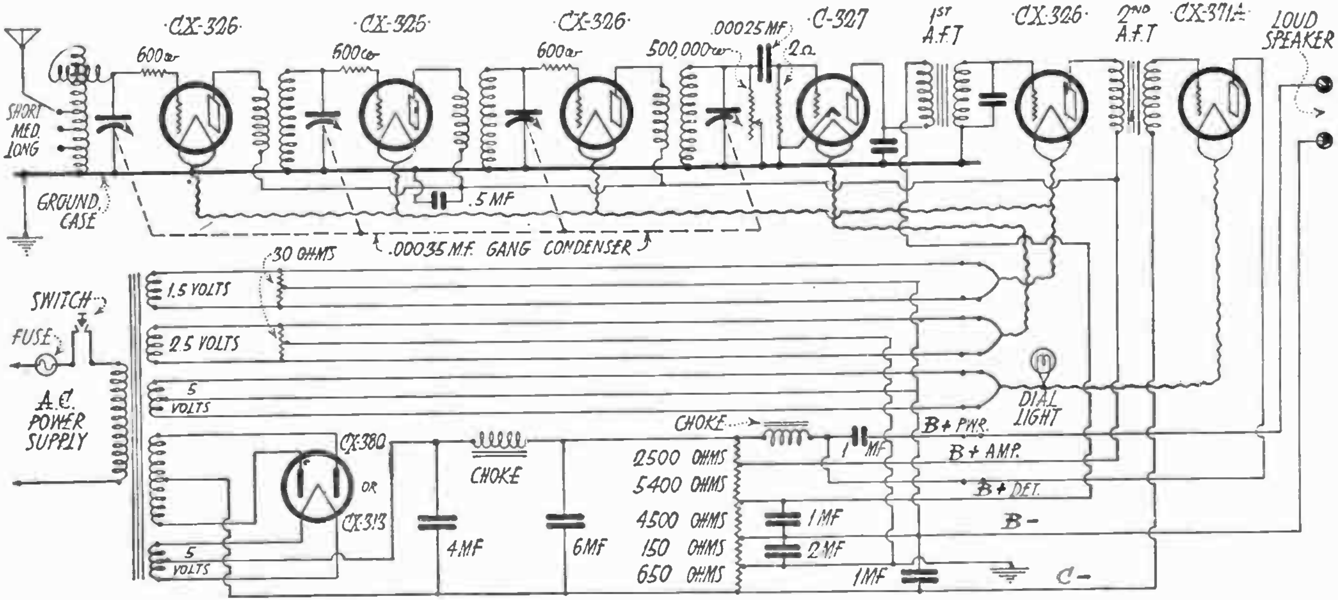


Fig. 3—A Typical AC Receiver.

transformer, and then goes through the 5400-ohm resistor and the 4500-ohm resistor to the negative "B" lead. From this point the circuit goes to the mid-point of the resistance connected across the 1.5-volt secondary winding of the power transformer and then to the filament terminals of the first R. F. Thus you will see that by placing a test point on the plate terminal of the first R. F. tube, and the other test point on one of the filament terminals you would obtain a voltage reading. If a reading is not obtained, it is an indication that there is an open in the circuit and it will be necessary to test each individual piece of apparatus in the circuit, until the defect is found.

The plate circuits of the second and third R. F. tubes and the first A. F. tube are identically the same as the one just described. You will, however, notice that there is a by-pass condenser from one side of the plate circuit to the chassis immediately below the second R. F. tube. One side of this condenser should be disconnected from the circuit and tested to see that it is not short circuited. See paragraph 107.

The plate circuit of the detector tube passes through the primary winding of the first audio-frequency transformer, down through the 4500-ohm resistor and the 150-ohm resistor, then up to the mid-point of the resistor connected across the 2.5-volt secondary winding of the power transformer, which is in turn connected to the filament terminals of the detector tube. By placing the test points across the plate terminal and filament terminal of the detector socket, you should obtain a voltage reading.

Starting at the plate terminal of the last A. F. socket, we find that the circuit goes through the choke coil, down through the 2500, 5400 and 4500 ohm resistances to the negative "B" lead, then up to the center tap of the 5-volt secondary winding of the power transformer, and from there to the terminals of the last audio-frequency tube.

TESTING FILAMENT CIRCUITS. Since the first three radio-frequency tubes receive their current from the same 1½-volt secondary winding, you will find that these circuits are practically the same. Connecting the test points to the two filament terminals on any of these sockets should give a voltage reading; the circuit in this case consisting of the 1.5-volt secondary of the transformer, and the wires leading to the various filament terminals of these particular tubes.

In making this test, it is necessary to call your attention to the fact that in order to completely test the 1.5-volt secondary winding of the power transformer it will be necessary to disconnect the 30-ohm resistor which is connected across the 1.5-volt terminal. This is explained in paragraph 106.

By carefully studying the diagram, you will readily see that the filament circuit of the detector tube is made up of the 2.5-volt secondary windings of the power transformer and the necessary wires to make the connections to the terminals of the socket.

The filament circuit of the last audio-frequency tube is composed of the 5-volt secondary winding of the power transformer and the necessary connections to the filament terminals of the socket. You will also note that the dial lamp is connected in parallel across this circuit.

TESTING RECTIFYING TUBE CIRCUITS. By examining the diagram, you will see that by connecting the test points to the plate terminals of the rectifying socket you will get a test on the high voltage secondary winding of the power transformer. If this tests open, it is an indication that the power transformer secondary winding is open, or that there is an open connection between the secondary winding and the socket of the rectifying tube.

By placing one test point on each of the filament terminals, you should receive a voltage reading, thus indicating that the 5-volt secondary winding used for lighting the filament of the rectifying tube is complete.

Placing one test point on one filament terminal of the rectifying socket and the other on one plate terminal of the rectifying circuit should give a voltage reading; the circuit consisting of one choke coil, the 2500, 4500, 5400, 150 and 650 ohm resistances. Should no voltage reading be obtained when making this test, then each individual resistor and choke coil should be tested.

TESTING AERIAL CIRCUITS. Placing one test point on the aerial binding post and the ground binding post should give a reading. No reading indicates an open circuit in the aerial inductance.

In some receivers a fixed condenser is sometimes placed in the aerial circuit or the ground circuit, and, of course, this circuit should then be tested according to the schematic diagram.

The continuity tests that we have just described can be applied practically to any electric receiver. We will, however, take a specific example and trace out the various continuity tests in the Radiola 17 receiver. A schematic circuit diagram of the Radiola 17 is shown in Figure 4. You will note that this diagram is divided into two separate sections, one consisting of the receiver assembly while the other consists of the power supply unit. The cable terminals and the terminal strip are numbered from front to back facing the front of the Radiola, No. 1 being next to the front panel and No. 11 next to the rear panel.

RECEIVER ASSEMBLY CONTINUITY TESTS

Remove All Radiotrons

Terminal	Correct Effect	Incorrect Effect caused by
Lug No. 1 to Lug No. 2.	Open	Shorted UX-226 socket.
Lug No. 3 to Lug No. 4.	Open	Shorted UY-227 socket.
Lug No. 5 to Lug No. 6.	Open	Shorted UX-171 socket.
Lug No. 1 to one side of filament contact to sockets Nos. 1, 2, 3 and 5.	Closed	Open connection.
Lug No. 2 to other filament contact of sockets Nos. 1, 2, 3 and 5.	Closed	Open connection.
Lug No. 3 to one side of heater contacts of socket No. 4.	Closed	Open connection.
Lug No. 4 to one side of heater contacts of socket No. 4.	Closed	Open connection.
Lug No. 5 to one side of filament contact of socket No. 6.	Closed	Open connection.
Lug No. 6 to one side of filament contact of socket No. 6.	Closed	Open connection.
Lug No. 7 to cathode contact of socket No. 4.	Closed	Open connection.
Lug No. 8 to plate contact of socket No. 5.	Closed	Open primary of first audio transformer or connection.
Lug No. 9 to plate contact of sockets Nos. 1, 2, 3 and 5.	Closed	Open primary of 1st, 2nd, or 3rd R. F. transformer or 2nd A. F. transformer.
Lug No. 10 to plate contact of socket No. 6.	Closed	Open primary of output transformer.
Across loud-speaker pin jacks.	Closed	Open secondary of output transformer.
Antenna lead to ground lead.	Closed	Open volume control.
Grid contact of socket No. 1 to ground.	Closed	Open volume control or poor contact of volume control arm.
Grid contact of socket No 2 to ground.	Closed	Open secondary of 1st R. F. transformer or grid resistance.
Grid contact of socket No. 3 to ground.	Closed	Open secondary of 2nd R. F. transformer or grid resistance.
Stator of condenser No. 3 (nearest output transformer) to ground.	Closed	Open secondary of 3rd R. F. transformer.
Grid contact of socket No. 5 to ground.	Closed	Open secondary of 1st A. F. transformer.
Grid contact of socket No. 6 to ground.	Closed	Open secondary of 2nd A. F. transformer.

POWER SUPPLY UNIT CONTINUITY TESTS

Remove Radiotron UX-280 and Disconnect Cable at Terminal Strip

Terminals	Correct Effect	Incorrect Effect caused by
Across terminals 1 to 2.	Closed	Open UX-226 filament winding and potentiometer.
Across terminals 3 to 4.	Closed	Open UY-227 filament winding and potentiometer.
Across terminals 5 to 6.	Closed	Open UX-171 filament winding and potentiometer.
Across filament contacts of UX-280 socket.	Closed	Open UX-280 filament winding.
Plate contact to plate contact of UX-280 socket.	Closed	Open high voltage winding of power transformer.
UX-171 potentiometer adjusting screw to terminal No. 10.	Closed	Open resistance strip.
Terminal No. 11 to plate contact of UX-280 socket.	Closed	Open high voltage winding of power transformer or filter reactor.
Across input plug.	Closed	Open primary of power transformer or line switch. If open, throw switch to other position and test. If both open, test switch separately.

Power Cable and Terminal Strip Color Scheme

Terminal or Cable Lug No.	Color	Terminal or Cable Lug No.	Color
1	Black with Yellow tracer	6	Green
2	Black with Yellow tracer	7	Green with Red tracer
3	Blue	8	Maroon
4	Blue	9	Maroon and Red
5	Green	10	Black with Green tracer

GENERAL TROUBLES ENCOUNTERED IN A. C. RECEIVERS

DEFECTIVE TUBES. The Radio-Trician is cautioned to give special attention to the tubes used in electric receivers.

Generally speaking, more trouble is caused by defective tubes than any other one thing in electric receivers. Paragraphs 102 and 104 give complete instructions on this subject.

NEUTRALIZING. There are several different things that may cause a receiver to lose its selectivity in the neutralized type of radio-frequency receivers. The most common cause is the unneutralized condition of the radio-frequency stages. This will not only cause the receiver to tune broad but it will cause the receiver to lose its sensitivity as well. The first step then is to correctly neutralize the receiver.

To do this it is first necessary to tune in accurately a signal on a frequency between 1000 and 1500 kilocycles. This signal should be produced by a modulated oscillator similar to the one described elsewhere in this Service Manual.

In order to neutralize a receiver, it is necessary to prevent filament current from flowing in a radio-frequency tube that is being neutralized. In the case of the old style sockets this can be easily accomplished by placing a small piece of paper or silk on the filament prong of the tube so that it will not make contact with its corresponding spring in the tube socket. When the tube is placed in the socket the filament should not light up. In the case of the newer type of receivers where the UX base is used, it is generally impossible to use this method and

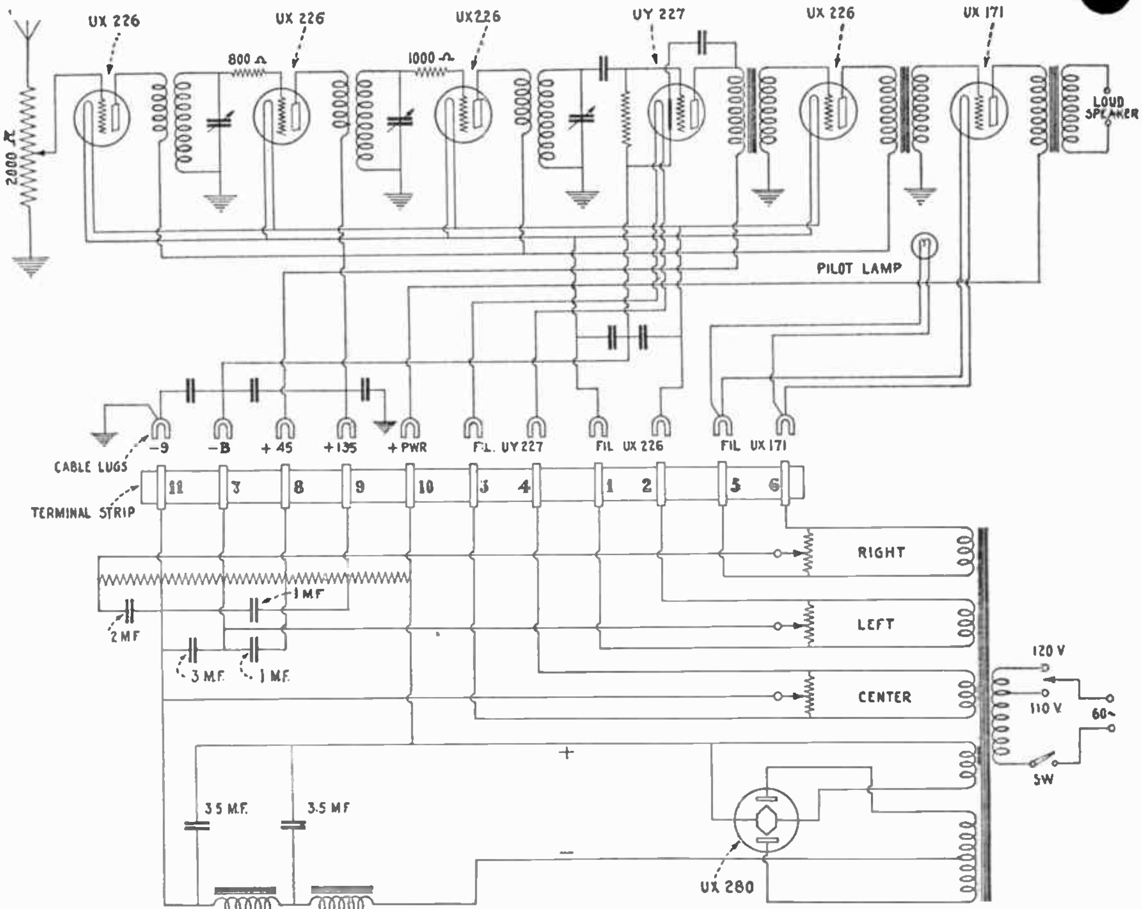


Fig. 4—Schematic circuit diagram of the Radiola 17.

a different procedure must be followed. In this case a "dummy" tube can be used by taking a tube that is in good condition and carefully cutting off one of the filament prongs so that it will not make a contact in the socket. A tube having a burnt out filament cannot be used for this purpose as the slight difference in the internal capacity caused by the incomplete filament wire will throw everything out of balance and defeat the full purpose of the adjustment.

It is possible to obtain special socket adapters which can be placed in the socket of the tube to be neutralized so that the filament of that tube will not light. This is probably the best method of obtaining this result. The above instructions apply to those receivers having their tubes wired in parallel.

If the receiver is wired with its filaments connected in series temporarily, strap the filament prongs of the tube together and replace it in its socket.

ume will probably increase because only the capacity of the neutralizing condenser remains, and it is not compensated for by the capacity of the tube which has been removed from the circuit.

The other radio-frequency tubes in the receiver should then be neutralized according to the above instructions.

After the receiver has been entirely neutralized on the high-frequency signal, then it should be also neutralized on a low-frequency signal, and on a frequency of about 650 kilocycles. If this requires a considerable change of capacity in the neutralizing condensers to make the two adjustments at different frequencies, the adjustment should be left about midway between the two points or slightly nearer the point used for the high-frequency station.

It is possible to use the signal from a broadcast station for neutralizing a receiver, but the results will not be as accurate as when the oscillator is used.

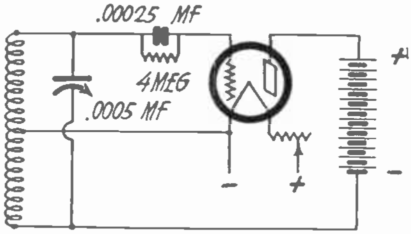


Fig. 5—Circuit Diagram of a Modulated Oscillator which can be used for balancing and neutralizing receivers.

Connect a lead wire to one terminal of the variable condenser on the modulated oscillator and bring the wire in close proximity to the lead-in wire of the receiver, and tune in the signal produced by the oscillator. For best results this signal should be reasonably loud with the volume control of the receiver turned entirely on.

Next, place the special neutralizing or "dummy" tube in the radio-frequency socket next to the detector tube. Slowly adjust the neutralizing condensers which correspond to the stage that is being neutralized, until the signal disappears entirely or is reduced to minimum audibility. When doing this use a fibre wrench or screw-driver to minimize body capacity.

When a signal is reduced to its lowest possible intensity, then that particular stage is neutralized. If the tube is now removed from its socket, the signal vol-

Synchronizing Condensers

Many electric receiver condensers will often get out of adjustment causing broad tuning and loss of sensitivity with the result that only loud local stations will be heard. Many service men will attempt to make satisfactory adjustments of condensers by using the signals from a local broadcasting station and will get very poor results. An efficient method of accurately ganging the condensers is by the use of a modulated oscillator located near the set to be balanced. Complete instructions for building such an oscillator are given in the Service Manual. When properly constructed, such an oscillator will give a very sharp signal adequately suited for such work.

The oscillator should be adjusted for a frequency of approximately 1000 kilocycles and the oscillator should be placed several feet away from the receiver. The aerial and ground wire should be removed from the receiver, and a lead wire attached to one terminal of the variable condenser of the oscillator should be brought in close proximity to the aerial nding post of the receiver. The signal ıould then be tuned in on the receiver ith the volume control on the receiver turned on full. The lead from the oscillator should then be moved away from the receiver until the signal is just audible. In making the following adjustments, the oscillator should not be changed in any way.

The tuning condensers on many one-dial receivers have a mechanical means of adjusting them to synchronism. This may consist of set screw adjustments on common shafts or on belt driven pulleys, small adjustable vernier condensers, adjustment of lever drives or the bending of condenser plate segments. Whatever the method used, it is usually described by the Radio manufacturer in his service literature, which should be consulted in all cases.

After the signal has been tuned in on the receiver, then each individual con-enser should be adjusted by the use of fibre wrench or screw-driver according the mechanical construction of the condensers, so that the signal is received with the loudest intensity. In making this adjustment neither the dial on the receiver nor on the oscillator should be moved. In some receivers no balancing by means of mechanical adjustment can be made with the possible exception of loosening the rotor plates on the shaft of the condenser and moving them slightly. This is a very tedious process and requires considerable patience on the part of the Radio-Trician. Still other receivers do not have any way by which the condensers may be adjusted. In this case, if it has been definitely determined that the condensers are out of synchronism, it will be necessary to return the entire set of variable condensers to the nearest service station maintained by the manufacturer of that receiver.

After making this adjustment, the oscillator should be changed to a frequency orresponding to approximately 60 on the dial and the signal then tuned in on the receiver. Slight readjustment of the gang condensers may then bring in the signals with slightly better results. However, if the coils and condensers in the receiver are correctly designed, signals should be received accurately and equally well on both the high and low frequencies.

Figure 5 gives a wiring diagram of a modulated oscillator which is easily and cheaply constructed. The size of the coil and variable condenser should be such that the entire broadcast wavelength band will be covered by the oscillator. If a .0005 mfd. condenser is used, then the coil should consist of 50 turns of No. 22 DCC wire wound on a 3-inch form and tapped in the center. The radio-frequency feed line may be connected from one of the terminals of the variable condenser.

A Convenient Method of Testing Without the Use of Meters

In locating trouble in any receiving set, it is a good idea to have a plan or system to work by. Since the detector is the heart of the Radio set, this part should be tested first and see that it is functioning properly. IMPORTANT: Before proceeding with the following test it is absolutely necessary that you make sure that the aerial is not grounded or connected to the ground in any way.

Remove all tubes but the detector. Then connect a pair of phones in series with the B plus detector terminal and B supply. Test for a "click" in phones as the detector filament current is turned on. Next, connect aerial to the plate terminal (P) of the radio-frequency tube preceding the detector. This will give a one-tube detector hook-up and will respond to signals within a range of 20 miles.

When this circuit tests all right, move antenna to the plate terminal of the second tube preceding the detector and insert a tube in the socket immediately preceding the detector. You now have a one-tube radio-frequency amplifier with a detector. Following the same general procedure, test any additional stage of radio-frequency that may be in the set.

If no signals are received or if the addition of a stage of radio-frequency does not increase the volume slightly, it is an indication of trouble in the circuit. This may be found by following the outline given on previous pages of this Service Manual. Always be sure that any particular stage (detector, radio-frequency or audio-frequency) is working satisfactorily before attempting to include additional stages in the hook-up. In radio-frequency stages, see that correct voltage is applied to the plate of the tube and also that the signal is ac-

(OVER)

curately tuned in. If there is an adjustment to prevent the tube from oscillating, see that it is adjusted properly. In the case of one or two dial sets, the condensers that are ganged together may need readjustment. The method of doing this depends entirely upon the construction of the set, as explained in the section of this Service Manual entitled Balancing Condensers. It is absolutely necessary for each radio-frequency amplifier to be in exact resonance with the incoming signal or the receiver will tune broad and have very little volume.

Now place phones in series between the primary of the second audio-frequency transformer and plate of the first audio-frequency tube and place a tube in the first audio-frequency socket. If signals are heard with good volume, it will indicate that the receiver is in good condition up to this point.

NOTE: If it is not convenient to place phones in series with the plate and primary of the second audio-frequency transformer as just described, place phone tips directly on the terminals of the primary of the transformer. This will answer the same purpose except that it will not indicate a defective primary winding of the audio-transformer if it should happen to be burned out or defective.

The same method of testing the audio-frequency section may be used regardless of whether the amplifier is transformer, resistance or impedance coupled or a combination of the three. As you determine that each stage of audio-frequency amplification is operating properly, proceed to test the next stage.

By carefully studying the circuit diagram Fig. 3 and applying the principles just outlined, the student should be able to locate and remedy any trouble found in any tuned radio-frequency receiver. Of course, in many cases it will not be necessary to test all of the different stages in the receiver to find the trouble.

NOTE: The statement was made above that all tubes except the detector tube should be removed from the receiving set. It is not absolutely necessary to do so and, in fact, in the case of an electric receiver using several tubes it will probably be best not to remove all the tubes. Merely remove that radio-frequency tube to which socket you are a taching the antenna.

SERVICING MERSHON CONDENSERS

In some Radio Receivers Mershon condensers are used. Simply analyzed, these condensers consist of rolled aluminum electrodes in a copper case, these electrodes being covered by an oxide film. The coated aluminum sheet is the anode of the condenser. The oxide film is the dielectric of the condenser and is formed electrolytically in the process of manufacture. A liquid called the electrolyte serves as the cathode and makes contact with the copper containing can to which external connection is made by clamping to the sub-panel of the radio set.

Although the Mershon will break down under an applied voltage of over 415, no damage will result unless the amount of leakage current and consequent heating of the electrodes and solution causes to boil. Instantaneous surges of voltag do not damage the film.

After the Mershon condenser has been unused for several weeks it may take as long as five minutes after the radio set is turned on for the condenser to reform properly and operate satisfactorily. However, after having been once reformed the operation of the condenser is instantaneous thereafter. The normal leakage current of the condenser is one quarter (¼) milliampere per microfarad.

The Mershon condenser will act as a rectifier and in making continuity tests this should be remembered. The can is always negative. If the test points are turned around so that the positive point is on the can the condenser will provide enough leakage to indicate on the meter. To be sure of any connection around the Mershon check both ways with the test points.

Radio Servicing Jobs and how to do them

A Simple Method of Locating the Dead Stage

If you watch an expert radio serviceman repairing a dead receiver, you will see that he pulls a tube out of a socket, pushes it back in place; does the same for one or more other tubes; finally to say: "The defect is in the first detector, or oscillator, or last I.F. stage." His actions make you think of these so-called "sees all, knows all, tells all" persons. It may seem like a "sleight of hand" trick, but this serviceman is working on sound radio principles.

By being more attentive, you will observe that he is listening to the clicks that emanate from the loudspeaker. When a tube is pulled out of and replaced in a socket and a click is not produced, that stage is *considered* dead.

The principle involved is simple. When a tube is pulled out of the socket, the supply current in that circuit stops flowing. This sudden change in current or circuit disturbance is relayed to the following tubes, on to the loudspeaker, which emits a click. That is why I call this testing procedure the "circuit disturbance test." Now by knowing the tube arrangement in the receiver, that is, which is the detector, oscillator, I.F., A.F. or R.F., amplifiers, the location of the defective stage is spotted. The test is not a positive check but it comes pretty near telling the truth. Furthermore, you can generally conduct this test with the chassis in the cabinet. Let me discuss the test for a couple of possible receivers.

The Circuit Disturbance Test of T.R.F. Receivers.—In Fig. *1* I have drawn a block diagram of the signal circuits in a typical T.R.F. set. The radio signal feeds into the first R.F. stage and then passes through successive stages to the loudspeaker. If only one stage is dead the chain is broken and signals cannot get through to be changed to sound waves.

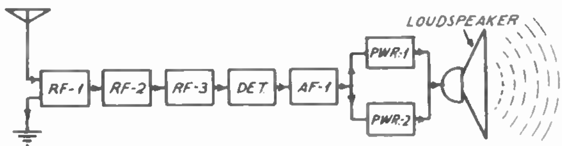


FIG. 1. *Block diagram of signal circuits of a T.R.F. receiver.*

I am going to assume that a defect may exist in any stage. The correct way of tackling this sort of a job is to find the stage in which the breakdown exists, instead of testing every part in every stage of the set, as many self-styled experts will do in solving this difficulty.

Suppose we start at the end instead of the beginning, and pull out and replace one of the power tubes. A click shows that the tube is getting plate current (hence, must have plate and filament voltage); proves that the loudspeaker is working as it reproduces signals passed to it from the output stage. The same test

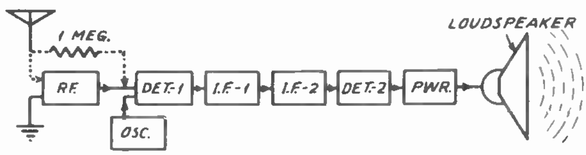


FIG. 2. *Block diagram of signal circuits of a superheterodyne receiver. If pulling out Det-1 produces a click and connecting the antenna to Det-1 does not result in signals, the OSC is probably defective.*

is made with the other power tube. If we get no click any of the things we have assumed above may be at fault. For example, the loudspeaker voice coil may be open, the tubes dead, there may be no voltage from the power supply, the output transformer may be open, etc. If the

A commercial multimeter.

tubes are warm to the touch they have plate voltage and current, although only an exact check can be made with meters.

Now if everything so far is tested to be O.K., we should repeat our test for the first A.F. stage. No click indicates trouble in this stage or in the coupling between it and the power stage. A circuit disturbance test on the detector and R.F. stages should be made in turn, until a click is not heard, isolating of course, the defective stage. Then the parts in that stage are tested. Clearly, by using the circuit disturbance test no time is wasted in testing parts which can be proved to be good.

When screen grid tubes are used, the test is even easier to make. Simply touch the control grid with a finger or take off and replace the control grid cap. This will change the plate current just as effectively as pulling out the tube, and is a lot easier. In the tuned R.F. section even a stage using a tube with no control cap can be tested by touching the stator of the variable condenser connected to the tube. Touching the stator will have the same effect as touching the control grid.

A Widely Used T.R.F. Receiver Test.—If you wish, you can use the signal from a local broadcast station for an R.F. check by connecting the antenna lead-in to the grids of the R.F. and detector tubes in succession, starting at the detector and working towards the antenna. To prevent the antenna from detuning the circuits tested, insert a series 100,000 ohm resistor. Again when you go from a signal to a no signal point you have located the defective stage. Furthermore, the signal should get louder as you pass from the detector to the antenna connections.

Still using a local broadcast as our testing signal, a check on the audio system may be made by using a pair of headphones. Of course, the following test would only be made if, in the previous special R.F. test, no signal were heard, indicating that the defect is not in an R.F. stage. Tune the set to a point at which a signal is normally picked up. Place the phones across the plate loads of the tubes, working from the detector to the output stage. A signal to no signal point isolates the defective stage.

Employment of a local broadcast as the test signal is widely made by expert servicemen, so I suggest you learn it. It is more positive a test for a defective stage than the click test. Unfortunately its use in testing supers is quite limited and as these receivers are more common, the click test is more universally used.

The Circuit Disturbance Test for Supers.—In testing for a dead stage in any super such as the one indicated in Fig. 2, the click test is the same as on the T.R.F. receiver until you reach the oscillator. However, if we can get clicks by pulling out the first detector, but no signals can be tuned in even if the antenna is connected to the grid of the first detector, we may safely consider the trouble to be in the oscillator.

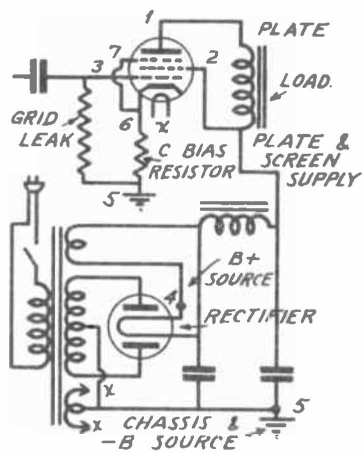


FIG. 3A. *A typical stage connected to the main supply. Continuity tests should be made between 1 and 4, 2 and 4, 3 and 5, 6 and 5, 7 and 5.*

When testing a super do not try to connect the antenna lead to the I.F. stages as no signals will be heard. The antenna lead can be hooked onto the first detector or any of the R.F. inputs. Headphones may be used between the loudspeaker and second detector.

If a super checks O.K. with the click test but no signals are heard, check the alignment, and especially the oscillator adjustments; subjects we will consider in a later job sheet.

A Little Experience Is Required.—The circuit disturbance method of checking for the dead stage is not fool-proof and a certain amount of experience will be required to get the best results. Therefore, whenever you get a set to work on, practice up on this click test.

Here is one of the reasons why a false indication may result. If the regulation of the power supply is poor, removal of a tube may cause a universal increase in plate voltages, and the disturbance may skip around the defective stage. Do not worry too much about this, as most sets have good regulation.

How To Test the Defective Stage with an Ohmmeter

Locating a dead stage is only the beginning of the service job, but a very substantial start, as you are getting nearer

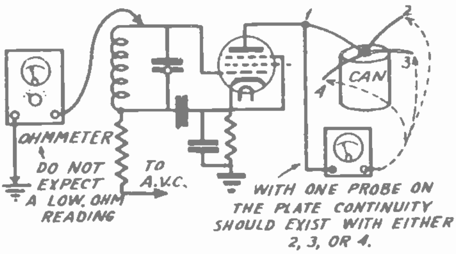


FIG. 3B. *Do not let these conditions baffle you.*

to the "sore" spot. A few more steps and you will be able to point to the defective part or connection.

It is almost logical to assume, if you found no surface defects, that the trouble is internal and naturally you will have to get into the chassis if you want to make the repair. But, before I would remove the chassis from the cabinet, I would question the tube in that stage. Of course, you know that a tube may light and yet be defective. For example, its emission may be low (although in general this will show up as distortion or weak signals); the plate may be shorted to the screen, the screen shorted to the grid, or the grid shorted to the cathode. You do not have to worry about this if you test the tube in the dead stage in a tube checker—for

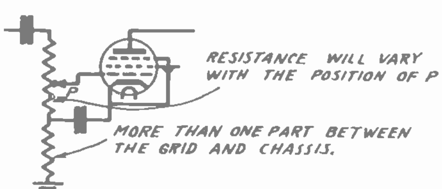


FIG. 3C

shorts and whether it is *good* or *bad*. If you happen to have a good replacement tube try it in the socket. Now if the tube is good, you are sure the defect is internal, and the chassis may be taken to your service bench, if that is the place you prefer to work.

A circuit diagram of the receiver while not an absolute necessity is a mighty handy thing to have, especially for a beginner. Suppose you don't have a diagram, is there any way you can start to test the stage? Yes indeed, and here is where your fundamental studies will aid you.

From your lessons you should know that the screen or plate of any tube in use should show continuity (a D.C. path) back to the most positive point in the circuit, the +B source. What is this point? It is the electron emitter of the rectifier, its cathode or filament.

Is there anything else that our studies tell us must be true about a receiver? Yes, since we have a +B source we must also have a −B source. This, in practically every diagram you have seen, is the chassis of the receiver. Furthermore, an electrode at a zero or negative potential must show continuity to it. These electrodes are the cathode or filament, control grid and suppressor grid of all tubes except the rectifier.

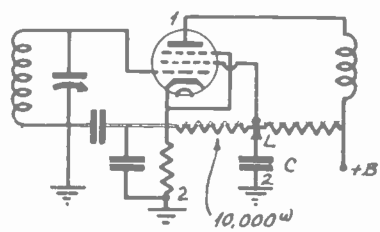


FIG. 3D. *If you suspect a leak or short in C, you must disconnect its connection at L, to test it. For if L is connected a test from 1 to 2 will show resistance regardless of the condition of C; and a test from L to 2 will show a resistance if C is leaky or good.*

Now that we have our general facts in mind let's get started.

Place the chassis and loudspeaker connected to it on the work bench and turn the chassis upside down or on its side, so the parts and the tube socket of the defective stage are easily identified and traced.

Locate the electron emitter prong (cathode or filament) of the rectifier and the plate prong of the defective stage tube. Place the ohmmeter probes on these two points.* A reading should be obtained. If the stage is not resistance coupled the reading should not be more than about 10,000 ohms, or less than 200 or 300 ohms. In a resistance coupled stage the reading may be as much as 500,000 ohms.

Suppose we do not obtain any reading—infinite resistance—we know that there is an open in the plate supply circuit. The filter system is all

* When using any ohmmeter or continuity tester the power cord of the set must be detached from the line. *THIS IS IMPORTANT.*

right, otherwise we would not get a circuit disturbance test on stages following the defective one. Look at the wire connected to the plate socket terminal. By following this wire we will be led to the plate load of the tube. It may be a resistor, transformer or a choke. If it is a resistor, place the *ohmmeter* probes directly across it. If you get no reading you have found the defective part and a new one will be required. Experience tells us that plate circuit resistors have a resistance between 75,000 and 500,000 ohms, and a power rating of 1 watt. The proper value to use will be found by experiment; a value of 100,000 ohms is generally used.

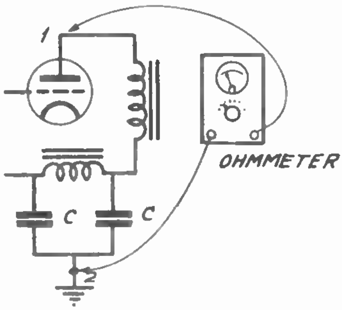


FIG. 3E. *If you test continuity in this case, and C happens to be an electrolytic condenser, the ohmmeter needle may creep up or down scale. Electrolytic condensers have polarity. Always connect the ohmmeter so the needle creeps up scale.*

If we obtained a reading on this resistor we follow the lead from its supply connection to the next object in the circuit and check it in the same way as described above. If it is a filter resistor it will have a value not greater than 100,000 ohms and a rating of 1 watt.

On the other hand, if the plate load was a transformer or coil, it is not possible to immediately spot the supply connection, because the part may be in a metal shield or "can." There will, however, be a number of other leads coming out of the can and we should be able to obtain continuity between one of them and the plate lead. Failure to do so indicates that the open is in the shielded part. Remove the shield as you may be able to resolder the break. Generally it won't hurt to take off a single turn of wire if necessary and by doing so you may save the price of a new part.

Screen circuits are treated in exactly the same way and in these circuits we will rarely find resistors which have a value of over 5,000 ohms. If a resistor is defective what watt rating should it have? A 1 watt rating is safe if the resistor merely connects from the +B supply to the screen. If it connects through another resistor to the chassis or cathode circuit a 5-watt resistor should be used.

If the plate and screen grid circuits test O.K., you should next check the continuity between the minus potential electrodes (control and suppressor grids) and the chassis. Except in resistance coupled circuits and AVC controlled stages, the resistance will be rather low. A resistor connected to the low potential end of an R.F. or I.F. transformer secondary indicates that the stage is A.V.C. controlled. Grid resistors *very* seldom are a source of trouble.

To complete the test of the supply circuit in the defective stage, continuity between the chassis and the cathode or filament should be checked. This will check the C bias resistor. For amplifier tubes the resistor will rarely exceed 500 ohms; for a detector it may check as high as 50,000 ohms. The volume control may be in the cathode circuit so turn the volume control on all the way and note the variation in reading.

Now if the supply circuit tests previously explained check O.K., there is another possibility of trouble which we must not overlook. There may be a short in some of the voltage supply circuits. For example, the screen, plate or cathode by-pass condenser might be broken down. A check with the ohmmeter between each of these elements and the chassis will quickly show up such a condition. A broken down condenser will not show over 100 ohms resistance. Of course, it may be leaky but then the symptom will lead us to look for such a condition. Before finally condemning a part, give it a test when disconnected from the rest of the circuit.

When making supply circuit continuity tests be on the lookout for shorted plate and screen supply parts. A check for continuity takes this in automatically. Experience will soon enable you to determine just about what values to expect. An I.F. transformer primary or secondary will run around 100 ω, an audio transformer primary 500 ω, and its secondary about 1,500 ω. An R.F. primary may run from a low value to 100 ohms, its secondary rarely exceeds 5 ohms.

The Defect May Be Caused by a Defect Elsewhere.—Bias and control grid parts usually burn out because of some defect in themselves. Of course, an open grid return resulting in excessive plate current might damage bias, plate and screen supply parts but this is rather unlikely. However, in the high voltage circuits we have another situation. A short between the low potential end of a supply part and the chassis or cathode would burn out the part. So after locating an open high voltage part don't just replace it. See if any shorts are present which might have burned it out. You don't want a new part to go up in smoke as soon as you turn on the power. Here is a simple and sure test. Connect your ohmmeter from the low potential end of the burned out part to the chassis. Unless there is a bleeder system a reading indicates a short. You should look for a broken down condenser or a short in the wiring. The presence of a bleeder system will usually result in a reading of 10,000 ohms or more. A short which will burn out a part is usually a direct short—shows up as zero resistance.

You have noted I have used the words "usually," "probably," etc., quite frequently. This is necessary because we can't be absolutely sure without a diagram. Sometimes we run upon the unexpected and then a diagram is a great time saver. Just as an example, some sets use diode AVC tubes made by connecting together the plate and grid or plate and cathode of a triode such as a 56 or 27. A direct short check on these elements with an ohmmeter might lead us off on a "wild goose chase" if we had no diagram or were unfamiliar with the circuit. Such points are exceptions and should be borne in mind, even though you will seldom meet them.

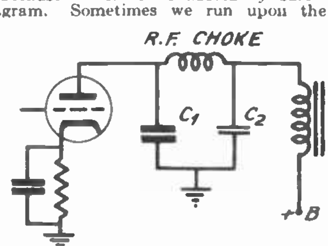


FIG. 3F. *If C^1 is shorted, the choke coil may burn out. In this case both C^1 and the choke must be replaced.*

A number of interesting tests and cases are given in Figs. *3A* to *3F*.

Although our discussion on how to test the defective stage with an ohmmeter was from the tube socket prongs under the chassis, you know that you could check the circuits (not parts) from the top of the chassis with the tubes removed and the chassis in the cabinet. On finding an open or short circuit you will be able to tell pretty well what might be the trouble. This procedure is necessary if the customer demands an estimate, before the chassis can be removed from the cabinet.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

How to Install a Visual Tuning Indicator

I did a small job on my own radio that convinced me that you would like to know about it. You can do it for others and make a profit. I have a well known make of receiver of the broadcast band type which has automatic

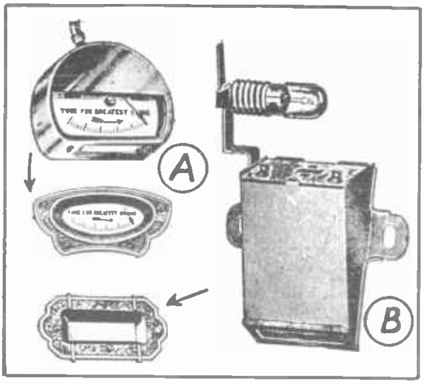


FIG. 1

volume control. Although this set brings in all the U. S. A. and Canadian stations that I want, it is very selective. When the other members of my family tuned it, they rarely set it "smack" in the center of the frequency of the broadcasting station. Of course, you know distortion resulted, and I would have to get up from my easy chair and tune the station in properly. I put an end to this by installing a visual tuning indicator (sometimes known as a resonant tuning meter) and now all members of the family tune the set correctly.

You may not run into exactly the same reasons for having a visual tuning indicator, but the chances are if you run across a receiver *with A.V.C.*, and no visual tuning meter, you might explain what these meters will do. You will in many cases get the job of installing the meter.

The job is really simple if you study the circuit diagram of the receiver you are going to work on; and can locate the tubes in the receiver, the C bias of which are controlled by the A.V.C. tube. When a signal is tuned in, the C bias on the controlled tubes automatically goes up and their plate currents go down. Now if you connect a milliammeter, the technical name for a visual tuning indicator, in their common plate supply leads, you can tell when the set is properly tuned; because when exact resonance exists, the plate current is at its minimum value.

Connecting the Parts. The parts you need are: A milliammeter (resonant tuning meter) and perhaps a .1 mfd. (450 volts) non-inductive bypass condenser. The tuning meters may be obtained in several different milliampere sizes and designs, as you will see in Fig. *1*. When one tube is under control use a 5 ma. meter; when two tubes are under control, use the 10 ma. size; when three or four tubes are controlled use the 15 ma. size. Although there are several designs, the two more common ones which I would suggest are shown. The most popular type is shown at *A*, and may be illuminated from the back or bottom. A pilot light should be installed; if the light from the tuning dial does not show through. Figure *1B* shows the popular shadow-graph design. Light from the rear lamp (shown) is interrupted by a vane, casting a shadow on the scale. The set is tuned for the narrowest shadow. Use the oval escutcheon (panel ornament) for the needle meter, and the rectangular escutcheon for the shadow graph indicator.

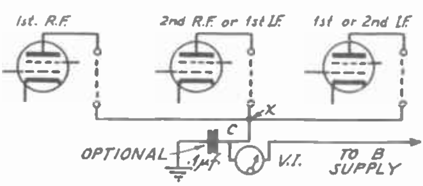


FIG. 2

Connect the meter in series with the plate leads of the controlled tubes as shown in Fig. *2*. The bypass condenser is optional; it often prevents interaction between circuits. The condenser should be mounted on the chassis at the point where you break into the circuit, and the tuning meter tested with it in or out before making the connection permanent.

You may run into receivers where the plate supply leads of the controlled and uncontrolled tubes are connected to a common terminal before connected to the main B supply. It is unwise to feed the plate current of the uncontrolled tube through the meter, as only small deflection changes will be obtained. This may be remedied by wiring the indicator as shown in Fig. 3, and in the circuit of only one of the controlled tubes. In this case the condenser must be used. Incidentally, many servicemen connect the meter into the plate circuit of only one controlled tube, using a 5 ma. meter. In every case the leads from the tuning indicator should be made so when no station is tuned in an up-scale meter reading (or a wide shadow) is obtained. when a strong signal is tuned the meter needle moves in the direction of the arrow (or a narrow shadow is obtained). Otherwise, interchange the meter connections.

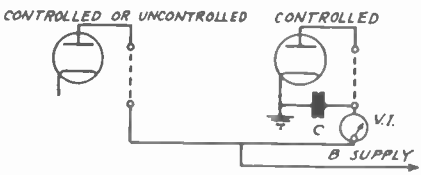


Fig. 3

Mounting Problems. Mount the meter on the tuning panel near the tuning dial, covering the cut-out with the proper escutcheon. If possible the indicator should be located vertically above the tuning dial, as the operator can watch both at the same time.

As you may find it difficult to mount the meter in place, I will give you a few suggestions. Turn the cabinet on its back and draw an outline of the space required for the installation of the meter on the panel of the cabinet. Then drill a series of holes (A) into the cabinet as shown in Fig 4. Use about a No. 32 or a 1/16th inch diameter twist drill. Remember you are working on the face of

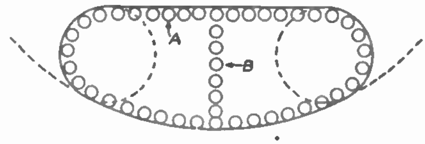


Fig. 4

the cabinet so be careful and do not mar the finish beyond the area that is not covered up by the escutcheon. Then take a sharp knife and cut along the line of the holes, thereby starting the opening for the meter. If necessary break the center piece up into two sections. You may do this by drilling the holes as shown by *B* in Fig. 4. Having trimmed the surface away between the holes below the level of the panel, you may insert a medium sized screw-driver and break the two pieces loose. Then pry the loose sections back and out. Incidentally many servicemen prefer to cut this hole out with a keyhole saw.

Instructing the Customer. Instruct the owner of the set properly. Explain that the tuning dial should be set when a station is tuned in so the tuning indicator gives maximum deflection, or the smallest shadow, depending, of course, upon the type of resonant tuning indicator used. Tell the set owner that strong or local stations will give the greatest indication; weak signals or stations very far away will possibly give only a "quiver." If the set is of the all-wave type, no indication will be observed on distant short-wave reception in some cases. After all, a tuning indicator is intended to tune powerful stations for best sound outputs.

Extra Receiver Revamping Hints

Now that I have you working on the circuits of a radio receiver, it is worth letting you in on a few extra hints on how a receiver may be improved; methods that will help earn extra money. These are not jobs that you would go out and get. but rather things you can do when a service job indicates their need. So be on the lookout for them.

Getting Greater Selectivity. In a number of old receivers you will find the so-called grid leak-grid condenser detector. These detectors are quite sensitive and work well on distant weak stations; but when locals or semi-locals are tuned in. distortion and poor selectivity inevitably results. Now this is easily remedied by changing to a plate type of detector, using automatic or fixed C bias.

The circuits shown in Figs. 5*A* and 5*B*

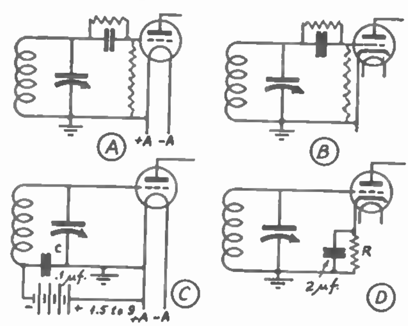


Fig. 5

are those of the grid leak-condenser detector combination, *A* showing the filament and *B* the heater type of tubes.

Their plate circuits are eliminated for simplicity. Furthermore the grid leak may be at the grid input instead of across the grid condenser. The recommended new connection for the *A* circuit is shown in Fig. *5C*; the required circuit for the heater tube shown at *B* is given in Fig. *5D*. A C battery and the .1 mfd. bypass condenser are used in one case; a resistor and a 2 mfd. condenser in the other. The proper value of the C bias voltage, whether it is obtained from the tion. The fact that you get stations indicates that the R.F. section is O.K.

Nevertheless, I would realign the R.F. system just to be on the safe side. This procedure will be considered later in your course. After all, I am now considering jobs that you are about ready to do. Assuming the chassis is in good order, let us consider some of the revamping procedures. If it is a battery set and has a 12A type tube, replace it with a 38 type tube; you will need a five prong socket

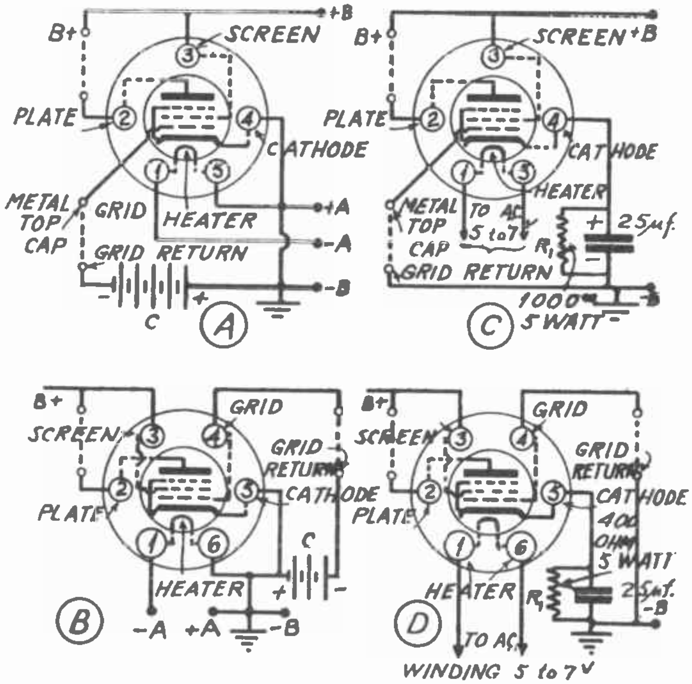


Fig. 6

Note: Tube symbols and bottom views of socket connections

drop across the resister or from the battery, must be determined by experiment. Vary the bias voltage in the case of the battery connection until the plate current is approximately .2 ma. For the heater cathode combination select either a 30,000 or 50,000 ohm, 2 watt resistor that gives you the required plate current. Of course, the final test is the quality of sound you get out of the receiver, and the bias should be further adjusted if improved quality is possible.

Getting More "Swat." Quite often you will run across a receiver that picks up all the desired stations, but the volume is low, even when the volume control is on full. Several changes in the chassis can be made, but before making any of them I would check up on the supply voltages and the tubes in the audio sec- and a screen grid clip with a flexible lead.

Mount the new socket in position in place of the original and connect the leads to it as shown in Fig. *6A*,* the connections for a battery receiver. Note the grid clip is connected to the original grid terminal. As you are working on a battery operated receiver it is, therefore, important that you apply the proper battery bias. Apply a C battery voltage of —9, —13.5, —18 and —25 volts for plate voltages of 100, 135, 180 and 250 volts respectively.

In case you should find it desirable to change the 71A type tube in a battery operated receiver to the 42 type tube, you should employ 180 volts of B battery

* All socket connections are shown as you would see them from the bottom of the chassis, while connections are being made.

voltage and —13.5 volts of C battery. Connect the 42 type tube as shown in Fig. *6B*. The 42 type tube does not require a grid clip; however a six prong socket will be necessary.

Now let us consider the A.C. operated receiver. Figures *6C* and *6D* show the proposed connections for the 38 and 42 type tubes when inserted in an A.C. operated receiver. Again you replace a 12A with a 38 and a 71A with a 42. Note that there is a special size of resistor R_1, for a 38 and a 42 type tube. The 25 mfd. condenser may be a dry electrolytic of the low voltage type. Connect its leads with the polarity as shown.

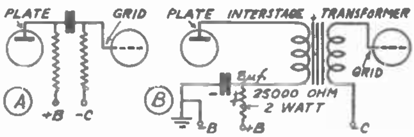


Fig. 7

Now if the set is of a more modern design, having a single or push-pull 45 type tube, I, for one, would not change it; for it is capable of giving good quality. I would raise the audio gain by changing a resistance coupler to a two to one turn ratio audio frequency transformer if a single tube were used, or a higher turn ratio if push-pull were employed (your experimental outfits tell you how to measure turn ratio). Where a single tube is used with an intermediate audio transformer I would use one with a higher turn ratio. Figure *7A* shows you the resistance coupler connections between two tubes in a radio receiver. Figure *7B* shows you the change-over to an inter-stage transformer. Note the 8+ mfd., 450 volt electrolytic condenser connected between the B plus terminal of the transformer and minus B, and the 25,000 ohm, 2 watt resistor connected to the plate of the tube. This combination of resistor and condenser is excellent for the elimination of motorboating in a receiver. It increases the stability of the amplifier. Remember this circuit and use it in A.F. stages that motorboat. Do not use it on the last audio stage of the receiver.

Replacing Old Screen Grid Tubes. While I am on the subject of changing tubes, I want to consider one more case, namely replacing the older screen grid tubes with super R.F. pentodes; that is, using 58 type tubes in place of the 24A tubes. The change is not worth making unless you incorporate the grid bias type of volume control. This change will give the receiver more life, less cross-modulation (local stations riding in on distant stations), and less tunable hum.

I have found that certain tubes should not be changed; that is, never change the first detector or oscillator tube of a superheterodyne receiver. Nor do I change the second detector or A.F. tubes except as previously mentioned. You may change the tubes in the preselector and I.F. stages only.

If a radio receiver uses several type 24 or 24A tubes in its radio frequency or I. F. sections remove them and insert type 58 tubes. The job is quickly done by replacing the five prong sockets used for the 24 type tubes with six prong sockets and ones of the same type or general construction. Use a hot soldering iron to pull off the leads from the old sockets. Mount the new sockets in place, and make the necessary connections. Figure *8A* shows the connections before, and Fig. *8B* the connections after the change-over. The socket connections differ somewhat. See Fig. *8C*. Note there is an extra prong, the suppressor. Connect the suppressor socket terminal to the cathode socket terminal as shown in Fig. *8B*. In addition, a new 50,000 ohm tapered wire wound volume control is used and connected in series with the bias limiting resistor R_1 Furthermore, these two items are shunted with a .25 mfd. condenser.

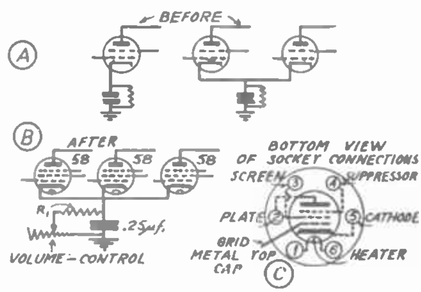


Fig. 8

The value of the resistor R_1 is easily found. Use a 2 watt, 300 ohm resistor when one type 58 tube is connected in the circuit. Then if you replace more than one tube; divide the number of tubes used into 300 and you will have the resistance in ohms of R_1. That is, 3 tubes will require ($300 \div 3 = 100$) a 100 ohm resistor.

Don't alter the lengths of the grid and plate leads unless absolutely necessary. Insert the new high gain tubes and realign the receiver for *best over-all results.*

Getting Customers Through Advertising

RADIO servicing is a business as well as a profession. In addition to knowing modern servicing techniques, the Radiotrician must be able to get radio repair business and must know how to convert this business into profit. Advertising need not be expensive; start with a small amount and build up gradually, checking results to make sure you are not wasting any of your advertising money.

Telephone Directory Advertising. When a radio set fails, the owner will invariably use the telephone to call a serviceman. You will therefore need a telephone sooner or later, with some one to answer calls and take messages while you are out. Later, when business warrants or you begin full-time servicing, you can adopt a firm name like *Brown's Radio Service*, so you will be listed by this name under *Radio Servicing* in the classified section of the telephone directory; remember, however, that you will have to pay business telephone rates in order to secure this listing.

A small display ad in the classified section of the phone directory is well worth considering right at the start. The more attention you give to the planning of this ad, the more effective it will be. In general, an ad should tell *who you are* (business name or your name, your qualifications and training, etc.), *where you are* (location and telephone number), and *what you have to sell* (radio service work, antenna installations, public address service, etc.); any space remaining can be used for a slogan, a special offer, an illustration or anything else which will attract favorable attention to your ad. Avoid crowding too much into the ad. A telephone directory ad used by one Radiotrician for a space one column wide and 2½" deep is reproduced actual size in Fig. *1*; this has just about the maximum permissible amount of copy for an effective ad.

Calling Cards and Tube Stickers. If you do good work and present a pleasing appearance, you can reasonably expect that customers will think of you when next in need of radio service work. But human memories are short, particularly as regards names, addresses and telephone numbers; you must leave this information with the customer, in a readily accessible location, if you want each successful service call to be a free advertisement for future jobs. Either calling cards or tube stickers, or both, can be used for this purpose.

As soon as you are ready to solicit radio service work, have a suitable business card printed. Samples of cards used by Radiotricians are shown in Fig. *2*; use these as guides in planning your own card. A simple

NATIONAL
RADIO SERVICE
W. L. Carey, Radiotrician
Formerly of 29 Sycamore Ave.
Takoma Pk., Md.
Quality Service on All Makes
Minimum Service Charge $1.00
OUR AIM: To Give the People of this Vicinity *the Best in Radio Service*
INTERCOMMUNICATING AND PUBLIC ADDRESS SYSTEMS
INSTALLATIONS — SALES — SERVICE
Sundays and Holidays until 1 P. M.
Call SH epherd 2519
1317 Flower Ave. Silver Spring, Md.

FIG. 1. Example of telephone directory ad.

card giving only your name, address, telephone number, a statement indicating that you do radio service work, and possibly a short slogan, should prove highly effective. N. R. I. students and graduates often place also on their cards one of the following statements: "Radiotrician," "Authorized Radiotrician," "Member National Radio Institute," "Graduate of National Radio Institute," or "Expert Radiotrician." Your initial order should be for at least one thousand cards. Some tube manufacturers will print special two-color cards with your name, address and telephone number at a lower price than would be charged by a local printer; these cards contain a small tube ad which often improves the appearance without detracting from the efficiency of the card. Each time you finish a service job, attach one of your cards to the inside of the radio cabinet with a thumb tack and direct the attention of your customer to it.

Many tube manufacturers supply gummed stickers imprinted with your name, address and phone number, at reasonable prices; one sticker can be placed on each new tube which you install, and on all tubes which you test.

Home Signs. You need an outdoor sign mounted on the porch railing or below a front window of your home, to indicate that you are in the radio service business. Have this sign made by a commercial sign painter, on a piece of sheet metal or plywood; it should be dignified, impressive and easy to read, and should be illuminated at night if possible.

Automobile Signs. If you use a car for radio service work, have the sign painter place an attractive ad on the spare tire cover or directly on the rear of the car. You can also have signs painted on pieces of heavy cardboard or ¼" plywood which are cut to fit exactly into the rear side windows of your car. These signs should give your business name, your address, phone number, and the words "Expert Radio Service," "Guaranteed Radio Service," or a similar slogan indicating your business. The car should always be spotlessly clean, for it reflects the type of work which you do.

Posters in Stores. Placards or posters placed in local drug stores, hardware stores, filling stations, garages, electric shops and general stores will often bring in jobs which you would not otherwise secure. Have a few of these painted on stiff cards approximately 12" x 18" in size, and place them in simple, inexpensive picture frames. You may want to make arrangements with the owners of the stores to pass on service calls to you on a commission basis, in which case the signs might carry the wording "Leave Calls for Radio Service Work Here," along with the same copy as your auto signs. Ordinarily the commission which you give should not be more than 10 per cent of your service charge. Do not overlook the possibility of arranging to do auto radio installation and service work for local garages on this same basis.

Printed Cards. A simple and convincing message which can be printed on a plain card the size of an ordinary postal card to announce the start of a new radio service business is shown in Fig. *3*; you can have five hundred or one thousand of these prepared by the local printer and can deliver them yourself during your spare time. Slip them in the door jamb or under the front door; never place them in mail boxes, for postal regulations prohibit this. Circulars advertising your business can be distributed in the same way.

If you do not have time to distribute cards yourself and cannot secure dependable boys to do this for you, consider having your message printed on regulation one-cent Government cards. In this case you will have to address each card; names and addresses of prospective customers in your vicinity can be obtained either from a city directory or from the special names-by-streets directory which is usually available at the local telephone office. Any one who has a telephone will usually have a radio. You can have the cards delivered to every home on a particular mail route to avoid the work of addressing each one; ask your postmaster for full details before having the cards

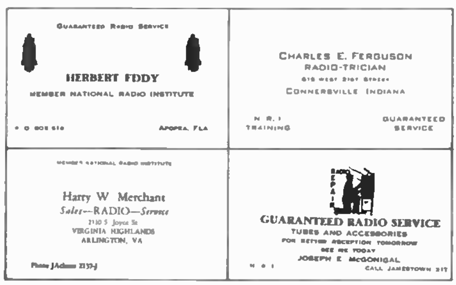


FIG. 2. Examples of business cards used by Radiotricians. These are greatly reduced in size; business cards are usually about 2" x 3⅜".

printed. Personally addressed cards are generally more effective than cards addressed to "box holder," however. You can get ideas for your circulars and cards from radio magazines and from tube manufacturers. Some tube manufacturers will even print ads on Government postcards for you, charging only for postage.

Special Suggestions. Newspaper advertising will not be taken up at this time, for it is very difficult to use successfully, requires much experimenting, and can be quite costly. Avoid newspaper advertising until such time as you can afford to run ads regularly for several months.

You will occasionally be asked to purchase space in programs for school, church and community affairs. This type of advertising does not pay quite as well as other forms, but there will be times when you cannot afford to stay "out." If the sponsors of the event in question are good customers of yours, they may feel offended at a refusal of a direct request. Consider these ads more in the sense of good-will ads than as immediate business-getters. When purchasing space in a program, offer to furnish a radio for entertainment purposes, even if it can be used only for a few minutes before and after the program. Place an attractive poster on this radio receiver, lettered something like "Radio Entertainment Furnished by Brown's Radio Service"; in this way you will get a little more for your money in the way of advertising.

Ask each new customer how he happened to call on you, and make a record of this when you return to your shop. Go over your records regularly to find out which types of advertising are bringing the most business, and concentrate your advertising allowance on these.

How Much To Charge The Customer

Any estimate or bill for radio service work should theoretically be based upon four separate items: *1.* The list prices of all parts used on the job, or your cost plus a reasonable mark-up to pay for the time and expense involved in getting the parts; *2.* A charge for labor, at an hourly rate which will give you a fair monthly salary; *3.* A portion of your overhead expense; *4.* A fair profit on the job. The average person does not appreciate the significance of overhead expense and profit, however, so these last two items should always be combined with the labor charge when making out a bill.

Charges for Replacement Parts. If a part has a widely established list price, charge that price regardless of the discount which is allowed you; radio tubes and all-wave receiving antenna systems are typical examples. For other parts, start with your actual wholesale cost and add a definite percentage; the equivalent of a wholesale discount of 40 per cent is a fair mark-up, and is figured as follows: Divide your total cost by 6, then multiply the result by 10 to get the customer's price. For example, suppose that you pay $3.60 for a power transformer, including transportation costs. Dividing this by 6 gives you $.60; multiplying $.60 by 10 gives $6.00 as the customer's price for the power transformer. Here is another example: a replacement loudspeaker cone is delivered to you at a price of $.96; carrying out the same calculations you arrive at a customer's price of $1.60 for the part.

Charging For Labor. To determine your final hourly rate for labor, you must first estimate these things: *1,* the number of hours per week which you will actually spend on radio service jobs; *2,* the total weekly cost of operating your business (your weekly salary plus the weekly overhead expense); *3,* your profit. An example will best illustrate how this is done.

Figuring Your Useful Weekly Time. Suppose that you plan to be on the job 8 hours every day for 5½ days a week, giving a total of 44 hours. Naturally you will not spend all of this time on work for customers; it takes time to give estimates, to pick up and deliver radio sets, to keep business records, buy parts, keep the shop clean, order advertising, etc. Let us say that 22 hours of each week are spent on work not directly associated with service jobs. This leaves 22 hours a week for actual service work.

```
Announcing
    a new radio service shop right in
    your own neighborhood.

Offering
    personalized, honest repair of any
    radio set, new or old. No guess-
    work; no parts unnecessarily re-
    placed; work done right in your home
    whenever possible; prices fair; all
    work guaranteed; no extra charge for
    evening calls.

Qualifications:
    Authorized Radiotrician and Tele-
    trician, trained in radio theory
    and modern servicing techniques by
    National Radio Institute.

When your radio fails,
    call Sycamore 7371 for a thorough
    inspection and a test of each tube.

Now do this:
    Slip this card into the back of
    your radio cabinet, where it will be
    handy when you need service in a
    hurry.

                 Dick Brown
            BROWN'S RADIO SERVICE
1132 Broad St.               Sycamore 7371
```

FIG. 3. Suggested copy for a card announcing that you are starting up a radio servicing business. It can be mimeographed, multigraphed or printed, as you prefer. Other side of card may be blank, may carry additional advertising copy, or may have stamp and address if card is to be mailed.

Figuring Your Weekly Operating Expense. First of all, how much do you expect to earn each week as a Radiotrician? Do you want $25 a week or $45 a week? Be fair; what do other skilled men in your locality earn? Consider also that as a beginner you may spend more time on the job than would an experienced Radiotrician. Start your weekly salary low, and revise it each six months if necessary. For purposes of illustration, let us say that you expect a salary of $30 a week for full-time service work; this will be one item in your weekly expense. (For spare-time work, figure the average number of hours you will work each week, and adjust your expected salary proportionately.)

Next comes an allowance for overhead expense; naturally this will have to be a rough estimate at the start, but after you have kept records for a year or so, you will be able to predict quite accurately what it will be. Suppose that you have invested a total of $300 in tools and equipment during your training period and while doing spare-time service work, with this equipment requiring replacement about once every three years. You thus have an expense of $100 a year for equipment, or about $2 per week. Your shop occupies a spare room in the house; what would you charge for this space if you were to rent it to an outsider? Let us assume it is $12 a month, which makes about $3 a week. The telephone bill may be $4 a month, advertising $12, car maintenance and operation $16, and incidental items about $4 a month during your first year of full-time service work—a total of $36 per month or about $9 per week. The total weekly overhead expense will thus be $2 plus $3 plus $9, or $14. Adding $30 for salary to this gives $44 as your total weekly operating expense.

Dividing $44 by 22 (the saleable hours of work) gives $2 per hour as your basic rate for labor. Let us say that you will be satisfied with a profit of approximately 10 per cent. Adding this to the $2 rate gives you $2.20 as your fixed hourly charge to customers for labor. This is not unreasonable for radio service work. Your minimum charge for any service job should not be less than your fixed charge for one hour of labor.

Example of a Charge. Suppose you have completed a job which required two resistors costing you $.10 each and one paper condenser costing you $.30, making a total parts cost of $.50. The time you spent on the job was 1¼ hours. Your bill might be prepared as follows:

Parts	**$ .83**
Labor	**2.75**
Total Charge	**$3.58**

Never indicate on the bill your fixed hourly rate, your time, or the mark-up in the price of parts. Some Radiotricians prefer to make the price a convenient even figure, such as $3.50, $3.60 or $3.75. When the cost of parts is very small in comparison to the labor charge, it is best to submit a single price, as follows:

Labor and Parts **$3.60**

or

Installation of 2 new resistors and one new paper condenser **$3.60**

Estimating Service Charges. When the customer wants to know beforehand the charge for a job, estimate the time required to locate the defect, estimate what new parts will be needed and how long it will take to install them, then figure your service charge in the usual manner. To be on the safe side, always add about 25 per cent more to the estimated charge to take care of unexpected trouble.

How To Service A Dead Receiver

AN ordinary radio receiver has four essential sections: *1, the R.F. section,* which selects and amplifies the desired modulated R.F. carrier signal after it is picked up by the antenna system; *2, the detector,* which separates the audio signal from the R.F. carrier signal; *3, the A.F. section,* which amplifies the audio signal; *4, the loudspeaker,* which converts the amplified A.F. signal into sound waves. These processes of amplification and detection are made possible by vacuum tubes, and these tubes can operate only if their cathodes are properly heated and their other electrodes are supplied with the proper D.C. potentials. The various circuits in a receiver therefore divide into two distinct groups, the *signal circuits* and the *power supply circuits.*

Causes of Dead Receivers. A radio receiver which will not bring in any programs whatsoever is said to be *dead.* There are only four fundamental causes for a dead receiver: *1, a defective tube; 2, an open connection or part* in the signal circuit or in the supply circuit; *3, a shorted part,* which either blocks a signal circuit or prevents application of a D.C. voltage to a tube electrode; *4, a defective part* which has changed in characteristics sufficiently to cause blocking of a signal circuit. A Radiotrician who is confronted with a dead receiver immediately makes a check for these defects. He knows that they may occur in parts which are either above or below the chassis, and since it is oftentimes a bit difficult to remove the chassis, he first makes certain that there are no defects above the chassis.

The Professional Technique for Dead Receivers. If a check for surface defects above the chassis fails to reveal the trouble, the Radiotrician removes the chassis from its cabinet and quickly checks the parts underneath for obvious defects. He then begins a systematic and speedy procedure for locating *the defective stage,* followed by an ohmmeter test to locate the defective part in that stage. Finally, he replaces or repairs the defective part. The steps in the professional service technique for repairing a dead receiver are, therefore:

1. **Check for surface defects above the chassis and test all tubes.**
2. **Check for surface defects beneath the chassis.**
3. **Locate the defective stage.**
4. **Locate the defective part.**
5. **Repair the defect.**

Checking for Surface Defects. Although this subject has already been thoroughly covered, it is so important in the case of dead receivers that I will review it briefly here. Check the antenna system to be sure it is up and in good condition. Make sure that the receiver is being supplied with power by noting whether the pilot lamps light and whether the tubes heat. Look for tubes which are not properly seated in their sockets; oftentimes tube prongs may not be making good contact with socket terminals. Be sure there are no loose parts above the chassis. Inspect tube shields and tube top cap connections. Finally, test each tube with a tube checker, and check the loudspeaker.

Next comes removal of the chassis and an inspection for open connections, broken parts, and charred parts underneath the chassis. If you find an obviously defective part, be sure to inspect other parts which are associated with it. For example, a shorted bypass condenser may cause large currents to flow through a resistor, giving the resistor a charred appearance. Although the resistor is defective, the shorted condenser is the true cause.

Locating the Defective Stage

Any method for locating the defective stage in a dead receiver should begin with a check of the power pack. Connect a high-range D.C. voltmeter between the chassis and the plate terminal of the last audio tube (or between the chassis and one terminal of the loudspeaker field coil); the meter should indicate a reading somewhere between 180 and 250 volts if the power pack is producing the correct D.C. voltage for the receiver. If this reading is secured, you can assume that the power pack is cleared of suspicion.

The Signal Generator Method. The most conclusive procedure for isolating the defective stage in a dead receiver is the signal generator method, also known as the dynamic stage-by-stage elimination procedure. It should be mastered and used whenever a check for surface defects fails to reveal the cause of a dead receiver.

The principle underlying this method is quite simple. In a superheterodyne receiver, as you know, the signal from a desired station enters the receiver at the carrier frequency of that station; at the output of the mixer-first detector stage there is a change to the frequency of the I.F. amplifier, and at the second detector there is another change, this time to the A.F. signal frequency. Audio signals then exist right up to the loudspeaker, where they are converted into sound waves. By introducing into certain stages, with an ordinary modulated R.F. signal generator, a signal which duplicates that which would exist if the receiver were performing correctly and were tuned to a station, we can locate the defective stage.

An essential requirement of this method is familiarity with the signal generator. You should know how to change its frequency band, how to adjust it to the desired frequency and how to control its output. Determine whether it has a condenser in series with its output, to block the flow of direct current; if the condenser is absent, insert a .002 mfd. condenser and a .1 megohm resistor in one of its leads, as shown in Fig. *1*. The resistor is optional but the condenser is necessary.

The receiver is always turned on while the defective stage is being isolated with a signal generator (S.G.). The procedure begins at the second detector; connect the S.G. ground lead to the chassis of the receiver, and connect the other S.G. lead or probe (known as the free probe) to the input of the second detector stage. If this stage uses a triode or pentode, connect to the control grid; if a diode, connect to the plate of the preceding tube (the last I.F. tube). Set the S.G. to the I.F. value of the receiver and advance the control on the S.G. to maximum output. If the second detector and the audio system are free from defects, you should now hear the S.G. tone.

If no tone is heard, a detector or audio system defect is indicated. We could use a special audio signal generator and advance it stage by stage toward the loudspeaker until its tone was heard, but an R.F. signal generator will serve just as well if used with the headphone and control system shown in Fig. *2*. You can easily assemble this yourself. The ground probe is connected to the chassis of the receiver, and the free probe is connected first to the output of the second detector (to the plate in the case of triode or pentode tubes, or to the load resistor in the case of a diode detector). The R.F. signal generator connections are not changed. If a tone is heard in the phone, you can assume that the second detector is okay. Now move the free probe from the detector output to the plate of each audio tube in turn, working toward the loudspeaker; when you reach a plate terminal at which no tone is heard, you know that you have just passed through the defective stage. If there are two tubes in the output stage, apply the probe to the plate of each in turn. Always adjust the volume control in the control box after making each new connection, to secure normal volume without overloading the phone.

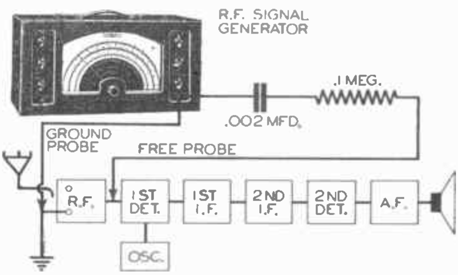


FIG. 1. Block diagram of a superheterodyne receiver, showing a signal generator connection to the first detector for locating a defective stage.

If the tone *is* heard in the loudspeaker when the S.G. is connected to the input of the second detector, you assume that the detector and audio systems are good, and omit the headphone test. Advance the free S.G. probe to the plate and then to the grid of the preceding I.F. tube; if the tone is heard, repeat for the other I.F. tubes until you arrive at the grid of the first detector. As long as all stages between the S.G. connection and the loudspeaker are good, the tone will be heard from the loudspeaker; the tone will no longer be heard when you have passed through the defective stage.

Assuming you have not yet located the defective stage, your S.G. will now be connected as shown in Fig. *1*. With this connection, you can determine if the local oscillator is functioning. Tune the S.G. to the frequency to which the receiver is tuned; if the tone is not heard when this is done, either the oscillator or its connection to the mixer-first detector is defective. If you like, you can make an additional check for a defective oscillator by tuning the receiver to a local station, then tuning the S.G. (without changing its connection) to a frequency which is above or below the local station frequency by the I.F. value of the receiver. For example, if the receiver is tuned to a 1,200 kc. station and the I.F. value is 460 kc., set the S.G. either to 1,660 kc. or 740 kc. If you now hear the program of the local sta-

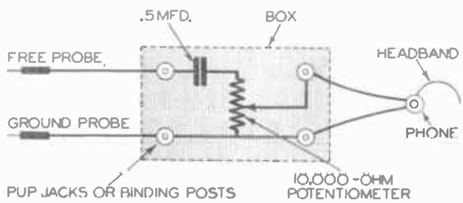


FIG. 2. Handy headphone unit for locating a defective stage.

tion from the loudspeaker, mixed with S.G. tone, you know that the local oscillator is defective and that the stages ahead of the first detector are good.

If the local oscillator is functioning, set the S.G. at the same frequency as the receiver, then advance the free S.G. probe to the plate and then to the grid of the R.F. amplifier stage, and finally to the antenna terminal of the receiver. The tone in the loudspeaker should stop for one of these points, if you have come this far without locating the defective stage.

If you use a series resistor in the S.G. lead as indicated in Fig. *1*, the loudspeaker tone should become louder as you move the S.G. probe toward the antenna terminal; when the tone becomes excessively loud, turn down the control on the S.G. until you secure normal output. Without the series resistor, the detuning effect of the S.G. on an R.F stage may offset the gain of that stage.

Circuit Disturbance Test. A quicker but less dependable method for isolating the defective stage after the main D.C. supply voltage has been checked is that known as the *circuit disturbance test.* This test is based upon the fact that each stage in a receiver is one link in a chain extending from the antenna terminal to the loudspeaker; any sudden plate current interruption or change along this chain will cause a surge of power to be relayed on to the loudspeaker (where it is heard as a click), if there are no defective stages between the loudspeaker and the point at which the disturbance was created.

There are a number of ways to produce a disturbance in a stage: *1,* pull a tube from its socket, then replace it (two clicks are usually heard when this is done); *2,* touch the control grid of a tube, or remove and replace the top cap connector. The Radiotrician uses whichever method is easier to apply to a particular tube.

A circuit disturbance test begins at the second detector tube when this tube is a triode or pentode; in the case of a diode second detector either the preceding or the following tube is removed. If a click is heard, you know that all stages between the point of the disturbance and the loudspeaker are good; if no click is heard, proceed toward the loudspeaker, introducing a disturbance in each stage in turn. (A howl rather than a click is often heard when a grid is touched.)

If the circuit disturbance test indicates that there are no defects in the audio system and second detector, work toward the first detector: pull out tubes or remove grid cap connections, remembering that there should be an indication of some sort from the loudspeaker each time this is done. The circuit

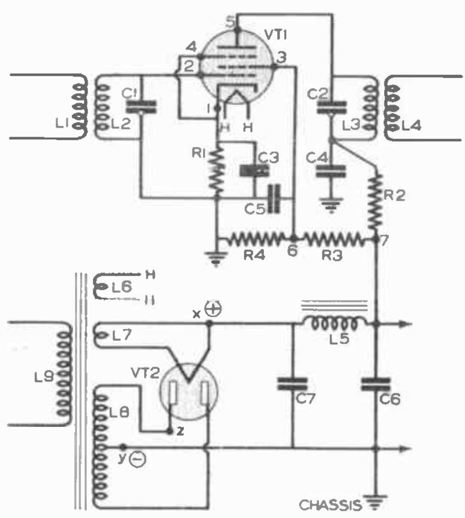


FIG. 3. Typical I.F. amplifier stage and its connections to the receiver power pack. *VT1* is the I.F. amplifier tube; its cathode is *1*; control grid is *2*; screen grid is *3*; suppressor grid is *4*; plate is *5*.

disturbance test will not reveal the condition of the local oscillator, however; no click will be heard when this tube is removed, but if a background noise and hissing are heard when the volume is turned up, indicating a "live" receiver even though no broadcasts are received, you can assume that either the local oscillator or a preselector (R.F.) stage is defective. If a circuit disturbance test on the R.F. tube indicates it is good, then the local oscillator will undoubtedly be defective.

The chief advantage of the circuit disturbance test is that it can be carried out in a few minutes, working from the top of the chassis. A signal generator test of the suspected stage will then verify the results of the circuit disturbance test and also tell whether the defect is in the input or output circuit. A typical I.F. amplifier stage is shown in Fig. *3:* if a tone is heard when the free S.G. probe is connected to point *5* (the other S.G. probe being on the chassis), we know that parts *C2, L3, L4* and all following sections are good. If the free S.G. probe is moved from point *5* to point *2*, and no output tone is now heard, we have conclusive evidence that there is trouble in the tube, that *C1* or *L2* is shorted, or that the tube is not receiving its proper electrode voltages.

Locating the Defective Part With an Ohmmeter

Before considering how the defective part can be located with an ohmmeter once its approximate location has been determined, let us consider the fundamental rules for checking continuity with an ohmmeter. The circuit in Fig. *3* will be used as our example.

RULE 1. There should be continuity between the cathode of the rectifier tube and all tube electrodes which are supplied with positive D.C. potentials. This rule therefore applies to screen grid and plate electrodes. Thus, in Fig. *3* you can trace from the plate of the tube (point *5*) through coil *L3*, resistor *R2* and choke coil *L5* to point *x*, which is at the cathode of the power pack rectifier tube.

RULE 2. There should be continuity between a plate terminal of the rectifier tube and all tube electrodes which are supplied with negative D.C. potentials. This rule applies to control grids and suppressor grids, and also to cathodes. Thus, in Fig. *3* you can trace from the control grid (point *2*) through *L2* to ground (the chassis), through the chassis to point *y*, and through either half of the power transformer secondary winding to a rectifier tube plate.

It is generally true that all tube electrodes trace to the chassis, but there will be a few exceptions. For example if resistor *R4* were omitted from the circuit in Fig. *3* (as it often is), this general continuity-to-chassis rule would not hold true for the plate and screen grid electrodes (*5* and *3*).

The procedure for isolating a defective part with an ohmmeter can be best explained by using Fig. *3* as an example. With the receiver power plug out of its wall outlet, connect the ohmmeter probes in turn to points *5* and *x*, *3* and *x*, *1* and *z* (or the chassis), *2* and *z*, and finally to *4* and *z*. In each case a definite reading of the ohmmeter clears that circuit of suspicion; an open circuit indication (no ohmmeter pointer movement) indicates a defect, and we then concentrate on the circuit between the two points to which the ohmmeter probes are connected.

Suppose that we found no continuity between points *3* and *x*. We would then move the ohmmeter probe from *3* toward point *x*, one part at a time. If we secured a continuity reading for *7* and *x* but not for *6* and *x*, we would then know positively that resistor *R3* was open.

If the defective stage is definitely located but continuity tests with an ohmmeter do not indicate an open circuit, the next step can be an ohmmeter check of each part in the suspected stage. A study of the circuit diagram will reveal the parts which are most likely to cause a dead receiver, and these can be checked first. For example, shorting of condenser *C5* in Fig. *3* would prevent application of a D.C. voltage to the screen grid; an ohmmeter check across either *R4* or *C5* would reveal this short, and the parts would then be checked individually to determine which one was at fault.

The procedure described here for using an ohmmeter to locate a defective part in a dead receiver applies equally well to improperly operating receivers. In the latter case, however, the values of individual resistors or combinations of resistors in series should be checked against the values specified on the circuit diagram. Changes in resistor values occasionally can cause a dead receiver, but more often the result will be an improperly operating receiver. Once you master radio circuits and become familiar with the paths for direct current flow, the actual location of a defective part will present no difficulties.

NATIONAL RADIO INSTITUTE

Washington D. C.

Radio-Trician

(TRADE MARK REGISTERED U. S. PATENT OFFICE)

Service Manual

Compiled solely for Students & Graduates

ON

SERVICING THE ATWATER KENT A. C. RECEIVERS

For convenience Atwater Kent receiving sets up to and including Model 52 can be classified in two main divisions. One division can be quite readily serviced by referring to Figures 1 and 2 of this service manual which shows the wiring diagram of Model 43 and also the connections of the power unit used in this receiver.

The Model 43 receiver is designed to operate in connection with the Atwater Kent Type F dynamic speaker and for this reason a different type of audio amplifier from that used in the other A. C. sets is used. In this receiver the single stage of straight audio is followed by a stage of "double audio" using two tubes of the power type. A special step-down output transformer is employed to connect the output of the set to the diaphragm coil of the speaker. The 125-volt D. C. required by the field magnet of the speaker is supplied by substituting for one of the filter chokes in the power unit filter, the field coil of the speaker. This coil serves to create a strong magnetic field and at the same time functions as part of the power unit system.

The connection between the power unit and speaker field is

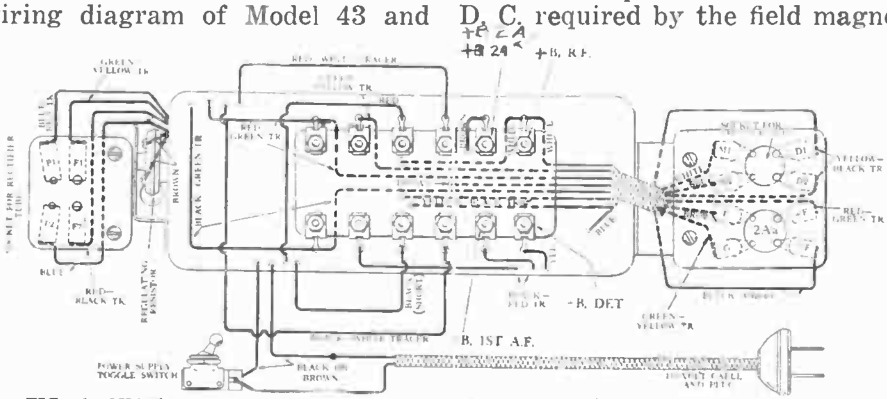


FIG. 1—SHOWING CONNECTIONS AND APPROXIMATE POSITION OF LEADS FROM SEALED CONTAINER IN MODEL 43 POWER UNIT.

In the early type of power unit for Model 43, two brown leads from the primary-shunt condenser connect to the + B, 2A terminal and to the brown P2Aa lead, respectively. In later models, these connections are made internally.

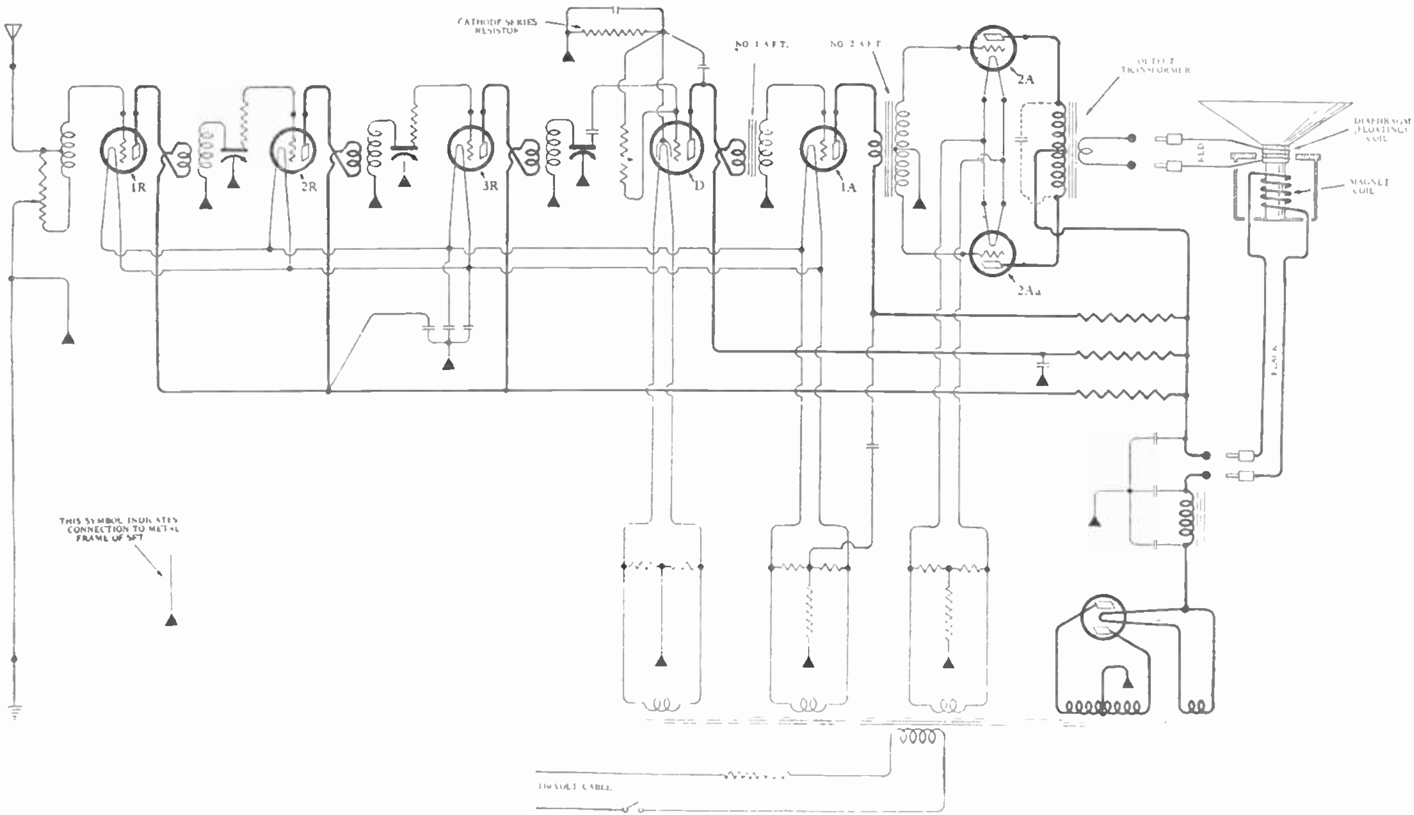


Fig. 2—Diagram of Model 43 Set and Power Unit. The output transformer is sealed in the power unit.

made through two prongs of a four-prong plug on the end of the speaker cord. The other two prongs connect the output of the set to the floating diaphragm coil of the speaker. This plug is of special design and fitted into special sockets in the set mounted in the rear of the cabinet. IT IS VERY IMPORTANT NOT TO REMOVE THIS PLUG FROM ITS SOCKET WHEN THE SET IS IN OPERATION, AS THIS WILL PUT AN EXCESS VOLTAGE ON CERTAIN PARTS IN THE POWER UNIT.

The Atwater Kent Models 40, 42 and 52 are 6-tube single-dial A.C. receivers with a complete power unit (sealed in a single metal container) incorporated in the metal cabinet that houses the set. The power unit supplies complete filament, plate and grid voltages to the set from the 110-volt A.C. power line.

Models 42 and 52 are equipped with an automatic voltage regulator in series with one side of the A.C. line. This device is so designed that owing to the heating effect, a voltage above normal (110) will increase its resistance value, and a voltage below normal will decrease its resistance, so that the voltage across the primary of the transformer is maintained at a constant value.

The circuit of each receiver has three stages of radio frequency amplification, the first stage acting as a coupling tube in order to eliminate the detuning effect of the different antenna sizes (which would otherwise disturb the synchronism of the three tuned circuits). There is a tuned detector and two stages of audio frequency amplification.

The volume control consists of a resistance connected across a section of the antenna coupling transformer. A slider on this resistance connects to the ground and the antenna is connected to one side of the resistance. By adjusting the slider, more or less of the antenna current may be shunted to the ground, thus decreasing or increasing the volume.

The schematic wiring diagram of Models 40, 42 and 52 is shown in Fig. 4. Model 52 does not have the shielded antenna lead. In that set, two 20-ft. leads are connected to the volume control, black for antenna and black-green tracer for

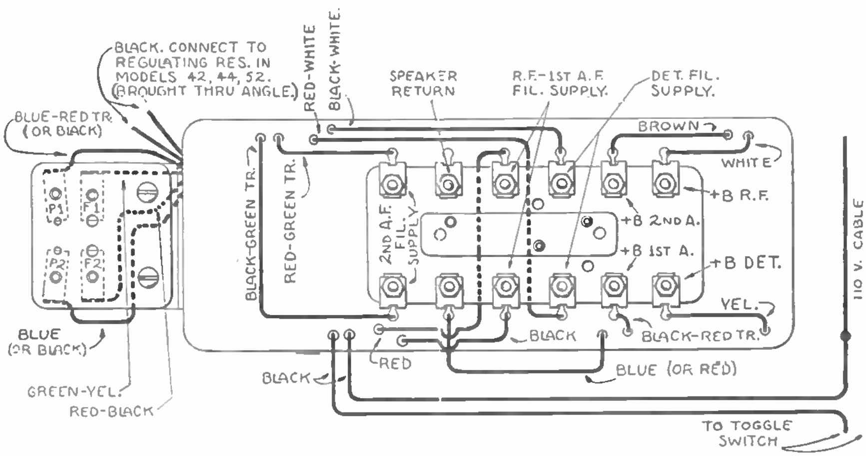


Fig. 3—View of Power Unit used in AK Models 40, 42, 44 and 52, showing connections from sealed container to panel assembly, rectifier socket and regulating resistance.

ground. The outside end of the antenna coupling transformer is connected to the grid contact of the first R.F. socket.

Servicing Receivers and A.C. Power Unit.

The main tests to be applied to a set when not operating properly may be classified as follows, applied in order named.

No. 1, Visual inspection. No. 2, Continuity test, with voltmeter. No. 3, Voltage test.

The conducting of these tests will now be outlined.

Visual Inspection

In order to make a satisfactory visual inspection of the wiring and condition of the parts in a receiver, it is necessary to remove the set from the cabinet. This presents no particular difficulties, and can be accomplished in a minimum of time.

Points For Inspection

The following features should be given special attention in making the general visual inspection.

1. Soldered joints—examine for firmness. A poor physical joint means a poor electrical connection. Note especially ground lug connections.

2. Screws, bolts and nuts—must be all tight.

3. Insulation on wiring—must be perfect and not cut or frayed through where it passes metal edges of tubes, contacts, etc.

4. Tube socket fingers—should be clean and tight.

5. Switches — switch blades should be clean and make good contact.

6. Dials—should not scrape on panel.

7. Grid resistances—note if intact and tightly riveted on.

8. R.F. transformers — examine for loose or damaged coils, or bad connections at terminals.

9. Variable condensers — check for foreign particles between plates and note spacing between rotary and stationary plates.

10. Rheostats or volume control —must operate smoothly.

11. Power supply cable—note condition of insulation on lead and condition of terminals at power end.

12. Power unit—cable connection panel must be bolted down tightly.

13. Supply cables — note if cut by power unit lid.

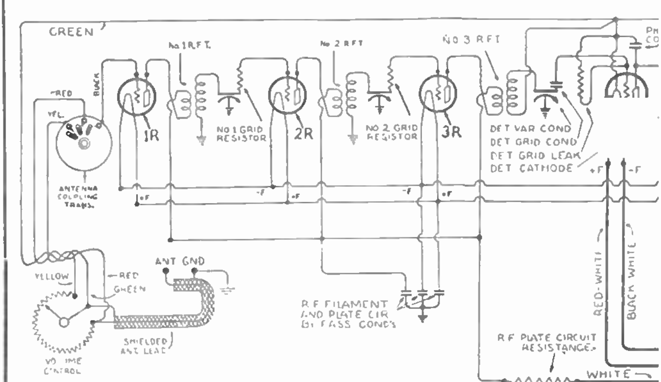


Fig. 4—Schematic wiring diagram of Atw

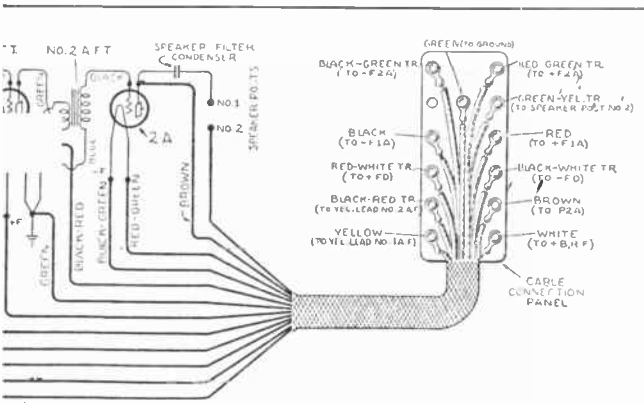
Continuity and Voltage Test

After the receiver has been thoroughly checked by visual inspection, the next step toward locating possible defects will be to apply the series of circuit continuity tests. These tests should be made with a low range DC voltmeter, zero to 50 volts, connected in series with a 45-volt B battery.

It will be necessary also to check the voltages supplied to the various circuits by the power unit.

TABLE I
VOLTAGE TEST CHART—ATWATER KENT A. C. SETS
(Measurements made while set is in operation)

Fil. Voltages (Use 0-5 AC meter)	Test Terminals (Colors of cable leads)	Model 36 Model 37 to Serial No. 1,265,000	Model 37 Serial No. 1,265,001 to 1,385,000	Model 37 Serial No. 1,385,001 and up	Model 38	Models 40, 42, 44 and 52
			Approximate Voltage			
:ector	Red-white tr. to black-white tr.	2.3	2.2	2.3	2.3	2.35
....'. & 1st A.F.	Red to black	1.4	1.45	1.3	1.3	1.45
Power (2nd A.F.)	Red-green tr. to black-green tr.	4.8	4.7	4.8	4.8	4.8
Plate Voltages (Use high resistance DC meter)						
Detector	Red-white tr. to yellow	30	25	30	48	44
R. F.	Red to any R.F. tube "P" contact (thru eyelet)	135	165	170	180	160
1st A.F.	Red to black-red tr.	110	135	160	160	155
Power (2nd A.F.)	Red-green tr. to brown	120	145	175	180	180
Bias Voltages (Use high resistance DC meter)						
On Power tube	F to G (socket 2A, thru eyelets)	25	30	45	45	45
On R.F. and 1st tubes	F to G (socket 1A, thru eyelets)	12	12	13	13	13



t Radio Receivers, Models 40, 42 and 52.

A high resistance voltmeter should be used for testing B voltages, one having several ranges, such as 0 to 10, 0 to 100 and 0 to 200, any one of which can be used by changing connections on the meter.

For testing filament voltages on the tubes, a low range A.C. voltmeter is used having a scale reading of 0 to 5 volts.

A milliammeter can be used for checking the amount of plate current being drawn by one or a group of tubes in order to determine if it is normal.

Table I gives the filament, plate and bias voltages on Atwater Kent A.C. sets. This table should be very helpful to Radio-Tricians servicing all models of A. C. Atwater Kent Receivers.

Figure 3 shows the connections from the power unit used in models 40, 42, 44 and 52. This view shows the approximate position of leads from the field container. In Models 40, 42 and 52, a hole is cut in the rectifier socket mounting angle and the two black leads are brought up through the hole and connect to the regulating resistance, which is mounted upright at the left hand end of the field container.

Table II gives the continuity test for power unit used in Models 40, 42, 44 and 52. For following test, remove table connection panel from unit.

TABLE II

Test	Correct Reading	Wrong Reading Indicates	Remarks and Further Possibilities
Across 2nd A. F. filament Supply.	Full	None—open 2nd A.F. fil. winding and open 2nd A.F. filament shunt resistance.	Nearly full—open filament winding. (Unsolder one fil. winding connection and test winding and fil. shunt resistance separately.)
Across R. F. 1st A. F. Filament Supply.	Full	None—open R.F. 1st A.F. fil. winding and open R.F. 1st A.F. fil. shunt res.	Nearly full—open filament winding. (Unsolder one fil. winding connection and test winding and fil. shunt resistance separately.)
Across Detector Filament Supply.	Full	None — open det. fil. winding and open detector filament shunt resistance.	Nearly full—open filament winding. (Unsolder one fil. winding connection and test winding and fil. shunt resistance separately.)
From +B R.F. to +B 2nd A.F.	Partial	None — open speaker (output) choke.	Full—shorted speaker choke.
+B 1st A.F.	Small	None—open 1st A. F. plate cir. res.	
+B Detector.	Very Small	None—open det. plate cir. res.	
Ground.	None	Shorted filter condens'r.	
F1 (on Rectifier Tube Socket).	Partial	None—open plate supply filter choke.	
From Ground to +B Detector.	None	Shorted by-pass condenser.	
One Side of 2nd A. F. Filament Supply.	Partial	None—open 2nd A. F. grid bias res.	Full—shorted bias res.
One side of R.F.-1st A.F. Filament Supply.	Partial	None—open R.F. 1st A.F. grid bias res.	Full—shorted bias res.
One side of Detector Filament Supply.	Full	Open connection to center tap of detector filament shunt res.	Examine connections under panel assembly.
+B 1st A.F.	None	Shorted by-pass condenser.	
P1, P2 (on Rectifier Tube Socket)	Nearly Full	None—open high voltage sec. winding.	
Each Terminal of A.C. Plug.	None	Grounded primary of power transformer.	Inspect A.C. cable and switch leads for accidental grounds.
Other Tests			
Across terminals of A.C. Plug. (Toggle Switch "On".)	Full	Open primary of transformer or open cable or switch leads.	
F1 to F2 (on Rectifier Tube Socket).	Full	Open rectifier filament winding or connections.	
One side of 2nd A. F. Filament supply to speaker return terminal.	Full	Open connection to center tap of 2nd A. F. filament shunt resistance.	

A comparison chart is shown in Figure 5 which shows the relation of the various receivers to each other. By studying the chart, you will readily see that all the receiving circuits are fundamentally the same as the Model 37 chassis represented in the extreme right-hand of the chart.

Models 38, 40 and 42 are developments and improvements on Model 37.

From Model 42 the three principle Models 43, 44 and 52 were developed, which were further modified into the remaining models shown in the chart. The following descriptions of the various models when studied in connection with the chart will enable the student to readily understand the different models.

MODEL 37 is a 6-tube single-dial receiver having three stages of Radio frequency amplification, the first stage being untuned. The volume control consists of a variable resistance connected directly between the antenna and ground post of the set.

MODEL 38 is a 7-tube receiver having the same circuit diagram as Model 37 with the exception that an additional stage of Radio frequency amplification is used.

MODEL 40 is a 6-tube receiver in a metal cabinet with a black dial and volume control and other minor differences. It has practically the same wiring diagram as the Model 37.

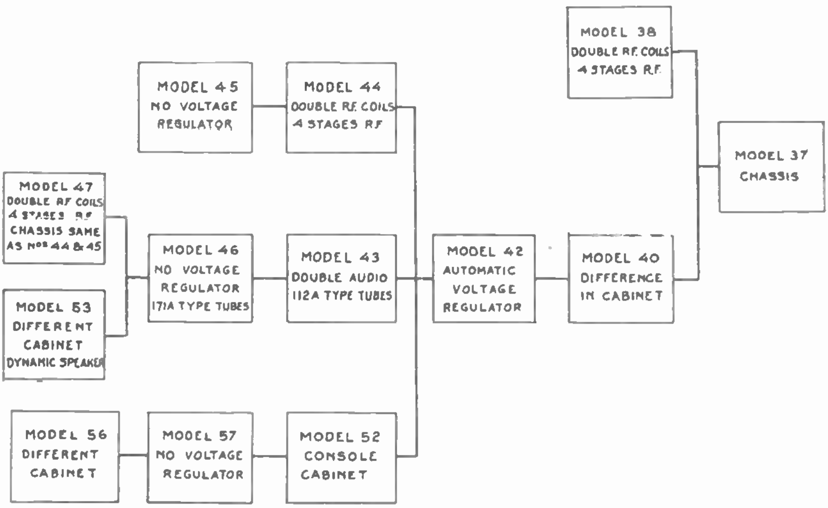


Fig. 5—Comparison chart showing relationship of various models to each other.

MODEL 42 is the same receiver as Model 40, but with an automatic voltage regulator.

MODEL 44 has the same wiring diagram as Model 42 with an additional stage of Radio frequency amplification.

MODEL 45 is the same receiver as Model 44, but with no voltage regulator.

MODEL 43 is a 7-tube receiver similar to Model 42 but with a "double audio" second A.F. stage of 112-A type tubes. This receiver is used with an electro-dynamic speaker.

MODEL 46 is similar to Model 43 but uses 171A type tubes in the second A.F. stage and it does have a voltage regulator.

MODEL 47 is similar to Model 46 but has four stages of Radio frequency amplification making chassis similar to Models 44 and 45, but with brass trimmings on variable condensers.

MODEL 53 is the same set as Model 46 but placed in a different cabinet with a built-in electro-dynamic speaker.

MODEL 52 is a console type of receiver using the same chassis as used in Model 42.

MODEL 57 is a 6-tube receiver the same as Model 52 but no voltage regulator. Antenna and ground posts instead of twenty-foot leads.

MODEL 56 is the same receiver as Model 57 with the exception that the cabinet is four inches lower.

Power Units

POWER UNITS FOR MODELS 40, 42, 44 and 52. Figure 3 shows the wiring diagram for the power supply unit in the early receivers for the above model numbers. During the latter part of 1928, a single-container-type of power unit used in Model 44 was modified by designing the condensers and speaker choke as a separate replaceable assembly in the power unit container. The same diagram can be used for testing as used for the first models.

THE POWER UNIT FOR MODELS 40 AND 45 has also been modified by designing the condensers and speaker choke as separate replaceable sections. The circuit diagram is practically the same as given in Figure 3.

POWER UNITS FOR MODELS 46, 47 AND 53 are similar to Model 43 except that the power unit is enlarged to provide adequate supply for the 171-A type tubes used in the double audio second A.F. stage. Also the voltage regulator is not used and the condensers in the power unit are contained in a separate replaceable section.

THE POWER UNIT IN MODELS 47 and 38 is practically the same as the power unit used in Models 40, 42, 44 and 52 with the exception that it does not have the regulating resistance in series with the primary circuit. Figure 3 shows the various connections on this power unit. However, the COLOR SCHEME ON MODELS 37 and 38 IS NOT THE SAME AS SHOWN IN THIS FIGURE. The circuit diagram will enable the Radio-Trician to successfully test the unit.

Consultation Service

NATIONAL RADIO INSTITUTE
WASHINGTON, D. C.

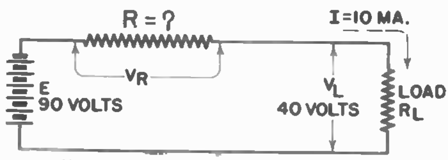
RESISTOR EXAMPLES

THIS data sheet gives practical examples of the important radio laws which you have studied in connection with resistors. Of course, in ordinary radio work you will rarely have to figure out more than one thing at a time; here we show several examples for each circuit only in order to emphasize the maximum possible number of basic radio principles.

EXAMPLE 1

A resistance load requires 40 volts and draws 10 milliamperes. It is to be connected into a circuit having a 90-volt source, with a series resistor being used to get rid of the undesired voltage. What ohmic value and wattage rating should the series voltage-dropping resistor have?

SOLUTION: First we draw the schematic diagram of the circuit, and place on it all known information, as follows:



Since we are to find the ohmic value of series resistor R by means of Ohm's Law, we must first know the values of E and I for this resistor ($R = E \div I$). We already know that I is 10 ma. because this is a series circuit, and the load current must flow through series resistor R. To change this 10-ma. current value to amperes, we move the decimal point three places to the left, and thereby get .01 ampere as the value of I.

To find the voltage drop V_R across R, we make use of Kirchhoff's Voltage Law. It says that the voltages dropped across the load and the series resistor must add up to the source voltage. The only voltage value for R which will meet this fundamental requirement is a value equal to the difference between the source voltage of 90 volts and the load voltage of 40 volts. Therefore, voltage drop V_R is equal to 90 — 40, which is 50 volts.

Knowing that V_R is 50 and I is .01, we can now use the Ohm's Law formula $R = E \div I$ to give us the ohmic value of R:

$$R = V_R \div I$$

$$R = 50 \div .01$$

$$R = 5000 \text{ ohms}$$

$$\begin{array}{r} 5000. \\ .01.\overline{)50.00.} \\ \underline{5} \\ 000 \end{array}$$

NOTE: Division with decimals is explained near the end of this data sheet.

Series voltage-dropping resistor R must therefore have an ohmic value of 5000 ohms. But can we use any 5000-ohm resistor? No. We must be sure that the resistor we use will be able to handle the amount of power which is lost in it as heat. That is why we figure out this power loss before choosing a resistor.

The power formula, you will recall, says that the power in watts is equal to the voltage drop across the resistor multiplied by the current flowing through the resistor ($P = E \times I$). Thus:

$$P = V_R \times I$$

$$P = 50 \times .01$$

$$P = .5 \text{ watt}$$

If series resistor R is located in open air, a 5000-ohm resistor having a wattage rating of ½ watt will serve the purpose. If the resistor is mounted underneath a chassis

RESISTOR FORMULAS

OHM'S LAW FORMULAS	POWER FORMULAS
$E = I \times R$	$P = E \times I$
$R = E \div I$	$P = I \times I \times R$
$I = E \div R$	$P = E \times E \div R$

PARALLEL RESISTANCE FORMULA

$$R = \frac{R_1 \times R_2}{R_1 + R_2}$$

E = VOLTAGE in VOLTS
I = CURRENT in AMPERES
R = RESISTANCE in OHMS
P = POWER in WATTS

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where air circulation is limited, we should provide an ample margin of safety by using a resistor having a considerably higher wattage rating than the computed power value. In other words, we should use a 5000-ohm resistor having a 1-watt or even larger rating.

EXAMPLE 2

The load resistance in our first example was 4000 ohms ($R = E \div I = 40 \div .01 = 4000$ ohms). Instead of a resistor, this load could be a vacuum tube which varies considerably in resistance during certain operating conditions. The load voltage, however, should remain constant at 40 volts. Will the tube still get 40 volts if the tube resistance drops to 1000 ohms?

SOLUTION: According to Ohm's Law, the load voltage will be equal to the load current multiplied by the load resistance ($E = I \times R$). When the load resistance drops to 1000 ohms, the total circuit current changes, the resistance changes, and hence the load current changes. Here is how we can figure the new load current value.

In our circuit now, we have a 5000-ohm series resistor and a load resistance of 1000 ohms. These two resistances are in series, so their values add. This means that the total resistance which the source "sees" in this circuit is 5000 + 1000, or 6000 ohms.

With a source voltage of 90 volts acting on a total resistance of 6000 ohms, the circuit current will be:

$$I = E \div R$$
$$I = 90 \div 6000$$
$$I = .015 \text{ ampere.}$$

Now we can figure out the load voltage:

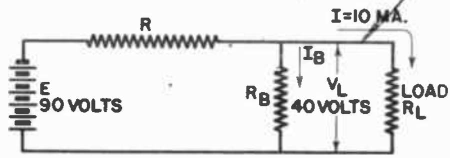
$$V_L = I \times R_L \text{ (same as } E = I \times R)$$
$$V_L = .015 \times 1000$$
$$V_L = 15 \text{ volts}$$

This load voltage value of 15 volts is certainly considerably lower than the required value of 40 volts. This demonstrates that in a simple series circuit, a change in load resistance will have considerable effect upon the load voltage.

EXAMPLE 3

By connecting a shunt or bleeder resistor across the vacuum tube load in the previous example, we can make the load voltage more nearly constant when the load resistance changes in value (improve the voltage regulation). What should be the ohmic values and wattage ratings of the series and shunt resistors, and how much will the load voltage change now when the load resistance drops from 4000 ohms to 1000 ohms?

SOLUTION: For the purpose of this explanation, we will first draw our circuit diagram and place on it all known values, as follows:



To begin with, we want the resistance of bleeder resistor R_B to be many times *smaller* than the ohmic value of load R_L, because this is one requirement for good voltage regulation. Stated in another way, we want R_B to carry several times as much current as the load. Let us say that we will make R_B carry 10 times the normal load current; this is 10 times .01 ampere, or .1 ampere.

We know that R_B will get the same voltage as the load, because it is in parallel with the load. Thus, knowing both the current and voltage of R_B, we can determine its resistance value by Ohm's Law:

$$R_B = V_L \div I_B \text{ (same as } R = E \div I)$$
$$R_B = 40 \div .1$$
$$R_B = 400 \text{ ohms}$$

The ohmic value of R_B should thus be 400 ohms. Its power loss will be $P = E \times I = 40 \times .1$, which is 4 watts. The nearest standard-size resistor readily available is 5 watts, and this would be considered the *minimum* safe size. Ordinarily a radio man would use a 10-watt resistor in this location to give ample margin of safety.

Now let us figure the ohmic value of series resistor R. We know that this resistor must drop 50 volts, because we still need 40 volts across the load. We must figure out, however, what the new current value through the series resistor is.

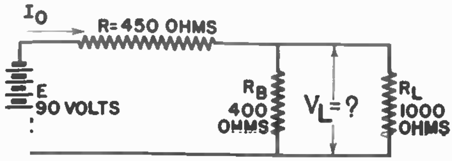
Kirchhoff's Current Law says that the current flowing through this resistor will be the sum of the currents flowing through R_B and R_L. This means that the series resistor current will be .1 + .01, or .11 amp.

Now we can use Ohm's Law to compute the ohmic value of series resistor R:

$$R = 50 \div .11$$
$$R = 454 \text{ ohms}$$

It would be quite difficult to secure a resistor having an ohmic value of exactly 454 ohms. Furthermore, such an exact value is not necessary in radio work. Instead, we use the nearest standard-size resistor. In this case, it would be a 450-ohm resistor. The power loss is $50 \times .11$, or 5.5 watts, hence a 10-watt resistor is the logical choice.

Now let us see what happens to the load voltage in this circuit when the load resistance drops to 1000 ohms. We first draw the circuit diagram in schematic form and put in all of our known values for this new condition, as follows:



If we know the combined resistance of R_B and R_L in parallel, and also know the current which would flow through this combined resistance value (this is the same as the current through series resistor R), we can figure out the load voltage by means of Ohm's Law.

First we figure the combined resistance (let us call it R_O) of R_B and R_L in parallel, as follows:

$$R_O = \frac{R_B \times R_L}{R_B + R_L}$$

$$R_O = \frac{400 \times 1000}{400 + 1000} = \frac{400{,}000}{1{,}400}$$

$R_O = 286$ ohms, combined resistance

This combined resistance of 286 ohms is in series with the 450-ohm value of R, insofar as the source is concerned. The total circuit resistance is then 450 + 286, which is 736 ohms. A source voltage of 90 volts acting on 736 ohms makes circuit current I_O equal to 90 ÷ 736, which is .12 ampere.

To find the load voltage now, all we have to do is multiply circuit current I_O by combined resistance R_O. This gives us .12 × 286, or 35 volts as the load voltage under the condition whereby the tube resistance has dropped to 1000 ohms. This is not at all far off from the desired voltage value of 40 volts, clearly proving the value of the bleeder resistor in keeping the load voltage reasonably constant.

We found in EXAMPLE 2 that the load voltage dropped to 15 volts under similar conditions but without the bleeder resistor. Thus we see that a shunt or bleeder resistor improves the voltage regulation of a circuit. The smaller the change in load voltage when the load resistance varies, the better is the voltage regulation.

REVIEW OF DECIMAL NUMBERS

ECIMALS are merely a convenient short-hand method of specifying fractional values. Since we encounter decimals occasionally when we read a meter or do a bit of figuring for radio circuits, the simple fundamental rules for handling decimal numbers are presented here in condensed form to refresh your memory. Read them once now, and refer to them whenever in doubt about a decimal problem.

We will start off this review with examples of a few decimal numbers and their fractional equivalents.

$$.1 = \frac{1}{10} = \text{one tenth}$$

$$.03 = \frac{3}{100} = \text{three hundredths}$$

$$.001 = \frac{1}{1000} = \text{one thousandth}$$

$$.0007 = \frac{7}{10{,}000} = \text{seven ten thousandths}$$

$$.00007 = \frac{7}{100{,}000} = \text{seven hundred thousandths}$$

$$.000001 = \frac{1}{1{,}000{,}000} = \text{one millionth}$$

$$.0025 = \frac{25}{10{,}000} = \text{twenty-five ten thousandths}$$

Any number of zeros can be added after a decimal number without changing its value. Thus, .03 is the same as .030 or .03000; 1.405 is the same as 1.40500; 7 is the same as 7.0 or 7.000.

Reading decimal numbers is easy when done the radio man's way. He does not ordinarily bother to use the fractional pronunciations; instead, he calls off the decimal point, zeros and numbers from left to right in their respective order. If a radio man walked into a store to buy a .25-mfd. condenser, he would simply ask for a *"point two five microfarad condenser."* To him, .025 would be *"point oh two five"*; .0025 would be *"point double oh two five"*; .00025 would be *"point triple oh two five."* With a number like 25.079, he would say *"twenty-five point oh seven nine."* Correspondingly, if speaking of a current of .75 ma. which is being measured by a milliammeter in a circuit, he would say and think *there is point seven five milliampere flowing in the circuit,"* instead of saying and thinking *"seventy-five hundreths of a milliampere."*

In radio work, it is often necessary to multiply or divide both whole numbers and decimal numbers by such values as 10 100, 1000, or 1,000,000. This is necessary when changing values in milliamperes to amperes and vice versa, or when changing values in ohms to megohms and vice versa. On the next page are simple rules for doing this.

MULTIPLICATION RULES

To multiply by 10, move the decimal point ONE place to the RIGHT.

10 × 7 = 70
10 × .7 = 7.0 = 7
10 × .01 = 0.1 = .1
10 × .0035 = 0.035 = .035
10 × 15.79 = 157.9

To multiply by 100, move the decimal point TWO places to the RIGHT.

100 × .01 = 01. = 1
100 × 15.798 = 1579.8

To multiply by 1000, move the decimal point THREE places to the RIGHT.

1000 × .01 = 010. = 10
1000 × 1.75 = 1750

To multiply by 1,000,000, move the decimal point SIX places to the RIGHT.

1,000,000 × .00025 = 250
1,000,000 × 2.5 = 2,500,000

DIVISION RULES

To divide by 10, move the decimal point ONE place to the LEFT.

.0035 ÷ 10 = .00035
125.7 ÷ 10 = 12.57

To divide by 100, move the decimal point TWO places to the LEFT.

.5 ÷ 100 = .005

To divide by 1000, move the decimal point THREE places to the LEFT.

5.7 ÷ 1000 = .0057

To divide by 1,000,000, move the decimal point SIX places to the LEFT.

750,000 ÷ 1,000,000 = .75
3,500,000 ÷ 1,000,000 = 3.5

MULTIPLYING DECIMAL NUMBERS

Decimal numbers are multiplied in the same way that ordinary numbers are multiplied in simple arithmetic. The number of decimal places in the answer is the SUM of the decimal places in the two numbers being multiplied together.

EXAMPLE: Multiply .0025 by 43

```
 .0025   <—4 decimal places
    43   <—0 decimal places
  ----
    75
  100          Total is 4 decimal places,
  ----
  1075         so the answer is .1075
```

EXAMPLE: Multiply .025 by .0043

```
  .025   <—3 decimal places
 .0043   <—4 decimal places
  ----
    75
  100          Total is 7 decimal places,
  ----
  1075         so the answer is .0001075
```

DIVIDING DECIMAL NUMBERS

A decimal can be divided directly by a whole number. The decimal point in the answer is placed directly below (or above) the decimal point in the decimal number, and empty places after the decimal point in the answer are filled in with zeros.

EXAMPLE: Divide .012 by 6

Set up the problem in the usual way:	6 | .012
Place the decimal point for the answer:	6 | .012 .
6 won't go into 0 or 1, so put down 00	6 | .012 .00
6 goes into 12 two times, so put down a 2:	6 | .012
The answer is .002	.002

To divide a whole or decimal number by a decimal number, first set up the number for division. Start with the number you are dividing by, and move its decimal point enough places to the right to change the decimal into a whole number. Next, move the decimal point for the other number the *same number of places to the right*, and put zeros in the empty places. Now you can divide in the usual manner as if worki with whole numbers:

EXAMPLE: Divide 140 by .0025

```
.0025 | 140.

0025. | 140 0000.

          5 6000.
  25 | 140 0000.
       125
        15 0
        15 0
           000
```

Note that in the first step, a decimal point has been placed after the whole number. Although a decimal point belongs after every whole number, it is shown only when needed for division purposes.

EXAMPLE: Divide .25 by .0014

```
.0014 | .25

0014. | 2500.

          178.5
  14 | 2500.0
       14
       110
        98
        120
        112
          8 0
          7 0
          1 0
```

You could increase the accuracy of the answer by adding more zeros after 2500. and carr ing out the divisi further, but a practi cal radio man would rarely add more than one zero in a problem like this. In fact, he would be more likely to stop with 178, or even call the answer about 180.

How To Service A Dead Receiver

AN ordinary radio receiver has four essential sections: *1, the R.F. section,* which selects and amplifies the desired modulated R.F. carrier signal after it is picked up by the antenna system; *2, the detector,* which separates the audio signal from the R.F. carrier signal; *3, the A.F. section,* which amplifies the audio signal; *4, the loudspeaker,* which converts the amplified A.F. signal into sound waves. These processes of amplification and detection are made possible by vacuum tubes, and these tubes can operate only if their cathodes are properly heated and their other electrodes are supplied with the proper D.C. potentials. The various circuits in a receiver therefore divide into two distinct groups, the *signal circuits* and the *power supply circuits.*

Causes of Dead Receivers. A radio receiver which will not bring in any programs whatsoever is said to be *dead.* There are only four fundamental causes for a dead receiver: *1, a defective tube; 2, an open connection or part* in the signal circuit or in the supply circuit; *3, a shorted part,* which either blocks a signal circuit or prevents application of a D.C. voltage to a tube electrode; *4, a defective part* which has changed in characteristics sufficiently to cause blocking of a signal circuit. A Radiotrician who is confronted with a dead receiver immediately makes a check for these defects. He knows that they may occur in parts which are either above or below the chassis, and since it is oftentimes a bit difficult to remove the chassis, he first makes certain that there are no defects above the chassis.

The Professional Technique for Dead Receivers. If a check for surface defects above the chassis fails to reveal the trouble, the Radiotrician removes the chassis from its cabinet and quickly checks the parts underneath for obvious defects. He then begins a systematic and speedy procedure for locating *the defective stage,* followed by an ohmmeter test to locate the defective part in that stage. Finally, he replaces or repairs the defective part. The steps in the professional service technique for repairing a dead receiver are, therefore:

1. **Check for surface defects above the chassis and test all tubes.**
2. **Check for surface defects beneath the chassis.**
3. **Locate the defective stage.**
4. **Locate the defective part.**
5. **Repair the defect.**

Checking for Surface Defects. Although this subject has already been thoroughly covered, it is so important in the case of dead receivers that I will review it briefly here. Check the antenna system to be sure it is up and in good condition. Make sure that the receiver is being supplied with power by noting whether the pilot lamps light and whether the tubes heat. Look for tubes which are not properly seated in their sockets; oftentimes tube prongs may not be making good contact with socket terminals. Be sure there are no loose parts above the chassis. Inspect tube shields and tube top cap connections. Finally, test each tube with a tube checker, and check the loudspeaker.

Next comes removal of the chassis and an inspection for open connections, broken parts, and charred parts underneath the chassis. If you find an obviously defective part, be sure to inspect other parts which are associated with it. For example, a shorted bypass condenser may cause large currents to flow through a resistor, giving the resistor a charred appearance. Although the resistor is defective, the shorted condenser is the true cause.

Locating the Defective Stage

Any method for locating the defective stage in a dead receiver should begin with a check of the power pack. Connect a high-range D.C. voltmeter between the chassis and the plate terminal of the last audio tube (or between the chassis and one terminal of the loudspeaker field coil); the meter should indicate a reading somewhere between 180 and 250 volts if the power pack is producing the correct D.C. voltage for the receiver. If this reading is secured, you can assume that the power pack is cleared of suspicion.

The Signal Generator Method. The most conclusive procedure for isolating the defective stage in a dead receiver is the signal generator method, also known as the dynamic stage-by-stage elimination procedure. It should be mastered and used whenever a check for surface defects fails to reveal the cause of a dead receiver.

The principle underlying this method is quite simple. In a superheterodyne receiver, as you know, the signal from a desired station enters the receiver at the carrier frequency of that station; at the output of the mixer-first detector stage there is a change to the frequency of the I.F. amplifier, and at the second detector there is another change, this time to the A.F. signal frequency. Audio signals then exist right up to the loudspeaker, where they are converted into sound waves. By introducing into certain stages, with an ordinary modulated R.F. signal generator, a signal which duplicates that which would exist if the receiver were performing correctly and were tuned to a station, we can locate the defective stage.

An essential requirement of this method is familiarity with the signal generator. You should know how to change its frequency band, how to adjust it to the desired frequency and how to control its output. Determine whether it has a condenser in series with its output, to block the flow of direct current; if the condenser is absent, insert a .002 mfd. condenser and a .1 megohm resistor in one of its leads, as shown in Fig. *1*. The resistor is optional but the condenser is necessary.

The receiver is always turned on while the defective stage is being isolated with a signal generator (S.G.). The procedure begins at the second detector; connect the S.G. ground lead to the chassis of the receiver, and connect the other S.G. lead or probe (known as the free probe) to the input of the second detector stage. If this stage uses a triode or pentode, connect to the control grid; if a diode, connect to the plate of the preceding tube (the last I.F. tube). Set the S.G. to the I.F. value of the receiver and advance the control on the S.G. to maximum output. If the second detector and the audio system are free from defects, you should now hear the S.G. tone.

If no tone is heard, a detector or audio system defect is indicated. We could use a special audio signal generator and advance it stage by stage toward the loudspeaker until its tone was heard, but an R.F. signal generator will serve just as well if used with the headphone and control system shown in Fig. *2*. You can easily assemble this yourself. The ground probe is connected to the chassis of the receiver, and the free probe is connected first to the output of the second detector (to the plate in the case of triode or pentode tubes, or to the load resistor in the case of a diode detector). The R.F. signal generator connections are not changed. If a tone is heard in the phone, you can assume that the second detector is okay. Now move the free probe from the detector output to the plate of each audio tube in turn, working toward the loudspeaker; when you reach a plate terminal at which no tone is heard, you know that you have just passed through the defective stage. If there are two tubes in the output stage, apply the

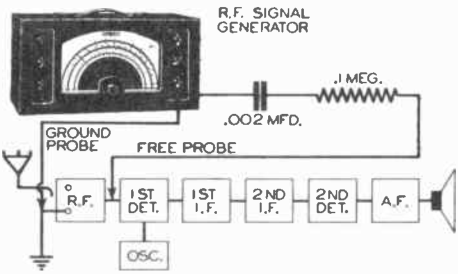


FIG. 1. Block diagram of a superheterodyne receiver, showing a signal generator connection to the first detector for locating a defective stage.

probe to the plate of each in turn. Always adjust the volume control in the control box after making each new connection, to secure normal volume without overloading the phone.

If the tone *is* heard in the loudspeaker when the S.G. is connected to the input of the second detector, you assume that the detector and audio systems are good, and omit the headphone test. Advance the free S.G. probe to the plate and then to the grid of the preceding I.F. tube; if the tone is heard, repeat for the other I.F. tubes until you arrive at the grid of the first detector. As long as all stages between the S.G. connection and the loudspeaker are good, the tone will be heard from the loudspeaker; the tone will no longer be heard when you have passed through the defective stage.

Assuming you have not yet located the defective stage, your S.G. will now be connected as shown in Fig. *1*. With this connection, you can determine if the local oscillator is functioning. Tune the S.G. to the frequency to which the receiver is tuned; if the tone is not heard when this is done, either the oscillator or its connection to the mixer-first detector is defective. If you like, you can make an additional check for a defective oscillator by tuning the receiver to a local station, then tuning the S.G. (without changing its connection) to a frequency which is above or below the local station frequency by the I.F. value of the receiver. For example, if the receiver is tuned to a 1,200 kc. station and the I.F. value is 460 kc., set the S.G. either to 1,660 kc. or 740 kc. If you now hear the program of the local sta-

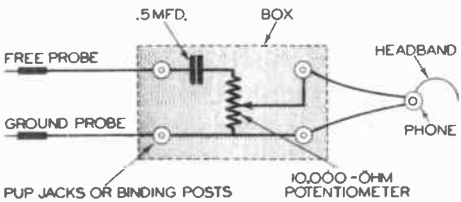


FIG. 2. Handy headphone unit for locating a defective stage.

tion from the loudspeaker, mixed with S.G. tone, you know that the local oscillator is defective and that the stages ahead of the first detector are good.

If the local oscillator is functioning, set the S.G. at the same frequency as the receiver, then advance the free S.G. probe to the plate and then to the grid of the R.F. amplifier stage, and finally to the antenna terminal of the receiver. The tone in the loudspeaker should stop for one of these points, if you have come this far without locating the defective stage.

If you use a series resistor in the S.G. lead as indicated in Fig. *1*, the loudspeaker tone should become louder as you move the S.G. probe toward the antenna terminal; when the tone becomes excessively loud, turn down the control on the S.G. until you secure normal output. Without the series resistor, the detuning effect of the S.G. on an R.F. stage may offset the gain of that stage.

Circuit Disturbance Test. A quicker but less dependable method for isolating the defective stage after the main D.C. supply voltage has been checked is that known as the *circuit disturbance test.* This test is based upon the fact that each stage in a receiver is one link in a chain extending from the antenna terminal to the loudspeaker; any sudden plate current interruption or change along this chain will cause a surge of power to be relayed on to the loudspeaker (where it is heard as a click), if there are no defective stages between the loudspeaker and the point at which the disturbance was created.

There are a number of ways to produce a disturbance in a stage: *1*, pull a tube from its socket, then replace it (two clicks are usually heard when this is done); *2*, touch the control grid of a tube, or remove and replace the top cap connector. The Radiotrician uses whichever method is easier to apply to a particular tube.

A circuit disturbance test begins at the second detector tube when this tube is a triode or pentode; in the case of a diode second detector either the preceding or the following tube is removed. If a click is heard, you know that all stages between the point of the disturbance and the loudspeaker are good; if no click is heard, proceed toward the loudspeaker, introducing a disturbance in each stage in turn. (A howl rather than a click is often heard when a grid is touched.)

If the circuit disturbance test indicates that there are no defects in the audio system and second detector, work toward the first detector; pull out tubes or remove grid cap connections, remembering that there should be an indication of some sort from the loudspeaker each time this is done. The circuit

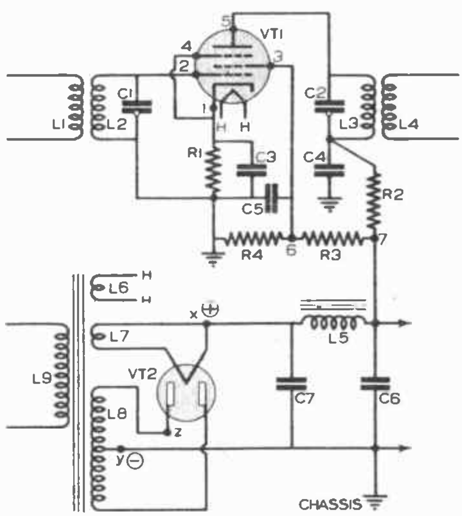


FIG. 3. Typical I.F. amplifier stage and its connections to the receiver power pack. *VT1* is the I.F. amplifier tube; its cathode is *1*; control grid is *2*; screen grid is *3*; suppressor grid is *4*; plate is *5*.

disturbance test will not reveal the condition of the local oscillator, however; no click will be heard when this tube is removed, but if a background noise and hissing are heard when the volume is turned up, indicating a "live" receiver even though no broadcasts are received, you can assume that either the local oscillator or a preselector (R.F.) stage is defective. If a circuit disturbance test on the R.F. tube indicates it is good, then the local oscillator will undoubtedly be defective.

The chief advantage of the circuit disturbance test is that it can be carried out in a few minutes, working from the top of the chassis. A signal generator test of the suspected stage will then verify the results of the circuit disturbance test and also tell whether the defect is in the input or output circuit. A typical I.F. amplifier stage is shown in Fig. *3:* if a tone is heard when the free S.G. probe is connected to point *5* (the other S.G. probe being on the chassis), we know that parts *C2, L3, L4* and all following sections are good. If the free S.G. probe is moved from point *5* to point *2*, and no output tone is now heard, we have conclusive evidence that there is trouble in the tube, that *C1* or *L2* is shorted, or that the tube is not receiving its proper electrode voltages.

Locating the Defective Part With an Ohmmeter

Before considering how the defective part can be located with an ohmmeter once its approximate location has been determined, let us consider the fundamental rules for checking continuity with an ohmmeter. The circuit in Fig. *3* will be used as our example.

RULE 1. There should be continuity between the cathode of the rectifier tube and all tube electrodes which are supplied with positive D.C. potentials. This rule therefore applies to screen grid and plate electrodes. Thus, in Fig. *3* you can trace from the plate of the tube (point *5*) through coil *L3*, resistor *R2* and choke coil *L5* to point *x*, which is at the cathode of the power pack rectifier tube.

RULE 2. There should be continuity between a plate terminal of the rectifier tube and all tube electrodes which are supplied with negative D.C. potentials. This rule applies to control grids and suppressor grids, and also to cathodes. Thus, in Fig. *3* you can trace from the control grid (point *2*) through *L2* to ground (the chassis), through the chassis to point *y*, and through either half of the power transformer secondary winding to a rectifier tube plate.

It is generally true that all tube electrodes trace to the chassis, but there will be a few exceptions. For example if resistor *R4* were omitted from the circuit in Fig. *3* (as it often is), this general continuity-to-chassis rule would not hold true for the plate and screen grid electrodes (*5* and *3*).

The procedure for isolating a defective part with an ohmmeter can be best explained by using Fig. *3* as an example. With the receiver power plug out of its wall outlet, connect the ohmmeter probes in turn to points *5* and *x*, *3* and *x*, *1* and *z* (or the chassis), *2* and *z*, and finally to *4* and *z*. In each case a definite reading of the ohmmeter clears that circuit of suspicion; an open circuit indication (no ohmmeter pointer movement) indicates a defect, and we then concentrate on the circuit between the two points to which the ohmmeter probes are connected.

Suppose that we found no continuity between points *3* and *x*. We would then move the ohmmeter probe from *3* toward point *x*, one part at a time. If we secured a continuity reading for *7* and *x* but not for *6* and *x*, we would then know positively that resistor *R3* was open.

If the defective stage is definitely located but continuity tests with an ohmmeter do not indicate an open circuit, the next step can be an ohmmeter check of each part in the suspected stage. A study of the circuit diagram will reveal the parts which are most likely to cause a dead receiver, and these can be checked first. For example, shorting of condenser *C5* in Fig. *3* would prevent application of a D.C. voltage to the screen grid; an ohmmeter check across either *R4* or *C5* would reveal this short, and the parts would then be checked individually to determine which one was at fault.

The procedure described here for using an ohmmeter to locate a defective part in a dead receiver applies equally well to improperly operating receivers. In the latter case, however, the values of individual resistors or combinations of resistors in series should be checked against the values specified on the circuit diagram. Changes in resistor values occasionally can cause a dead receiver, but more often the result will be an improperly operating receiver. Once you master radio circuits and become familiar with the paths for direct current flow, the actual location of a defective part will present no difficulties.

Extra Money Jobs and how to do them

Uses For Circuit Diagrams and Pictorial Layouts In Servicing

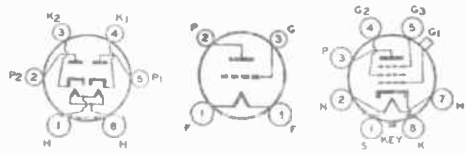
THE Purpose of This Job Sheet. In the previous job sheet, I have shown you how you would service a dead receiver. As you will recall, isolation of the defective stage was followed by a general continuity test. If this did not reveal the defect, a test was made for opens, leaks or shorts in the parts in the defective stage.

It is generally known that manufacturers issue service manuals or bulletins to aid the serviceman in making these tests. These bulletins give circuit connections in the form of schematic circuit diagrams; they often include tube layout and pictorial layout diagrams, all highly useful for making these basic tests on a dead receiver. These diagrams are even more important for servicing an improperly operating receiver, as you will shortly see.

It would be impossible to show in this job sheet all the different forms in which schematic circuits are prepared; likewise I cannot tell how to trace circuits or tell how various stages operate. All this is fully covered in your regular Course. The real purpose of this job sheet is to show you the types of diagrams which are found in service manuals, to point out how these diagrams can help you in servicing receivers, and to emphasize the value of your regular Course in radio servicing.

Any one watching a Radiotrician at work cannot help but be impressed by the speed and ease with which he carries out the professional servicing procedures and locates the defective part in a radio receiver. To many his ability seems uncanny, and yet the tests which he makes are remarkably simple, once their principles and purposes are clearly understood. Speed in applying the tests depends, however, upon knowing where to find the various stages, parts and terminals involved.

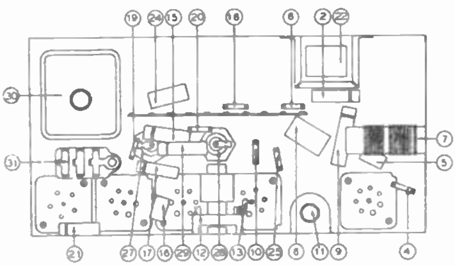
For example, in isolating a defective stage you should know what stages are used in the receiver and where they are located; you should be able to point to the mixer-first detector stage, the R.F. preselector stage, the output stage, the power rectifier tube, etc., on the chassis. Once you have isolated the defective stage in a receiver, you should be able to identify the terminals on the tube sockets in that stage. Furthermore, you should be able to locate the various parts which make up the continuous path from any positive tube electrode to the cathode of the rectifier tube. Later, after you have become more familiar with radio receiver circuits and have learned that there are special control circuits such as automatic volume con-



Typical tube socket connection diagrams; the small numbered circles indicate the positions of the socket terminals as they appear when you look at the *bottom* of the socket. To a Radiotrician these tell which terminal on a particular tube socket goes to the cathode, which goes to the plate, etc.

trol (A.V.C.), automatic bass compensation (A.B.C.), and automatic frequency control (A.F.C.), you should be able to recognize the parts associated with these circuits and either include or eliminate them from your test as required. All this information is obtained most easily by referring to the circuit diagrams and pictorial layouts which are prepared by receiver manufacturers for the convenience of servicemen. In this job sheet we will first consider the various types of diagrams which are available, and then take up the uses for these diagrams in actual servicing work.

Schematic Circuit Diagrams. No radio serviceman, not even an expert, can look at a radio receiver chassis and immediately identify each part and its purpose in the receiver. Of course, the expert could trace each and every wire and then draw up a circuit diagram for the receiver, but this would take hours of tedious work. When a Radiotrician finds that a knowledge of the circuit connections in a particular receiver is necessary, he secures a service manual containing the circuit diagram of that receiver. In a radio service shop where one or more men are servicing sets on a full-time basis, a complete set of service manuals for all receivers is kept on hand as a part of the shop equipment, and is considered just as essential as the multimeter, signal generator and tube tester. (N. R. I. maintains a file of receiver circuit diagrams. If you have a receiver to repair or experiment with, but do not have a service manual for it, write in to N. R. I. giving the make and model number of the receiver and a list of the tubes used in it, and the circuit diagram for it will be loaned to you.)



This particular type of pictorial layout diagram, showing locations of parts on the chassis but omitting all wiring, is typical of those found in the service manuals for some Philco receivers.

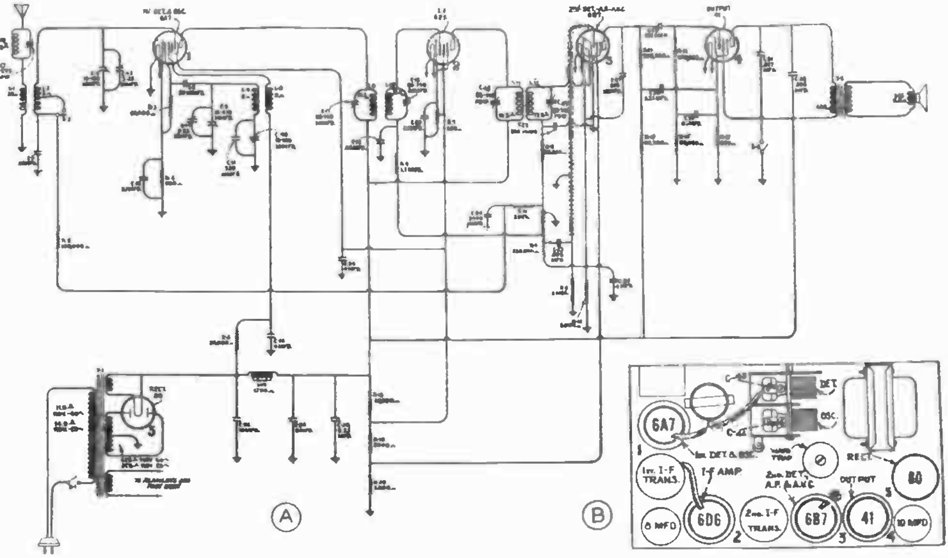
Another point I want to emphasize is that a serviceman is never required to read a complete receiver circuit diagram while servicing any receiver. He may have to analyze the particular section of the diagram in which the defect is located, in order to figure which parts might, if defective, cause the observed trouble, but the professional servicing technique makes it unnecessary to study more than that one section at a time. Careful study of your regular Course will give you this ability to analyze circuit diagrams.

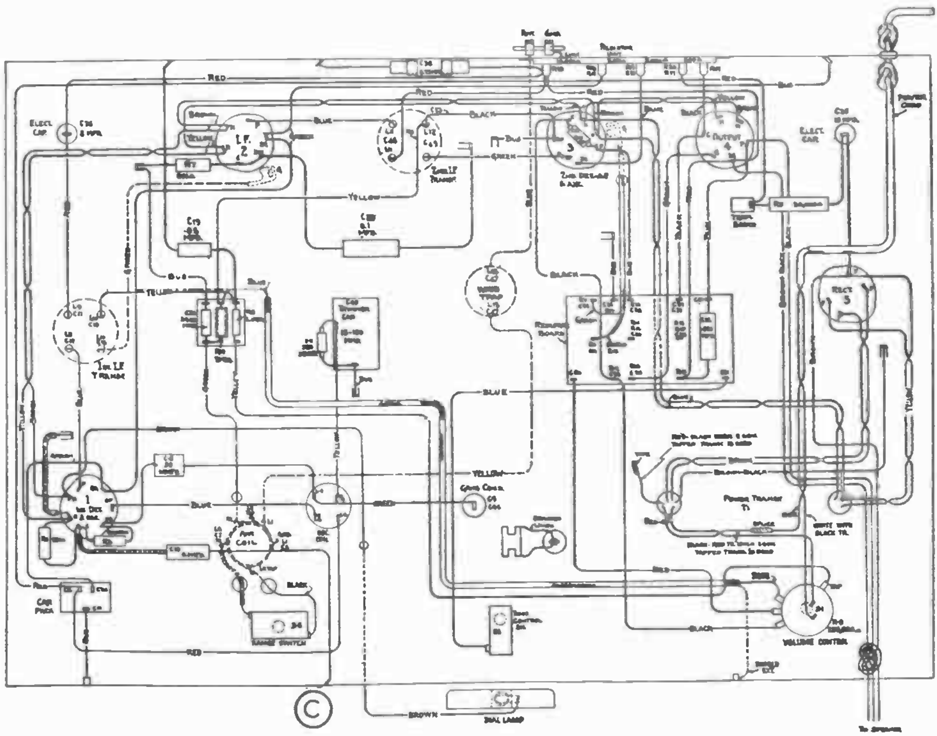
Tube Layout Diagrams. With the information given in a circuit diagram, the Radiotrician can determine the function of each tube on the receiver chassis and can carry out a dynamic or circuit disturbance test for locating the defective stage in the case of a dead receiver. When there are two or more tubes of the same type on a chassis, however, it is considerably more difficult to determine the function of each tube without additional information. In a case like this, the Radiotrician will refer to the tube layout diagram which generally accompanies the circuit diagram. This tube layout diagram not only tells what tubes are used, but shows exactly where they will be found on the chassis, and indicates the stage in which each tube is employed. A tube layout diagram generally indicates tube positions as viewed from the top of the chassis, but with a little experience you can make this diagram serve just as well when working on the bottom of the chassis; a tube is readily identified by noting its relation to adjacent, easily-recognized parts. As you acquire experience, you will become familiar with socket connections for the more common tubes and will be able to work on these tubes without referring to a tube chart.

Tube Charts. When you turn over the chassis of a receiver in order to get at the socket terminals for a particular tube, you are confronted with the problem of identifying the various socket terminals. Sometimes this information is provided right on the circuit diagram, by using a combination pictorial and schematic diagram for each tube in place of the usual schematic symbols. Some manufacturers give tube socket connections on the tube layout diagram, while others give the connections on the pictorial layout diagram. You can identify tube socket terminals even without these diagrams, however, for tube manufacturers prepare special charts for servicemen which show the socket connections for all tubes. When you are ready to begin actual work on radio receivers, I suggest that you secure one of these tube charts from your local radio parts distributor.

Pictorial Layouts. In a few service manuals you will find, in addition to the diagrams just described, a pictorial layout diagram which shows the approximate position of each part on the chassis and which may also show the actual wiring. A brief review of the professional servicing technique for dead receivers will serve to show you how a pictorial layout can be used to advantage when available.

The circuit diagram and the tube layout diagram give you all the reference information which is necessary for locating the defective stage in a dead receiver. After the defective stage is isolated, you will make continuity tests with an ohmmeter; these involve locating the cathode and a plate of the rectifier tube, as well as identification of tube socket terminals for other tubes, and hence you must refer to tube connection diagrams or tube charts. When the





These diagrams are typical of those found in radio receiver service manuals. At *A* is the most important of all, the schematic circuit diagram; you should eventually be able to service receivers with this diagram alone. At *B* is a tube and chassis parts layout as viewed from the top of the chassis; oftentimes this diagram will also show the positions of the adjusting screws or nuts. At *C* is a pictorial layout diagram showing the actual position of each part underneath the chassis; the part numbers on this diagram correspond to those in the circuit diagram. The connecting wires are shown here, but some manufacturers omit all wiring from pictorial layout diagrams. NOTE: These diagrams are presented here simply to give you a general idea of the types of diagrams which are available to servicemen; no attempt has been made to make these diagrams easy to read in this job sheet.

defective circuit is located, you check continuity through each of the various parts which make up this circuit.

In checking an electrode circuit for continuity, one ohmmeter probe is connected to the common terminal for the electrode circuit under test (either the cathode or a plate of the rectifier tube), and the other or free probe is moved from point to point along the circuit. The parts in the circuit may be checked individually or in combinations; for each measurement, the ohmmeter reading is compared with the values specified on the circuit diagram in order to determine whether the parts are normal or defective. Finally, the defective part may be checked by itself with the ohmmeter. The ability to interpret properly the ohmmeter readings which are secured is highly essential in this procedure, and this ability in turn depends upon mastery of the fundamental radio principles presented in your regular Course.

The location of specific parts in a circuit may be speeded up considerably, however, by referring to a pictorial layout diagram. Use the circuit diagram to determine what parts are in the circuit under consideration, note their identifying numbers, and refer to the parts layout diagram to determine the location of each of these parts. It is then a simple matter to locate the parts on the actual radio chassis. Oftentimes you can locate a part on a pictorial diagram more quickly by noting the tube socket terminal to which the part is connected on the circuit diagram, then locating that same terminal on the pictorial diagram and tracing the wiring from that terminal until you come to the desired part.

Use of Circuit Diagrams in Servicing an Improperly Operating Receiver. The same diagrams which are used in servicing a dead receiver are made use of in servicing an improperly operating receiver. For example, if an observation of the receiver performance and a study of its circuit diagram lead you to believe that certain parts in a definite stage can logically be suspected, the tube layout diagram will enable you to identify the position of the tube belonging to that stage. The circuit diagram will give valuable clues as to where to find the suspected part, for the diagram will indicate other parts which are connected directly to it and which may be more readily identified. If the pictorial layout diagram is available, it of course provides an easier way for locating the suspected part. If you suspect that a certain condenser is open, you can test it by shunting it with a good condenser while the set is in operation; if the original trouble was a squeal, and this stops when the good condenser is tried, you know that the original condenser should be replaced.

The circuit diagram is again brought into use in the final step, the replacement of the defective part. In the case of resistors and condensers the diagram gives you the correct electrical value of the part in question. There is no need to get an exact duplicate resistor or condenser from the receiver manufacturer if you can secure from your local radio distributor a part having the correct electrical value. You must, of course, get a resistor with the same or higher wattage rating, and for a condenser the voltage rating should be the same as that for the original part or higher, but these ratings can easily be estimated once you master circuit theory.

Appraising Receiver Performance by Means of Diagrams. A quick survey of a circuit diagram will give you sufficient information to appraise the performance of a radio receiver. This appraisal will tell you whether you can expect good distant reception or whether the set is intended only for local and semi-distant reception; it will also tell you what to expect in the way of fidelity and selectivity. Customers sometimes demand receiver performance far beyond the original intentions of the set designer; you should know when a receiver is performing as well as can be expected of it, and this ability to appraise receiver performance by means of a circuit diagram will come to you almost automatically as you progress with your Course.

Use of Diagrams in Aligning Receivers. A circuit diagram reveals the various circuits which must be adjusted during a receiver alignment or tune-up procedure. With this information, the Radiotrician can generally locate the various adjustments on the chassis and carry out the alignment. Sometimes the locations of the adjusting screws are indicated on the tube or pictorial diagram.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

How To Service A Radio Which Distorts

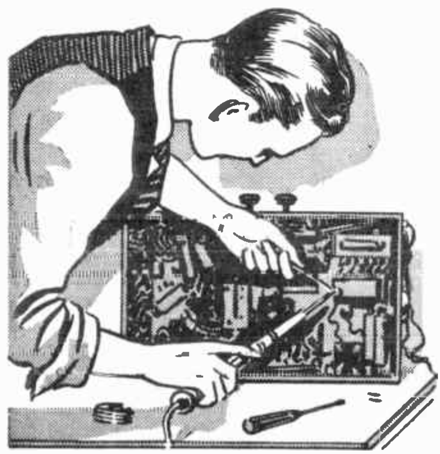
NO RECEIVER has been made which is free from distortion. Up to 5% distortion is considered acceptable by receiver designers, and even 10% distortion cannot readily be recognized by the average radio listener. It is distortion way in excess of this maximum acceptable value which brings a call for a serviceman; the distortion has then reached the point where programs sound raspy, garbled, or even unintelligible. This distortion is due to a defect in a tube or part rather than to the limitations of receiver design.

Possible Causes of Distortion. There are a number of loudspeaker defects which can cause distortion; these include lack of field excitation, weak magnetic field, an off-center voice coil which is rubbing against the pole pieces, loose voice coil wires, warped or torn cones, soft or hard cones and iron particles or dirt in the air gap around the voice coil. In each case the defect prevents the voice coil and cone from following faithfully the variations in the sound signal, with the result that the reproduced sound wave has a different wave form from that of the sound signal.

Another very common cause of distortion is overloading of a tube when the receiver is tuned to a strong local station (making the tube handle more R.F., I.F. or A.F. signal current than it was originally designed to take). If the distortion occurs only when the volume control is advanced, the defect is in a stage following the volume control; if the distortion occurs on a local station even at the minimum setting of the volume control, the overloading is in a stage ahead of the volume control.

Weak or gassy tubes are also common causes of distortion. A tube with weak emission no longer has a linear grid voltage-plate current characteristic, with the result that a sine wave signal fed into the stage will come out distorted. A gassy tube can upset the operating voltages in any stage having a resistor in its grid circuit, moving the operating region off from the linear portion of the characteristic curve and thus causing distortion.

By far the most common cause of distortion, however, is an improper D.C. operating voltage on an electrode in an R.F., I.F., detector or A.F. stage. For example, too low or too high a plate voltage on a tube can change the linear *Eg-Ip* characteristic to a curved characteristic; a low or high screen grid voltage can do the same thing. An improper C bias voltage may move the operating region from a linear to a curved part of the characteristic curve, causing ditortion.



Once you locate the cause of distortion in a receiver, the job can be completed in a jiffy by unsoldering the leads of the defective part, putting a new part in its place, and soldering the joints for the new part.

Checking of the D.C. operating voltages therefore assumes an important position in the procedure for servicing receivers which distort. When an improper voltage is found, a logical process of reasoning tells you what circuit defects could cause the incorrect voltage. For example, the main D.C. supply voltage could be lowered by a leaky power pack filter condenser.

Although it is customary to connect screen grid and plate by-pass condensers to the chassis, in some receivers they may be connected to the cathode instead. If one of these by-pass condensers should become leaky, in the case of a cathode connection, it will "bleed" current through the cathode-to-chassis C bias resistor, driving the control grid of the tube more negative than normal and moving the operating region of the tube to a non-linear portion of the characteristic curve; distortion is the result. A leaky coupling condenser or an open grid resistor in an audio stage having resistance-capacitance coupling to its input can also change the C bias voltage enough to cause distortion.

When servicing a receiver for distortion, study of the circuit diagram will reveal many possible causes for the observed trouble if you will ask yourself this simple question: "Which parts could, if defective, cause wave form distortion when a sine wave signal by itself is passing through the audio stages, or when a sine wave signal modulated on a carrier is passing through the R.F. and I.F. stages and the detector?"

Distortion Test For Loudspeakers. To determine whether or not distortion is originating in the loudspeaker, connect your phone test unit across the primary of the output transformer (to the input terminals of the loudspeaker if no output transformer is present). Tune the receiver to a station and adjust the potentiometer for normal volume in the phone. If distortion is less in the phone than in the loudspeaker, or if there is no distortion at all in the phone, the defect is in the loudspeaker.

Systematic Service Technique. If the loudspeaker test indicates that distortion is in a receiver stage, test all tubes; some servicemen prefer to test tubes even before making the loudspeaker test. After this, measure the voltage which is applied to the plate-cathode of the power output tube. In A.C. receivers the plate voltage on this last tube should be about 250 volts, in universal A.C.-D.C. receivers it should be about 80 volts, in auto radio receivers about 200 volts, and in battery receivers it should approach the maximum B battery voltage. If the voltage is below normal, look for a power supply defect.

Next in order is a defective stage isolation procedure for the audio amplifier system. Starting at the output stage and working toward the second detector, connect your phone test unit to the plate and chassis of each single-tube stage in turn (to the two plates in the case of a two-tube output stage) and listen for distortion while a signal is coming through the receiver. The defective stage will be between the points where you hear and do not hear the distortion. This stage should then be carefully analyzed. Check each electrode supply voltage, then study the circuit for the stage to determine what part could, if defective, cause the distortion. If the stage employs a grid resistor, be sure to test for a gassy tube and a leaky coupling condenser in the input to the stage. These two tests can be made with a high-resistance voltmeter. A simple vacuum tube voltmeter will serve just as well; use its d.c. voltmeter section, starting with the highest voltage range and switching to lower voltage ranges if you can safely do so. You will find these tests quite easy to make.

To check for a gassy tube, connect the test clips of the vacuum tube voltmeter across the grid resistor terminals, then turn

FIG. 2. Loudspeaker servicing accessories. A—Radio repair cement for cementing speaker cones, with can of thinner which can be used for loosening cemented wires and removing dust caps from cones. B—Cone cement in handy metal tube. C—Celluloid shims for re-centering voice coils, in convenient carrying case. There are four shims in each thickness: .005", .0075", .010" and .0125".

on the set. If the vacuum tube voltmeter indicates a d.c. voltage when this is done, you know that the tube in the stage is gassy or the coupling condenser is leaky. Pull out the tube; if the meter reading returns to zero, the tube is gassy; if the meter reading is unchanged, the coupling condenser is leaky.

If the audio system is found to be in good order, the next step is a defective stage isolation procedure for the R.F. and I.F. stages. No one technique is universally used for this purpose; some servicemen prefer to use a special test I.F. and R.F. amplifier which can be tuned from about 100 kc. to 1,700 kc., making it serve the same purpose as the phone-potentiometer unit which you used in the audio system. This special amplifier may contain two stages of I.F. amplification followed by a detector which feeds into a phone unit. The input of the test amplifier is connected in turn to the plate and chassis, and then to the grid and chassis of each I.F. and R.F. stage in turn, starting at the second detector and working back to the antenna terminal; for each connection the test amplifier is tuned to the frequency of the signal reaching it. The defective stage will be between the points at which distortion is and is not heard. This special test instrument is quite costly in commercial form, and cannot readily be constructed in the average radio shop; for these reasons I do not recommend its use by a beginner.

The procedure which is favored by most servicemen is that involving a check of the electrode voltages for each tube in the R.F. amplifier system, the I.F. amplifier system, and the second detector. The measured voltages are checked against the values specified in the service manual when this information is available, and in other cases they are compared with the expected voltage values for the various stages; when an improper voltage is found, the circuit diagram is studied to determine which parts should be suspected. A vacuum tube voltmeter can be used to check for gassy tubes in stages having a resistor in the grid return circuit.

How To Re-Center A Loudspeaker Voice Coil

Practically all of the loudspeaker defects which cause distortion will be obvious to you as you learn more about loudspeakers from your regular Course and as you acquire practical experience with different types of loudspeakers. Troubles which can occur in dynamic or moving-coil loudspeakers will now be considered, along with the causes and the remedies; re-centering of the voice coil is a part of the remedy in practically every case.

1. A rattling sound will occur if one of the screws which holds the spider becomes loose. Tighten the screw.

2. Chattering or rattling will occur if: *a*, the seam in the paper cone opens; *b*, one of the spokes in the spider breaks; *c*, the edges of the cone break away from the rim of the loudspeaker, or become loose; *d*, the voice coil leads break away from the cone. It is sometimes possible to re-cement a seam on the cone, to re-cement the cone to the metal rim, or to re-cement the voice coil wires to the cone by using a special loudspeaker cement like that shown at *A* and *B* in Fig. *2*, but there will be cases where replacement of the entire cone is necessary. A broken spider or a tear along the edge of the cone cannot very well be repaired, so replacement is necessary. Replacement cones can be secured from radio supply houses or directly from the manufacturer of the receiver; always give the model number and make of the receiver, the diameter of the rim of the loudspeaker, and any other available information pertaining to the loudspeaker, when ordering a new cone.

3. A scraping, raspy sound which is accompanied by distortion of bass notes and which is especially noticeable on voice programs may be due to a warped voice coil or spider, an off-center voice coil, or iron particles or dirt in the air gap surrounding the voice coil. All these defects cause the voice coil to rub against the pole pieces. If the voice coil or spider is badly warped, replace the entire cone-voice coil-spider assembly. To get dirt out of the air gap, remove the entire cone assembly, and either blow the dirt out or remove it with a pipe cleaner which has been coated with a little vaseline so particles will stick to it. Wipe out all vaseline when you have finished.

4. Distortion and absence of bass notes, accompanied by sizzling or buzzing sounds, may indicate loose wires on the voice coil. It may be possible to re-cement the wires, but it is better to replace the entire cone assembly.

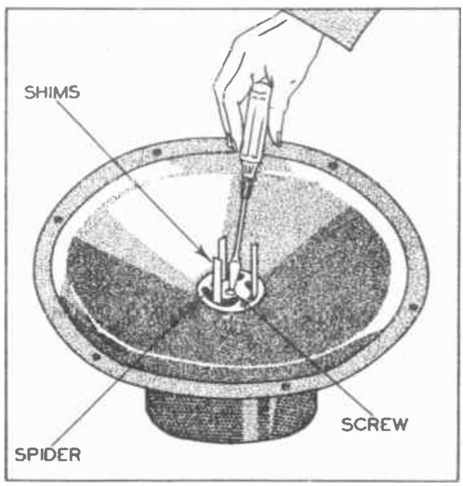


FIG. 3. Re-centering a loudspeaker voice coil with the aid of celluloid shims.

5. A pronounced bassy output (a lack of high frequency notes) will occur if the paper cone becomes soft and loses its stiffness. Replace the cone assembly.

6. Rattling, with absence of high frequency notes will occur if the paper in the cone

becomes hard. The entire cone system should be replaced. When a cone has been in use for over five years, softening or hardening should be suspected.

7. Some cones are surrounded by a soft leather ring which is attached to the rim of the loudspeaker; this leather ring may dry out and harden, producing a buzzy sound accompanied by poor bass response, for the cone will be unable to move the distance required for faithful reproduction of bass notes. If the leather ring is badly cracked or torn, replace the cone assembly; if it is merely stiff, try softening the leather by applying mineral oil or Neatsfoot oil (a leather softener).

How to Re-Center the Voice Coil. Loudspeakers may have either an internal or an external spider, as you will learn in your regular Course. The procedure for the re-centering in the case of an internal spider is shown in Fig. *3;* the single screw in the center of the spider is loosened, flexible celluloid shims are inserted through the slots in the spider to center the voice coil, the screw is tightened, and the shims are removed. Sometimes the voice coil will center itself when the screw is loosened, eliminating the need for shims.

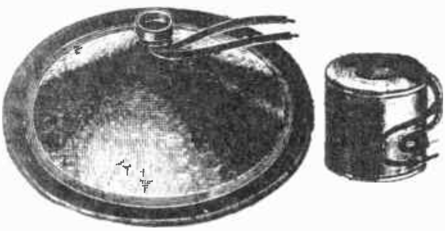


FIG. 4. Left—typical replacement cone. Note that the voice coil is attached to the center of the cone. The voice coil leads emerge from the cone end of the coil, and are fastened to the cone with cement so no strain is placed on the delicate coil wires. Right—typical replacement loudspeaker field coil.

Servicemen generally prefer flexible celluloid loudspeaker shims like those shown in Fig. *2C,* but you can cut suitable shims yourself from stiff paper for temporary use. The shims used on any one voice coil should all be the same thickness, and just thick enough to go in snugly without forcing. After you have re-centered the voice coil, test for rubbing by moving the cone carefully in and out with your fingers, being sure that you do not push it to one side during this test.

Loudspeakers having an external spider around the voice coil are centered in much the same manner, except that there will usually be two or three screws holding the spider in place. Loosen the screws, then tighten them again, for often the voice coil will automatically re-center itself when this is done. If this fails, insert shims between the voice coil and the central core in the manner just described. If a dust cap covers the inside of the voice coil, remove it, and cement in position again after the job is done.

Replacing the Cone Assembly. When the cone system of a loudspeaker is to be replaced or is to be removed in order to clean out the air gap, the following procedure is recommended; first of all, unsolder the two flexible leads which go to the cone. Slip a knife under the cardboard ring which is cemented to the front edges of the cone, and run the knife around the entire rim so this cardboard ring can be removed and saved for use with the new cone. Now slip the knife under the back edge of the cone, to free it from the steel rim. Remove the spider screws, and the entire cone-voice coil-spider assembly will come out.

When installing the new cone assembly, like that shown in Fig. *4,* rotate it so that the voice coil leads are near the terminals to which they connect. At the same time, the holes in the rim of the cone should line up with the holes in the steel rim of the loudspeaker.

Sometimes the cone which is supplied you as a replacement will be longer than the original cone, and one or more cardboard rings will be supplied with the cone. Cement these rings to the steel rim of the loudspeaker, then place the cone in position, center the voice coil with shims, tighten the spider screws, cement the edges of the cone to the spacer rings, and cement the original cardboard outer ring to the front of the cone.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

How Improperly Operating Receivers are Serviced

WHEN you are confronted with a receiver which plays but gives unsatisfactory performance, your ability to analyze the situation and reason out the proper approach to the problem is of great importance. You are looking for a defective tube, a defective part, a poor connection, or a change in an adjusting condenser, and everything you do must lead you closer to the defect which is causing the trouble. Sometimes it will be possible to go directly to the defect, while at other times you may be able to locate the defect by a logical process of elimination supplemented by a few simple tests. In the majority of cases, you will first determine which section of the receiver contains the defect; next you will locate the defective part or connection. This job sheet will give you the professional technique for servicing improperly operating receivers when the only test instruments available are a signal generator, a multimeter, a tube checker, and a phone with potentiometer control.

Obvious Indications. In servicing an improperly operating receiver, what you hear and what you see while the receiver is in operation may be a direct clue to the defect, eliminating the need for stage and circuit-isolating procedures. A few examples will illustrate what I mean. If a radio program as reproduced by the loudspeaker seems to be distorted, with the distortion most noticeable when a man is speaking, and occasionally a br-r-r-ing sound, you can immediately concentrate upon the loudspeaker, for the voice coil will very likely be rubbing against the pole pieces. You can check for this by shutting off the receiver power and pushing the outer edges of the cone in carefully and uniformly with your fingers; if you can feel the voice coil rubbing when this is done, there is no need to go any farther. You have located the trouble.

If hum is heard along with a program, and a glance at the chassis reveals a blue glow between the electrodes of the rectifier tube (not on the glass), a gassy tube has been located. From your knowledge of radio circuits, you know that this condition in the rectifier tube can be caused by a defect in the filter system, so before inserting a new rectifier tube you would check all parts in the filter system, especially the filter condensers.

There are two important reasons for listening carefully to the customer's complaint: 1, because the customer often gives valuable clues to the location of the defect; 2, to find out exactly what the customer expects you to do.

Indirect Indications. It is only rarely that the observed effects in an improperly operating receiver are a direct clue to the defect; in the majority of cases you will have to figure out what the probable causes can be, then check those parts which are logical suspects. For example, if you hear distortion, you should immediately think of the various causes for distortion in a receiver. First of all, improper electrode voltages on any tube could produce distortion. Immediately you think of the main power pack in the receiver, which provides all electrode voltages, and you check its output voltage. Next in your list of suspects should be improper C bias for some tube; you ask yourself, "How can the C bias be changed from its normal value?," then resort to basic circuit theory to answer this question and secure new suspects.

Suppose that you are dealing with an audio amplifier circuit like that shown in Fig. *1;* in this circuit the flow of plate current through resistor *Rc* produces a voltage drop which is applied to the grid through *Rg* to serve as the normal C bias. If condenser *Cc* becomes totally conductive, it will short out the voltage across *Rc* and thereby bring the C bias to zero, causing distortion on high-level signals.

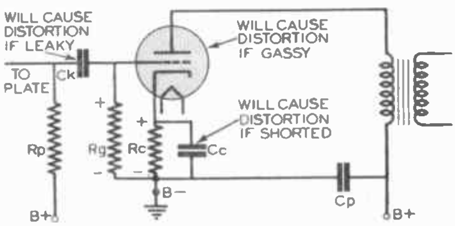


FIG. 1. Typical audio amplifier stage; several different defects in it which can cause distortion are indicated.

Leakage in coupling condenser *Ck* may also cause distortion. Under this condition, the D.C. plate voltage on the preceding tube will send direct current through *Ck* and *Rg* to ground, making the grid end of *Rg* positive with respect to the chassis as indicated in Fig. *1.* This positive voltage offsets the normal negative C bias on the grid, causing the tube to operate with a positive grid bias. As a result, grid current will flow and distortion will occur. A gassy tube will also allow grid current to flow, causing distortion. Once a circuit analysis like this is made, simple tests of the suspected parts should reveal the defect.

As another example, let us suppose that the customer complains of a squeal when tuning to any station. Certain above-the-chassis surface defects should immediately come to mind; a tube shield may be missing or out of position, or a connection to the top cap of an I.F. tube may be defective in some way. These surface defects can be quickly checked and eliminated.

If the complaint is squealing but no surface defect can be located, you would look for a circuit defect. A very common cause of squealing is a defective screen grid by-pass condenser in a screen grid or pentode I.F. amplifier circuit like that in Fig. *2.* In your Fundamental Course you learn that the screen grid is placed between the control grid and the plate of a tube to provide a path to ground for feedback currents which would otherwise travel from the plate to the control grid and cause oscillation. The screen grid must be fed with a positive D.C. voltage; this is usually applied by means of a voltage divider like *R1-R2* in Fig. *2,* and condenser *C6* is placed across *R1* to place the screen grid essentially at ground potential for the R.F. feedback signals. If condenser *C6* opens, the screen grid no longer provides a low-reactance path to ground for feedback currents, and oscillation occurs in the stage; the oscillation signal combines with the incoming radio signal to produce a beat note which is heard as a squeal when the receiver is tuned to a station. If the squeal stops when condenser *C6* is shunted with a good condenser, we know that the condenser is defective and should be replaced.

One more example—if a receiver blasts and distorts on local programs, and has an A.V.C.-controlled I.F. circuit like that shown in Fig. *2,* we immediately suspect that the A.V.C. control for this stage is ineffective. The stage cannot reduce its gain automatically as the strength of the incoming signal increases, with the result that the amplifier and possibly also the demodulator are overloaded, causing distortion and blasting. With a thorough knowledge of circuit theory, you can look at the circuit in Fig. *2* and reason out that this condition could be caused by a shorting of condenser *C5.*

Importance of Fundamental Training. The ability to reason from an observed effect to possible causes is highly essential in the servicing of improperly operating radio receivers. As you have just seen, this effect-to-cause reasoning is based upon a complete knowledge of radio theory, of how circuits work, and of the purpose of each and every part in the circuit. With this training and with a certain amount of actual experience you will soon find yourself able to associate observed effects with one or more causes. However, when studying your regular Course, do not attempt to memorize that an open screen grid by-pass condenser can cause oscillation or that a leaky coupling condenser can cause distortion; try to learn *why* these and other defects can cause certain observable symptoms.

I also want to point out at this time that you are just beginning to learn the professional radio servicing technique and that you still have a great deal of fundamental circuit theory to study in your regular Course; for this reason I suggest you refer frequently to the reference text book you now have, "Radio Receiver Troubles, Their Cause and Remedy," when practicing the servicing of improperly operating receivers. This book lists a great many possible causes for the usual trouble symptoms. When you have completed your Course and acquired a certain amount of experience in your own home in the manner recommended in a later job sheet, you will find that the material in this reference book is no longer necessary.

Defective Stage Isolation. You can readily see that the defects discussed in connection with Figs. *1* and *2* could exist in any one of a number of different stages in a radio receiver. It is highly desirable that the defect be isolated to a particular stage; unfortunately, there is no simple procedure for isolating the defective stage in an improperly operating receiver. Each symptom calls for a more or less different procedure. Although these procedures will be considered in detail in later job sheets and in your regular Course, I will briefly review the procedures here for three common symptoms: hum, noise, and weak signals.

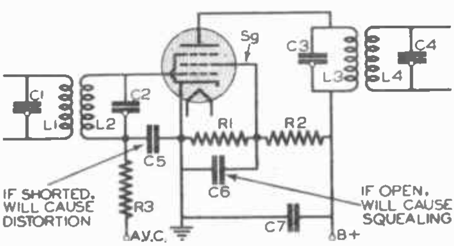


FIG. 2. Typical I.F. amplifier stage.

Hum. To isolate the defective section or stage when the complaint is hum, remove the output tube or tubes temporarily and listen for the hum. If it is heard now, it is originating in the loudspeaker or in the power pack filter; the hum-bucking system in the loudspeaker may be defective, but more than likely the input filter condenser or some other part in the power pack filter system is defective. If removal of the output tube stops the hum, replace the tube and remove the tube from the preceding stage. If this does not stop the hum, it is very likely originating in the output stage. Continue pulling out and replacing tubes, one stage at a time, working toward the antenna input circuit until you reach a tube which, when pulled out, has no effect upon the hum; you have then isolated the defect to the stage following that from which the tube is removed. You can now refer to the circuit diagram, study the circuit for that stage, and reason out what defects in that stage could possibly cause hum. (Instead of pulling out a tube, you can short its control grid to the chassis; this is an equally effective procedure for preventing the hum signal from passing through that stage.)

Noise. The procedure for isolating a stage which is causing noise is much the same as that for hum, except that you definitely must pull tubes in this case. Noise is caused by a poor connection in a part, by a poor soldered joint, or by a make-and-break shorting connection. If noise originates in a signal circuit, it will be relayed through the receiver stages which follow the defect; if noise originates in a part or connection which is carrying direct current, it will cause changes in the main power supply and these in turn will react upon all stages. Pull out one tube at a time and then replace it, starting at the receiver input and progressing to the loudspeaker. You have located the defective stage when you come to a tube which, when pulled out, will stop the noise. If no tube will stop the noise, it is undoubtedly originating in the power pack. Having located the defective stage, you can then check each connection and each part by wiggling it with a stick of wood while the set is turned on; if the noise increases or stops when a particular part of lead is moved in this manner, you have located the defect.

Weak Signals. Any complaints that signals are too weak to give the desired loudspeaker volume require a special stage-isolating technique. Keep in mind that careful observance of the symptoms, particularly as they are described by the customer and reasoning out of the probable defective section or part comes ahead of any test procedure.

If local stations are heard satisfactorily but favorite distant stations are weaker than normal or cannot be heard at all, you would look for a defect in the R.F. system. It may be a poor antenna (in which case a hissing noise will accompany distant programs) or a defect in an R.F. stage. This trouble may also be due to improper alignment; you can check this very easily by varying the settings of the alignment adjustments while the set is tuned to a weak station, to see if a change in setting will increase the signal intensity; if these changes give no improvement, restore the original settings and look for an R.F. or I.F. circuit defect.

To locate the defective stage, connect the signal generator to the input of each stage in turn, starting at the second detector and working back to the antenna terminal. Use a 100,000 ohm resistor in series with one signal generator lead to prevent detuning of the stage to which the connection is made. As you progress toward the receiver input, the tone heard in the loudspeaker should increase in volume, making it necessary to reduce the signal generator output level in order to maintain a constant tone level. If, while doing this, you pass through a stage which does not give this increase in loudness or even gives a decrease in loudness, you have passed through the defective stage.

On the other hand, if favorite distant stations are weaker than normal but all of them can still be picked up along with locals, you would naturally assume that the R.F. system was working and that the defect was in the audio system. If the receiver has automatic volume control, you know immediately that the manual volume control will be in the input of the audio system, and can make a simple test to determine whether the volume control circuit is at fault. If the volume of a program changes when this manual volume control is adjusted, you know definitely that the trouble is in the audio system proper; if the setting of the volume control has no effect upon the volume, you can be pretty sure that the trouble is in the volume control circuit itself.

If an audio system defect is indicated, you can check the system by tuning in a local station and connecting your phone test unit to the plate and chassis of each stage in turn, working from the second detector toward the loudspeaker. Failure to hear a louder signal in the phone each time you advance one stage indicates that you are passing through the defective stage.

The General Technique. The primary purpose of this job sheet is to indicate that there is a clearly defined procedure for isolating the defect in any receiver which plays unsatisfactorily. I do not expect you to apply the professional servicing technique to an improperly operating receiver until you have mastered the fundamentals of radio circuit operation as presented in your regular Course, for the specific techniques required for each type of complaint require considerable reasoning which is based upon this knowledge. The techniques will be presented in detail later, but we can summarize the general procedure for an improperly operating receiver as follows:

1. Listen carefully to the customer's complaint, then verify it by trying out the receiver yourself and observing the defects or troubles very carefully. Tune in a number of local and distant stations and adjust each receiver control; very often this will reveal to you an effect which was completely overlooked by the customer and which nevertheless is a direct or indirect indication of the nature of the defect. With a clear understanding of the customer's complaint and the actual condition of the receiver, you will be better able to satisfy the customer.

2. Consider all of the observed effects carefully to see if any of them will lead you immediately to the defective section or part.

3. Check for surface defects, making sure that the antenna and ground systems are intact and are properly connected to the receiver, that all tubes are in place, that all tube shields are in place, and that there are no misplaced top cap connections.

4. Test each tube carefully with a tube checker, not merely for the good-bad indication, but also for leaks and for shorts between elements of the tube.

5. Reason from the observed effects to the most likely causes, utilizing your knowledge of radio fundamentals and radio circuits. Refer to the circuit diagram while doing this, and use the diagram also to help you locate on the chassis any parts which might cause the observed trouble.

6. Carry out the correct defective stage isolation procedure for the effects observed, in order to limit the defect to a smaller portion of the receiver.

7. Check the output voltage of the power pack and the D.C. electrode voltages in the defective stage or section; this is especially important when distortion is present.

8. Test the parts in the defective stage, starting with those which are the most likely offenders.

9. Replace the defective part or repair the defective connection.

How to Service a Receiver Which Hums

ANY receiver which operates from an A.C. source will have a certain amount of hum current in the output of the receiver. Complete elimination of this hum current is not possible nor is it necessary, for in a normal radio receiver in good condition, the hum will hardly be noticeable even when the receiver is tuned between stations. If you will listen carefully, you can hear this hum on practically any receiver. By listening for this hum in a number of new receivers, you will become familiar with the amount of hum which is considered acceptable to the average radio listener, and you will realize that there is no need to waste time in trying to eliminate hum which normally would be unnoticed by a listener.

Hum is always more pronounced when the radio chassis is in its cabinet, for the cabinet serves to improve the response to low frequency notes. Each time you work on a receiver, listen carefully for the amount of hum when the chassis is still in the cabinet and when the chassis is out of the cabinet: in this way you will learn to determine how loud the hum can be in the chassis alone without making it annoying to the customer when the chassis is returned to the cabinet.

Three Types of Hum. When the hum in a receiver increases to the point where it becomes annoying to the set owner, the customer will call in a serviceman and ask him to "get out that hum." Actually, however, there are three different forms of hum, with a different servicing procedure for each.

1. Hum Due to Mechanical Vibration. When a hum is heard but it does not come out of the loudspeaker, you can be sure that some part on the receiver is vibrating. To check this, place your fingers on the voice coil or cone to prevent it from moving; you should still hear the hum, but will not be able to feel it with your fingers. By listening carefully to various parts, you should be able to locate the one which is vibrating. The procedure for eliminating this vibration was covered in a previous job sheet, and simply involves tightening the part in question so it cannot vibrate.

2. Tunable Hum. This type of hum is heard only when a station is tuned in. If the hum is heard only on one station, it is more than likely originating in the station transmitter. The trouble will undoubtedly be corrected in a few days by the station operator. You can check for this by tuning in the station on other receivers; the same hum should be heard on each set. Tunable hum which is heard on all local stations, however, is due to a receiver defect; the ripple voltages in the power pack are getting into the R.F. system and modulating the carrier of the station which is tuned in. The trouble may be due to inadequate power pack filtering, to misplaced grid wires, to ineffective shields of tubes which are located near power transformers or iron core choke coils, to a direct electrostatic pickup of ripple voltages by the grid leads of R.F. tubes, or to a cathode-to-heater short or leak in an R.F. tube.

3. General Hum. When hum is heard from the loudspeaker at all times, regardless of the setting of the receiver tuning dial, it is definitely originating in the receiver. If the intensity of the hum varies with the manual volume control setting in an A.V.C.-controlled receiver, the hum is probably originating in the second detector circuit. If the volume control has no effect upon the hum, it is originating somewhere in the audio system or in the loudspeaker; it may be due to a defective tube, to a circuit filter system defect, or to a power pack defect.

Common Causes of Hum. In the majority of cases, hum in a receiver is due to one of two common causes: 1, a defective tube; 2, a defect in the power pack. The wise serviceman usually checks these two causes before even attempting to isolate the trouble to a particular section or stage.

When hum is the complaint, your first step can well be a check of all tubes with a good tube checker. Allow each tube to warm up for a minute or so, then check for leakage between the cathode and the filament, for this leakage can allow A.C. voltages in the filament circuit to get into the signal circuit and produce hum. At the same time, check each tube for emission in the usual manner; the indicating meter on the tube checker will indicate whether the tube is good or bad. A bad tube, having low emission, can cause hum trouble. Be sure to make a thorough test of the full-wave rectifier tube; both diodes of this tube should show about equal emission, for the average filter system in a receiver loses its effectiveness when the rectifier diodes become unbalanced.

The power pack filter system should be checked next, for any defect here can relay the hum voltages to any of the stages in the receiver or directly to the loudspeaker, producing either tunable hum or ordinary hum. Locate the power pack filter condensers, and while the receiver is in operation, shunt each one of them in turn with an 8 mfd., 500-volt electrolytic condenser. Be sure that you connect this test condenser with the proper polarity (its red or plus lead should go to the positive terminal of the condenser being tested). If the hum stops or is greatly reduced when a condenser is shunted in this manner, that condenser has either opened up or has lost its capacity, and should be replaced. This shunting procedure will not test for leakage, however; to do this you must unsolder one lead of the electrolytic condenser in the receiver and then measure its resistance with an ohmmeter. Take two readings, reversing the ohmmeter probe for one; if the higher reading is below 50,000 ohms, the condenser is leaky and should be replaced. Some servicemen prefer this simple test for leakage: allow the receiver to heat up for a few minutes, then feel the sides of each electrolytic condenser; if any are warm, they should be unsoldered and checked for leakage with an ohmmeter. Condensers which remain cool have negligible leakage, and need not be checked.

When checking the power pack, be on the lookout for tuned chokes in the filter system. A small-size condenser (about .1 mfd.) shunting a choke coil, or a 1 to 2 mfd. condenser connected to a mid-tap on a choke coil, indicates that a tuned circuit is being used to filter the output current of the rectifier tube. The air gap in the core of the choke coil may have changed, causing the resonant frequency of the filter circuit to change. Try different condensers which are rated at about the same value as that used, in order to locate one which will be sufficiently different in capacity to retune the circuit to the hum frequency and thereby eliminate the hum trouble.

If the preceding checkup of tubes and the power pack filter system fails to reduce the hum sufficiently, the next step is a systematic procedure for isolating the defective stage. It is well to start this by shorting the primary terminals of the loudspeaker input transformer; this prevents any hum voltages from reaching the loudspeaker through this transformer. If hum is heard when this is done, you know that it is either getting into the loudspeaker through the field coil leads (in which case you would look for a defect in the filter system associated with the loudspeaker field coil or for a defect in the loudspeaker field supply if that is separate from the receiver supply) or hum is getting into the loudspeaker by magnetic induction from some nearby part. Remove the short after this test has been made. If the loudspeaker has a hum-bucking coil (a small coil mounted on the central core of the loudspeaker and connected in series with the voice coil), and you suspect that some one may have reversed the connections to this coil. try reversing these connections temporarily. Use whichever connection gives the least hum.

If the preceding tests fail to locate the trouble, you can be pretty sure that the hum is originating in one of the stages of the receiver. If the chassis is still in its cabinet, you can isolate this stage by pulling out the

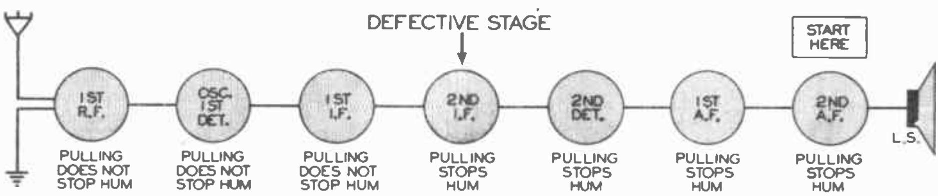


FIG. 1. Example illustrating the professional procedure for isolating the defective stage in an improperly operating receiver when hum is the complaint.

tubes one at a time, working from the output stage to the R.F. input stage, as described in the previous job sheet, and as illustrated in Fig. *1* in this job sheet. If the chassis is on your work bench, it may be easier to short the grid of each tube in turn. In either procedure, when you come to a stage which, even though placed out of action, allows the hum to exist, you know that the trouble is in the following stage. Check tween the tube and the power pack, allowing this metal to touch the chassis; if this reduces or eliminates the hum, try another tube; if this fails, install a shield.

Quite often, tunable hum is due to R.F. current in the power line; it may be produced there by a faulty power line connection which causes rectification and modulation of the A.C. current on the R.F. This

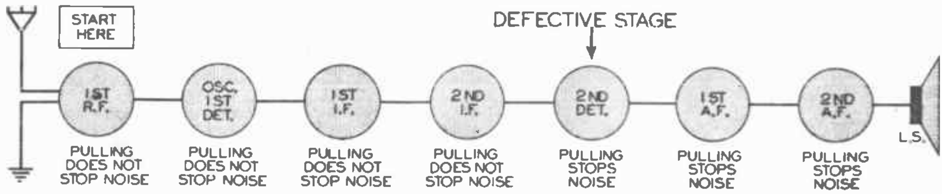


FIG. 2. Example illustrating the professional procedure for isolating the defective stage in an improperly operating receiver when noise is the complaint.

the by-pass condensers in that stage first of all by shunting each in turn with a good condenser of the correct size. Try moving the grid lead away from tube filament leads, to see if this will reduce or eliminate the hum. Check for open grid circuits, as a tube having a "floating" or open grid is very susceptible to hum pickup.

If the receiver in question is an older model having a grid leak-condenser detector, try placing a metal shield around this tube if you have traced the trouble to this stage. These tubes are easily affected by the hum field set up by power transformers and choke coils. For a preliminary test, you can simply place a sheet of metal be-

hum-modulated R.F. current enters the receiver through its power cord, and causes tunable hum when it gets into the R.F. stages.

This trouble is chiefly encountered in locations where power lines are on poles rather than underground.

Try this when you encounter tunable hum: Reverse the receiver power plug in its outlet to see if this will eliminate the hum; if it has no effect, connect two .05 mfd., 600-volt condensers in series between the two power line leads, and ground the common terminal of these condensers. If hum is getting in through the power line, these condensers will by-pass it to ground.

How to Service a Receiver Which is Noisy

As you already know, noise in a receiver may be due to a make-and-break connection which intermittently causes a circuit to open or a part to become shorted. The defect may exist in a tube, inside a part, or in an exposed connection. The slightest jarring of the receiver causes the connection to make and break, with the result that we hear noise. This defect can occur in any section of the receiver, as well as in the antenna system. Fortunately, the noise will be most severe when the defective part itself is jarred; this simplifies locating the trouble.

When you are called in to service a noisy radio receiver, make sure that the noise in question is actually receiver noise and not atmospheric noise (static) or man-made interference. Check the antenna system next by shaking the antenna and ground leads. If this does not increase the noise, remove the leads and short the antenna and ground terminals of the receiver; if the noise is still heard, you know that it was not coming in over the antenna system. Now insert a line filter in the receiver power cord; if the noise is still heard now, you are sure that it is internal noise. If a line filter stops the noise, however, you know that it is coming in over the power line. As soon as you have serviced a few noisy receivers, you will find yourself able to detect internal noise almost immediately without making all these checks, simply by slapping the chassis; if noise results, the chassis has a defect.

Before removing the chassis from its cabinet, be sure that there are no surface defects. Carefully examine the chassis for loose parts, wiggling them to see if any one will pro-

-duce noise. See that all tube shields are in place and that top cap connections make firm contact with tube caps but not with shields. Tap each tube to see if any one has loose internal connections which may be causing the noise. Inspect the loudspeaker connections, for if the defect is here there will be no need to remove the chassis. Make this inspection while the receiver is turned on, using a wood stick or bakelite rod to move the wires and jar suspected parts.

Quite often this preliminary checking of a noisy receiver is not necessary. For example, if the noise occurs only when the volume control is adjusted, you know that the volume control potentiometer is defective and should be replaced. The same is true of a noisy tone control. If the noise occurs when the wave band change switch is wiggled, you know that there is a defect in the switch. If noise occurs only when you are rotating the tuning dial, you suspect immediately that the rotor and stator plates of the variable tuning condenser are touching or that there is poor contact between the rotor and the condenser frame. One of the rules of professional servicing is to try first of all to make the effect reveal the defect to you directly or after simple tests.

If the foregoing tests do not locate the defect, take the chassis out of the cabinet. Now make an inspection for surface defects, moving each part and wire with your insulated rod while the receiver is turned on; in the majority of cases, this simple procedure will locate the defect. Give special attention to the power pack system; wiggle all parts in it, including chokes, filter condensers, voltage dividers, power transformers, fuses, etc. Do not be afraid to apply pressure to transformers and chokes when doing this.

The tube-pulling procedure for isolating the defective stage comes next. Proceed to pull out tubes one at a time, starting at the receiver input and working toward the loudspeaker as indicated in Fig. 2. The first stage which stops the noise is the defective stage. Once the defective stage has been isolated, try shorting its grid to the chassis after you have replaced the tube. If the noise is in the input of this stage, this test will very likely stop the noise; if this grid-shorting test has no effect on the noise, the trouble is very likely in an electrode supply circuit. Measure the D.C. plate and screen grid voltages; if either one fluctuates each time the noise exists, you have located the defective circuit.

Having found the defective stage or the defective circuit, push each lead and part in it vigorously. Shielded parts having internal connections should be tapped and jarred in an attempt to open a concealed connection. If you prefer, you can turn the receiver off and connect an ohmmeter across each part or connection in turn while moving the part, noting whether any change in the ohmmeter reading occurs. It will be best to use alligator clips on your test probes while doing this, so you will have your hands free to move the part. This procedure should reveal the defective part or connection.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

How To Align An All-Wave Superheterodyne

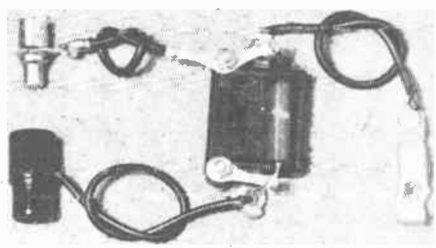
NATURAL aging of the coils and condensers in the tuned circuits of a superheterodyne receiver, or changes in the electrical values of these parts due to vibration and fluctuating temperatures, are the most common reasons for misalignment. You can suspect this trouble if the receiver has poor selectivity along with poor sensitivity. If sensitivity is poor but selectivity is good, however, look for a circuit defect. You can verify the need for alignment by tuning first to a distant station at the high-frequency end of the band; if you can get increased volume now by changing the setting of any high-frequency trimmer or I.F. trimmer, the set requires alignment. Now tune to a distant low-frequency station and rock the dial while adjusting the oscillator low-frequency padder; if volume can be increased, the set requires alignment.

There are a number of other symptoms in superheterodyne receivers which point directly to misalignment. If the receiver has poor sensitivity or is completely dead in the middle of a band, with sensitivity gradually improving as you tune toward either end of the band, there is poor "tracking" between the preselector and the oscillator. If the receiver will pick up distant stations satisfactorily at one end of the dial but poorly or not at all at the other end, you likewise have "tracking" trouble. If the dial readings do not correspond to the frequencies of the stations tuned in, the oscillator is misaligned with respect to the station dial.

The Alignment Problem. Every superheterodyne receiver has three separate sections which require perfect alignment with each other: 1, the I.F. amplifier; 2, the oscillator; 3, the preselector (this includes the mixer-first detector and the R.F. amplifier stage if used). An all-wave superheterodyne has an extra preselector section and an extra oscillator section for each short-wave band.

The I. F. Amplifier. In general, the I. F. amplifier should be aligned at the frequency recommended by the manufacturer. A change is sometimes necessary to eliminate interference from a local low-frequency station which is operating at the original I.F. value of the receiver, or to eliminate squealing on stations whose frequencies are some multiple of the I.F. value.

You can safely assume that 999 receivers out of 1000 have peaked I.F. amplifiers. Only when a super has three or more I.F. transformers does the question arise as to whether the I.F. amplifier should be band-passed or peaked, and even for band-pass



Suggested assembly of standard signal generator coupling unit. Cover exposed resistor and condenser leads with friction tape after soldering the connections. The mica condenser used here has mounting holes to which soldering lugs can be bolted to anchor the leads, but any other arrangement of parts which follows out the circuit in Fig. *1* will serve equally well.

circuits you must first make a peak adjustment. (I am assuming in this job sheet that you have mastered the fundamental principles of the superheterodyne receiver as presented in your regular Course, and hence am not explaining technical terms pertaining to supers.) If peaking a receiver causes oscillation (squealing), but all tube shields are in place and all electrode voltages are normal, it is very likely that the receiver was intended for a band-pass adjustment. Band-passing involves decreasing the capacity across one winding of an I.F. transformer and increasing the capacity across the other winding, to give a flat-top response curve; the alignment procedure for flat-top I.F. amplifiers is covered in your regular Course.

The Preselector. The preselector for a broadcast band super or for one band of an all-wave super may consist of a simple tuned antenna transformer, a single R.F. amplifier stage, or a band-pass R.F. circuit feeding into the first detector. The preselector is tuned by one or two sections of the variable tuning condenser, and must therefore follow the tuning dial readings for that band. If the I.F. amplifier is band-passed, the preselector must either tune broadly (if a single tuned circuit) or be band-passed (if a double-resonant circuit).

The Oscillator Stage. The oscillator stage in a superheterodyne invariably operates at a frequency which is above the frequency of the station being received by an amount equal to the I.F. value. There must be one oscillator coil section for each band, and each oscillator coil section must track with its corresponding preselector section.

Other Adjustments. Occasionally you will encounter receivers which have additional adjustments. For instance, you may find an I.F. trap in the antenna circuit; you may find wave traps or image-rejecting circuits in the preselector. The service manual or circuit diagram for the receiver will indicate how these should be adjusted.

Identifying Alignment Trimmers. In a broadcast band super the I.F. trimmers will usually be inside the I.F. transformer shields, with either one or two adjusting screws or nuts visible at the top, side or bottom of each shield. Occasionally the I.F. trimmers may be on the chassis near each transformer; you can identify them by tracing their leads to an I.F. transformer. Still considering the broadcast super, the oscillator and preselector high-frequency trimmers will be found on the variable condenser gang, and the oscillator low-frequency padder will be on the chassis along with any trimmers which may be used for wave traps or other special tuned circuits.

In an all-wave receiver the I.F. trimmers will be in essentially the same locations as for a broadcast band receiver. Your greatest difficulty will be in locating and identifying the preselector and oscillator trimmers. If the R.F. coils for a given stage are all housed in a common shield, the preselector high-frequency trimmers will either be inside the shield, with the adjusting screws showing at the side, or will be ganged together on a bakelite or ceramic strip located near the group of coils. The oscillator coils for all bands may also be mounted in a common shield in this manner. The oscillator low-frequency padders are always on the chassis, and always have more plates than the high-frequency trimmers. Each R.F. coil should have one high-frequency trimmer for each band, and each oscillator coil should have one high-frequency trimmer and one low-frequency padder for each band; if this does not hold true, refer to a circuit diagram to determine which are omitted. The trimmers belonging to any one band can readily be identified by tuning the receiver to that band, then touching each trimmer screw in turn with a metal screwdriver; a change in the operation of the receiver will be noticed when you touch a trimmer belonging to that band.

Identifying Stages. Before you can connect the signal generator to a superheterodyne receiver for an alignment, you must identify the various stages and tubes in the R.F. section. Inasmuch as this subject was covered in a previous job sheet, it will not be repeated here. Locate the preselector (R.F. amplifier) stage, the oscillator stage, the mixer-first detector stage, and the various I.F. amplifier stages.

Apparatus Required for Aligning. The same apparatus which was used for aligning T.R.F. receivers is suitable for aligning supers, provided that the signal generator can be tuned to the I.F. value of the receiver and to any frequency on any band in the case of an all-wave super. All commercial signal generators meet these requirements. Practically all multimeters have a suitable output meter for alignment work.

In aligning a super, it is necessary to make signal generator (S.G.) connections directly to the input of a stage rather than to the antenna and ground terminals of the receiver. The connection used must not appreciably affect the tuning circuit of the stage; this requirement can be met by inserting the standard coupling unit shown in Fig. *1* between the signal generator and the control grid of the tube.

Order of Aligning Stages. In any superheterodyne alignment procedure, the I.F. system is aligned first; after this, the preselector and oscillator are made to track, first on the broadcast band and then on the short wave bands; finally, any special tuned circuits, such as an A.F.C. circuit, are aligned. Although alignment procedures may vary in minor details, the main steps in aligning an all-wave super will generally be as follows:

A. Align the I.F. stages.

1. Connect S.G. to input of first detector, using standard coupling unit.
2. Connect output meter to output stage or across load resistor of diode detector.
3. Set S.G. at I.F. value of receiver.

4. Adjust I.F. trimmers for maximum gain, repeating adjustments once.

B. Align preselector and oscillator for broadcast band.

1. Connect S.G. to antenna and ground terminals of receiver.
2. Tune receiver and S.G. to 1400 kc.
3. Adjust oscillator high-frequency trimmer for maximum output indicator reading.
4. Adjust preselector high-frequency trimmers for maximum output.
5. Tune S.G. and receiver to 600 kc. and make rocking adjustment of oscillator low-frequency padder. (If the receiver does not have this padder, proceed to step C.)
6. Realign the oscillator high-frequency trimmer at 1400 kc.
7. Realign the oscillator low-frequency padder at 600 kc., then repeat step 6.

C. Align preselector and oscillator on short-wave bands.

1. Set the band-change switch on the receiver to a short-wave band.
2. Tune receiver and S.G. to a frequency near the high-frequency end of the band being aligned.
3. Adjust the oscillator high-frequency trimmer associated with this band for maximum output.
4. Adjust the preselector high-frequency trimmers associated with this band for maximum output.
5. Tune S.G. and receiver to a frequency slightly higher than the lowest R.F. frequency in the band, then make a rocking adjustment of the oscillator low-frequency padder for this band.
6. Repeat adjustments 2, 3, 5 and 3 again.

S.G. Output Level. When aligning an A.V.C.-controlled super with the aid of an audio output indicator, the S.G. output level must be kept below the threshold point to prevent A.V.C. action, but if a tuning indicator or the vacuum tube test circuit described in a previous job sheet is used across the diode detector load as a guide for alignment adjustments, any S.G. output level may be used.

Peaking the I.F. Amplifier. With the signal generator connected to the input of the first detector for an I.F. adjustment, set the S.G. to the I.F. value recommended by the receiver manufacturer. Using an aligning tool, adjust the I.F. trimmers for maximum output, working from the input of the second detector to the output of the first detector. Reduce the signal strength of the S.G. whenever necessary, in order to keep the output meter reading below half-scale. Repeat the entire alignment procedure once, for there is a certain amount of interlocking between the various I.F. circuits, and one adjustment may detune a previous circuit slightly.

Preselector-Oscillator Adjustments for the Broadcast Band. Having peaked the I.F. amplifier, connect the S.G. to the antenna and ground terminals of the receiver, and tune both the S.G. and the receiver to 1400 kc. Adjust the oscillator high-frequency trimmer for maximum output. (You may find two settings which give maximum output; choose that one which has the least capacity.) Preselector high-frequency trimmers are then adjusted for maximum output.

Rocking Adjustments for Oscillator Low-Frequency Padder on Broadcast Band. If the rotor plates for the oscillator and preselector sections of the tuning condenser have exactly the same shape, the receiver will very likely have an oscillator low-frequency padder; this requires a special rocking adjustment during alignment. Set the receiver and the S.G. both to 600 kc. Now tune the receiver back and forth through 600 kc. (rock the tuning knob), while turning the oscillator low-frequency padder slowly *in*. Watch for a sudden high point in the swing of the output meter, because at that point the tracking is correct. If the reading of the output meter gets less as you make this adjustment, turn the low frequency padder out until you secure maximum swing. With a little practice, you will find this rocking adjustment quite easy to make.

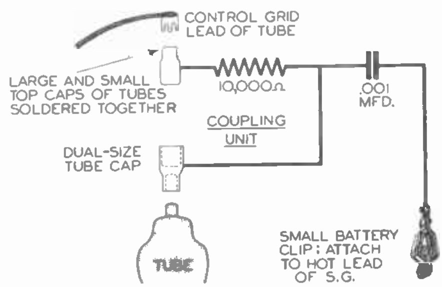


FIG. 1. Standard coupling unit, used for making a signal generator connection to a control grid lead of an R.F. tube (in modern R.F. tubes the control grid invariably goes to a top cap). The grounded S.G. lead goes to the receiver chassis; the other S.G. lead, commonly called the hot lead, goes to the battery clip on this coupling unit.

After completing the rocking adjustment, realign the oscillator high-frequency trimmer at 1400 kc., and realign (by rocking) the low-frequency padder at 600 kc. Although other high and low frequencies in the broadcast band may be used for this adjustment, 1400 kc. and 600 kc. are recommended by most manufacturers.

Preselector - Oscillator Adjustments on Short-Wave Bands. An all-wave super may have as many as five bands, each with its high-frequency trimmer and low-frequency padder adjustments. For each band the high-frequency trimmers are adjusted with the tuning condenser set near minimum capacity, in the same manner as is done at 1400 kc. in the broadcast band. Next, with the tuning condenser near maximum capacity, the rocking adjustment is carried out for the oscillator padder. Finally, realign the oscillator high-frequency trimmer by rocking the condenser gang, and repeat the oscillator low-frequency padder rocking adjustment. After you have adjusted one band, proceed with the next band. The dial readings of the band under adjustment will suggest suitable S.G. settings at the high and low frequency ends of the band.

Be on the lookout for all-wave receivers which do not have low-frequency padders, for these padders are quite often omitted. In a case like this, it is best to refer to the service manual for alignment instructions.

A.F.C. Circuit Alignment. In some of the newer superheterodyne receivers you will find an automatic frequency control circuit which requires alignment; the action of this circuit is thoroughly covered in your regular Course. The alignment procedure is likewise given in your regular Course, and will therefore be covered here only briefly.

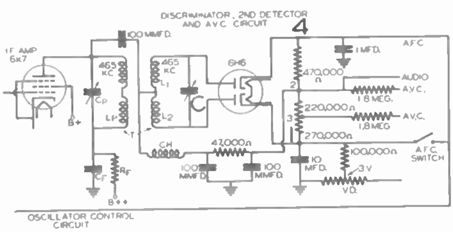


FIG. 2. Section of a typical automatic frequency control circuit showing the parts involved in an A.F.C. alignment job.

A typical A.F.C. circuit is shown in Fig. 2. Strictly speaking, there is only one adjustment in this A.F.C. circuit, involving condenser *C* which is connected between the plates of the 6H6 double-diode tube for the trimmer condenser across the primary of discriminator transformer *T* is adjusted for maximum output beforehand as a part of the I.F. amplifier peak alignment. Connect your vacuum tube amplifier test circuit (described in a previous job sheet) between the cathodes of the double diode tube (to points *1* and *4* in Fig. *2*, with the input condenser in your test circuit shorted, and the potentiometer fully advanced to secure maximum transfer of voltage). Note the reading of the test circuit meter before making this connection, then adjust condenser *C* in the A.F.C. circuit until the meter pointer exactly returns to this original position. This adjustment for zero D.C. voltage between points *1* and *4* is very critical. Be sure that the final adjustment is correct when the adjusting tool is removed. This completes the A.F.C. circuit alignment.

General Data on Superheterodyne Alignment. The general superheterodyne alignment procedure described in this job sheet gives exactly accurate tracking for only two dial settings in each band. If the variable condenser in a super has slotted end rotor plates, tracking can be made more accurate on the most-used band (the broadcast band) by bending these rotor plate segments. After completing the conventional alignment procedure for the broadcast band, rotate the tuning condenser until the first segment of each rotor plate meshes completely with the stator plates. Note the tuning dial reading for this condition, and set the S.G. exactly to this frequency. Now bend each of the meshing rotor segments in turn one way or the other for maximum output. Repeat for each additional segment on the rotors, resetting the S.G. and bending each segment in turn for maximum output. This will give you the best possible alignment on that particular band, the broadcast band; now proceed to align the short-wave bands, without touching the rotor plates again.

If removal of the chassis from the cabinet makes it impossible to set the receiver accurately to a desired frequency, tune the receiver to 1000 kc. (using the dial escutcheon as a guide), remove the chassis without changing the dial setting, then attach a simple indicator (a length of stiff wire) to the chassis or condenser frame and bend it so it ponts exactly to 1000 kc. on the dial. This wire thus replaces the indicator on the receiver cabinet.

If a squeal is heard when aligning the I.F. amplifier and this is not the modulation tone of the S.G., simply change the receiver tuning dial to a position where no squeal is heard. If it is impossible to secure correct tracking between preselector and oscillator, look for a defective part in the oscillator circuit.

Double spot (image) reception may be obtained on the highest frequency range of the receiver. Example: The set has an I.F. of 460 kc., and you are tuning in an 18 megacycle (18,000 kc.) signal from the S.G. The oscillator in the set should be at 18,000 kc. + 460 kc. (18,460 kc.) to bring in the signal. However, with the S.G. still at 18,000 kc. you may be able to hear a signal when the receiver is set to 17,080 kc. (18,000 — 460 — 460). Adjustments should be made with the receiver set at the *higher* of the two frequencies.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

How To Align A Tuned R.F. Receiver

WHEN Is Alignment Needed? When the observable symptoms in an improperly operating receiver are poor sensitivity accompanied by broad tuning (poor selectivity), one of the first things a Radiotrician will suspect is lack of alignment. This can be quickly checked by tuning the receiver to a weak or distant station and using an alignment tool (a special insulated screwdriver having a minimum of metal) to change each of the aligning adjustments about one-quarter turn in either direction; restore the original setting each time before proceeding to the next trimmer. If volume increases in any case, the set should be realigned; if that clears up the trouble, there will be no need to look for other defects. Tampering with the R.F. system, constant vibration and shock, changes in weather conditions, and general aging will throw tuned circuits out of line, causing poor selectivity and poor sensitivity.

In an earlier job sheet I pointed out that whenever a receiver is brought to your work-bench for general repairs, it should be given a complete overhaul, after the defect has been repaired, as a part of the service procedure. This overhaul includes tightening all loose parts, resoldering all poor joints, checking tubes, cleaning the chassis thoroughly, cleaning the plates of the variable tuning condensers, then aligning the R.F. system. The alignment part of the overhaul procedure is particularly important, for it will in practically all cases restore the original performance of the receiver and thereby create customer satisfaction. In this job sheet I will consider the alignment procedure for a tuned R.F. receiver; superheterodynes will receive attention in a later job sheet.

Equipment Required. Only two instruments are required for aligning either a super or a tuned R.F. receiver:

1. An accurately calibrated R.F. signal generator (S.G.) which can be tuned to any of the R.F. or I.F. frequencies which may be present in the radio receiver. The S.G. should have a control for varying its output voltage, and there should be means for modulating its output with a tone signal when desired.

2. An output indicator having a number of different voltage ranges or means for controlling its sensitivity. This output indicator can well be a part of an ordinary multimeter.

Signal Generator Connections. The signal generator is very easily connected to a tuned R.F. receiver for alignment purposes. Simply remove the antenna lead-in connection from the receiver, connect the shield on the cable of the S.G. to the ground terminal of the receiver (leaving the ground wire connected), and connect the other S.G. lead to the antenna terminal of the receiver. In other words, feed the output of the signal generator directly into the antenna and ground terminals of the receiver, as indicated in Fig. *1*.

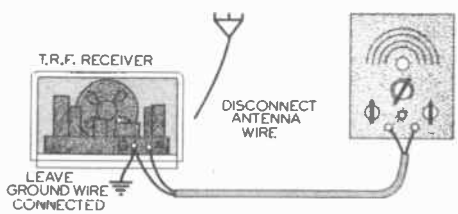


FIG. 1. Signal generator connections for aligning a T.R.F. receiver.

Output Indicator Connections. These are exactly the same for either a T.R.F. or superheterodyne receiver. A number of different connections are possible; in each case use whichever is the easiest to make.

One connection which is satisfactory for any receiver is that shown in Fig. *2*, involving an output indicator connection to the input of the loudspeaker. Actually you are connecting the output indicator in parallel (in shunt) with the voice coil when this connection is used for a dynamic loudspeaker.

Since the voice coil connection shown in Fig. *2* requires that the output indicator have a low A.C. voltage range, and this is not always provided on a multimeter, the connections shown in Figs. *3* and *4* are more widely used. In Fig. *3* is an output indicator connection for a single-tube audio output stage, while in Fig. *4* is the connection for a two-tube audio output stage. An output indicator always has a condenser in series with its meter circuit, in order to prevent direct current from flowing through the A.C. voltmeter. In other words, an output indicator is simply an instrument for measuring the audio output voltage of the A.F. amplifier in a receiver.

Radiotricians who have had considerable experience with tuned R.F. receivers will often align them "by ear" without using an output indicator or signal generator; they do this by tuning the receiver to a station and varying each adjustment for maximum volume as heard from the loudspeaker. This procedure is not recommended for beginners, however, for it is difficult to detect small changes in loudness. Far more reliable results are obtained with an indicator. An

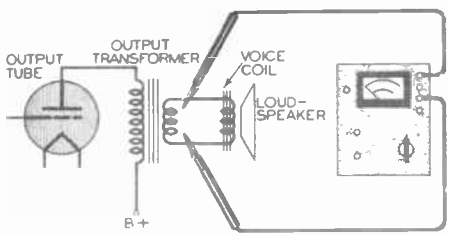


FIG. 2. Output indicator connections to the voice coil of a dynamic loudspeaker. A multimeter is here being used as an output indicator.

exception is the universal T.R.F. receiver, which can be aligned by ear just as well as with an S.G. and output indicator.

When a receiver is provided with a visual tuning indicator, no output indicator connection is needed. The alignment can be carried out by watching the tuning indicator. With receivers employing a diode detector, the vacuum tube amplifier circuit described in a previous job sheet may also be used as an output indicator. Merely connect the input resistor or potentiometer of the unit across the diode load resistor in the receiver.

Types of T.R.F. Receivers. Alignment is required in a T.R.F. receiver whenever the variable condensers in the tuning system do not all tune exactly to the same signal. The procedure for aligning a tuned R.F. receiver therefore centers around the construction of the ganged variable condensers. The procedure itself is quite simple; it involves feeding into the receiver an R.F. signal having the same frequency as that to which the receiver is tuned, then adjusting each section of the variable condenser for maximum audio output voltage as indicated by the output indicator. Three types of construction will be encountered in the variable condensers of T.R.F. receivers, each requiring a different type of adjustment: 1, variable condensers which are not equipped with trimmer condensers; 2, variable condensers having trimmer condensers; 3, variable condensers having trimmer condensers and slotted rotor end plates.

Receivers Without Trimmers. Although tuned R.F. receivers which are not equipped with trimmer condensers are now quite rare, you may run across one of them from time to time. Do not spend too much time aligning such a receiver, for the customer really needs a modern set which will give better station separation. If the customer insists upon a complete service job, connect the S.G. and output indicator, set the S.G. at the frequency of the customer's favorite local station, tune the receiver to this frequency for maximum output, loosen the set screws which hold the rotors of the gang tuning condenser in position, then rotate each rotor section in turn for maximum output. When this adjustment has been completed, tighten the set screws again. Sometimes it is not possible to move the condenser rotor sections individually; in this case you can secure some sort of alignment by bending the variable condenser leads away from or toward the chassis to secure maximum output.

Receivers Having Trimmers. When a tuned R.F. receiver is provided with tuning circuit trimmers (small adjustable condensers in parallel with the tuning condenser sections), alignment is carried out by adjusting the capacity of each of these trimmers in turn for maximum output while the receiver is tuned to the customer's favorite high-frequency station. If no station is indicated, align at a higher broadcast band frequency, about 1,400 kc. These trimmer condensers will usually be mounted directly on the variable condenser gang. Reception at the lower broadcast band frequencies can be improved by bending the rotor plates.

Receivers Having Trimmers and Split Rotors. A receiver of this type is intended to be selective over the entire broadcast band; when it gets out of alignment, it is the duty of the Radiotrician to see that the set is properly realigned in order to restore its original performance. Tune the receiver and the signal generator to 1,400 kc., set the receiver volume control at its normal setting for a local station, then adjust the output of the S.G. until the output meter gives about one-third of full-scale deflection. Now adjust the trimmers on the variable condensers for a maximum output meter reading (no special order is required); reduce the S.G. output whenever necessary to prevent the output meter from going off-scale.

To adjust the split rotor plates of each variable condenser section, rotate the receiver tuning knob until the first split sections on the tuning condenser rotors mesh completely with the stator sections. Retune the S.G. to give maximum output under this condition, adjusting its output if necessary to make the output meter read about one-third of full-scale. Now bend the first split sections (the meshed sections) on the rotor of each condenser section in the direction which gives a maximum deflection on the output meter. Turn the tuning knob again until the second rotor segments are completely meshed, retune the S.G. for this new setting, and repeat

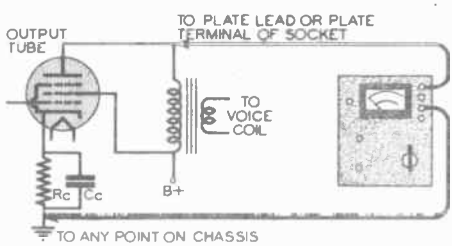


FIG. 3. Output indicator connections to the plate and chassis of a single-tube output stage.

the adjustment. When all of the split segments have been adjusted in this manner for maximum output, retune the receiver and the S.G. to 1,400 kc. and readjust the trimmers, for this plate-bending procedure may have affected the previous adjustments. The receiver is now correctly aligned.

General Alignment Data. When a tuned R.F. receiver has been aligned, you may find

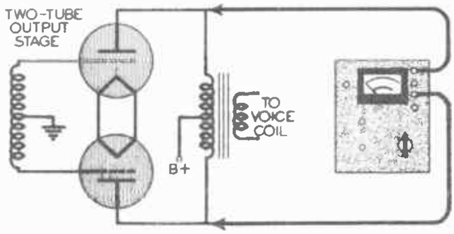


FIG. 4. Output indicator connections to the two plates of a two-tube output stage.

that music and speech no longer sound natural. This will be particularly noticeable in receivers having more than three tuned stages. It is due to the fact that the receiver is now too selective for broadcast band reception, and is cutting off the higher audio frequencies (cutting the side bands). This fault is very easily corrected; simply change the trimmer condenser adjustment for one of the R.F. stages slightly. If this does not give sufficient correction, repeat for another trimmer; if you turn the adjusting screw in on one trimmer, turn the screw out on the other, moving each a little at a time until the quality seems normal again.

T.R.F. Alignment Don'ts. Don't try to align an old T.R.F. receiver until you have given it a thorough overhauling, cleaning out all dirt and grime from the R.F. coils and the tuning condensers. Don't adjust any trimmer condenser until you know its purpose. Don't align a receiver unless all shields and shield connections are tight and properly in place.

How To Neutralize A Neutrodyne Receiver

Thousands of "neutrodyne" receivers, popular in the early days of radio and famous for their ability to tune in stations without "squealing," are still in existence. When these receivers get out of balance, however, they will squeal. It is important that you know how to neutralize or rebalance a squealing neutrodyne receiver.

The neutrodyne circuit employs triode tubes as R.F. amplifiers, with special coils and condensers to balance or neutralize the R.F. voltage which, if it were allowed to feed backward through the plate-to-grid path inside each R.F. tube, would cause regeneration or squealing. General aging of parts, placing of new tubes in the receiver, or changing the position of wiring will often change the neutralizing adjustment, with the result that sharp hissing noises and squeals are heard when stations are tuned in.

Always be sure that you have a neutrodyne receiver before attempting to make any neutralizing adjustments. Identifying characteristics are triode R.F. tubes, with one neutralizing condenser for each tuned R.F. stage. These neutralizing condensers will be mounted on the chassis or on a small insulating panel. Do not confuse alignment trimmer condensers (which are mounted on variable condensers) with neutralizing condensers. On very old neutrodyne receivers, the neutralizing condenser may consist simply of two metal rods mounted a short distance apart in a glass or fiber tube, with a metal sleeve fitting over the tube; the position of this sleeve is changed in order to vary the capacity.

Midget trimmer condensers (sometimes called book condensers) are actually provided for neutralizing adjustments; the connections of these condensers are covered in your Fundamental Course. Once you locate the neutralizing condenser for each stage, you can carry out the neutralizing procedure given below regardless of the type of neutralizing circuit employed.

Neutralizing Procedure. Always neutralize a squealing neutrodyne receiver before aligning; a second neutralizing procedure may perhaps be necessary after alignment. Of course, if the set is originally way out of alignment, it may be wiser to align before neutralizing, and repeat both adjustments at least once again. The general neutralizing procedure is as follows:

1. Tune the receiver to a local broadcast station operating on a frequency somewhere near 1,500 kc., or connect a modulated signal generator to the antenna and ground terminals of the receiver and tune the S.G. to 1,500 kc.

2. Open the filament or heater circuit of the tube in the last R.F. stage, either by unsoldering the lead to a filament terminal, by slipping a short length of soda straw or a pill capsule over one tube filament prong, or by inserting a standard neutralizing adapter between the tube and its socket.

3. Turn the receiver on. With no filament emission, plate current will not normally flow through a tube. If the signal to which the receiver is tuned can be heard from the loudspeaker, we know that this signal is passing from the grid to the plate (inter-electrode capacity) inside of the cold tube; this stage therefore needs neutralizing in order to cancel the undesirable feed-back signal. If signals can flow through the cold tube in this direction, they can also flow in the opposite direction when the tube is operating, producing annoying oscillations or squeals.

4. Adjust the neutralizing condenser in the stage until the signal is at minimum volume or cannot be heard, then retune the receiver dial for maximum volume and readjust the neutralizing condenser for minimum volume. This completes the neutralizing adjustment for that stage. Once a stage has been neutralized, do not make any more changes in that stage, and above all, do not change the tube in that stage. Proceed to neutralize all other R.F. stages in the same manner, one by one, working toward the antenna.

The mere fact that the complaint is squealing when stations are tuned in does not mean that you have a neutrodyne receiver. If you cannot locate any neutralizing condensers, the set is definitely not a neutrodyne. Many receivers which use triode R.F. tubes are not neutrodynes; these usually have grid suppressors (resistors) connected between each control grid and tuning circuit to drop R.F. feed-back voltages and prevent squeals. When other means for eliminating squeals in receivers of this type fail, try increasing the sizes of these grid suppressor resistors.

If a neutrodyne receiver squeals at some other frequency, say at 800 kc., after you have eliminated the squealing at 1,500 kc., repeat the neutralizing adjustment at this new frequency. If this produces oscillation again at 1,500 kc., it will be necessary to reduce regeneration in some other way, possibly by reducing the plate voltages. On receivers having line voltage switches or taps, simply move the switch to a higher-voltage setting; this will reduce the voltage applied to the power pack and thus reduce all plate voltages. Before making any change in the power supply system, however, be sure that there are no receiver circuit defects which could be causing regeneration.

Extra Money Jobs and how to do them

What To Do When A Receiver Plays Intermittently

INTERMITTENT reception presents perhaps the most perplexing of all problems which confront the Radiotrician. The complaint is easily recognized, for the receiver will play satisfactorily for a time, cut off entirely or play improperly for a while, then return to normal again, with the process repeating itself at regular or irregular intervals. Sometimes the set will perform satisfactorily for days at a time, then begin its cycle of intermittent operation again. There is no way for the serviceman to tell whether it will take ten minutes or ten days to find the trouble.

Because of this difficulty in estimating beforehand how long it will take to locate the defect, intermittent receivers should rarely if ever be serviced in the customer's home. Make an inspection for surface defects above the chassis, check the antenna system, then take the chassis and loud-speaker to your work-bench, place the set in operation, and proceed with other work while waiting for the intermittent condition to develop. Make as many tests as you can each time the intermittent condition occurs.

When intermittent reception is the complaint, the customer can often give valuable clues which will speed up the isolation of the defect. If the following questions are carefully answered by the customer and are properly interpreted, short-cuts in the professional servicing technique for intermittent receivers will often be obvious.

1. Does intermittent operation begin as soon as the set is turned on, or after it has been in operation for a number of hours?

2. How long does the period of improper operation ordinarily last? Is normal reception restored immediately, or does reception remain poor indefinitely once the receiver cuts off?

3. Will touching a tube, slapping the cabinet, or turning the power switch off and on restore reception during the period of improper operation?

4. If the set cuts off at regular intervals, how long does the receiver play properly? How long does it play improperly?

5. Is the receiver entirely dead when cut-off occurs, or does it play improperly, with reduced volume, hum, noise, squealing, etc.?

Remember that you will have to turn on the receiver and wait for the intermittent condition to occur before you can do any testing. If the trouble occurs only about once a day, and can then be cleared up by jarring the receiver or flipping the power switch off and on, it would be wise to suggest that the customer wait until the trouble becomes more severe; otherwise the time spent in waiting for the defect to occur may run the service charges up as high as $30. When the intermittent condition occurs often enough and lasts long enough to be seriously annoying, however, there are definite pro-

A simple, easy-to-use vacuum tube voltmeter like this is ideal for locating defects which cause intermittent operation of a receiver. Many different ranges are provided for A.C. and D.C. voltage measurements, direct current measurements and resistance measurements. Aural listening tests with this unit are made by removing the jumper wire from the two right-hand PHONE jacks and plugging a phone unit into these jacks. The range-selecting switch is set at 100 x V, the red probe of the test leads is placed in the left-hand A.C. jack, and the black probe is placed in the other A.C. jack. If greater phone volume is required, change to a lower voltage range. Always place the black clip on the chassis or on the terminal closest to ground potential.

cedures which can be used for locating the trouble; these will be taken up in this job sheet immediately after we consider common causes for intermittent defects.

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Common Causes of Intermittent Reception. Thermal shorts or opens (produced by heat) account for a great many intermittent defects. A metal part in some circuit may be almost touching another part or the chassis; when the receiver is turned on, the chassis and parts on it become warm, and the metal parts expand enough to touch and produce a short. If the short is in a high-voltage circuit, such as a plate supply lead, a spark and a slight noise may occur each time the parts touch.

Poorly soldered connections may have a thermal open circuit. Expansion of a wire with heat may cause it to move slightly away from a soldered joint, breaking the connection. The heat may be produced by current flowing through the wire and joint, or by general heat which is always present in a chassis when the receiver is in operation.

Thermal defects are often traced to tubes. Electrodes will touch each other or electrode leads will open; oftentimes the open circuit may be incomplete, giving rise to noise. A thermal defect in a tube can also cause hum, oscillation, distortion, lowered sensitivity, or a dead receiver, depending upon which electrode is affected. A tube checker will not always reveal a thermal defect, hence you must depend upon other means for locating the trouble. As a last resort, you can advise the customer to secure a complete new set of tubes; if this clears up the intermittent trouble, you know that one of the old tubes was the cause.

If it is the current flowing through a joint which produces a thermal open, the source of heat will be removed as soon as the open occurs, cooling will take place, and the connection will be made again. Under these conditions there will be a regularly recurring intermittent condition, with the time interval being determined essentially by the amount of current flowing and the size of the part. For example, when the break is in the filament of a tube, the filament will heat quite rapidly when the connection is made and will cool equally as fast when the break occurs, with the result that the interval of time between intermittent conditions will be short. In power transformers, however, there is so much metal in the vicinity to be heated and cooled, that the interval between intermittent conditions will be considerably longer. The interval of time between one cut-off and the next can therefore serve as a clue to the trouble. The following table indicates probable causes of trouble when cut-off occurs regularly at definite intervals of time.

Time	Probable Cause
0-3 minutes	—Tubes or poor connection.
3-5 minutes	—Resistors, especially cathode bias resistors which heat up after tubes are warm, and other parts which dissipate heat rapidly; loudspeaker fields are in this classification.
3-5 minutes (Universal AC-DC sets)	—Series filament resistors and heavy duty bias resistors which sag and touch the chassis.
Over 5 minutes	—Power transformers and large resistors.

When a thermal defect is due to general heat from the chassis, it will usually take quite a long time after the receiver is turned on before the intermittent condition occurs. Furthermore, since the various power circuits which ordinarily heat the chassis will not be affected by the thermal contact, the changed condition will usually continue once it starts. Normal operation can be restored only by turning off the receiver and allowing it to cool for a few minutes. This type of intermittent condition is much easier to repair, for the usual isolation tests can be made while the receiver is operating improperly.

You will also encounter intermittent conditions in which there is no regular interval of time between cut-offs and there is no logical explanation for the cut-off. One day the cut-off may occur quite often, another day it may occur only every few hours, and the trouble may clear up entirely for a few days. Such trouble is usually due to opening up of a by-pass or coupling condenser. Oftentimes, you can make the intermittent action occur by wiggling the condenser, thus proving that the condenser is defective. High-resistance carbon volume controls, if noisy when rotated, are also possible causes of intermittent reception. The remedy obviously is replacement of the defective part.

Another intermittent condition you may encounter is that in which there is an extremely small break in a signal or supply circuit, with a tiny arc (often not visible) developing across it most of the time to give normal operation. The arc may fail at irregular intervals for various reasons, causing a signal circuit to open or interrupting the power in a supply circuit. For example, an open control grid or screen grid lead (either inside or outside a tube) will often stop reception. Snapping the power switch off and on, touching a control grid, or pulling out and returning any tube to its socket is generally sufficient to send through the receiver a surge of current which will restore normal operation.

Service Technique for Intermittents. The clues obtained from the customer's answers to your questions may not lead you directly to the defect, but they will usually give you a good general idea of what the trouble is, and will allow you to concentrate on one section of the receiver.

When the clues point to tube trouble, and the receiver has glass tubes, note if any of the filaments cease glowing during the intermittent condition. With metal tubes, this is of course impossible, but you can wiggle and tap each tube in turn; oftentimes this will force the development of the open or short, thereby locating the defective part immediately.

Go over the top of the chassis carefully, looking for loose or poor contacts. Wiggle each part vigorously or try to move it out of position; this may lead you directly to the trouble. If noise or clicks are heard or there is any other change in receiver performance when one particular part is moved, and all leads to it have been checked, replace the part.

Check the loudspeaker next, by wiggling each output transformer and field coil lead vigorously with your long-nosed pliers while the set is in operation and tuned to a station; also squeeze the field coil and tap it with the insulated handle of a screwdriver (The plier handles should preferably be taped, to eliminate chances of a shock.) Inspect the voice coil leads carefully, but do not apply force to them.

Next comes a thorough inspection for surface defects underneath the chassis. First look for visible arcing joints, then begin a systematic probing of all parts and connections, starting at one corner of the chassis and working back and forth until you have tested every connection and lead by pulling and by shaking. Do not be afraid to pull a lead away from its joint while making this inspection, for any joint which will separate so easily is not worth having. Be on the lookout for poorly soldered joints, where solder is rough and there is excessive rosin over the joint. Before resoldering a suspicious joint, apply extra force to it in an attempt to cause cut-off, so you will know when you have located the defect. If clues indicate that you are dealing with a thermal contact, give special attention to current-carrying leads and their connections, concentrating on those parts which can logically be suspected because of the time interval observed. If there is no regular interval between cut-offs, then all parts must be tested.

The servicing procedure up to this point might really be called a thorough inspection for surface defects. If this fails, a procedure for isolating the defective stage becomes necessary. A simple vacuum tube voltmeter (v.t.v.m.) can be used effectively for isolating the defective stage when the complaint is intermittent reception. It can be used for measuring either D.C. or signal voltages. Furthermore, some instruments of this type have provisions for plugging in headphones so as to permit aural listening tests at any point in the receiver. The tube in the instrument provides rectification, and hence serves to demodulate a modulated R.F. or I.F. signal.

To listen to the output of a diode detector in a receiver, prepare your v.t.v.m. for aural listening tests (phone tests) and connect it between the negative end of the diode detecor load resistor and the chassis.

To listen to the output of any audio stage, prepare your v.t.v.m. for aural listening tests and connect it between the plate terminal of any A.F. tube and the chassis.

To check for a leaky coupling condenser or a gassy tube, use your v.t.v.m. as a D.C. voltmeter and connect it across the grid resistor in the stage under suspicion. A D.C. voltage across the resistor means that current is flowing through the resistor due to one of these defects.

During receiver alignment (considered in later job sheets), the v.t.v.m. can be used as an output indicator by connecting it to measure the D.C. voltage developed across the load resistor of the diode detector.

In general, the v.t.v.m. should be used with a headphone for aural listening purposes when checking for noise or distortion, and should be used in a conventional manner as a D.C. voltmeter when checking D.C. voltages or aligning tuned circuits.

Now let us see how a vacuum tube voltmeter can be used for isolating the stage or at least the section which contains an intermittent defect. First of all, you will want to know whether the defect is in the audio system or in the R.F. and detector system. To do this, listen to the output of the second detector by using the v.t.v.m. as an aural indicator. In the case of a diode detector, connect the v.t.v.m. across the diode load resistor; in the case of a triode or any other detector tube, connect the v.t.v.m. between the plate of the detector tube and the chassis. Keep the v.t.v.m. leads and the phone leads away from chassis parts as much as possible.

When you hear the intermittent condition from the loudspeaker, pick up the phone carefully and listen to it. If the audio output has gone down, you have an indication that the trouble is in a previous stage (an R.F. stage, I.F. stage or the second detector). If the response in the phone is the same as before, you know that the trouble is in an audio stage, following the phone connection. If you are in doubt as to whether a change in phone volume occurred, force the receiver back to normal while listening to the phone; a sudden change in volume can then be recognized.

When working with an A.V.C.-controlled receiver which is equipped with a visual tuning indicator, there is no need to make this test for isolating the defective section; if the break occurs in the R.F. or diode detector circuit, the tuning indicator will show a change each time it occurs, whereas if the break is in the audio system, there will be no change in the tuning indicator reading before and after cut-off.

If your vacuum tube voltmeter indicates the presence of an audio circuit defect, isolate the defective stage by connecting the v.t.v.m. (still set for use as an aural indicator) to the plate and chassis respectively of each single-tube stage in turn, working toward the loudspeaker (connect to the two plates in the case of a 2-tube output circuit), and wait for cut-off each time. The first stage you come to for which a change in phone volume occurs during cut-off will be the defective stage.

If your test circuit indicates the trouble is ahead of the second detector load, advance the v.t.v.m. one stage at a time from the second detector toward the antenna, making a connection to the plate and chassis in each case.

While the receiver is performing properly, set the v.t.v.m. to the *highest* D.C. voltage range which gives a clearly audible signal in the phone, then place the phone on your work-bench and proceed with other work until intermittent operation again occurs. The use of a high voltage range keeps at a minimum any detuning of receiver tuned circuits due to the input capacity of the v.t.v.m.

In the case of a receiver which does not have A.V.C., when you reach a connection at which there is no change in phone volume during cut-off, you have just passed through the defective stage. If the receiver has A.V.C., as is usually the case, the defective stage and all stages following it will show a *decrease* in phone volume during cut-off, and all stages ahead of it (toward the antenna) will show an *increase* in phone volume during cut-off. Turn off the v.t.v.m. after you have finished, in order to conserve battery life. *IMPORTANT*: Do not touch metal parts of the ungrounded test clip while the receiver is on, for high voltages exist at the plate terminals on which you place the clip during this test.

You are able to secure an audio output from any R.F. or I.F. tube simply because a vacuum tube voltmeter which measures A.C. voltages also acts as a detector in rectifying the modulated R.F. or I.F. signal. This audio signal will become weaker as you move toward the input of the receiver, but you can increase the phone volume, if you desire, by setting the v.t.v.m. to a lower voltage range. Tests made in the N.R.I. laboratory indicated that it is often possible to hear audio signals in the output of the R.F. preselector stage, but in general you will not be able to secure satisfactory volume at points between the antenna and the output of the mixer-first detector stage. Always tune to the strongest local signal when isolating a defective stage in this manner. If there is no broadcast station in your locality which provides a sufficiently strong signal for this defective stage isolating technique, it will be necessary for you to use a signal generator as your signal source for this test. Connect it to the antenna and ground terminals of the receiver, and set it for a modulated R.F. output signal. Of course, if the intermittent operation occurs only occasionally, you would not want to use a battery-operated signal generator for this purpose, because its batteries would be run down.

Once you have located the defective stage, try replacing the tube in that stage first of all. After this, push on all enclosed (shielded) parts, wiggle all condensers and resistors in the stage, pull on all leads and do anything else which might possibly force the open circuit or create the short circuit which is causing trouble. If this fails, remove the shields from R.F. coils and examine the internal parts, giving especial attention to the leads going to the coil terminals. These may be too tight, with the result that changes in temperature loosen the leads at the terminals and cause an open inside the soldered joint where it is not readily visible. If all these tests fail, begin replacing coupling and by-pass condensers, and finally replace resistors and signal circuit transformers. This last procedure will invariably bring results when everything else fails.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

Replacing The Antenna In A Better Location

WHEN your inspection of a radio installation during a service call reveals an obsolete, inadequate antenna, you have an excellent opportunity to sell a modern all-wave antenna system (at the regular list price) and install it in a better location than the existing antenna (charging your hourly rates for labor). Furthermore, many stores which sell radios do not have service departments; you can boost your income considerably by contracting with these drug, hardware, furniture and general stores for the installation of new receivers and the erection of modern antenna systems. Your greatest problem will be in providing supports which place the horizontal pick-up section of the antenna high enough above the ground and above surrounding objects to give good signal pick-up; this job sheet will be devoted exclusively to this important problem.

Locating The New Antenna. The following factors, listed in the order of their importance, should be considered when choosing a location for a new antenna: *1.* The existing supports or those which you provide should be the required distance apart for the type of antenna being installed, and should be high enough to give ample clearance over all objects in the line of the antenna; *2.* The antenna should be easy to erect in the chosen location; if supports are required, simple and inexpensive masts should be adequate; *3.* One support should be above a window near the receiver location; *4.* The location should permit a neat installation; *5.* If the owner is anxious to receive certain distant stations, an L-type antenna should be pointing toward those stations; if a doublet antenna (with transformer at center) is used instead, it should be pointing at right angles to these stations for maximum signal pick-up.

Selecting The Antenna Kit. For antenna erection work, two types of systems are generally used: *1.* A Tee, doublet or dual antenna system in which the transmission line connects at or near the center of the horizontal pick-up w[illegible] *2.* An L-type system in which the transmission line or lead-in connects to one end of the horizontal aerial wire. For broadcast antennas the lead-in will usually connect directly to the horizontal wire, while for all-wave antennas the connection will usually be through an antenna transformer. Ease of erection will generally govern the type of antenna you will choose. Four typical antenna installations will now be analyzed.

Example No. 1. Suppose that you are to install an all-wave antenna on a suburban or country home like that shown in Fig. *1*, which has a brick chimney extending about 5 feet above the ridge of the roof; there is

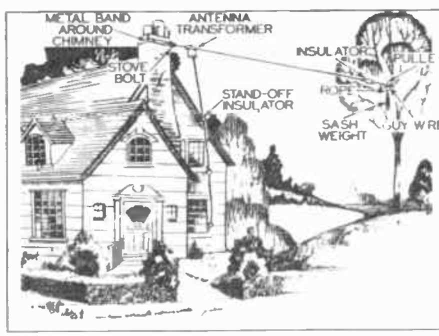

FIG. 1. All-wave antenna installation employing a chimney and a tree as supports.

one large tree about 100 feet straight back of the house, and another large tree about the same distance to one side of the house. The customer wants to locate the radio in the living room, which is at the front right side of the house.

You examine the location carefully, and decide that the chimney is in an ideal location for one antenna support, since it will permit dropping the lead-in wire directly down to a window of the living room if an L-type antenna is used. The tree at the right is obviously ideal for the support. (If the customer had specified a receiver location at the rear of the house, a doublet type antenna extending from the chim ' to the other tree would be better.)

Start work by placing a metal band (cut from heavy galvanized sheet metal) around the chimney near the top. Pull the ends of the band together with one or two long stove bolts, then anchor the transformer end the band, then anchor the transformer end of the antenna to this band with guy wire. If you loop guy wire around the chimney in place of the band, be sure to use metal brackets at each corner to prevent the wire from cutting into the mortar between the bricks. Never fasten an antenna to the tile lining in a chimney, for the top tile may not be firmly anchored.

Now get an extension ladder and place it against the tree. Thread guy wire through a section of an old bicycle tire or tack the wire over a section of a wooden hoop (to

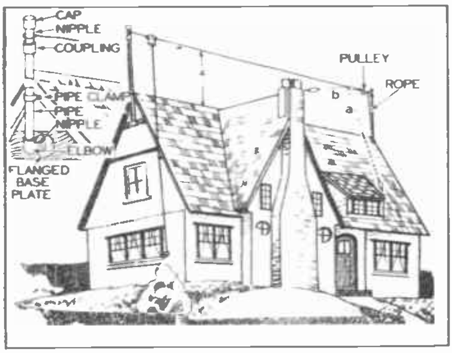

FIG. 2. All-wave antenna installation employing two self-supporting iron masts on a house roof.

prevent the wire from cutting into and choking the tree), then loop this around the tree trunk at the correct height. and twist the ends together; leave ample room inside the loop for future tree growth. (A long galvanized lag screw with hook, such as is used for clothesline poles, may be screwed into the tree and used as an anchorage for the antenna). Use a pulley, rope and window sash-weight at the tree to allow for motion of the tree during winds; the weight need not be more than a foot or two below the pulley.

Example No. 2. An all-wave antenna is to be installed on a home like that shown in Fig. 2, having a steep slate roof which should not be walked on, no trees in the vicinity, no rear garage, and a maximum distance of about 50 feet between house peaks. The receiver is located in the living room, at the left side of the house. The customer will not permit erection of a tower or mast in the vicinity of the house.

Two iron pipes, each about 6 feet long and ¾" or 1" in diameter, may be erected at the extreme ends of the house and used as antenna supports; no guy wires will be needed if the pipes are anchored as shown in the detail sketch in Fig. 2. Start at the left mast, which is almost directly above the receiver location. Place a ladder against the house, then fasten two short lengths of 1" or 2" thick wood to the side of the house with wood screws (with lag screws in the case of a brick house), placing one board a few inches below the ridge and the other about 18 inches below the ridge. Mount a pipe flange on the lower board, insert in it a nipple, then put on the elbow and insert the pipe mast, after first placing a coupling, nipple and cap on the upper end and attaching the transformer end of the antenna. Fasten the pipe to the upper block (or directly to the projecting ends of the roof near the peak) with a pipe clamp and wood screws. Install the other mast in the same way, but attach a pulley and rope to it at the top to simplify tightening of the aerial wire. Use an auxiliary rope to pull the antenna across the roof.

If the antenna length exceeds the distance between supports, three procedures are possible: *1.* Cut off surplus wire if using a broadcast antenna; an all-wave antenna may be shortened not more than about 3 feet with only a slight loss in effectiveness; *2.* Bring the free end of the antenna down along the side of the roof to a dormer as indicated by dotted line *a* in Fig. 2, or to the chimney as at *b*; *3.* Cut off the extra length of wire, duplicate it with the same length of about No. 18 enamel-covered wire, wind this smaller wire on a long porcelain insulator, cut the regular antenna near the transformer, fasten its ends to the insulator, then bridge over the break with the coil just formed, making soldered connections. In the case of an unequal doublet system, cut the surplus from the longer section and insert a coil of equivalent length in that section near the antenna transformer. For a balanced doublet, cut half the surplus from each end and insert one equivalent coil in each section, near the transformer.

Example No. 3. An ordinary all-wave antenna is to be installed on the roof of an apartment house like that in Fig. 3. No antenna supports are available on or near the roof. Two masts, each about 10 feet high, can be erected; use either ¾" galvanized pipe or 2" x 3" wood poles which are free from knots. In many towns and cities the use of iron pipe is compulsory, since it does not present a fire hazard. For each pipe mast you will need a one-foot square baseboard about one inch thick, a flanged base plate (or a 2" x 4" block with a hole drilled half-way through for the pipe), a coupling, a nipple, and a top cap. Fasten the flanged base plate to the center of the baseboard, then place the baseboard on the roof at the selected location for the mast nearest the receiver location; it is not necessary to fasten the baseboard to the roof, since the guy wires will apply sufficient down pressure to prevent slipping. Place the coupling nipple and cap on the top of the mast, attach the antenna and the three guy wires, then insert the mast in the flanged base plate and anchor the lower ends of the guy wires. Large lag screws, either of the hook type or the eye type, are ideal anchorages for guy wires. With brick construction, use a star drill or star chisel to make holes in the bricks or mortar, and place expanding sleeves (usually made of lead, and available at most hardware stores) into these holes before inserting the lag screws. Install the other mast in exactly the same way, after first attaching a pulley and rope to it for tightening the antenna. Attach the antenna and complete the installation in the usual manner.

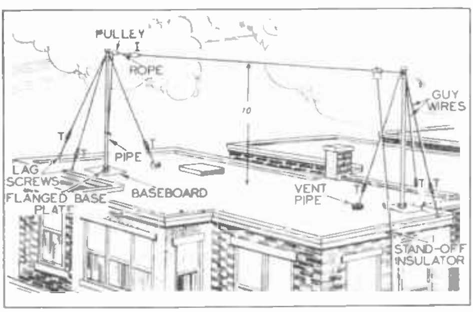

FIG. 3. All-wave antenna installation employing guyed iron pipe masts located on the flat roof of an apartment building. Insulators are designated as *I*. and turn-buckles as *T*.

If wood masts are used, drive a large nail through the baseboard into the bottom of the mast to prevent it from slipping off the board, and drill a small hole near the top of the mast through which guy wires can be threaded after they have been wound around the mast.

Example No. 4. An all-wave antenna is to be installed on a two or three-story city dwelling having a flat roof, as shown in Fig. *4*. The roof itself is not large enough for a two-mast antenna installation like that used in Fig. *3*, but there is a high clothes-pole in the back yard, serving all floors of the building. A 10-foot extension mast fastened to the top of this pole will provide an ideal antenna support; use either a 2" x 3" wood pole or a 1-inch diameter iron pipe, fastening it to the pole with strips of

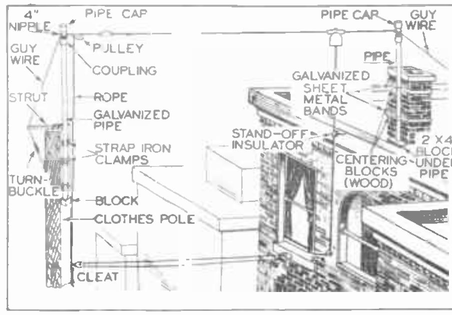

FIG. 4. All-wave antenna installation in which an extension mast on a clothes pole in the back-yard serves as one support.

galvanized sheet iron or with pipe clamps. Allow the bottom of the pole to rest on a spike or block so it will not slip down through the clamps. Before fastening the pipe permanently, place the coupling nipple and cap on the upper end, attach a pulley and one guy wire, and thread a length of rope through the pulley.

The chimney of the building can well be the other antenna support; generally it will be necessary to anchor a short mast against the chimney with bands of strap iron. Be sure to use an iron pipe at this point, for a wooden pole would present a fire hazard. To erect the antenna, start at the chimney; attach the transformer end of the antenna here. Now attach a strong piece of cord to the free end of the horizontal wire, and drop both the cord and the wire to the ground. Carry this cord up to the top of the clothespole, then pull up the aerial wire, and attach its insulator to one end of the rope. Pull the aerial into position, and anchor the rope to a cleat on the clothes-pole.

How To Erect An Antenna Mast When Required

When no antenna supports are available and short masts are inadequate, a simple full-length antenna mast like that shown in Fig. *5* can be considered. The latticed lower section is permanently installed, with a single 10 or 15-foot length of 2" x 2" wood pivoted to its upper end in such a way that this top mast can be lowered when necessary. Assemble the lower section with two twenty-foot lengths of 2" x 3" wood and short lengths of 1" x 2" pine for cross bracing as indicated in Fig. *5*. Mount a grooved

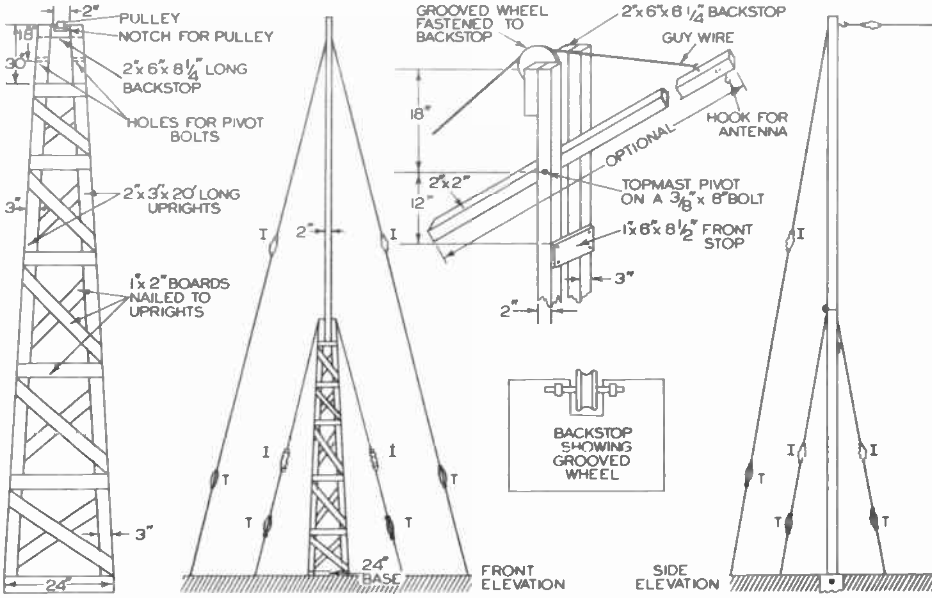

FIG. 5. Suggested design for a thirty-foot high wooden mast. Insulators are designated as *I*, and turn-buckles as *T*.

wheel in a notch cut into the backstop, fastening its shaft with staples or screw eyes; now place four large screw eyes at the top of the lower mast. Attach guy wires to these, making each one about ¼ longer than the lower mast.

For the base of the lower mast, drive two 2-inch by 3-inch stakes into the ground 24" apart, at the selected location for the mast. The stakes should be at least 2½ feet long, should be pointed at one end, and should be driven down far enough so that about 3 inches of each stake will project above ground. Drill holes in opposite faces of these stakes, then drill corresponding holes in the lower ends of the latticed mast for ⅜-inch diameter bolts. Place the lower mast on the ground with the holes lined up, then insert the bolts. Attach two of the guy wires to anchoring stakes located about 10 feet away from the base, then pull on the other two guys to raise the mast into position. The mast will tilt backward and remain up. Anchor the other two guys, then adjust all guys until the mast is vertical.

For the upper mast, select a 10 to 15-foot length of 2-inch wood which is free from knots and flaws. Drill a bolt hole about 18 inches from the lower end; attach screw-eyes at the top for the aerial wire and for three additional guy wires. Attach this to the lower mast with a ⅜-inch by 10-inch pivot bolt. Attach guy wires and the antenna, place the rear guy wire in the groove of the pulley wheel, pull up the mast, and either bolt or tie its lower end to the front stop. Anchor the guy wires to the same stakes used for the lower section, or to separate stakes set farther away from the base. Proceed to attach the antenna to its other support and complete the installation in the usual manner.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

Restoring Marred and Broken Radio Cabinets

OPPORTUNITIES for extra profit will often suggest themselves to an alert Radiotrician when making a service call. You have an excellent opportunity to find out whether the customer needs a new main radio or a table-model radio for the kitchen or bedroom. You can make recommendations for these new radios, then arrange with a local radio dealer to complete the transaction, giving you a commission. Servicemen and radio dealers very often work together in this way, with the serviceman doing all radio work for the dealer. Incidentally, this will give you excellent training in the merchandising branch of radio if you eventually plan to open a retail radio store.

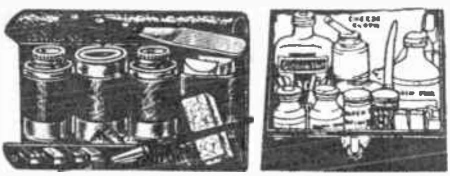

FIG. 1 Typical radio cabinet touch-up kits. Left—RCA refinishing kit, containing cleaning oil, rubbing oil, abrasive powder, sandpaper, an assortment of stick shellac, two packages aniline stain powders, one touch-up brush, one spatula, one rubbing block and an instruction sheet in a leatherette case. Right—Golden Star touch-up kit, a similar but larger unit in a carrying case. Furniture polish, cheese-cloth and an alcohol lamp are included with this kit.

More important yet are extra-money jobs involving an application of your radio training, such as restoring the finish on the radio cabinet, installing a better antenna system, adding a tuning indicator or other special circuit feature to the receiver, installing a push-button tuner, adapting the receiver for electric phonograph and public address connections, and installing headphones, pillow loudspeakers, extension loudspeakers, remote control switches, time switches, photoelectric controls, inter-communicating systems, farm receivers and wind-driven power supplies. The remainder of this job sheet will deal with the restoration of radio cabinets, and following job sheets will show you how to do other extra-money jobs.

Refinishing the Radio Cabinet. It is not at all uncommon for a serviceman to put from $5 to $15 worth of work into a chassis in order to restore it to its original operating condition, then install this chassis in a marred or broken radio cabinet and consider the job finished. To the customer the cabinet is as much a part of his radio as is the chassis, and the cabinet still looks old and out of place. But it doesn't take long to clean the cabinet with furniture polish and fill in any scratches and gouges once you learn the correct procedure. If on your first visit to a customer it is obvious that the cabinet is in need of refinishing, ask the customer as you leave: "Would you like to have me touch up the cabinet after I bring back your receiver?" If the answer is "yes," you can bring your cabinet refinishing kit along with the repaired chassis, and do the work right in the home.

Cabinet refinishing is a profession in itself, and men trained in this work are located in practically every large town. The average housewife rarely thinks of calling such a man, however, except when a general refinishing of all furniture is contemplated. Radio dealers likewise hesitate to call in a professional cabinet refinisher; your ability to restore the finish of new radio cabinets (which are damaged during shipment

FIG. 2. Typical scratch removers; these generally contain a solid stain at one end (which is rubbed into scratches and slight defects) and a brush or buffer at the other end to smooth the applied stain. This is to be considered as "first aid" for minor scratches such as sometimes occur when delivering radio cabinets, rather than as a permanent repair.

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while displayed on the floor) and repair the cabinets of trade-in radios will be a decided asset in your transactions with radio dealers. Furthermore, if you are in a small community where there is no competent man for this work, you can extend your activities to other pieces of furniture as well.

In this job sheet we can only consider the simpler refinishing jobs. If you want to learn more about the subject of furniture refinishing, particularly the refinishing of entire cabinets, I suggest you get in touch with the Golden Star Polish Mfg. Co., Kansas City, Mo. This firm sells complete refinishing kits with instruction books, as well as all necessary supplies.

Tools and Materials Required. The supplies required for filling in an ordinary scratch, a deep scratch or a deep hole, for repairing broken ornamental wood-work, for refinishing a damaged surface and for polishing an entire cabinet are remarkably few considering the fine work which can be done. Remember that "practice makes perfect;" practice on old furniture in your own home until you are confident you can do a neat job. Know your limitations, so you can turn down jobs which are beyond your ability.

You will need the following supplies:

1 pint of rubbing oil. Mix ⅜ pint linseed oil with ⅛ pint benzine and place in a tightly-corked bottle.

1 tube or can of furniture glue, of a reliable make.

½ pint of turpentine.

½ pint walnut stain (alcohol base).

½ pint mahogany stain (alcohol base).

½ pint wood alcohol.

1 small can of plastic wood.

½ pint quick-drying clear varnish.

½ pint high-quality furniture polish.

1 scratch remover.

1 stick of transparent burning-in shellac, and assorted light and dark sticks of walnut and mahogany stick shellac.

1 small can of 0000 pumice powder.

1 package each of medium, medium-fine and fine sandpaper.

1 small camel hair artist's brush.

3 or 4 yards of cheesecloth.

1 alcohol lamp (you can make this by cutting the spout off a small oil can so that only an inch of it is left, then rolling up about a 1-foot length of cheese-cloth and pushing it through the spout from the bottom so that about half inch of cloth projects up. The remainder of the cheesecloth is pushed into the can so that it is immersed in the wood alcohol with which the can is filled.)

1 spatula. (A grapefruit knife may be used instead.)

Many of these items may be purchased from a hardware store, and others can be secured from a paint store. They are not expensive. Keep them in a small wooden box with a hinged cover, and place this box in a location where it will be handy to find when you want to take it out on a job. If you prefer, you can buy a complete refinishing kit which will contain all of the necessary materials; these are obtainable from your radio jobber or distributor. Typical kits are shown in Fig. *1*.

Removing An Ordinary Scratch. We will now consider the procedure involved in removing a simple scratch which is deep enough so that it cannot be covered with ordinary furniture polish or the simple scratch removers shown in Fig. 2, yet is not so deep that the white of the wood shows at the bottom of it. The photographs in this

TO REMOVE SCRATCH

HEAT ... **and g**

SAND with fine grade of sandpaper

FINISH wit ice

job sheet illustrate the procedure involved; study them carefully, for they will help you to develop a suitable technique.

First of all, spread newspapers or cloth on the floor around the cabinet, and place on the cabinet a sheet of cardboard for the alcohol lamp, box of pumice powder, rubbing oil, spatula, stick shellac, and stain. Heat the tip of the spatula by holding it in the blue portion of the alcohol lamp flame; get the blade just hot enough so it will melt off a little of the stick shellac. The alcohol lamp is essential, for any other flame will discolor the shellac. Use the color of shellac which most nearly matches the finish of the wood; if the bruise merely presses down the wood without breaking through the finish, it is best to use the transparent stick shellac, for this will allow the original color and grain to show through. Holding the shellac near the scratch, transfer the shellac to the scratch a little at a time, reheating the spatula when necessary, until the depression is entirely filled. If the shellac is bubbling while on the spatula, allow to cool a second or so until the shellac is smooth on

al ol flame, ellac on it

THEN fill indentation until shellac comes above woodwork

g oil and pumn cloth

POLISH entire surface of cabinet

the blade. Smooth out well around the edges with the slightly-heated spatula, being careful not to burn the surrounding finish, then remove surplus shellac with a razor blade or fine sandpaper. Now form a small wad with a piece of cheesecloth, moisten this with the rubbing oil, dip the wad in the box of pumice powder, then rub the wad carefully over the filled-in scratch, working with the grain of the wood. For a brighter finish, repeat once using rotten-stone instead of pumice. Finally, polish the entire surface of the cabinet, including the scratch, with furniture polish.

Filling In A Deep Scratch. When the scratch is so deep that the white of the wood shows, it will be necessary to apply stain first if you plan to use transparent shellac. With colored shellac, staining is optional First trim the edges of the scratch smooth with a sharp knife, removing all splinters; in the case of an old scratch clean out dirt thoroughly with a knife, cutting away more wood if necessary. Now pour a small quantity of stain into a small glass, then thin out with wood alcohol until the desired shade is secured. Always make the stain lighter than you need, and apply enough extra coats with the small brush to give the desired match. Allow the stain to dry, then proceed to fill in the scratch with transparent stick shellac; smooth it out with a warmed spatula, trim off surplus shellac with a razor blade, rub down with a wad of cloth dipped in oil and pumice stone, and apply furniture polish.

Filling in Gouges With Plastic Wood. Deep bruises, gouges or holes should be filled in with plastic wood rather than with stick shellac. Broken wood ornaments can be repaired with plastic wood in much the same manner. It is a good idea to enlarge the bottom of the depression slightly, to make the plastic wood hold better. There should be no varnish, oil, dirt, or loose particles of wood in the depression, so clean out thoroughly with a knife, then wipe out with alcohol. Apply the plastic wood with the tips of your fingers or with the spatula, and smooth the surface with the spatula. When building out from a surface to replace an ornament, shape with your fingers to match the rest of the design. Allow the plastic wood to dry thoroughly, then cut or sand the surface down, or trim it to the shape which you desire. Next, apply stain carefully with the small brush until the plastic wood matches the finish of the cabinet. Sand lightly again, then apply a coat of clear varnish. Allow twenty-four hours for this to dry, sand smooth with medium-fine or fine sandpaper, then rub down with the oil wad dipped in pumice stone, working with the grain. Finally, finish the job with furniture polish.

Regluing Broken Cabinets and Loose Veneer. Clean out all foreign material such as grit, dust and old glue from the break, so that the broken parts can be fitted together as closely as possible. Apply glue to both surfaces of the break, and allow the glue to become tacky by keeping the surfaces apart for five to ten minutes. Now bring the broken parts together and apply pressure either with a weight or a clamp. Alw protect the surfaces of the cabinet with wo en blocks when doing this, as illustrated

Fig. *3*. Allow about twenty-four hours for the glue to dry, then remove the clamp and cut away any surplus glue which has oozed out of the joint; smooth with fine sandpaper, then treat the exposed fracture just as if it were a small scratch. If finishing nails are used to hold the broken parts together, drive the heads below the surface of the wood, then fill the nail holes with stick shellac or plastic wood.

Refinishing a Surface. A small section of a radio cabinet sometimes becomes disfigured due to spilling of hot water, coffee or alcohol, or becomes cracked and discolored due to exposure to weather. In a case like this it will be wise for you to refinish a complete panel or section of the cabinet which includes the defective region, so that any difference in the color of that section will not be too apparent. First of all, remove the finish from the section until you are down to the bare wood; do this by securing a small can of varnish remover and applying with a paint brush. Allow it to stay on the surface until

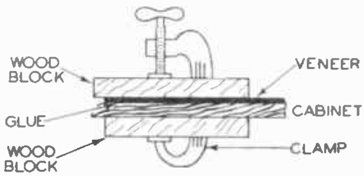


FIG. 3. Use one or more clamps like this when regluing loose veneer on a cabinet.

the varnish begins to curl up, then scrape or rub off the varnish with a putty knife or scrubbing brush. If the first application of the varnish remover is not sufficient, apply a second and even a third coat. Finally, wipe the surface of the wood clean with a rag dipped in the varnish remover.

Allow the bare surface of the wood to dry thoroughly, then smooth down carefully with medium grade sandpaper. Be sure that the entire surface is clean before proceeding with the refinishing. Mix a quantity of stain to a shade which will match the rest of the cabinet, then apply carefully with a brush. If this gives too dark a finish, wipe the surplus stain off before it gets a chance to dry. Allow the stain to dry, sand with medium-fine sandpaper or with steel wool, wipe with a tack rag (dip a rag in varnish, and allow it to dry until it feels sticky but the varnish does not come off the rag), and apply clear varnish with a clean brush, working with the grain of the wood. (Some cabinet refinishers prefer to apply a priming coat of shellac or special wood filler across the grain, rubbing this in with a wood block, after applying the stain.) Do not use too much varnish; it is better to use less when in doubt. Wipe off excess varnish around the edges. After the varnish has hardened (at least a day will be required), smooth with medium-fine sandpaper or with 2/0 steel wool, then dust off and clean with a tack rag, and apply a second coat of varnish. When the second coat is thoroughly dry and there are no open pores which indicate the need for a third coat of varnish, rub the surface with a wood block which has been covered with felt and dipped first in oil then in the powdered pumice stone. Polish until you get the desired finish. If you want a high-gloss finish, repeat the rubbing process, using rotten-stone powder this time instead of powdered pumice.

The importance of using a clean brush when applying either stain or varnish cannot be emphasized too strongly. Furthermore, the surface being refinished must be absolutely free from dust particles before applying varnish. Work of this nature is best done in a room which is practically air-tight and free from dust, and ample time should be allowed for the varnish to dry before moving the cabinet.

Polishing. The final step in any cabinet refinishing job is a polishing of the entire cabinet. You can purchase excellent furniture polish for this purpose from any reliable hardware store or drug store. If you wish, however, you can prepare a suitable polish yourself in a few minutes and at a cost of only a few cents. Here is the formula:

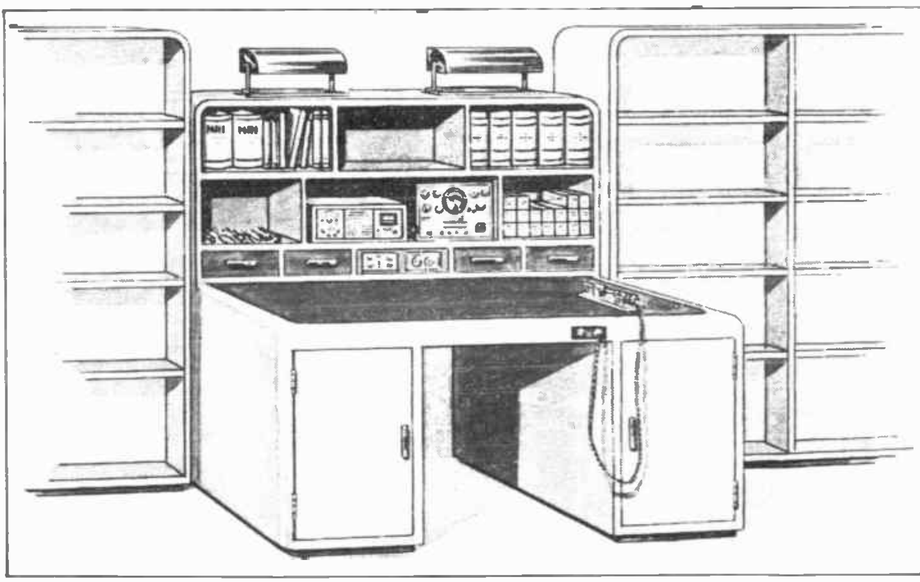
Mix together one part paraffin oil, one-half part white vinegar, one-fourth part of Johnson's liquid wax, and two and one-half parts water. Measure carefully with a graduated measuring cup to be sure that the proportions are correct. To each pint of the completed polish add one-half teaspoonful of powdered pumice stone and one-half teaspoonful of granular (flaked) Ivory soap. Place all these ingredients in a bottle having a small neck, and shake thoroughly. Be sure that you shake this mixture before using.

Apply a thin coat of furniture polish to one section of the cabinet at a time, using a small pad of cheesecloth for the purpose. Polish this section with a dry, clean piece of cheesecloth before proceeding to the next section; this picks up any dirt which has been loosened by the soap and pumice in the polish. Always work with the grain when polishing a cabinet. Old wax may be removed with a cloth dipped in turpentine. If furniture having a natural dull finish is dirty, clean with a cloth dipped in mild soapy suds and wrung dry, then wipe with a clean, dry cloth. Do not use a wax polish in this case.

Planning Your Service Bench and Shop

A SPECIAL workshop with an elaborate service bench is not needed for carrying out the laboratory experiments in connection with your regular Course, nor for acquiring servicing experience, but sooner or later, if you have chosen radio servicing as your profession, you will want to have a workbench and a special room for radio work, to increase your efficiency. Furthermore, an efficient modern workbench in a carefully planned shop will create a good impression when customers bring in their radios or call for them, as they occasionally do. These customers will tell their friends about your fine shop, and this "mouth-to-mouth" advertising is the very best you can possibly secure.

Location of Shop. A great many independent servicemen have their shops right in their own homes; this fact is recognized by most radio set owners as a normal condition in the radio servicing industry. As a general rule, a store is profitable only for large service businesses where two or more men are employed, and where radio receivers and electrical appliances are sold. Don't rush into the merchandising field; concentrate on your radio servicing business at first, working from your own home, so you can build up your capital in preparation for future expansion.



Artist's sketch of the completed workbench for which plans are given in this job sheet. It has room for all the tools, instruments, supplies and power facilities you will need for servicing radio sets; finished in a dignified modern color scheme such as cream and dark green enamel, it will inspire you to better work and favorably impress all who come to your shop. Later you can build shelves which can be set against the wall alongside the bench. Two 75-watt lamps in reflectors will provide adequate illumination.

Almost any available space in a home may be converted into a service shop. Possibly you have extra space in the basement which can be partitioned off with wood panels or plywood. A basement location should be near an outside entrance if possible, so you can carry radio sets directly from your car into your shop, and so your customers can come directly into the shop. Later you may want to rebuild the entrance to give it a dignified, commercial appearance. Many a serviceman is using the first room off the front entrance of his home as a service shop, just as dentists and doctors do.

Equipping Your Shop. By keeping in mind the goal of a profitable full-time service business, and making each step in the equipping of your shop a part of the final scheme, you can start your own permanent business with very little capital. The most important piece of furniture in your shop is the workbench; this should provide a well-lighted working space at the proper height, with shelves for your portable test equipment (an all-wave signal generator, an all-purpose multimeter, and a tube tester) and for the simple vacuum tube circuit analyzer described in a previous job sheet. Later on, you can purchase bench type test equipment and mount it permanently on your workbench, reserving the portable equipment for outside work.

Your workbench should have space for your N. R. I. text-books in suitable binders, and for any tube charts, reference books, radio catalogs and technical books which you may have. There should be room for the service manuals which are published yearly and which you will want to acquire as soon as your business warrants (N. R. I. will gladly loan you service information on any receiver while you are getting started, but once you begin getting a reasonable amount of business you will not want to hold each job for several days while waiting for our reply.) There should be a number of A. C. power outlets, one or perhaps two antenna connections, a ground connection, and terminals for any other types of power supplies which you may find advisable.

The tools which are essential for radio service work are described in an earlier job sheet; these should be kept in your tool box right on the bench, ready to be carried out when you are called to a customer's home, until such time as you can get a duplicate set of tools which can be kept on the workbench at all times.

Plan to build up a stock of tubes and parts gradually; the farther away you are from a radio parts jobber, the more complete your stock should be. A stock of carbon resistors, wire-wound resistors, paper condensers, mica condensers, and electrolytic condensers can be made quite complete without a large investment. You might also keep on hand one each of standard 175 kc., 260 kc., and 456 kc. I. F. transformers, but do not attempt to stock volume controls, R. F. coils and oscillator coils since exact replacements will usually be required for these parts. A stock of tubes will involve the greatest expenditure of money. From a tube manufacturer get a list of the replacement tubes which were most used during the previous year, and order one or more of the first twenty or thirty tubes on this list.

Workbench Plan. General construction features of the modern service bench which we recommend are shown in Fig. *1.* The

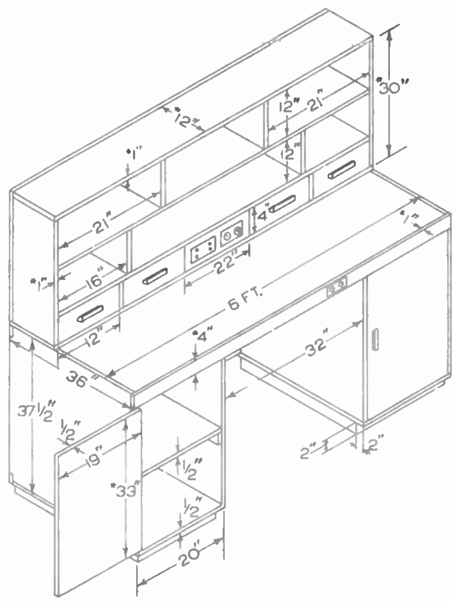


FIG. 1. Dimensioned sketch of a modern service bench which you can build for your shop. Dimensions marked with an asterisk (*) are approximate, and depend upon the actual sizes of the finished lumber used.

working surface of the bench is 39½" above the floor, this being a convenient height at which to work either while standing up or sitting on a high stool. The working area on top of the bench is six feet long and two feet deep, with a one-foot deep shelf unit at the rear. The bench top is supported by a cabinet at each end, which provides additional storage space.

Five-ply plywood is used extensively in the construction of this bench; this usually comes in 4' x 8' sheets about one-half inch thick. One-inch thick finished lumber is used for the shelves, shelf supports, the bench top supports, and for connecting pieces, while 2" x 2" pieces form a base for each cabinet. If you anticipate difficulty in cutting the pieces accurately to size, ask a friend who is handy with tools to help you, or have them cut to size by the lumber company or a local carpenter. The important dimensions are given in Figs. *1* and *2*; those dimensions which are marked with an asterisk (*) should be checked carefully before cutting any pieces, for finished lumber is usually considerably thinner than the size ordered.

Construct the Cabinets First. Constructional details for the left-hand cabinet are shown in Fig. *2*. The two sides, the back, the bottom, the 19" x 35" shelf (not shown) and the 19" x 33" door (not shown) are of five-ply plywood. The height of the inner side is less than that of the outer side by the thickness of the bench top (check this thickness, for if the one inch lumber is actually only ¾" thick, you will have to add ¼" to the specified height of the inner side). Cut notches in the corners of the side pieces as indicated, for the 6' long lengths of 1" x 4" lumber which join together the two cabinets. Make these notches the actual size of the lumber (usually 3¾" x ¾"). Fasten the shelf and top supports to the plywood pieces with 1¼" long flathead wood screws, keeping the heads on the inside in each case. File off any screw points which come through the outside of the plywood. Make the base next, using 2" x 2" wood and assembling either with ordinary nails or with the special corrugated nails which are available in most hardware stores. Fasten the base to the bottom of the cabinet with glue and wood screws keeping it flush with the back and the inner side; this will leave a 2" space at the front and at the outer side for toe room and to improve appearance.

As an aid in assembling the cabinet, secure four 20" lengths of 1" x 4" wood; nail one into each set of notches on the side pieces, and one across the lower front corners to hold the sides exactly 19" apart. Use small nails, since you will remove these pieces after assembly. Now fasten the bottom plywood piece to the bottoms of the side pieces, using glue and about 1" finishing nails or [illegible]" flat-head wood screws. Next, fasten the back piece between the two side pieces. Finally, fasten the shelf in position with wood screws, after applying glue to the top of each shelf support. The temporary boards may now be removed. Before driving nails or drilling holes for screws, draw a pencil line as a guide, to make sure that the nail or screw will go exactly into the middle of the other piece. Countersink all screw holes, and drive the heads of nails below the surface of the wood with a nail punch.

Having finished the left-hand cabinet, make another exactly like it but with the inner and outer sides interchanged. The base will be flush with the inside and back edges of the bottom board, just as before. Assemble the pieces in the same order and follow the same procedure as for the left-hand cabinet. Now place the two cabinets exactly 32" apart and fasten the three six-foot lengths of 1" x 4" lumber into the notches at the top front, top rear, and bottom rear of the cabinets. If you plan to use the bench permanently in the location of assembly, use glue and either nails or

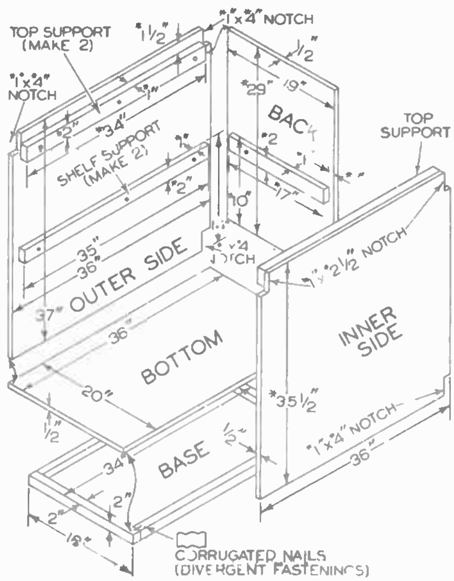


FIG. 2. Detail sketches of the parts used in building the left-hand cabinet. Dimensions marked with an asterisk (*) are approximate, and depend upon actual sizes of lumber.

screws; if, however, it may be necessary to take the bench apart in order to move it into some other room, use only wood screws here.

The top of the workbench is made with 1" thick boards covered with a single sheet of ½" plywood. The boards can be anywhere from 6" to 12" wide, and should preferably be of the tongue and groove type. Assemble the boards with corrugated fasteners to form a sheet 71" long and 34" wide, then cut from five-ply plywood a single piece of exactly this same size. Fasten the boards to the plywood with wood screws, working from the board surface so that there are no screw heads in the plywood surface. If you prefer, you can use either a solid green or a solid brown color of linoleum in place of the plywood, provided you change all dimensions on the work bench to accommodate the reduction in the total thickness of the top. The top, when finished, should fit exactly into the space provided by the 1" x 4" pieces and the outer side pieces. Use small metal angle brackets underneath the top to fasten it to the top support pieces. Now round off the corners of the workbench and shelf as indicated in the sketch of the finished bench. Use a plane and wood file, and smooth down with sandpaper.

For the horizontal pieces in the shelf unit get two 70" and two 72" lengths of 1" x 12" finished lumber. Cut two 30" long pieces of the same lumber for the end pieces, four 12" long pieces for inside vertical supports and four 4" long pieces for inside vertical supports. The panel for the antenna and ground terminals and the power outlet, located in the center of the lowest shelf, can be 4" x 22", cut from ½" plywood. The four drawers can likewise be made from ½" plywood; for each drawer you will need two pieces 4" x 12", two pieces 4" x 11" and one piece 11" square. Assemble the drawers with glue and brads, then attach simple bar handles of modern design.

Two 19" x 33" pieces of ½" plywood serve as cabinet doors; mount with chromium-plated hinges after cutting notches for each hinge, then install concealed latches like those used on modern kitchen cabinet doors.

A single piece of plywood approximately 32" x 72" can now be nailed to the back of the shelf unit: this can either be ¼" plywood, ½" plywood, or any other similar material. Now remove the two end drawers in the shelf unit, and drill and countersink holes for two wood screws which will hold the shelf unit in position on the top of the workbench, flush with the back of the bench.

Power connections can be made next. First of all, install a two-wire porcelain fuse block (also known as a two wire branch block) somewhere on your bench, such as inside one of the cabinets. Connect a heavy-duty rubber covered appliance cord to this block, attach an ordinary electrical plug to the other end of the cord, then connect the fuse block to the electrical outlets which are set into the front of the workbench and mounted on the center panel of the shelf unit. Use chromium-finished plates on these outlets.

Finishing Your Workbench. First of all, remove all hardware, including the drawer and door handles, the door hinges, the electrical outlet plates, and the antenna terminal plate, then remove the top shelf and the top of the workbench. If you are using linoleum for the top, lay it aside until the final assembly; otherwise treat the top along with the other pieces, as follows. Fill all cracks, poor joints, and nail holes with plastic wood or some other crack filler. Allow to dry, then sand down any rough spots.

Apply a coat of flat white paint to both the inside and outside of each part of your workbench, including the top. Allow two days for this to dry, smooth any rough spots in the paint with sandpaper or steel wool, then apply a second coat and allow two more days for drying. Repeat the smoothing process if necessary, then wipe off all dust carefully with a cloth moistened with turpentine and apply the finishing coat of high-grade enamel. Use an enamel which will dry to the touch in four hours: this is sold under such trade-names as Super-Enamel or Nu-Enamel, and generally contains a high percentage of tung oil. Here is a suggested color scheme: Use dark green or brown for the exposed portions of the base and for the top of the workbench; use cream or white enamel for the cabinets and the entire shelf unit. If you like, you can paint the inner surfaces of the shelves and the fronts of the drawers the same color as the base and bench top Apply one color at a time, allowing it to dry before starting the second color. Allow a few days for the first coat of enamel to dry, then rub down the entire bench lightly with fine steel wool or fine sandpaper to remove irregularities and dust particles on the surface. Wipe carefully, then apply a second coat of enamel. Allow at least a week for this to dry before reassembling and using your workbench. For the final step, apply several coats of ordinary floor wax and rub each down briskly with a soft cloth. Now you have a workbench of which you can well be proud; it will justify every minute of the time spent in constructing and finishing it.

Here are a few hints which will give you a better paint job. Use a clean brush, about 2" or 3" wide, with long bristles which are set in rubber. Clean out the brush with turpentine each time after you finish, then suspend it in turpentine. Both the paint and the enamel should have the consistency of ordinary cream when ready to use. Stir thoroughly after opening the can, and add thinner only if absolutely necessary after stirring for at least fifteen minutes. Always paint in one direction on a single surface. Never apply so much paint or enamel that it begins to run. Before leaving the job, go over all corners carefully with the brush to remove any surplus paint.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

How to Install Farm Receivers

RURAL districts form an important market for radio receivers. Although electrification of rural areas is progressing, there are still many farm homes which are not served by power lines; radio sets on these farms must secure their power either from batteries or from a farm power plant. The only essential difference between farm radios and ordinary A.C. receivers is in the power supply; you should have no trouble in applying ordinary radio techniques to the installation and servicing of farm receivers. If you are located in a town which serves a farm area, rural customers can boost your income considerably.

Farms With A.C. Power. When a farm home is supplied with 115-volt, 60-cycle power, the radio installation problem is no different from that for any urban home. A standard A.C. receiver, generally of the all-wave type, can be used. If there is no man-made interference in the vicinity, an ordinary L-type antenna having a total length of not more than 40 feet will give as good results as the average simple all-wave antenna on short-wave bands; use this length if the owner desires the best possible short-wave reception and fair broadcast reception, but use an over-all length of over 100 feet if the owner desires the best possible broadcast and only fair short-wave reception. An outdoor ground will usually be necessary for best results. A lightning arrester should always be installed on any farm antenna system, in order to comply with fire insurance regulations.

Farms With 32-Volt D.C. Power. A 32-volt farm power plant usually consists of a gas engine-driven 32-volt D. C. generator which charges a large 32-volt storage battery. For a home having this power, by all means recommend a 32-volt farm receiver. These will usually have the filaments of tubes connected in series-parallel to keep the drain on the power system as low as possible. A special 32-volt vibrator-rectifier-filter pack will usually be built right into the receiver to supply the required D.C. voltages for the other tube electrodes.

If the receiver to be installed is designed for some other operating voltage, it may be possible to adapt this receiver to 32-volt

Unit for reducing 32-volt output of farm power plant to 6 or 2 volts for tube filaments of a battery receiver.

This self - rectifying vibrator unit boosts 2, 6, 12 or 32 volts D.C. to higher D.C. values for farm radios.

operation. If the receiver is old and inadequate in performance, or if the cost of adapting it to the power system approaches that of a new receiver, by all means recommend a new set.

A 6-volt farm receiver using "B" and "C" batteries may be adapted to 32-volt D.C. operation by adding a voltage-limiting device and a 32-volt vibrator type voltage booster. The voltage-limiting device will usually have an inexpensive voltmeter to indicate the voltage applied to the radio set. Receivers designed for operation from 1.5-volt and 2-volt filament batteries, with plate supply requirements of from 90 to 180 volts,

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may also be adapted to 32-volt operation in this manner, but there is considerable waste of power when using this method.

A 115-volt, 60-cycle receiver can be adapted to a 32-volt D.C. power system by employing a rotary converter consisting essentially of a 32-volt D.C. motor which is connected to the farm power plant and which drives a 115-volt, 60-cycle A.C. generator; the two units ordinarily have a common armature. A ripple and noise filter must always be used with a rotary converter; sometimes this will be mounted in the base of the converter.

Farms Without Power Supplies. Farms which are off the main highways will seldom have power line facilities. If no independent power supply is present and a radio receiver is to be installed, your recommendations should be based upon the factors now to be discussed.

Batteries for farm radio receivers: *A*—Air cell "A" battery; 1.4-volt unit will give 1,500 hours continuous service at current drain of 200 ma.; 2-volt units are available in various capacity ratings; air cells cannot be recharged. *B*—2-volt storage battery, rated at 150 ampere-hours for radio use in sets having 1.4 or 2-volt tubes. All storage batteries can be recharged. *C*—6-volt storage battery, available with various ampere-hour ratings. *D*—Dry "A" battery pack, available with 3-volt output for 2-volt tubes (a voltage-reducing resistor is needed) and with 1.5-volt output for 1.4-volt tubes.

First of all, the farmer should consider the installation of his own electric power plant, to provide power for electric lights and home appliances as well as for a radio receiver. If there is a possibility that an A.C. power line will eventually be brought up to his farm, you should recommend a 115-volt, 60-cycle A.C. generator system driven by a gasoline engine, so that standard electrical appliances and an A.C. radio can be used. When electrification is a remote possibility, either an A.C. system or a conventional 32-volt battery system charged by a gas engine-driven generator can be considered. Careful investigation should be made of both systems, comparing initial installation costs and upkeep expenses.

Battery Receivers. When the additional cost makes the installation of a complete farm power plant out of the question, a battery receiver must be considered. Give careful consideration to the power consumption of the receiver, for constant charging or changing of batteries is a nuisance and can be quite costly. Filament power consumption and B supply drain are of almost equal importance. A battery receiver should have only as many tubes as are necessary to give loudspeaker operation; four tubes can provide all the audio output required for the average room. The loudspeaker should be either of the magnetic or the permanent magnet dynamic type, since these require no excitation power. When higher audio power output is desired, choose a receiver having a class B push-push output stage, for with this arrangement the power consumption is high only while high volume is required.

To conserve filament power, special low-filament-current tubes are invariably used in farm battery receivers. Three series of tubes are in general use: *1.* Two-volt tubes, designed to operate from dry cells or an air cell battery; *2.* 1.4-volt tubes, designed primarily for operation from a 1.5-volt dry cell; *3.* Ordinary 6.3-volt tubes, for operation from a 6-volt storage battery.

A 3-volt dry battery pack can be used with a 2-volt receiver in place of an air cell if a 10-watt wire-wound resistor of the proper value is placed in series. To find the correct value in ohms for the resistor, divide 1 by the receiver filament current drain in amperes. Example: If filament drain is .24 ampere, use a 4-ohm resistor.

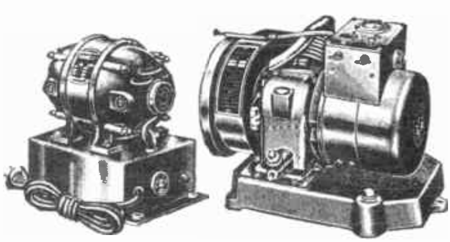
One-Battery Farm Receivers. Many farm receivers are designed to operate from a single battery. Newest of these are the receivers employing 1.4-volt tubes and designed to operate from a 1.5-volt dry battery pack. This one battery furnishes filament power to the 1.4-volt tubes and furnishes the correct D.C. electrode voltages by means of an efficient vibrator-rectifier-filter system. Similar receivers operating from a 6-volt storage battery are also available; these are designed to have a very low battery drain.

Battery Chargers. A 6-volt farm receiver installation is not complete unless some means is provided for recharging the battery. Either a gasoline engine-driven generator or a wind-driven battery charger is suitable for farm use. A gas engine-driven battery charging generator is ordinarily placed in the basement under the receiver, along with the storage battery. The battery is connected to the output of the generator through a cut-off relay. When the battery is to be charged, the owner either presses the engine-starting button or starts the engine manually; as soon as the engine reaches normal speed, the cut-off relay automatically connects the battery to the charging generator. Since the battery is charged only when the receiver is not in use, no interference problems are involved. A storage battery used with a radio set should be given the same attention as a battery in an automobile; distilled water should be added regularly, and the condition of the battery should be checked regularly with a hydrometer.

Installing a Wind-Driven Power Supply

Wind-driven generators for battery-charging purposes are becoming increasingly popular in farm radio installations. The initial cost of a wind generator is ordinarily less than half the cost of a gas engine-driven generator, and a suitable high mounting for the wind-driven unit can generally be erected by the farmer at little expense. Ready-made steel towers are also available. With a wind-driven generator there is practically no operating cost. With a gas engine-driven generator the cost of charging a battery is likewise quite low; about 20 gallons of gasoline a year should suffice for the average radio. A gas engine-driven generator is a reliable source of power; it will operate at any time, whereas a wind-driven generator requires a minimum wind velocity before it will begin to charge.

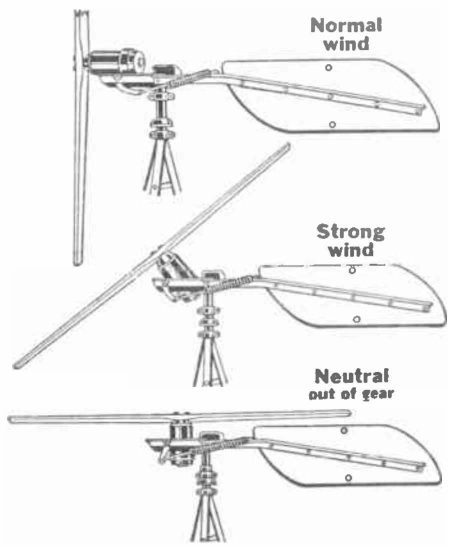
A wind-driven generator usually consists of a two-blade propeller mounted on the shaft of a generator, with a vane or tail attached to the assembly to keep the propeller facing into the wind when in use. A governor



Rotary converter for changing 32 volts D.C. to 110 volts, 60 cycles A.C. for ordinary A.C. radios. Line filter is in base of unit.

Gas engine generator unit with remote-control push-button starter, for producing 110 volts, 60 cycles A.C. for ordinary A.C. radios and for farm lighting purposes.

is usually provided to keep the speed of the propeller essentially constant; this governor can either tilt the propeller at an angle, control an auxiliary speed-regulating propeller, or decrease the efficiency of the main propeller in some other manner. A mechanism is also provided for locking the propeller at right angles to the wind when not in use or when the wind is too strong. The generator is usually of the 6-volt, 3-brush self-excited type. In addition, there will be a control panel containing an ammeter to



Typical wind-driven generator unit.

indicate the rate of charge and discharge, and a relay which operates for both overload and underload conditions. The receiver will often be in operation while the battery is being charged, and hence a filter is usually incorporated in the charging system to eliminate interference noise. Instructions for installing each type of wind-driven unit are supplied by the manufacturer and should be followed, but a few general hints will help you.

Wind generator units will ordinarily operate in wind velocities as low as 5 miles per hour, provided the propeller receives the direct force of the wind. If the propeller is "pocketed" between trees or buildings, so that wind is deflected around or above it, it will be difficult to secure satisfactory operation even in strong winds. In open country, height is not essential, but where there are buildings or trees in the vicinity, the wind generator must be mounted on a tower or pole which will place it sufficiently above surrounding objects.

Two wires must be run from the charging generator to the control panel in the basement of the home; sometimes this control panel can be placed in a weatherproof box mounted outside the house. If the generator is less than 50 feet away from the battery, use No. 8 B. & S. gauge copper wire with weatherproof insulation; for distances between 50 and 100 feet, use No. 6 B. & S. wire; for distances of 100 to 200 feet, use

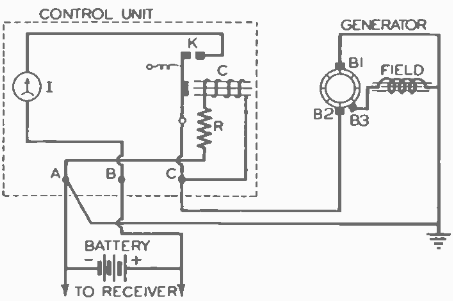


FIG. 1. Circuit diagram of typical wind-driven battery charger installation.

No. 4 wire. Since battery charging will be more or less irregular in a wind-driven installation, it is best to use a battery having a high ampere-hour rating. Batteries designed especially for radio use and rated at between 160 and 300 ampere-hours will give better performance than automotive storage batteries.

Generator Data. The generator unit will be essentially like that used in automobiles. The use of a 3-brush collecting system on the commutator makes it possible to maintain approximately constant power output for a considerable range of variation in speed. The circuit diagram of a typical wind-driven generator installation is shown in Fig. *1*; note that relay coil *C* and resistor *R* are in series with the generator at all times. Resistor *R* limits the current flow until sufficient generator voltage has been developed to charge the battery; when this voltage is reached, the current flowing through relay coil *C* is sufficient to close contacts *K*, connecting the battery and ammeter in series directly across the generator. If the battery voltage exceeds the generator voltage after contacts *K* have closed, current will flow through relay coil *C* in a reverse direction, demagnetizing the core of this relay and opening contacts *K*.

The battery should never be disconnected from a wind generator installation without first stopping the propeller or shorting resistor *R* to place a heavy load upon the generator. It is possible to vary the position of the third brush on the generator to change the speed at which contacts *K* will close, but the instructions of the manufacturer should be followed closely when making this adjustment.

Interference Problems. Any wind-driven generator may produce interference. A whining sound which changes in frequency with variations in wind velocity will probably be due to arcing at the brushes. To cure this, clean the commutator by wrapping 00 sandpaper over the end of a rectangular stick and holding this against the commutator while the generator is rotating. Slide the sandpaper back and forth along the commutator until the entire surface is smooth and bright. To make the generator act as a motor and rotate independently of the wind while cleaning the commutator, connect together terminals *B* and *C* in Fig. *1*. If the brushes require reseating, place a strip of sandpaper around the commutator with the cutting surface up, then rock the armature by hand while all brushes are resting on the sandpaper; this will make the brushes conform to the curved shape of the commutator.

If interference is still present, try grounding the frame of the generator to the tower and grounding the tower to the earth. Ground the control box if it is of metal. Place a .5 mfd. condenser between brushes *B1* and *B2* and a similar condenser between brushes *B1* and *B3* on the generator to reduce sparking. Finally, try running the antenna in a different direction or using a noise-reducing antenna.

Clicking sounds can be identified as due to the relay by listening to the receiver and to the control box at the same time. The trouble can ordinarily be cured by cleaning the relay contacts if they are pitted or rough, or by shunting the relay contacts with a .5 mfd. condenser in series with a 10 to 20-ohm resistor.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

How to Install a Push-Button Tuner

AUTOMATIC tuning has met with public approval, for it provides accurate tuning with no effort on the part of the listener, and permits almost instantaneous change-over from one station to another; manual tuning, on the other hand, requires considerable time and skill, and careless manual tuning results in distortion which soon becomes irritating to listeners.

Automatic tuning is fairly new, and consequently there are many older receivers in existence which lack this modern feature. These older sets are often performing satisfactorily, and consequently their owners can hardly be expected to purchase new receivers simply to secure the automatic tuning feature. Owners of these sets are ideal prospects for a push-button tuner. You can install these tuners yourself, at a charge which will insure you a fair profit and still be reasonable to the customer considering the fact that you have brought his receiver up-to-date Many different types and models of push-button tuners are on the market; standardize on one or two types and install at least one of them on radio receivers in your home for demonstration purposes.

Converter Type Push-Button Tuners. A converter unit is the simplest type of push-button tuner which you can add to a radio receiver, but at the same time it is the most costly. Briefly, the converter contains a combination oscillator-mixer-first detector stage which converts an incoming radio signal to the fixed frequency to which the broadcast receiver is set when automatic tuning is desired. The outdoor antenna is connected to the converter, and the output of the converter feeds into the antenna and ground terminals of the receiver. A typical converter unit is shown in Fig. *1;* since this has a self-contained power supply and is provided with a 15-foot cable, remote control push-button tuning is perfectly possible. The extra cost of this unit is quite justifiable when the customer desires remote control in addition to push-button tuning.

The method of connecting a remote control converter to a receiver is shown in Fig. *2.* The connecting cable contains three wires, with red, black and silver-colored insulation respectively. Two of the wires connect the antenna and ground terminals of the receiver to corresponding terminals on the remote control unit, while the third wire connects the antenna to the third terminal on the converter. Plugging the converter A.C. power cord into a nearby wall outlet completes the connections. If this converter connection interferes with reception on short-

FIG. 1. Meissner remote control automatic tuning unit, a converter-type unit which permits push-button tuning of any one of seven stations from any point up to fifteen feet away from the receiver. The eighth button restores manual tuning at the receiver, and the knob on the cabinet controls volume. This unit may be used with any T.R.F. or superheterodyne receiver.

wave bands, you can install a double-pole, double-throw toggle switch on the receiver panel and connect it as shown in Fig. *3;* for manual tuning on short-wave bands, the switch is thrown to the left, disconnecting the converter and connecting the aerial directly to the receiver.

With the converter connected, turn on the receiver and tune to the lowest possible broadcast frequency (somewhere between 530 kc. and 560 kc.). No interference should be heard at this setting; this is a test you should make before considering a converter unit. Turn on the converter unit and adjust it for minimum volume, then advance the receiver volume control until a hiss is just heard. Mark the setting of the receiver volume control in some way now, as it will be necessary to use this setting whenever automatic tuning is desired. Allow both receiver and converter to warm up for about half an hour, during which you can make a list of the seven local and near-local stations chosen by the customer, look up their frequencies, assign one to each button while keeping in mind the range of frequencies controlled by each knob (indicated in Fig. *2*), and place station call letter tabs on the buttons. When the set has warmed up, advance the volume control on the converter, push in a button, and rotate the small knob above that button until the desired station is heard with maximum volume; if the receiver has a tuning indicator, use it as a guide. Repeat for each other button. Each adjusting knob controls two tuned circuits in the converter, one for the oscillator and the other for the R.F. input circuit.

Lower-priced converter units, designed to be mounted on a superheterodyne chassis and connected directly to the I.F. section of the receiver, are also available; one of these is shown in Fig. *4*. These units are used when remote control is not wanted;

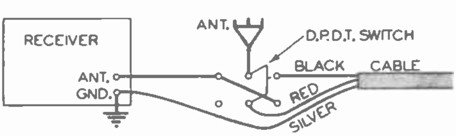


FIG. 3. Special switch connection for disconnecting Meissner remote control unit when tuning short-wave stations.

they replace everything ahead of the I.F. amplifier, and can be used with any broadcast or all-wave A.C. superheterodyne having an I.F. value of between 456 kc. and 465 kc. Filament voltages and other electrode voltages are secured by connections to the proper points in the receiver. Instructions for installing are furnished with each unit.

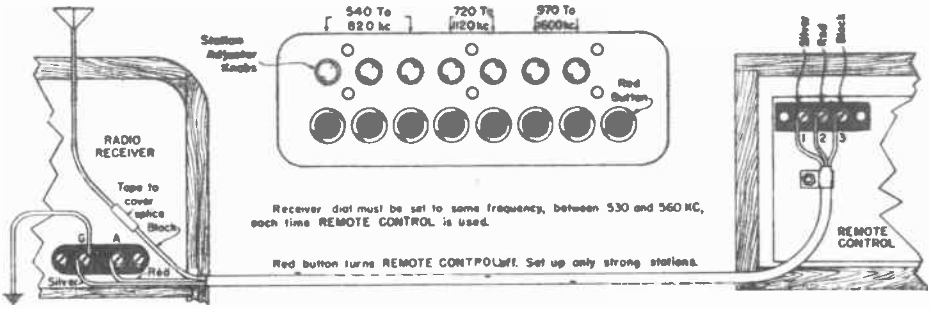


FIG. 2. Connections for Meissner remote control tuner.

Trimmer-Type Push-Button Tuners. When a receiver has only two tuned sections in its R.F. system (a two-section variable tuning condenser), one of the inexpensive push-button tuner units shown in Fig. *5* may very easily be installed to provide automatic push-button tuning. Connections are simple; the chief problem is in finding a suitable location for the unit either on the receiver front panel or somewhere on the cabinet. The space required is ordinarily about 3" x 7" on the front panel, and there must be about 6" of room directly behind the chosen location. Whenever possible, the tuner should be mounted directly on the chassis, to simplify removal of the chassis; metal brackets can be used for this purpose. Connecting leads should be kept as short as possible; in a broadcast receiver a location near the variable tuning condenser will be satisfactory, while in an all-wave receiver the push-button tuner should be placed as close as possible to the band-changing switch.

FIG. 4. Meissner push-button converter unit designed for mounting directly in a receiver.

The tuner units shown in Fig. *5* each have two sets of trimmer type condensers, one for the oscillator circuit and one for the R.F. input circuit of the receiver. Each push-button controls a switch which first disconnects any other trimmers which may be in the circuit, then inserts a pair of trimmers which are preadjusted to tune in the station assigned to that push-button. (This mechanism is fully explained in your regular Course.)

With one type of push-button tuner installation, the main tuning condenser in the receiver is automatically disconnected from the receiver circuit when push-button tuning is used; this is known as the *full automatic system*. It is entirely satisfactory for a broadcast band receiver, but is not recommended for installation by servicemen in all-wave receivers. In the other type of installation, the trimmers in the push-button tuner are in parallel with the respective sections of the variable tuning condenser in the receiver when automatic tuning is used. This is known as the *semi-automatic system*, because the main tuning dial of the receiver must be turned to the highest possible broadcast band frequency when push-button tuning is desired. If properly connected, this system will be satisfactory for all-wave receivers.

Tuner lead 5 goes [illegible] the tuning [illegible] frame in all cases. [illegible] the manua[illegible] button on the tuner is depressed, the two si[illegible]gle-pole, double-throw switches in the tuner connect lead *1* to lead *2* and connect lead *3* to lead *4*, restoring the original receiver circuit and permitting the receiver to be tuned manually in a normal manner. When one of the other push-buttons is pressed, these two circuits are opened and one trimmer condenser in each section is connected into the receiver circuit.

FIG. 5. Typical trimmer-type push-button tuners. These can be secured from radio jobbers and mail order radio supply houses. Each comes complete with escutcheon, mounting screws, and a sheet of printed call letters for U. S. broadcast stations, from which tabs for the desired stations can be cut.

Full-Automatic Operation. A schematic circuit diagram for a full-automatic connection of a push-button tuner in a typical receiver is shown in Fig. *6A*. The general procedure for making these connections is as follows: *1.* Disconnect *all* leads from the *two* terminals which are on opposite ends of the stator of the mixer section of the gang tuning condenser, and solder these leads together (if some are above and some below the chassis, make the connection with a short length of insulated wire which is run through a hole in the chassis); 2. Connect push-button tuner lead *2* (Fig. *6A*) to either terminal of the mixer stator (use whichever is more convenient); 3. Connect push-button tuner lead *1* (Fig. *6A*) to the leads which you disconnected from the stator. Make oscillator circuit connections the same way, connecting lead *3* (Fig. *6A*) to the common junction of the original oscillator stator leads, and connecting tuner lead *4* to one terminal of the oscillator stator. Keep all leads as short as possible.

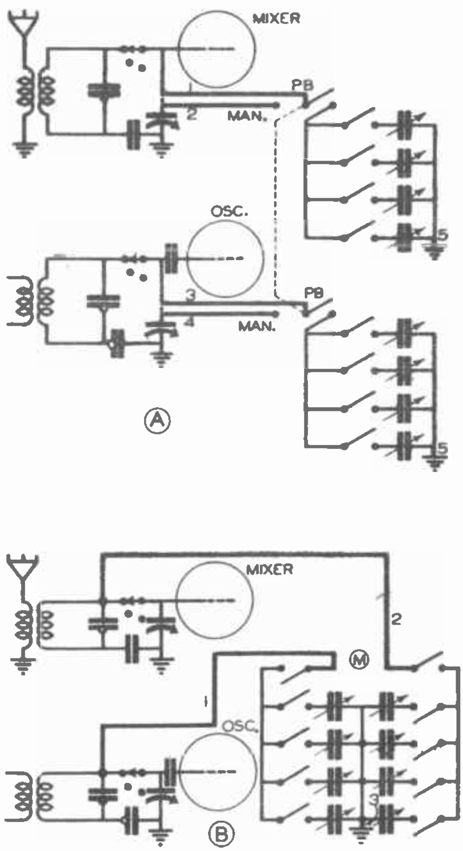


FIG. 6. Full-automatic (*A*) and semi-automatic (*B*) connections of a trimmer-type push-button tuner to an all-wave superheterodyne having a two-section variable tuning condenser.

[illegible]*omati*[illegible] *[illegible]ation.* The [illegible] fun[illegible]da-[illegible] for [illegible] type of push button [illegible] shown in Fig. 6B. Note that there are only three leads to the push-button tuner. Pressing the MANUAL push-button opens the two upper switches marked *M*, disconnecting the tuner; pressing any other button closes the switches at *M*, and at the same time closes the switches for the desired pair of trimmer condensers.

With broadcast receivers, lead *1* may be connected to the oscillator stator section of the tuning condenser, and lead *2* may be connected to the mixer stator section. With an all-wave receiver, leads *1* and *2* should be connected to the oscillator and mixer coils for the broadcast band rather than to the stator sections of the variable condenser, so that these leads are disconnected at the receiver end when the MANUAL button is pressed and the band-changing switch is set to a short-wave band; this prevents any capacity between the leads and the chassis from affecting the receiver dial calibration on short-wave bands. Since the contacts on the band-changing switch connect directly to these coils, it is usually simpler to make connections to the switch contacts. The switch will be under the chassis, so drill two holes through the chassis for the leads.

Trimmer Adjustments. In push-button tuner units, no one trimmer covers the entire broadcast band. Trimmers having only a few plates are used to tune in stations at the higher broadcast band frequencies, while trimmers having many plates are used for the lower-frequency broadcast band stations. This is done to prevent any adjustments from being too critical. In a six-button tuner the range of each adjustment will be very much like that shown for the adjusting knobs in Fig. 2.

Before setting up the trimmers for a tuner, make a list of the stations which the customer wishes to tune automatically. These should be only local stations and nearby stations which are received reliably at all times. Determine the frequency of each selected station, arrange them in the order of frequency, assign each station to a button having an adjustment range which will permit its reception, and insert the station call letter tabs on the buttons or on the escutcheon.

After the tuner is installed, turn on the receiver and allow it to operate for about half an hour so that all parts reach normal operating temperatures, then push in the MANUAL button, tune in one of the selected stations manually, note the nature of its program, then push in the button for that station and rotate the adjusting screw for the oscillator trimmer (using an aligning screwdriver) until the same station is heard. If the program is heard at two or more settings, the loudest will invariably be correct; the other settings will be for distant stations on the same network. Adjust first the oscillator trimmer, then the mixer trimmer for maximum volume; if the receiver has a tuning indicator, use it as a guide. Set up each other button in this same manner.

A modulated R.F. signal generator can be used for preliminary adjustments if desired; set the signal generator to the frequency of the station assigned to a button, then adjust the trimmers for that button until you hear the signal generator tone with maximum output. Repeat for each other button. This gives sufficiently accurate trimmer settings so that the correct stations will be heard when the receiver is connected to an antenna. Repeat all adjustments again, adjusting for maximum program volume or by using a tuning indicator as a guide.

If stations do not come in exactly at the correct points on the dial during manual tuning after a tuner is installed, adjust the receiver trimmers to correct the calibration. Usually it will be sufficient to adjust the high frequency trimmers for each tuning band. It is a good idea to call back in about one week and check all adjustments again, for the trimmer settings may change slightly during this first week.

Receivers With Three Tunable Circuits. You will sometimes be asked to incorporate automatic push-button tuning in receivers having a three-section variable condenser. A few tuner units are so designed that they can be combined to serve three and even four tunable circuits simultaneously, and this can be done in special cases. When automatic tuning is desired only for local stations, an ordinary two-section push-button tuner unit may be connected to the mixer and oscillator circuits, allowing the first R.F. stage to act as an untuned stage. Local stations will ride through this stage, permitting satisfactory reception. It is best, however, to use a converter unit for receivers of this type.

How to Install Electric Time Switches for Controlling Radios

EVERY ONE is familiar with the ordinary electric clock, but few know that it is now possible to purchase, at very reasonable prices, combination clocks and electric switches which will turn a radio or electrical appliance on or off at any predetermined time. Since the installation of one of these time switches is simple and requires only a few minutes, you can make a nice profit on each unit sold. Two distinct types of time switches for home use are now on the market; one type has a twelve-hour dial like an ordinary electric clock, while the other has a twenty-four hour dial.

An example of the first type, the self-starting Telechron unit, is shown in Fig. *1*; this unit sells for less than ten dollars. There are forty-eight keys arranged around the face of the clock dial, one corresponding to each fifteen-minute period of time in 12 hours. Pulling out a key causes the switch in the clock to close for that fifteen-minute period of time to which the key corresponds; for example, with the key at 12:00 pulled out and a radio connected to the unit, the radio would be turned on automatically at 12 o'clock and turned off at 12:15. If more than one successive key is pulled out, the radio will operate for the corresponding number of fifteen-minute periods. If a listener desires to hear certain programs which are scattered through a half-day period but are all broadcast by the same station, he need only look up the times of these programs in the daily newspaper and pull out the corresponding keys; the clock will do the rest, turning the radio on at the beginning and off at the end of each desired program. Each key automatically returns to the neutral position at the end of its fifteen-minute period of control; keys must therefore be reset each day.

To install the Telechron time switch, you need only plug the power cord of the clock into a wall outlet and plug the radio set power cord into an outlet provided at the back of the time switch. The toggle switch just below the clock dial should be set at *A* for automatic operation, and at *M* (shorting the contacts of the time switch) when the radio is to be operated manually, independently of the clock.

A time switch like this does not tune the radio; it simply controls the power to the receiver. The automatic turning on of the set usually attracts the attention of the listener, however, and he can easily retune it if a different program is desired. Many people use an automatic time switch like this as an alarm clock, setting it to turn on the radio at the desired time in the morning; the essential requirement is that the time at which the clock is set and the time at which the switch is to operate be not more than eleven hours and forty-five minutes apart. The contacts on this unit are designed to handle safely the power drawn by any radio receiver.

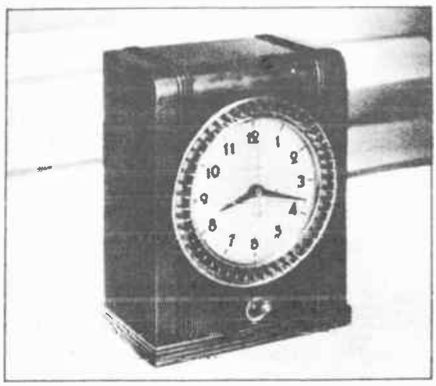


FIG. 1. Telechron Model 8B53 "Organizer" household time clock, made by Warren Telechron Co., Ashland, Mass., for controlling radio receivers and low-power electrical appliances.

One example of the twenty-four hour type of switch, known commercially as "Tymit," is illustrated in Fig. *2*; the power cord of the unit is plugged into any 110-volt A.C. wall outlet, and the device to be controlled, such as a radio set, is plugged into a receptacle at the left side of the switch unit. The circuit diagram of this unit, shown in Fig. *3*, is representative of that for all simple electric time switches. While this unit can be used as a timepiece if desired, its chief utility lies in its automatic switching. There are two manual switches, with interlocked action, on the face of the unit; one turns on the automatic switch feature and the other disconnects it. A synchronous motor-driven electric clock inside the unit rotates the entire dial face. On the dial are divisions for every fifteen minutes of the day, as well as notations for morning, afternoon, evening and night. There are two movable pointers; one should be set to the time at which the switch is to turn on the radio, and the other should be set to the time at which the radio is to be turned off. Once set, the switching action will be repeated each day at the same time. To start the clock (it does not have

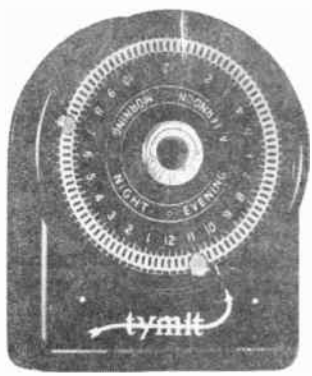


FIG. 2. Model No. 6 "Tymit" electric clock-operated time switch with 24-hour dial, made by the Tork Clock Co., Mount Vernon, N. Y.

a self-starting movement like the Telechron unit) it is only necessary to lift and release a lever on one side of the unit.

The Tymit unit contains a single-pole, single-throw switch with pure silver contacts arranged to give a quick make and break, and capable of handling currents up to 6 amperes (600 watts at 110 volts). The price of this unit is less than ten dollars, but this price, like any price quoted in this job sheet, is subject to change; a model giving two off-and-on operations a day is available for one dollar extra. For handling more than 600 watts of power, it is neces-

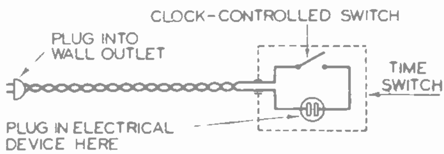


FIG. 3. Circuit diagram of a typical household electric time switch.

sary to use a commercial clock timer, having essentially the same clock movement but using mercury tube switches in place of metal contacts.

Many other uses for electric time switches almost suggest themselves. A unit can be used to turn on certain lights in the home at night when the family is away, to ward off burglars; some use a time switch to turn an oil burner off at bedtime and on again early in the morning, to turn poultry house lights on for predetermined periods of time in the evening or before sunrise, to defrost the refrigerator regularly each day, or to control the operation of electrical appliances such as small heaters, fans, bells, small electric advertising signs of all kinds, etc.

When ordering an electric time switch it is wise to specify the use to which it will be put. Standard electric clock switches are made for 110-volt, 60-cycle operation; models having eight or ten-day hand-wound clock movements are also available, but usually at higher prices than the more widely used A.C. models. Hand-wound time switches designed especially for controlling poultry house lights can be obtained from mail order houses like Sears, Roebuck and Company or Montgomery Ward, and sell for about twenty dollars.

How to Install Simple Photoelectric Controls

Completely assembled photoelectric control systems are now on the market at prices low enough to allow you a good profit when making installations for stores, factories, offices and homes in your locality. A photoelectric cell, popularly known as an "electric eye," is the heart of each of these systems. The cell is connected into the grid circuit of an ordinary amplifier tube, and a beam of light from a powerful light source is focused on the light-sensitive cathode of the cell; a variation in the amount of light falling on the cathode causes a change in the voltage on the grid of the amplifier tube, and this in turn produces a change in amplifier tube plate current which can be made to operate a small relay. The contacts of the relay can be connected to control an electrical device directly or through a power relay.

Typical Photoelectric Equipment. The problems involved in installing a typical photoelectric control system will now be taken up; the system made by Photobell Corporation, 123 Liberty Street, New York City, and illustrated in Fig. *4* will be used as an example. This system is designed for indoor use, but similar equipment with weatherproof housings for outdoor installations is also available. Photoelectric apparatus is handled by most mail order radio supply houses, and in some cases you can secure it directly from the manufacturer at wholesale prices by identifying yourself as an N. R. I. student or graduate.

An exterior view of the Photobell model PA light source is shown in Fig. *4A*; this unit consists of a 115 volt-to-6-volt step-down transformer, a 21-candlepower automobile headlight bulb, a reflector and an adjustable lens for concentrating the light into a beam. This light source will control the photocell satisfactorily at distances up to 40 feet. If an infra-red filter is placed over the lens to cut out all visible light rays, making the light beam invisible, the maximum operating distance will be reduced to about 25 feet. As a general rule, it is best to limit the operating distance to less than the maximum value to insure a trouble-free installation which is independent of fluctuations in line voltage and of variations in light output due to aging of the bulb or to the accumulation of dust on the lens, the reflector or the glass envelope of the photo-

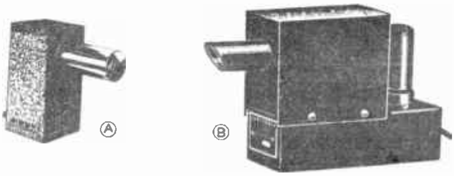


FIG. 4. Typical photoelectric control system, consisting of Photobell model PA light source (*A*) and Photobell model FR505 photoelectric relay unit (*B*).

cell. Although this light source will operate only from A.C. power, other light sources are available with a line-dropping resistor in place of the transformer, for universal A.C.-D.C. operation.

The Photobell model FR505 photoelectric relay is shown in Fig. *4B*; this is arranged for universal A.C.-D.C. operation, and employs a line cord with a self-contained resistance to lower the 110-volt line voltage to the correct value for the filament of the all-metal amplifier tube located at the right side above the chassis. Total power consumption of this unit is 35 watts. A caesium type photoelectric cell is mounted just behind the metal visor at the left side of the unit; the relay is also mounted above the chassis, and smaller circuit parts are mounted under the

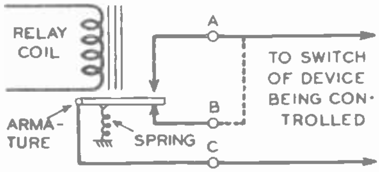


FIG. 5. Arrangement of contacts on a single-pole, double-throw relay. Upper lead to device being controlled may go either to terminal A or terminal B, depending upon whether the device is to be turned on or off by the relay.

chassis. The relay is of the single-pole, double-throw type; the laminated silver contacts are connected as shown in Fig. *5* and are capable of handling a 1/2 horsepower motor if necessary. This unit can also be obtained with other relay contact arrangements. The switch terminals of the device being controlled should be connected to whichever pair of contacts (*A* and *C* or *B* and *C* in Fig. *5*) gives the desired action. A control is provided on one side of the steel cabinet for varying the sensitivity of the unit.

When ordering any photoelectric control system, it is always best to describe in detail the particular application which you have in mind; the manufacturer can then supply you with a unit having the proper type of circuit and the proper relay contacts for that application. When a single interruption of the light beam is to close the relay and keep it closed until a lever is tripped, as in photoelectric burglar alarm installations, a latch-in type of relay should be used. Oftentimes an ordinary relay can be converted to the latch-in type by mounting a pivoted wire hook in such a way that it will catch and hold the armature the instant the relay operates.

Relay ratings must be carefully considered in any photoelectric installation. If the load to be controlled is greater than the rating of the relay provided with the unit, it will be necessary to use an extra relay connected as shown in Fig. *6*. Relay No. *1* in this diagram is the low-power relay in the electric eye unit; as you can see, this relay controls the current flow to the coil of relay No. *2*, the power relay. The rating of this power relay should be equal to or higher than the power rating of the load to be controlled. Additional information on relays and on photoelectric control systems is given in your regular Course.

Simple Photoelectric Applications. The photoelectric control system just described is ideal for announcing the arrival of a person at any given point. Doctors, dentists, and owners of small stores may want to keep the front door open at all times and yet have some means of knowing when a person enters. By installing the light source on one side of the door, directing it into the photoelectric relay mounted on the opposite side of the door, and connecting a chime or buzzer to operate whenever the light beam is interrupted, you have a means for announcing each arrival. Filling stations can use a somewhat similar arrangement to indicate the arrival of a car at the gas pump, as illustrated in Fig. *7*. Naturally, the details of these installations will vary, but by following the recommendations of the manufacturer of the equipment used, you should be able to install a successful and dependable system.

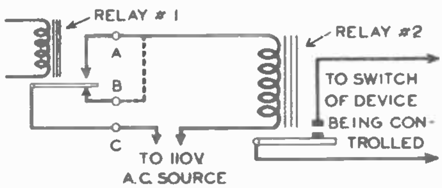


FIG. 6. When the relay in the photoelectric control unit is too small for the device being controlled, an A.C. power relay (No. 2) should be connected between the small relay and the device to be controlled.

Photo-relay installations are ideal for counting persons or objects which intercept a light beam. It is only necessary to connect a magnetic counter and a source of power in series with the contacts of the relay; each interruption of the light beam will then actuate the counter.

Another application is illustrated in Fig. *8*; a photoelectric relay unit is mounted on a garage in such a way that light from the spotlight of a car in the driveway can be directed on the photoelectric cell. This actuates the relay in the unit; this relay can be connected to control a solenoid which trips a lever and releases weights which pull the door open, or can be connected to operate an electric door-opening mechanism directly.

Photolectric equipment is especially valuable for turning on lights at dusk and turning them off in the morning automatically; all store owners using window displays and all persons having illuminated outdoor signs are ideal prospects for your services. With these applications, no separate light source unit is required, for the sun itself serves as the light source. Many manufacturers have special photolectric units for these illumination control applications, designed to respond to gradual changes in light rather than to sudden complete interruptions of a light beam. A long list of other successful photoelectric applications has been prepared by the Photobell Corporation and can be obtained free on request from this firm, along with literature and prices on photoelectric control equipment.

FIG. 7. Electric eye announces cars at this gas station.

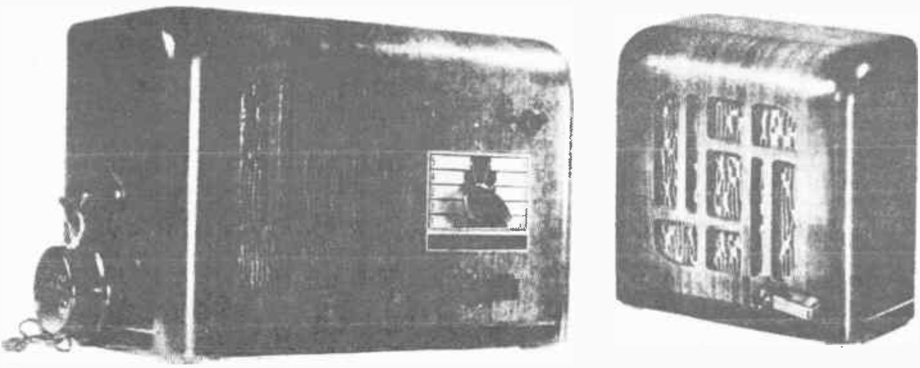
FIG. 8. Electric eye opens garage doors for motorist.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

How to Install Intercommunicating Systems

INTERCOMMUNICATING systems may consist simply of two units connected to provide two-way communication between two points, or they may be more elaborate systems for connecting together many points one at a time, all at a time, or any number at a time. These systems are essentially a combination of radio and public address units, and consequently their installation and servicing is a specialized branch of radio which rightfully belongs to the radio serviceman.



Courtesy Allied Radio Corp., 833 W. Jackson Blvd., Chicago, Ill.

Master station (left) and sub-station unit (right) of the Knight intercommunicating system. Up to ten sub-stations may be connected by cable to the master station. Each sub-station unit contains a moving coil microphone-loudspeaker unit and a "talk-listen" switch which is normally in the "listen" position. The master station has a combination on-off switch and volume control, a jeweled pilot light, a ten-station selector switch, a "listen-talk" lever and a headphone; lifting the headphone from its hook disconnects the master station loudspeaker, insuring privacy for a conversation. The master station can talk to any one desired sub-station at a time; sub-stations can call the master station but cannot talk to each other.

Intercommunicating systems can be considered in two groups according to the method used for conveying intelligence signals from one point to another: *1.* Cable units, in which wires are used to provide direct paths for audio signals between the various units; *2.* Carrier units, in which a low-frequency R.F. carrier (usually about 100 kc.) is modulated with the audio signal and made to transfer this signal over the regular power line in the building to the various units in the system. At each receiving location, the audio signal must be removed from the carrier (by a detector stage) before being amplified and reproduced by the loudspeaker.

Cable-connected systems are to be preferred for complex arrangements, such as where any two persons in a large system are to carry on a conversation without the possibility of others being able to listen in. With carrier systems, such an arrangement could be accomplished but would be quite costly. Carrier intercommunicating systems are most often used for secret communication between only two locations; when there are more than two units in the usual carrier system, all tuned to the same carrier frequency, a conversation can be heard at all units. Carrier systems have the advantage of portability, for the units can be moved to any part of the building and placed in operation simply by plugging into the nearest power outlet. With cable systems, on the other hand, the locations of the various units are more or less permanent.

Printed in U. S. A.

The units of a typical intercommunicating system are similar in size and appearance to a midget radio receiver, as can be seen from the illustrations in this job sheet. Each unit contains a small permanent magnet dynamic loudspeaker which also serves as an over-size permanent magnet dynamic microphone for talking purposes, and most units will also have a listen-talk switch. In a cable system, at least one unit must contain an audio amplifier; it will usually be a universal A.C.-D.C. amplifier containing one or more voltage amplifier stages, a power amplifier stage and a rectifier stage. When the listen-talk switch on the amplifier unit is in the *listen* position, the line cable is connected to the input of the audio amplifier, and the moving coil dynamic unit is connected to the amplifier output to serve as a loudspeaker; in the *talk* position of the switch, the moving coil unit is connected to the imput to serve as a microphone, and the output of the amplifier is connected to feed into the cable going to other units.

In a carrier system each unit must be complete in itself, and all units must be the same. Besides a voltage amplifier stage, a power amplifier stage and a rectifier stage, a carrier unit must contain a detector stage which is preceded by a tuned R.F. circuit, and must have an oscillator stage. The listen-talk switch is again the important control; although it may be simple in external appearance, it will generally have a combination of switch elements. In the *listen* position, the tuned circuit of the oscillator is connected between the detector stage and the power line, the connection to the line being made through a coupling condenser; at the same time this switch places the moving coil unit across the amplifier output to serve as a loudspeaker. In the *talk* position, the moving coil unit is connected to the audio input of the amplifier through a transformer, the oscillator stage is connected with its tuned circuit, the output of the audio amplifier is made to modulate the oscillator stage, and the oscillator stage is in turn made to feed the modulated R.F. signal into the power line through the coupling condenser.

Installing Carrier Systems. The installation of a carrier intercommunicating system simply involves plugging each unit into a convenient 115-volt A.C. or D.C. power outlet, then tuning each unit to the same carrier frequency. It may be necessary to reverse the power cord plug on one or more of the units in order to secure satisfactory operation. If a three-wire system of wiring is used in the building, with one of the wires serving as a common ground, there is a possibility that the two carrier units may be connected to different ungrounded wires; in this case, a .25 mfd., 600-volt paper condenser should be connected between the two ungrounded wires of the house wiring system at the junction box, to provide a path for radio signals.

Installing Cable Systems. The simplest hook-up of cable units is that in which all units are connected together in parallel by a two- or three-wire cable; with this arrangement the master station (the only one having an audio amplifier) can talk with any of the sub-stations but the sub-stations cannot talk to each other. The master station has a selector switch or a series of push-button switches which permit selecting anyone of the substations for a conversation. Each sub-station consists simply of a moving coil unit which is connected to the cable; if a two-wire cable is used, there is no talk-listen switch, all switching being done at the master station. If a three-wire cable is used, the sub-stations will each have a talk-listen switch.

Courtesy Wholesale Radio Service Co., Inc., 100 Sixth Ave., New York City.

One unit of the Lafayette "Multiple Master" Intercommunicating system; this same unit is used at each station, with up to seven units in a system. Each unit has six push-button station-selecting switches, a power switch, a jeweled pilot light, a volume control and a "listen-talk" switch. Each unit can talk with any other unit; up to three private conversations can be carried on simultaneously in a six or seven station system. The connecting cable used must have one wire more than the number of stations in the system. To use, press the button of the desired station, press the "listen-talk" lever, call the station, then release the lever and listen for an answer.

When it is essential that each station be able to call any one other station, a more costly and more versatile system is required. Each station must have a complete amplifier unit and switches which permit connection to any other desired station. Each station must also have a listen-talk switch and a multiple-wire cable; ordinarily this cable will have one wire for each station in the system and one common wire. The maximum number of stations is determined by the original design of the unit. If a unit has six station-selecting push-buttons and a seven-wire cable, six stations may be connected into the system. Three independent two-way conversations can be carried on simultaneously with this hook-up; group conversations are also possible with many systems.

When special hook-ups are required, you will find that the manufacturer of the system being considered will work out difficult problems with you, and will even build special amplifier units when necessary. If you standardize on the products of a single reliable manufacturer and become thoroughly familiar with those products, you should have no difficulty in choosing and installing the best possible hook-up for a particular application.

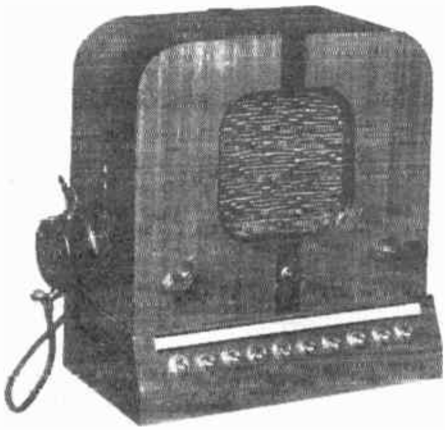
Cable-Installing Hints. Cables for intercommunicating units are installed in much the same manner as indoor telephone lines. You can either attach the cable to a baseboard with ordinary insulated staples or fasten it just above the baseboard molding with special metal clips designed for this purpose. When it is necessary to run a cable from one room to another, drill a suitable hole either through the door frame or through the plaster walls, using a bit and brace or a twist drill. Ordinarily it will be necessary to drill from each side, after accurately locating the hole, then fish the cable through the wall with a length of stiff wire. All cables should be made as inconspicuous as possible and should be chosen to match the color of the wall or baseboard in the room.

When running a cable up to a desk across a floor area which is used as a passageway, it is wise to place the cable in a metal floor loom or floor molding to prevent people from tripping over it and to protect the cable from wear.

Although hum problems are seldom encountered in intercommunicating systems, it is nevertheless a good idea to avoid running any cable parallel to exposed A.C. power lines. The frequency response of the average intercommunicating unit is sufficiently limited to prevent amplification of ordinary hum components.

Intercommunicating systems, like radio receivers and public address systems, change from year to year. Performance is constantly being improved, units simplified and costs reduced to meet the changing needs of home, business and industry. Complete installation instructions are supplied by the manufacturer with each unit; these instructions should be easy for you to understand and follow, since they involve essentially the same radio principles and techniques covered in the regular N. R. I. Course. If you can service radio receivers, you will have little trouble in installing and servicing intercommunicating systems.

As a general rule, intercommunicating systems are made by firms which specialize in public address equipment. A great many of these firms advertise in the technical radio



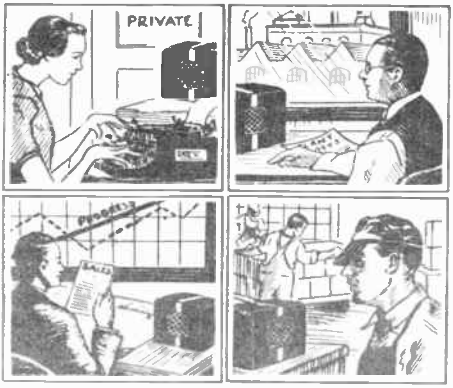
Courtesy Operadio Mfg. Co., St. Charles, Ill.

Station unit of the Operadio type C intercommunicating system. Each station uses the same master unit, and can therefore call any other station at will. Up to eleven stations may be used in a system. Each unit has a combination on-off switch and volume control, a "listen-talk" switch, an earphone with switch for privacy, a jeweled pilot lamp, and ten station-selecting switches.

journals; you can either buy your units directly from the manufacturer or through their agents or distributors in your locality. Mail order radio supply houses also handle one or more types of systems, so there should be no difficulty in securing the equipment needed for this work.

It is not enough that you be familiar with the various types of intercommunicating systems and know the general installation procedures for them; you must also be able to recognize a situation in which there is a genuine need for one of these systems, and must be able to sell your system and your services to the person or organization involved. A few successful installations will attract favorable attention and build up your reputation, with the result that additional business will naturally be directed to you. It is a good idea to include intercommunicating systems as one of your technical accomplishments on your business card, on your letterhead and in advertisements if you intend to get as much of this profitable specialized business as possible.

Uses for Intercommunicating Systems. Doctors and dentists who employ a secretary, a nurse, a receptionist or a laboratory technician who is ordinarily stationed in a different room will find a small two-station intercommunicating system of great value. The doctor can talk to his assistant without leaving his desk, and the assistant can likewise announce new patients and ask questions without entering the doctor's office.



Secretary—plant superintendent—sales department—shipping department—these are typical locations for sub-stations in an industrial plant having an Operadio type B intercommunicating system. The master station, operated by the head of the organization, can call any sub-station; sub-stations can neither call the master station nor talk to each other in this particular system, but can talk to the master station once they are called. Special sub-station units having call switches are also available; with these, any station can originate a call.

Any small stores, factories and business houses having executives who are constantly discussing ideas and problems with assistants will find an intercommunicating system of value. This is true even though there are regular telephones for inter-office communication, since an intercommunicating system leaves the telephones free for outside calls. In a factory for example, it may be desirable to have constant and instantaneous contact between the owner, the factory manager, the sales manager, the factory superintendent, and the shipping department. In a typical business office you can install a system which allows the president, his secretary, the vice-president, the comptroller and the receptionist to contact each other simply by twisting a knob; there is no phone to pick up, no number to dial, and no operator to delay the call.

Another typical application is that in which the customer is received at the most convenient, comfortable and pleasant part of a building, while the products being sold are kept elsewhere. Restaurants, wholesale distributors and certain types of stores come under this classification. With an intercommunicating unit in the dining room of a restaurant and another in the kitchen, waitresses can give their orders to the cook without even entering the kitchen. In stores, the clerk in charge can call the stock room simply by turning a switch or pressing a button. If you can prove to a prospect that an intercommunicating system will improve his service to customers, will save time and money or will make a better impression on customers, you have a good chance to make a sale. Few if any people who have once used intercommunicating systems will part with them; learn the reasons why these systems are so successful in existing installations and use these reasons for selling new installations. Selling is essentially the convincing of a prospect that he cannot be without the product you are selling.

Home owners are also prospects for small intercommunicating systems. You can easily set up a system which will allow the chauffeur to be called by the housemaid, or will allow the lady of the house to give instructions to the gardener or cook. Furthermore, a system can be used to provide communication between the nursery and the living room, so that parents can listen for unusual noises in the nursery while entertaining or resting. If the father spends considerable time in his den, study, workshop or garage, an intercommunicating system will permit calling him without the usual annoyance of shouting or invading his retreat.

It is also possible to use intercommunicating systems for paging purposes; in this case, the master station can connect to all stations simultaneously or to one station after another, calling the name of the person desired. When paging is to be accomplished in a large, noisy room it will be best to provide one station with additional amplification and a larger loudspeaker.

INVERSE FEEDBACK

THE output of any amplifier contains a considerable percentage of distortion, along with a.c. hum and noise. One effective method of reducing distortion, hum and noise makes use of the principle of inverse feedback. Feedback, as the name implies, means feeding part of the output voltage of an amplifier back into its input circuit.

If the feedback voltage arrives at the input exactly *in phase* with the original input voltage, we have *positive feedback*, often called *regeneration*.

If positive feedback is carried far enough in an amplifier, the amplifier becomes unstable and finally becomes entirely independent of the input, giving oscillation.

For *inverse feedback* or *degeneration*, the phase relation between input and feedback voltages is reversed. The feedback voltage is made to arrive *180° out of phase* with the input signal. This means whenever the input signal rises in a *positive* direction, the feedback voltage rises in a *negative* direction, and vice versa. The feedback voltage, therefore, always opposes the original input signal. For a resultant input, we get the actual difference between the two voltages, and this is always smaller than the original signal.

Since inverse feedback *reduces* the effect of the original input voltage, the output is also reduced. This amounts to a reduction in the amplifier gain. Such action is characteristic of all inverse feedback circuits.

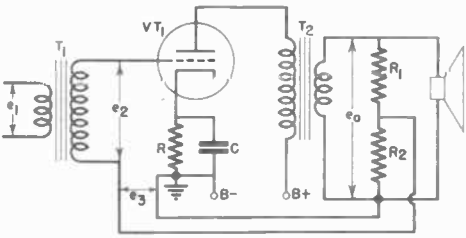


FIG. 1. Basic inverse feedback circuit.

An important point to remember is that unlike positive feedback, which makes an amplifier unstable and sometimes causes oscillation, inverse feedback drops the gain and output, making the amplifier entirely stable and always under control.

So far, the only result of inverse feedback we have seen is a reduction in gain. Let us see what benefits this sacrifice may offer.

REDUCTION OF DISTORTION, HUM AND NOISE

Let us examine the circuit given in Fig. 1. Except for a few minor changes, it is a conventional one-tube power amplifier. Note that the lower end of input transformer T_1 is not returned to ground, but is connected to voltage divider R_1-R_2 across the secondary of output transformer T_2. R_1 and R_2 are large in resistance compared to the impedance of the loudspeaker, so that they absorb very little power from the circuit. The exact amount of

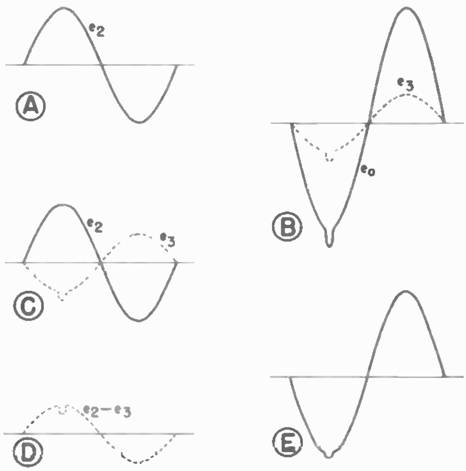


FIG. 2. Curves showing result of inverse feedback.

feedback voltage which is being fed back into the grid circuit by this arrangement can be regulated by adjusting the values of resistors R_1 and R_2.

Now, what happens when an input signal is applied to the circuit? First, the input signal e_1 induces in the secondary of T_1 the grid voltage e_2, which after amplification appears in the output as e_0. Let us assume that although e_2 is a pure sine wave input voltage as in Fig. 2A, the output e_0 looks something like that in Fig. 2B. The "bump" on the output wave may represent noise or distortion or hum or all three as they are generated in the amplifier tube. The bump thus represents something which should be eliminated, because it was not present in the original signal.

Through our feedback circuit, a portion (e_3) of the distorted output e_0 is fed back to the grid in series with e_2, as indicated by the dotted curves in Figs. 2B and 2C.

For our purpose, we can assume that all these things occur instantaneously; that is, there is no time delay between the time e_2 is applied to the grid and the instant that e_3 is fed back into the grid circuit.

Suppose we have connected the windings of output transformer T_2 so feedback voltage e_3 arrives exactly 180° out of phase with input voltage e_2, as shown in Fig. 2C. This means we have inverse feedback. Since e_2 and e_3 are of opposite polarity, they oppose each other and we have a resultant input which is equal to their difference. This is illustrated by the curve in Fig. 2D, which is obtained by subtracting e_3 from e_2 in Fig. 2C.

The final output due to the new reduced input will be something like that in Fig. 2E.

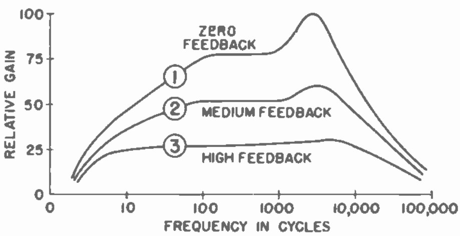


FIG. 3. How inverse feedback improves response.

It is apparent that this is a much better reproduction of the original input than that obtained in Fig. 2B.

Through the use of inverse feedback we have taken the distortion components of the output and put them back into the input in such a direction that they tend to cancel themselves.

It is true the output is reduced in amplitude in the process, because of the reduced effective input voltage, but if input signal voltage e_1 is increased, the output can be brought back to its former level while the distortion components remain substantially reduced.

The absolute value of reduction of all distortion, hum and noise by inverse feedback depends upon the amount of the output voltage which is fed back to the grid circuit, and upon the gain of the amplifier without feedback. In general, the gain of an amplifier and the distortion in its output due to the action within its circuits are reduced equally in per cent. This means that if feedback voltage is increased until the gain has been reduced 50%, distortion will be reduced 50% also. The input voltage can then be doubled, so the output returns to its former value but the distortion in that stage gets no larger than 50% of its value without feedback.

Suppose we have an amplifier which, without feedback, has a frequency-gain characteristic like curve *1* in Fig. 3.

Let us say the poor response below 100 cycles is due to coupling condensers that are too low in capacity, the peak at 3000 cycles to resonance effects in a transformer, and the loss of frequencies above 10,000 cycles to the shunting effect of tube capacities. Obviously, an amplifier with such a response would not give high-fidelity reproduction.

Now let us see what improvements inverse feedback might make. With a medium amount of output voltage fed back into the input in proper phase, we get response curve 2 in Fig. 3 This is considerable improvement. Observe that although the over-all gain has been reduced, the low and high-frequency response is nearer the response of the intermediate range, and the undesirable peak at 3000 cycles has been cut.

How feedback brings this about may be visualized as follows: Below 100 cycles and above 10.000 cycles, where the amplifier's inherent gain was low, the output voltage also was low This meant the feedback voltage was small in magnitude, so the input was not reduced a great deal. For the peak at 3000 cycles, however, the gain originally was high. The output voltage tended to be high also, but in so doing the feedback voltage was made quite large. When this was fed back, it cancelled a large part of the original input and cut the gain considerably.

Even greater improvement in frequency response can be obtained if the value of the feedback voltage is increased, as in curve 3

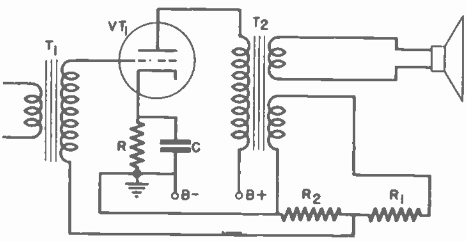


FIG. 4. Circuit using extra winding for feedback.

of Fig. 3. Observe, however, that any increase in feedback is always accompanied by an additional reduction in effective gain. Inverse feedback in most cases may be increased as much as desired, as long as large enough driving voltages for satisfactory output can be supplied.

Loudspeaker Damping. Since feedback has such a pronounced effect on the performance of an amplifier, it might be expected that it would change the effective characteristics of the vacuum tubes. It does exactly that.

In the circuit of Fig. *1*, one of the effects of feedback is to lower the apparent plate resistance of the tube. This not only improves the power efficiency of the stage but it also has a very beneficial effect on the performance of the loudspeaker.

Most loudspeakers suffer from what is called "hangover." This means that if a signal is put into the loudspeaker, it moves for the moment as it should, but, after the signal has passed, the loudspeaker cone may oscillate to and fro several times from its own inertia. This extra motion produces sound which should not be present.

Since a loudspeaker is essentially a motor, in that it transforms electrical energy into mechanical energy, it will also act as a generator. Therefore, if the cone makes any extra motion, it will generate a voltage of its own.

If the power tube feeding the loudspeaker has a low plate resistance, it will provide a substantial load for the loudspeaker and damp out the oscillations. Unfortunately, some power tubes (particularly pentodes) have a high plate resistance and do not damp the loudspeaker sufficiently.

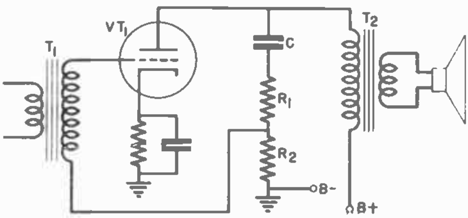


FIG. 5. Circuit using a plate voltage divider.

Any reduction in the plate resistance of the power tube will help. It is not readily seen how inverse feedback accomplishes this, but we can easily visualize what happens to reduce "hangover."

When a surge signal is fed to the circuit of Fig. 1, the loudspeaker cone moves in accordance with the signal. If the cone attempts to make any extra motion, however, it acts as a generator and some extra voltage is fed back through the feedback circuit to the input. This voltage is amplified and returned to the loudspeaker in opposite phase, so all motion is stopped. For any spurious voltages created by cone oscillation, then, the amplifier produces others in opposite phase which damp out the oscillations.

Other Corrections. Just as inverse feedback corrects for varying impedances in the speaker and coupling networks, so does it compensate for changes in output level due to other causes.

It is well known that any tube will change its characteristics over a period of time as it ages and wears out. Also, any change in filament and plate operating voltages has a pronounced effect on the gain of an amplifier.

If inverse feedback is incorporated in an amplifier, the effect of any of these things is substantially reduced. Why this is so should be apparent from the "bucking" action of the feedback voltage on the input. Inverse feedback always cuts the gain of an amplifier, but whenever the output voltage tends to rise, the gain is cut more. Whenever the output voltage tends to decrease, the gain is cut less. The final result is an output level that is nearly constant.

Of course, this compensation is limited and cannot increase indefinitely. With a high value of feedback, however. a surprising amount of correction can be realized. For instance, if feedback is great enough, a tube which is weaker than normal will still perform satisfactorily in the feedback amplifier. Also, when feedback is high enough, the output of an amplifier will be reduced only a few per cent, even when the filament or plate voltage is greatly reduced.

APPLICATIONS OF FEEDBACK

There are many other ways of obtaining inverse feedback. We shall describe a few basic circuits.

It is seldom necessary that the total output voltage be fed back into the grid circuit, and for this reason almost all feedback circuits use some form of voltage divider to reduce the feedback voltage. In the circuits shown in Figs. 4 to 8, the voltage divider resistors are marked R_1 and R_2. The total output voltage in each case is applied to R_1 and R_2 in series, and that part of the output which is fed back is developed across R_2. The exact amount of feedback can be regulated by varying the resistance values.

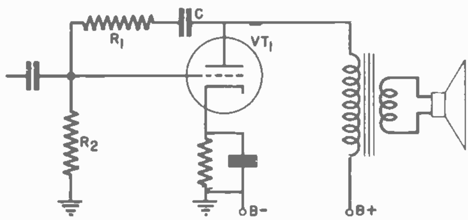


FIG. 6. A parallel feedback circuit.

The output voltage developed across the average low impedance loudspeaker voice coil does not always yield sufficient feedback voltage for satisfactory correction of distortion. An extra secondary winding having a greater number of turns can be added to the output transformer as in Fig. 4 This increases the feedback voltage with correspondingly better results.

In order to get a high feedback voltage without an extra transformer winding, the voltage often is taken directly from the plate of the tube, as in Fig. 5. Condenser C serves only as a blocking condenser to prevent short-circuiting the d.c. plate voltage and prevent application of the plate voltage to the grid. The capacity of C should be high enough so the reactance of the condenser is small compared to the resistance of R_1 and R_2, otherwise the feedback will not be constant for different frequencies.

The feedback voltage may be fed in *parallel* with the input instead of in series. This is usually done with resistance-coupled input circuits, as shown in Fig. 6. Note that R2 is not only part of the feedback voltage divider circuit, but it is also the grid leak for the tube. C, as before, is only a blocking condenser.

For feedback over two stages, the circuit in Fig. 7 is often used. Observe that the feedback voltage is inserted in the cathode circuit. The feedback could not be applied to the grid of the first tube because we have a phase shift of 180° in each tube, and with two tubes this makes a total shift between input and output of 360°. The voltage at the grid of the first

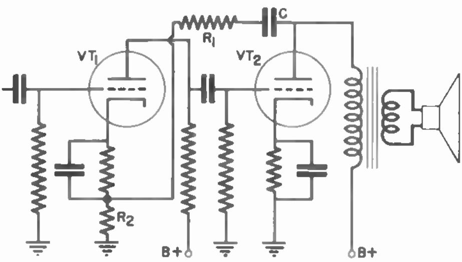


FIG. 7. Plate to cathode feedback over two stages.

tube, therefore, is exactly in phase with the output voltage, and coupling the feedback to the first grid would result in positive feedback.

Feedback, however, can be applied to the grid of the first tube in a two-tube amplifier if an output transformer winding is used. Fig. 8 is an example of this. In this case the connections to one transformer winding may be reversed, if necessary, for proper phasing. R_3 serves only to load the transformer winding properly, and has no direct effect on the feedback voltage.

Cathode-Resistor Feedback. A different type of inverse feedback is used in the circuit of Fig. 9. This is a conventional voltage amplifier stage except that the cathode resistor bypass condenser has been omitted. With no condenser, the plate load impedance is not only that due to the output transformer but to cathode resistor R_2 as well, and a small part of the output voltage is developed as e_3 across the cathode resistor. Any voltage appearing across R_2, however, also appears in series with input voltage e_2. Since the plate voltage is 180° out of phase with the input voltage, e_3 is out of phase with e_2 and we have inverse feedback.

FEEDBACK LIMITATIONS

For all inverse feedback circuits, it has been assumed the feedback voltage is always 180° out of phase with the input voltage. Unfortunately, this is not always true. In addition to the recognized 180° phase shift in each tube, there is always phase shift in each

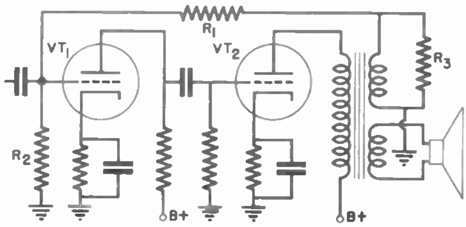


FIG. 8. A parallel two-stage feedback circuit.

coupling condenser or audio transformer. These extra phase shifts are quite small at medium audio frequencies and seldom give trouble, but both at extremely high and extremely low frequencies they can become quite large.

The maximum shift that can occur in a coupling network either at high or low frequencies is plus or minus 90°. This is not a desirable situation, but the only result of it is that at extreme frequencies our feedback circuit will do little to compensate for noise, distortion, hum, etc. The improvement due to feedback over the normal range of frequencies will not be disturbed.

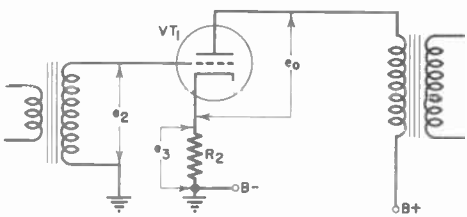


FIG. 9. Cathode degeneration circuit.

When more than two stages are included in the feedback path, it is possible that the network change in phase would result in positive instead of negative feedback, causing oscillation.

In conclusion, it should be pointed out that inverse feedback cannot ordinarily be used in an amplifier unless provided for in the original design. This data sheet is intended to help you understand how existing feedback systems work, not to show how to incorporate feedback in a circuit.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

Restoring Marred and Broken Radio Cabinets

I'm now going to show you how to do something which can make you more money—make you a more popular Radio-trician because it is something that the

TO REMOVE THE SCRATCH

majority of the radio men do not know how to do—I'm referring to restoring marred and broken radio cabinets. (This instruction can also apply to other household furniture as well.)

Constant house cleaning; constant fingering of the radio cabinet; the whim of the housewife to first put a small lamp, then some ornamental object on the top of the cabinet; and her constant desire to change the position of the radio, in other words, "everyday use," results in scratches, dulling of surfaces and even breaking of some part of the cabinet.

Now, radio set owners want their cabinets to have a good appearance. Help keep their interest in their receivers. Keep the appearance of their cabinets in shipshape order.

If you go to work for a radio dealer or distributor, your services will be more valued if you can repair and refinish those radio cabinets in their stock which have lost their beauty by mars or breakage. The radio manufacturer is not responsible for the cabinet or the chassis once he has turned the shipment over to the transportation company. It is the dealer or jobber's duty to either file claim with the transportation company (and collection on claims is usually bothersome) or restore the appearance of the cabinet himself. *Here is where you come in.*

Furthermore, demonstrator sets, those used in the showroom of dealers or distributors' stores, always take on that worn out look. In order to be able to sell these floor samples, the cabinet must be refinished. If you ever go into radio selling yourself, you will be glad of your ability to refinish or repair the outside of a cabinet.

Therefore, in this Practical Job Sheet I am going to tell you what tools and materials are necessary to do this work properly. I'll tell you how to fill in an ordinary or deep scratch; how to fill in deep holes or broken off ornamental woodwork; how to refinish a destroyed surface; and finally, how to properly polish the entire cabinet.

Tools and Materials Required. The tools and materials that you will need are comparatively few, when we consider the fine work which can be done with them. You must remember that "practice makes

HEAT the knife over an alcohol flame, then gather on it a bit of shellac

perfect." You should practice on furniture in your own home or that of your friends. In that way you will get the knack, learn how to turn out a workmanlike job, the kind that impresses your customer and inspires confidence. Incidentally, do a good job on the radio cabinet and you'll be surprised how much work you'll get to do on other furniture.

You will need:

1 pint bottle of rubbing oil. Mix two-thirds linseed oil to one-third benzine.

THEN fill the indentation until surface comes slightly above the woodwork

1 tube of furniture glue. Use a reliable make.
½ pint of turpentine.
½ pint of walnut stain—alcohol base.
½ pint of mahogany stain—alcohol base.
½ pint of wood alcohol.
1 small can of plastic wood.
½ pint of quick drying clear varnish.
½ pint of reliable furniture polish.
1 stick of transparent, burning-in shellac.
1 small can of 0000 pumice powder.
1 small artist's (hair) brush.
3 or 4 yards of cheese cloth.
1 alcohol lamp. (You can make one from a small oil can. Cut the spout off so only an inch of it remains. Roll up a foot length of cheese cloth, pulling it through the spout. The rest is pushed into the can, which is then filled with wood alcohol.)
1 scalpel. (This is a knife-like instrument used by cabinet makers for burning-in the transparent stick shellac.) Often called a spatula.

These supplies can be purchased from any hardware store. They are not expensive. Get a small wooden box, with a hinged cover, and keep in it a small amount of each of the items listed. Have this box handy so you can carry it out with you.

Removing an Ordinary Scratch. Now to remove a simple scratch, one that is not deep but which is sufficiently ugly that it cannot be covered with ordinary furniture polish.

Study carefully the photographs shown. They will help you to develop the technique. Notice in the first illustration that the necessary equipment including the alcohol lamp, box of pumice powder, rubbing oil, scalpel, burning-in shellac and stain in a glass with the brush are placed on a piece of cardboard so that drippings will not affect the rest of the cabinet.

Be sure to spread newspapers or a cloth on the floor under the furniture you are about to work on so as to protect the floor or floor covering.

If the scratch does not show white, proceed to burn in the shellac. Holding the scalpel in your right hand place its tip in the flame of the alcohol lamp—in the blue portion. Be careful not to get the blade too hot; just hot enough so that it will melt off a little of the transparent burning-in shellac when its tip is applied to the stick. Notice too that the burning-in shellac is kept close to the scalpel while applying the latter to the scratch. When the scalpel gets cool, heat it. Melt off more shellac and work it into the scratch. Don't apply too much. Just enough to fill in the scratch. Finally when the entire scratch has been filled in, heat the scalpel and trim off the surplus shellac which has accumulated around the edge of the scratch so it will be flush with the surface of the cabinet.

Follow this with an oil-pumice polish. Form a small wad with a piece of cheese

SAND with a fine grade of sandpaper

cloth which is then moistened with the rubbing oil. Dip the oily wad in the pumice powder and rub it into the filled-in scratch just as if you were sandpapering it. Be sure that you follow the grain of the wood. Finally polish the entire surface with furniture polish.

Filling in a Deep Scratch. Where the

scratch is deep you will find the white of the wood showing. First use stain on the scratch. If the stain that you have on hand is too dark, it will be necessary to thin it out. Pour enough of the dark stain for the job at hand in a small glass or fruit jar cover. Thin out with wood alcohol until the desired shade is obtained.

With the small artist's brush apply the proper shade of mahogany or walnut stain. Allow it to dry and then proceed to: fill

FINISH with crude oil, rubbing-in mixture

in with burning-in shellac, smoothing out with a hot scalpel, *sandpapering it*, polishing it with a wad dipped in oil and pumice-stone and finally finishing the entire surface with furniture polish.

Using the Plastic Wood. There will be cases where the simple procedure of applying burning-in shellac will not suffice. A deep bruise or scratch must be filled in; a broken wooden ornament may require building up with plastic wood. Before you apply this material, be sure that the surface to which it is to adhere is perfectly clean. There should be no varnish, oil or dirt. Clean with alcohol. Now you can apply the plastic wood with the tips of your fingers, smoothing flat surfaces off with a clean scalpel; and in the case of building out, shape the surface with your fingers so it appears to match with the rest of the design.

Allow the plastic wood to dry thoroughly. Then the surface is worked down with sandpaper so it is flat or takes the shape that you wish. A little stain is applied with a small hair brush so that the plastic wood blends with the original finish of the cabinet. The surface is then polished with an oil wad dipped in pumice-stone. Finally, finish with furniture polish.

Repairing a Break. It is not unusual for a leg to break, a part or ornament to break off, veneer to open or some other fracture to exist in the cabinet. Figure *1* shows a fracture in a leg. It is not a smooth break but one that has broken off following the grain. You will notice, that if you mesh the broken parts together it takes on an unbroken appearance. Such a break is extremely easy to repair. But before you start, be sure that the break will go together perfectly. Clear away any of the splinters that prevent this.

If the broken part is an old fracture, be sure that you wash away the old glue with hot water. Test to see whether the joint goes together snugly. Now spread glue on both surfaces of the fracture and let the glue dry for a few minutes until it gets tacky. Only then should you carefully press and fit the broken fracture together. More than merely bringing the glued parts together is required. The fracture must be pressed together with force using "C" clamps as shown in Figure *2*. ("C" clamps can be purchased in hardware stores.) Where "C" clamps cannot be used, the broken piece should be held in place by driving in small finishing nails or brads. Be sure that the heads of the nail are set below the surface of the wood. The holes may be filled in later with stick shellac.

Notice particularly in Figure 2, that the surface of the cabinet is protected from the clamps by wood blocks. Tighten up until the glue starts to "ooze" through the fracture.

Allow the glue to dry thoroughly. It takes at least 24 hours. Remove the clamps, if they were used, and with a

POLISH with dry rag over entire surface

Photographs—courtesy RADIO RETAILING

knife cut away the surplus surface glue. Sandpaper the exposed fracture and then treat it as if it were a scratch.

Refinishing a Surface. Quite often a radio cabinet becomes disfigured due to accidents like spilling hot water, coffee or alcohol, or to exposure to the weather. In such cases it will be wise for you to refinish the defective surface. It will be necessary to remove all of the finish until the wood surface appears bare. Although it requires a little more work, the final appearance of the job will pay for the effort taken. Select a complete panel or part of the cabinet, so that a difference in color in that section will not be too apparent. For example if surface *A* in Fig. *1* becomes defective, refinish only that panel and not part *B* too.

You must remove the varnish with varnish remover. A small can of this preparation can be obtained from your local hardware store. Apply the varnish remover

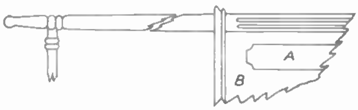


Fig. 1

with a paint brush and let it stay on the surface until the varnish begins to curl up. Then with a putty knife or a scrubbing brush, scrape or rub off the varnish. If you are not successful with the first application of the varnish remover, apply another coat and perhaps a third one. Wipe the surface clean with a rag soaked in alcohol.

Let the cabinet or the surface dry and then go over it with fine sandpaper. Be sure that the surface is clean before you proceed to refinish it. First mix the stain to a shade that will match with the rest of the cabinet. Apply it with a brush. If the finish is too dark, wipe the surplus stain off before it gets a chance to dry. Allow the surface to dry and if you notice that the surface is again rough, rub smooth with fine sandpaper. Now brush on the varnish, following the grain in the wood. Don't use too much varnish. It is wiser to use less when in doubt. Always wipe off the excess varnish around the edge so it will dry hard in a short time. After the varnish has hardened (at least a day will be required) sandpaper smooth and apply a second coat of varnish. When the second coat is thoroughly dry and there are no open pores, to indicate need for a third coat of varnish, polish the surface with a wad dipped in oil and powdered pumice-stone. Polish until you get the desired finish.

If you want a soft velvet-like appearance, finish further using rotten stone powder and in the same way that you use powdered pumice.

I cannot stress too strongly the need to use a clean brush in applying stains or varnishes. The surface to be finished must be absolutely free from dust particles. In fact I would take the cabinet into a room which was particularly free from dust—above all, allow sufficient time for glue and varnish to become thoroughly dry.

Polish and Polishing. After every job, be sure that the entire cabinet is polished with a suitable furniture polish. Hundreds of successful servicemen take a few minutes of their service time to polish the cabinet of a receiver that they have been working on. It is surprising what effect it has on radio set owners. They will say to themselves—"There is a man who knows his business." Above all, never demonstrate a receiver whose cabinet has not been polished. If you deliver a machine to a customer's home, be sure it is polished before you leave.

You can buy excellent furniture polish from any reliable hardware or drug store. If you wish, a suitable polish can be made in a few minutes and at a cost of a few cents. Here is the formula: *1* part paraffin oil, ½ part white vinegar, ¼ part of Johnson's liquid wax, *2*½ parts water. Use a graduated measuring cup. Add ½ teaspoon powdered pumice-stone and ½ teaspoon of granule ivory soap to every pint of completed polish. Place all the ingredients in a bottle which has a small neck and shake thoroughly. Be sure that you always shake this mixture before applying it.

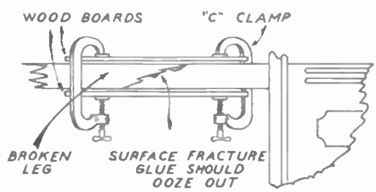


Fig. 2

A thin coat of polish is applied to the complete surface of the cabinet with a small pad of cheese cloth. Apply the polish to only one section of the cabinet at a time. Then polish with a dry clean piece of cheese cloth. This is necessary so that you can immediately pick up the dirt which has been removed by the soap and pumice in this polish.

Do not use a wax polish on furniture that has a natural dull finish. Merely use a dry clean cheese cloth. If necessary the cheese cloth may be dampened with water

Note: Most radio mail order supply houses sell a complete touch-up (refinishing) kit. Philco and R. C. A. distributors also have kits in stock.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

How to Erect a Complete, Simple and Effective Antenna System

The antenna system is the link between the radio receiver and the radio waves sent out from a radio transmitting station. Since the reception can be no better than the aerial, the antenna or aerial, as it is sometimes called, must be as efficient as possible.

It is too bad that poorly installed antennas work, after a fashion, because this sometimes leads the set owner to think that he is getting the best possible reception, whereas a good aerial system would make it so much better.

What Constitutes a Good Antenna System. An antenna system of the usual radio receiver is made up of five parts, namely: *1*, straight-away (aerial wire and insulators); *2*, lead-in; *3*, ground lead; *4*, ground and *5*, the lightning arrester. All parts of the antenna system are absolutely necessary except the lightning arrester. The arrester, however, is a protection and is only compulsory if the house is insured against fire. Besides it is inexpensive and a good sales point.

The straight-away shown in Fig. *1* picks

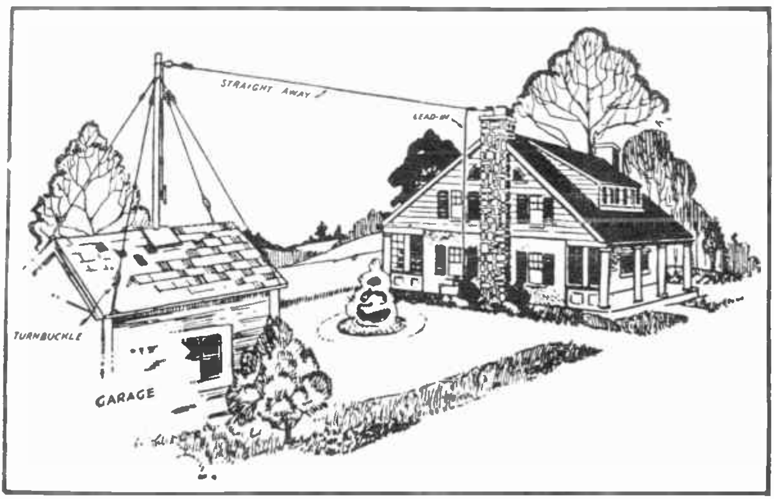


FIG. 1. *A simple, effective Antenna System*

up the radio waves, causing a radio current to flow in the aerial wire; the current flows down the lead-in wire, through the receiver, to the ground lead into the ground. The entire straight-away lead-in, ground lead and the ground are essentially the pick-up system. Naturally if any part of this system is grounded ahead of the receiving set, signals will not take the proper path through the receiver. This shows the importance of perfect insulation of the straight-away and the lead-in wire up to the receiver.

It should be understood that every home, every installation, offers a differ-

It is easy to identify a good radio man by the aerial he puts up. Poor aerials "stick out" like a "sore thumb." Aerials, like parts in radio sets, wear out and should be replaced when found necessary to improve radio reception.

A neat workmanlike aerial is a good advertisement for you. If you have a good antenna system at your own home, if your friends and relatives display good aerials, which you erected, you can point to them as examples of your work and readily convince the set owner that you are the one to put up his new aerial or replace his old one.

ent problem, which you must carefully study before deciding the proper aerial location. Here are a few hints:

The straight-away and the lead-in must be kept as far away as possible from trees, shrubbery, phone and power lines, large metallic surfaces such as tin roofs or, in the case of apartment houses, away from the elevator motor house. The straight-away should be as far off the ground as possible and must not double back on itself. It should be about 70 feet long. It is worth while to sacrifice length to get the straight-away clear of objects that cut down the strength of the incoming signals. The lead-in wire should go directly to the window closest to the receiver.

Position of the Straight-Away. Study Fig. *1* carefully. It appears possible to run the straight-away either from the chimney to the garage or from the chimney to the tall tree. The room in which the receiver is to be located definitely decides which position of the straight-away is the more desirable.

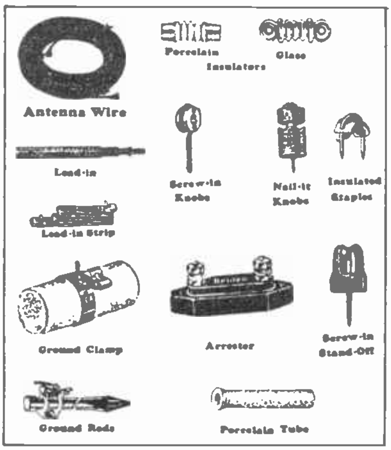


FIG. 2. *A few of the common parts required for antenna systems*

Assume that there is an outside water spigot or hose attachment near the room where the set is placed and the room faces the garage. We decide, therefore, that the aerial should run towards the garage.

Parts Required. Using Fig. *1* as our example let us see what material will be required. To begin with we need:

1. About 75 to 100 feet of straight-away antenna wire. Seven strand tin coated antenna wire is good and easy to work with.
2. A suitable length of lead-in wire No. 14 rubber insulated wire. Black or white covering to match the external appearance of the house should be selected.
3. Two lead-in strips to be placed across the window sill.
4. Flexible rubber insulated wire for the indoor connections from the window strips to the receiver. A covering whose color matches the room baseboard and window frame should be selected.
5. A ground clamp to make contact to the external water pipe.
6. "Nail-it-knobs" to hold the external lead-in wires.
7. Insulated staples for holding the indoor lead wires.
8. Two glass or pyrex antenna insulators for each end of the straight-away.
9. An external type lightning arrester.

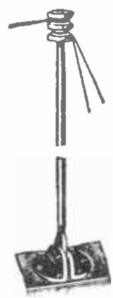
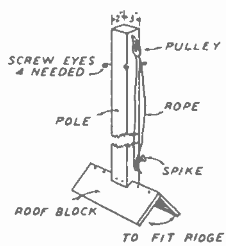


FIG. 2A FIG. 2B

This is the equipment that you can buy from any mail order house or radio distributor.

For this installation you will need a heavy galvanized wire and an eye bolt to support one end of the straight-away to the chimney. For the other end you must have sufficient equipment to erect the small mast on the garage. You can obtain from radio mail order houses, for a very reasonable price, complete masts and fittings for this purpose. Figure *2A* illustrates one of these complete masts. It consists of a solid rust-proof steel rod, insulator, and guy wires, also adjustable base to fit flat or sloping roofs. Figure *2B* shows a three piece one-inch pipe mast fitting consisting of pulley, collar for guy wires and adjustable base. For those who prefer to make their own mast, as shown in Fig. *2C*, you will need:



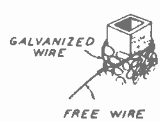


FIG. 2C FIG. 2D

1. A 10 foot, 2" by 3" pole free of knots.
2. Eight large screw eyes.

3. One pulley with wood screw eye attached.
4. One 20 foot length of clothes line to pass around the pulley. This is used to pull the mast end of the straight-away into position.
5. Four lengths of galvanized wire, turnbuckles and insulators to guy, insulate, and support the mast.

Tools Required. Only a few tools are required, tools that you most likely have around the house. You will need a hammer and a nail to start the holes for the screw eyes and for screws; a screw driver to secure such parts that require wood screws; and a pair of combination pliers to cut antenna, guy and lead wires to their proper length. The hammer, a saw and a plane will be necessary to build the mast. Finally, a soldering iron will be used to secure all joints made.

Erecting the Straight-Away Supports. If I were doing this job, I would prepare the mast and roof block on the ground before

How the pitch of a roof can be closely estimated from the ground by using a folding ruler.

Courtesy of Popular Mechanics

I did anything else. If you decide to make a wooden mast, Fig. *2C* shows the essential parts of this pole, including the V angle roof block which secures the mast to the roof.

Taking two 12 by 20 inch boards about one inch thick, nail them together to form a V which will fit snugly on the ridge of the roof.

Now cut a V into one end of the pole so that it will fit on the outside of the V shaped roof block. Nail the pole to the roof block. On that side of the pole that will face the chimney, screw in the pulley two inches from the top. On the same side one foot from the base, drive in a long spike. A foot from the top and on all four edges make a hole with a nail and then screw in four husky screw eyes for the guy wires. Slip the rope through the pulley and secure both free ends to the spike. (If you desire you may use an ordinary awning toggle instead of the spike.)

It may be difficult for you to judge the exact length of the guy wires on your first jobs but you will soon learn to make accurate estimates. Be sure that you don't cut the lengths too short.

Now you're ready to take the mast to the garage roof. Swing the pole vertically in place. (If you secure two of the guy wires it will stay in place.)

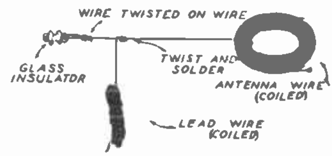


Fig. 3

Secure the other guy wires. If the pole is not exactly upright, adjust the turnbuckles to make everything even and secure.

While you are on the roof of the garage attach an antenna insulator to the rope. Slip one end of the rope through the eye of the insulator and secure it with knots. Be sure that the other end of the rope is fastened to the spike.

Go to the top of the house. Slip the galvanized wire around the smoke stack and form a sturdy loop as shown in Fig. *2D*. (This loop should run through an eyebolt at the back of the chimney to prevent slipping.) Leave enough free wire to loop through an insulator 2 to 4 feet away from the house. You can perform this step of the job when you are ready to string the straight-away.

Preparing the Straight-Away and Lead-In. Your next step is to prepare the straight-away. This must be done near an

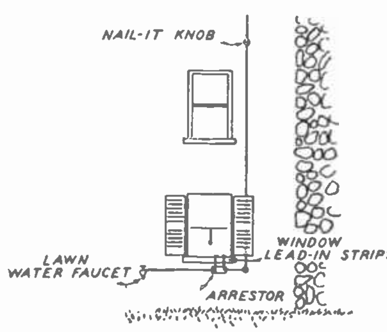


Fig. 4

electric power socket. While your soldering iron is heating, secure a long coil of antenna wire to one end of a glass antenna insulator. Note carefully how this is done from Fig. 3. With your knife, strip about six inches of the insulation from one end of the coiled lead-in wire. Be sure both the lead-in and antenna wires are clean and bright at the point of connection. Twist this bare lead-in wire around the antenna wire near the insulator and finish curling with your combination pliers.

Make a good soldered connection. If you wish, this joint may be further protected by winding on regular electrical friction tape.

Erecting the Straight-Away. Begin with the chimney end of the antenna. Slip the free wire, looped around the smoke stack through the glass insulator and secure by twisting. After the insulator has been attached to the wire from the chimney wire, take the other end of the straight-away to the roof of the garage.

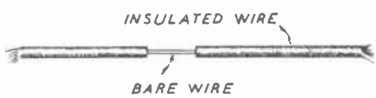


Fig. 5

Slip the end of the straight-away through the insulator on the pulley rope. Cut the antenna wire so that the straight-away will end about one foot from the mast. Secure the wire to the insulator by twisting.

Now you can pull the straight-away taut and tie the free end of the rope to the spike in the mast.

Lightning Arrester, Ground and Window Strip Installation. The next step is to make the necessary connections at the window to which the antenna and ground leads are to go.

Directly under the external sill of the window and to the side nearest where the receiver is placed, screw on the lightning arrester as shown in Fig. *4*.

Scrape the water pipe, which is to be used for a ground, perfectly clean and attach the ground clamp. There are several ground clamps on the market and it will be perfectly obvious to you how to strap or clamp them around the pipe.

Measure off a length of lead-in wire sufficient to go from the window strip to the lightning arrester around a nail-it-knob and to the ground clamp. Scrape one end clean and bolt it to the ground clamp; pass this wire around the jaws of the nail-it-knob that has been partially driven in, directly above the ground. After you have positioned the wire on the knob, nail the knob firmly to the side of the house. Straighten the ground lead wire and pull it toward the lightning arrester. Be sure that the lightning arrester is placed with the terminal marked GND toward the ground. At this point scrape off about two inches of the insulation as shown in Fig. *5*. Loop this bare wire around the GND terminal of the arrester which is then screwed tight with your screw driver or pliers. The remainder of the ground lead is neatly formed around the sill and is brought to one of the window strips. It is then cut off, cleaned of its insulation and the wire connected to the Fahnstock clip usually found on window strips.

We now return to the antenna lead-in. At a level with the window directly above the lead-in window, nail the lead-in wire to the side of the house, insulating it with a nail-it-knob. Bring this wire down to the lead-in window and anchor it to the wall with a nail-it-knob. Clean a portion of the insulation and connect it around the terminal of the lightning arrester marked ANT. The remaining lead-in wire is shaped around the sill and connected to the second window strip as previously explained.

Completing the Internal Connections. The entire outside portion of the antenna is completely erected. We merely have to come indoors, complete the antenna and ground lead-in connections. Measure off and cut two lengths of the flexible rubber insulated wire, sufficient to reach from the window strips to the receiver. Allow about three feet extra wire to connect to the receiver's ANT and GND terminals.

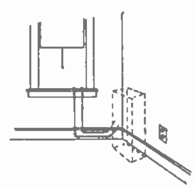


Fig. 6A

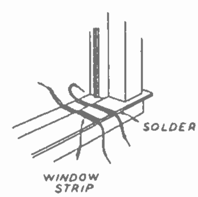


Fig. 6B

The ends of the wires are cleaned of insulation, connected to the inner terminals of the window strips and carried to the proper ANT and GND terminals at the receiver. The wire is formed around the window sill, tacked to it, with insulated staples, led to the baseboard and directed to the position where the receiver is to be placed. At this point a couple of insulated staples are used so that the leads will be firmly anchored in place. Use enough insulated staples throughout the entire extension so that it remains neat and in place.

Notice the position of the receiver in Fig. *6A* and the layout of the lead wires.

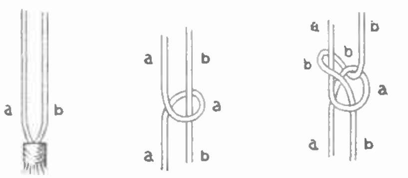
I recommend that you solder the joints at the window strips to prevent corrosion. If you do, there will be four joints that require soldering; see Fig. *6B*.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

How to Make Reliable Power, Ground and Antenna Lead Extensions

Power Line Extensions. The next chance you get to examine an all electric radio receiver power cord attachment or the cord attachment to any electrical appliance, measure the length of the cord which plugs into the wall power receptacle. Rarely will you find them over 6 feet long. In most cases the power cords on electrical appliances are short—too short in fact. Of course, in some cases, the appliances can be taken close to the electric outlet. But how about the radio? Quite frequently the owner desires it put some place away from the outlet. Here is another job to satisfy your customers.



1A — *First Step* 1B — *Second Step* 1C — *Third Step*

There are two procedures to take: *1*, lengthen the cord; *2*, make a semi-permanent wall receptacle extension. Which should you suggest? Personally I recommend the cord extension if it was only necessary to add 3 to 5 feet; where the available wall receptacle is 6 to 15 feet away, I would make an outlet extension. Incidentally, while doing the latter I would insert intermediate receptacles, so that lamps, vacuum cleaners or the like could be attached without disturbing the power connection to the radio. In any event, you should tell the customer what you plan to do and get permission to complete the job.

Let us take the first case, *lengthening the power cord*. First of all determine how much more double wire cord you need. Be sure the final length will permit you to lay the free cord on the floor near the baseboard. No housekeeper likes to see wire going "helter-skelter" across the room. Buy cord that is a close match in size and color to the one already used and be sure that it is approved by the Fire Underwriters. (Approved cord has little metal underwriter approved tags about every three feet along its length.) Now let us see how to attach this extra length.

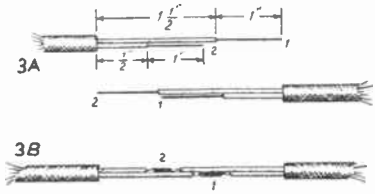
Before removing the plug cap on the existing cord, note how it is put on. This will help you in putting it on the new length. Taking the cap off is easy. Unscrew the terminal screws that hold the two wires; pull the wires loose; push the cap back on the cord; untie the knot which anchors the connection in the cap, and finally pull the cap off the cord.

Prepare one end of the new length of wire cord as follows: Push the covering of the new cord back about 3 inches. If the covering does not push back, cut it off with a knife. This will leave two free insulated wires about 3 inches long. Slip on the plug cap so the prongs of the cap point in the direction of the free wires. Make a tight knot as shown by Figs. *1A*, *1B* and *1C*, so that 2 inches of wire protrude. Strip about one inch of insulation off of each wire. Scrape the wires, twist and if you wish, tin them. Pull on the cord so the knot sets in the space provided for it in the hollow of the cap. Bring one lead around the nearest prong and loop the free wire clockwise under one terminal screw. Tighten this screw. Bring the other wire around the other prong and loop the free end clockwise under this terminal. Then tighten the screw. Figures *2A* and *2B* will help you see what I mean.

Now splice the two remaining free ends. Study Figs. *3A* and *3B* carefully. Both free ends are prepared alike. Push or strip the cord covering so about 2½ inches of wire remains free on each cord. Prepare both ends as shown by Fig. *3A*. Take both bare wires marked *1* and make a double twisted joint as shown in Fig. *3B*. Do the same for wires marked *2*.

Printed in U. S. A.

The two leads are gaped open and the joints soldered. Using ⅜" friction tape, (regular tape ripped down the center) tape each joint by itself. Now tape the entire joint. If you follow these instructions carefully, your job is completed.



Figures *1C* and *2A* show an Underwriters Knot; while Fig. *3B* is a Western Union duplex joint. Both are approved practice.

Now let me take up the *semi-permanent receptacle extension*. To be sure it does not conform to underwriters specifications, but it is without question far superior and safer than long cords running at random on the floor. In some localities only electricians are allowed to make such extensions. You will have to govern yourself accordingly.

Figure *4* shows, among other things that I will shortly take up a typical power line extension. The actual lengths are shorter than they usually will be, so as to make our illustration compact. To do this job, you need (see Fig. *5*) the following material:

1. A double twisted lead, approved extension cord.

2. A plug cap.

3. One or more receptacles.

4. A number of large insulated staples.

Cut a suitable length of twin wire electric cord. At one end attach a plug cap as previously explained. At the point where you plan intermediate receptacles, prepare the wire as shown in Fig. *6*. The actual connections to the receptacle are shown in Fig. *7A*. You should have no difficulty here. The end receptacle is an identical device only slightly differently connected. Figure *7B* clearly shows what to do. Place the fibre base plate shown in Fig. *7C* over the bottom of the receptacle; extensions *1* and *2* of the fibre base slip into parts *1* and *2* shown in Fig. *7B*.

How would you test this extension before tacking it to the baseboard? With your Special Home Experimental Outfits you build an ohmmeter which you may use here. Place the plug and end receptacle in front of you. When you connect the ohmmeter to the two prongs of the cap or the two slots of the receptacle you should get no rea 'ing. This means there is no short circuit.

Here is how you test the extension for an open in either lead. Place one probe of the ohmmeter (see Fig. *8*) on, let us say, prong No. 1 of the plug cap; and place the other ohmmeter probe in either slot 3 or 4 of the receptacle. One of these connections should give an ɔhmmeter reading. Now change the pro͏be connections to the other plug cap prong and the other receptacle slot. If a reading is again obtained with the ohmmeter, the extension has no opens.

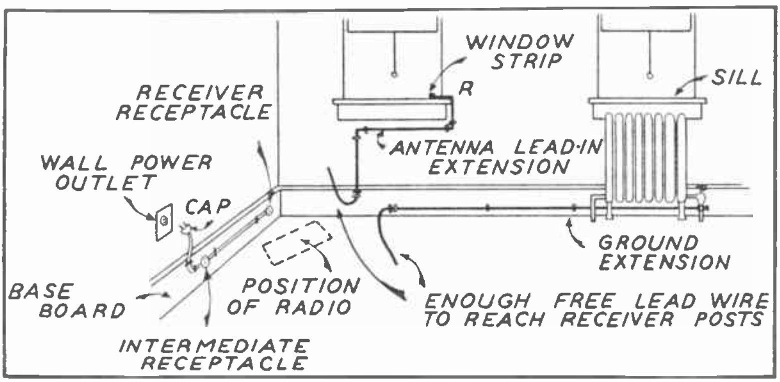
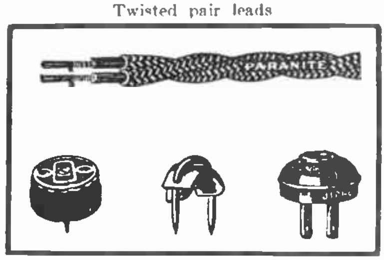


Fig. 4

Twisted pair leads



Outlet or receptacle — Insulated staple — Plug Cap

Fig. 5. *Typical material for a power extension*

Now let us consider the tacking of the extension. Start with the plug cap. Insert it half way into the wall receptacle. Pull the cord gently to the baseboard and tack down with a staple. The first staple should be at the upper edge of the baseboard. You must be extremely careful in your use of staples. They must not enter

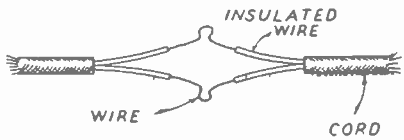


FIG. 6

the cord. When the staple is finally hammered into the board, only the fibre around the staple should hold the wire against the board, as shown in Fig. *9*. Be sure the staple is large enough for the cord used. Now you may temporarily pull out the cap. Make a sharp (L) right angle bend to the wire. and tack the wire down with another staple. Continue down the entire length of the extension, using enough holding staples to keep the wire cord in place. About every three feet should suffice. Use two staples at each bend and two at the end. Complete the job by screwing the receptacles to the baseboard with the wood screw usually provided. You may connect the ohmmeter to the two prongs of the cap to be finally sure there is no short circuit. Plug the cap into the wall outlet

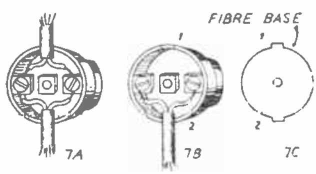


FIG. 7

Inside Ground Extensions. In the average home, an indoor or outdoor water pipe is the best ground. The connection to the water pipe is made, as you know, by means of a ground clamp. There are a variety of them. You are familiar with this phase of radio. What are you to use in place of the water pipe when it is too far away from the receiver? Perhaps a steam or hot water radiator is close by. Usually they are under the main window of the room. Figure *4* shows a typical condition.

The proper thing to do is to tack the wire to the bottom of the baseboard as shown. Note the two insulated staples at ground clamp and receiver ends of the wire. They are used to firmly anchor the wire.

The resistance of the ground lead should be low. Number 14 B & S gauge rubber insulated, black or white covering to match the baseboard is the best type of ground wire. However, you may use heavy flexible wire, such as used for power extensions if you wish. Above all, be sure the pipe is electrically clean before you attach the ground clamp, and a firm joint between the wire and clamp is used. Use a lug connection if possible.

Internal Antenna Lead-In Extensions. The indoor antenna lead-in wire or extension is generally an "eye-sore." Many a serviceman gets into ill favor by not keeping this lead wire out of sight. The rule to follow is: Make the lead short and inconspicuous. Figure *4* will help me explain what I mean.

The outdoor lead-in terminates at the window strip. From that point to the receiver you must follow the above mentioned rule. Use single lead heavy flexible insulated wire to match the wood

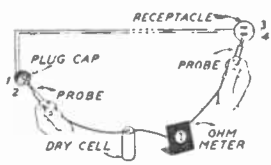


FIG. 8

work. Note in this illustration that the lead-in extension is brought around the right (R) side of the window sill—not over the sill. Then the extension is stapled to the under edge of the sill moulding. At the left (L) side, it is lead down to the baseboard. Note that the downward lead is in back of the receiver. You will find the entire lead-in extension satisfactorily out of sight.

Incidentally, if the window strip could be placed at the left (L) side of the window, a large portion of the extension could be eliminated. You must keep your eyes open and your mind alert to make the installation electrically good and physically neat.

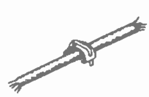


FIG. 9

Referring again to Fig. *4*, observe that the power, ground and antenna lead extensions do *not* cross and are not *near* each other. This is the ideal method to follow. Remember *neatness* commands favorable attention and leads to more jobs.

How To Detect Defects in an Antenna System and How To Repair Them

Unless some part of the antenna system has broken away from the insulators or anchors, the owner of the installation will never suspect a defect. But there are many ways that an antenna system may become defective. In fact, you can walk down any street and spot defective systems, call on the owner and tactfully mention the condition. Chances are that you will get the job. You will be called upon to check and repair antenna systems when you install a new receiver or make set repairs.

Learn to recognize a good antenna system. Then and then only will you be able to tell when one is poorly erected or defective.

Defects in the lead-in and straight-away are the most serious and are due to shorts, opens, poor contacts and age.

The supports of the straight-away may become defective allowing the straight-away to sag and touch some grounded object such as a vent pipe or metal gutter. The straight-away may have fallen down on a tin roof thus grounding the entire antenna. When the lead-in passes around sharp objects and the lead-in insulation becomes frayed due to it moving in the wind, a short at this point may arise. These are obvious defects which you can see and easily remedy with nail-it-knobs, insulators and stand-offs.

By opens we mean a break in the aerial circuit. The wire may have broken due to too much strain. This defect is often recognized when the lead-in hangs down from the point of the break. Opens, however, sometimes occur at joints and these cannot be readily seen. You can easily test for opens as will be brought out later on. When the aerial appears O. K. but you suspect an open, always examine the joints.

Intermittent (make and break) contacts occur at the various joints, where the lead-in joins the straight-away, where it joins the lightning arrester, the window strip and the antenna post on the receiver. The contact may be corroded and may at one moment be electrically good and at the next open. This will result in crackling noises.

Age is the greatest enemy of good antenna systems. No matter how well an aerial has been erected, the straight-away will in time corrode, the insulators will gather soot and this, on becoming moist, will tend to short the aerial. The only remedy is to put up a new straight-away. The lead-in wire may be retained as its insulation will prevent the wire itself from corroding. Of course, a new soldered connection from lead-in to straight-away is required. The insulators should be wiped off with a cloth before using again.

Lightning arresters may break down or the connections to them may become loose. In the former case the aerial will be shorted and in the latter we will have noisy reception.

Shorts in the ground system are not important as long as the wire stays shorted. Only when the short is alternately made and broken do we hear noises.

Now let's see how we can test out the aerial and ground system for these various defects. It is easy to test for a shorted antenna. Use the ohmmeter you build in your experimental outfits and test between the aerial and ground leads. These leads, of course, must be disconnected from the set. If you get a reading on the meter, you know that there is an electrical path between the aerial and some part of the house that eventually connects to the ground. This path is the short which must be removed.*

Your test won't tell you the location of the short and you will have to inspect the lead-in and straight-away, looking for the unintentional ground. When found, you must insulate the wiring at that point.

To check for an open in the antenna system, connect the aerial and ground leads together at the set. Take your ohmmeter up on the roof and test between the straight-away and some grounded object such as a vent pipe or metal gutter. Be sure you make an electrical contact with your probes. You might have to scrape the connection points. If the aerial and lead-in is not open, you will get a reading on your ohmmeter.

There is no test for intermittent contacts—go over the contacts with a hot soldering iron or try to work them back and forth in your hands. If noise results when you do this, when the receiver is turned on, you know that the contact is bad and that it should be resoldered.

A lightning arrester can be checked with the ohmmeter by disconnecting the aerial lead and testing across the two posts on the arrester. You should not obtain a reading; but if you do, a new arrester should be installed.

The ground wire is usually short and therefore a quick visual inspection can be made for a break. Shake the wire and see if noise results in the receiver. If it does, locate the poor contact and tighten it up or solder it.

* This check does not apply to all noise-reducing antennas. A proper check will be considered in another job sheet.

FM — APRIL-MAY 1937 ISSUE

RADIO-TRICIAN
REG. U.S. PAT. OFF.
Service Sheet
Compiled Solely for Students and Graduates
NATIONAL RADIO INSTITUTE, WASHINGTON, D.C.

FAIRBANKS-MORSE

The Model 56 Chassis
Employed In The Models
5619 and 5645

ALIGNMENT PROCEDURE

To obtain maximum performance the model 56 receiver must be aligned perfectly. It is urged that the following instructions be studied carefully before any alignment adjustments are attempted. Proper adjustment of the various tuned circuits will be possible only through the use of an accurate and reliable signal generator employed in conjunction with an output meter, which may be connected across the voice coil leads of the loud speaker.

NOTE—All adjustments should be made with the volume control "full on." Any desired variation in signal strength should be obtained by adjusting output of signal generator.

INTERMEDIATE FREQUENCY ALIGNMENT

1. Turn the gang condenser to maximum capacity (fully meshed).
2. Set the band selector switch on the "Broadcast" position.
3. Supply a 456 kilocycle signal from the signal generator to the antenna lead of the receiver through a .1 Mfd. condenser connected in series with the signal generator lead.
4. Adjust the four trimmers of the two intermediate frequency transformers (see Figure 1) for maximum output with minimum input from the service oscillator.
5. Adjust the wave trap trimmer "A" (see Figure 1) for **minimum** output.

RADIO FREQUENCY ALIGNMENT The parallel or high frequency trimmer condensers for the broadcast band are on the gang condenser. These trimmers are used for aligning the high frequency end of the broadcast band. Location of the trimmers is shown in Fig. 1. The oscillator adjustable series padding condenser is used for tracking the oscillator at the low frequency end of the broadcast band. The padding condenser may be adjusted from the top of the chassis through the hole indicated in Figure 1. While making padding condenser adjustments the gang condenser should be rotated back and forth across the signal to insure adjustment to the peak of greatest intensity.

DIAL ADJUSTMENT Before making any alignment adjustments, close the variable tuning condenser (maximum capacity), place the dial pointer in a horizontal position (gang condenser still closed) and then proceed with the following adjustments.

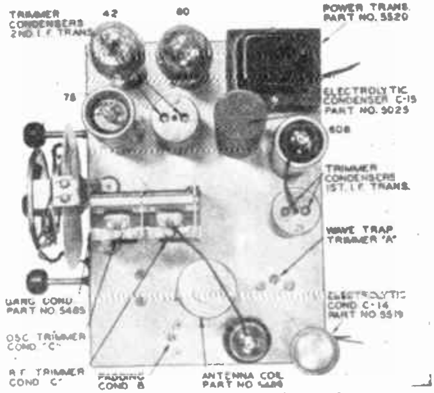


Fig. 1. Top view of model 56 chassis

Readers who file Service Data in separate binders remove page carefully, trim on dotted line for same size as data published heretofore.

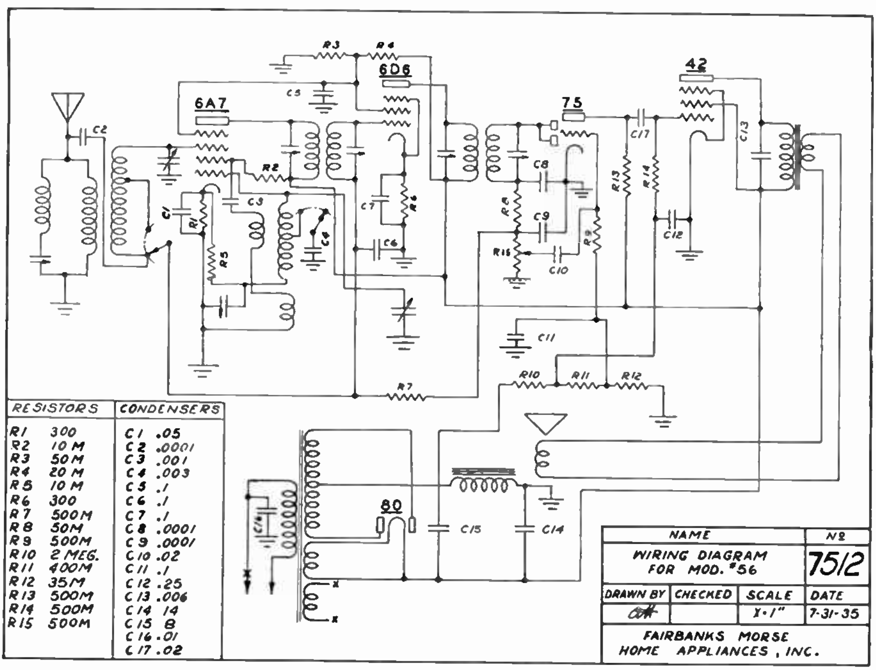
Alignment Procedure

BROADCAST BAND

1. Turn the band selector switch to the broadcast (counter-clockwise) position.
2. Tune the receiver to 1500 kilocycles.
3. Supply a 1500 kilocycle signal from the signal generator to the antenna lead of the receiver through a standard dummy antenna or a 200 Mmfd. (.0002 Mfd.) condenser, connected in series with the signal generator lead.
4. Adjust the trimmer condensers on the gang condenser (Figure 1) for maximum output with minimum input from the signal generator.
5. Tune the receiver to 600 kilocycles.
6. Supply a 600 kilocycle signal to the antenna of the receiver through the same connections as previously used.
7. Adjust the broadcast band oscillator padding condenser "B" (top of chassis, see Figure 1) for maximum output with minimum input from the signal generator, at the same time rocking the tuning condenser back and forth across the signal to insure the peak of greatest intensity.
8. Check at 1500 kilocycles and then at 600 kilocycles. Make any adjustments necessary to obtain satisfactory calibration.

SHORT WAVE BAND

1. Turn the band selector switch to the short wave position.
2. Tune the receiver to 6 megacycles.
3. Supply a 6 megacycle signal from the signal generator to the antenna lead of the receiver through a 400 ohm carbon resistor (dummy antenna), connected in series with the signal generator lead.
4. The 6 megacycle signal should be received near the 6 megacycles on the dial. If this is not the case, check the oscillator tube, switch connections and coils. No adjustment is necessary on this band.



Schematic Diagram of the Model 56 Chassis

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FAIRBANKS-MORSE

The Model 43 Chassis
Employed in the Models
43T1B and 43C1B

Alignment Procedure

To obtain maximum performance the model 43 receiver must be aligned perfectly. It is urged that the following instructions be studied carefully before any alignment adjustments are attempted. Proper adjustment of the various tuned circuits will be possible only through the use of an accurate and reliable signal generator employed in conjunction with an output meter, which may be connected from plate to ground on the output tube. A fixed condenser (.1 Mfd.) should be connected in series with the output meter.

NOTE—All adjustments should be made with the volume control "full on." Any desired variation in signal strength should be obtained by adjusting output of signal generator.

INTERMEDIATE FREQUENCY ALIGNMENT

1. Turn the gang condenser to maximum capacity (fully meshed).
2. Set the dial pointer at 530 kilocycles and then tighten the set screw.
3. Supply a 456 kilocycle signal from the signal generator to the grid of the type 1C6 first detector tube through a .1 Mfd. condenser connected in series with the signal generator lead.
4. Adjust the four trimmers of the two intermediate frequency transformers (see Figure 1) for maximum output with minimum input from the service oscillator.

RADIO FREQUENCY ALIGNMENT The parallel or high frequency trimmer condensers for each stage are located on the gang condenser (see Figure1).

1. Tune the receiver to 1500 kilocycles.
2. Supply a 1500 kilocycle signal from the signal generator to the antenna lead of the receiver through a standard dummy antenna or a 200 Mmfd. (.0002 Mfd.) condenser, connected in series with the signal generator lead.
3. Adjust the oscillator stage trimmer condenser ("A" Figure 1) for maximum output with minimum input from the signal generator.
4. Adjust the Radio frequency trimmer ("B" Figure 1) for maximum output with minimum input from the signal generator.

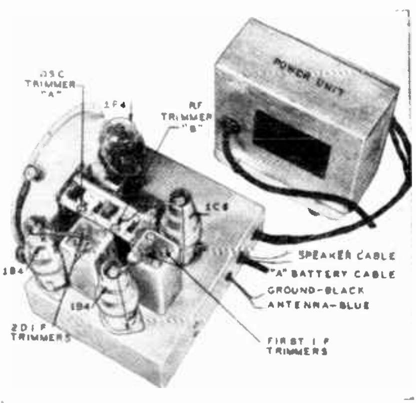

Fig. 1. Top view of model 43 chassis

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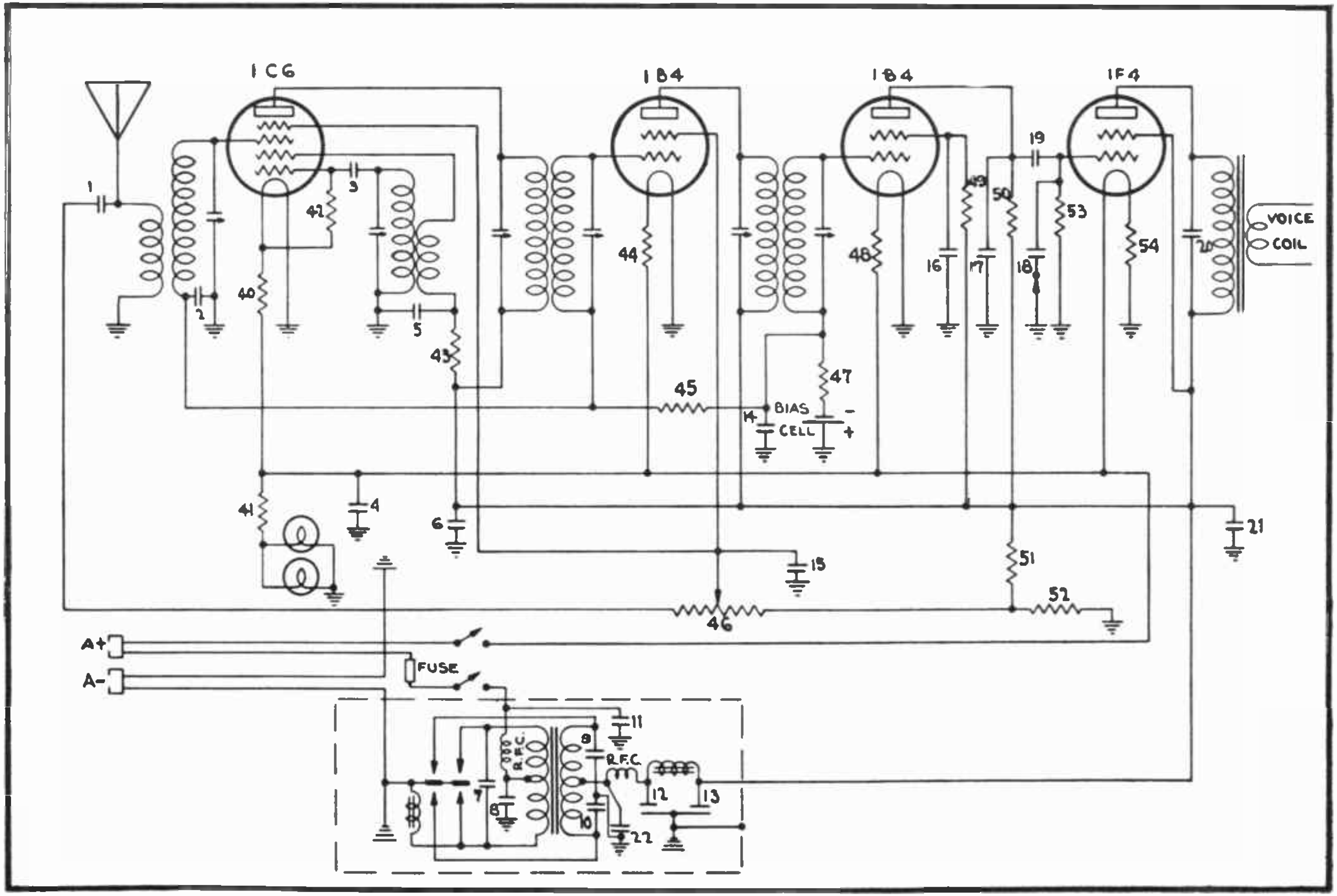


Schematic Diagram of " Model 43 Chassis

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

Wave Traps—When Needed—How Made and Installed

It is because radio receivers are not perfect that the wave trap, a simple interference eliminator, has come into wide use. To be sure, they will be needed less and less, because radio sets are constantly being improved in design; yet at times they may be used with even a modern all-wave receiver. A wave trap helps reduce interference between a desired and an undesired station, called station interference. This simple device is nothing more than a tuned radio circuit, consisting of a coil of wire and a variable condenser connected into the antenna system so the undesired station or interfering signal can be tuned out (eliminated) or made less objectionable.

Before I tell you how to build and use this device, let me explain to you how to tell when a wave trap may help eliminate interfering signals—notice that I said "may help." This device is not a "cure-all."

A most common defect with some receivers is the lack of selectivity, particularly where local or powerful stations are picked up. Where you come across a receiver that cannot tune out the local or some more distant high-powered station; that is, when the interfering station spreads over the dial scale for ten or more divisions or, let us say, 30 to 100 kilocycles, try a wave trap Of course, if several stations act in the same manner, you can make up your mind that the set is out of date and should be replaced with a modern receiver. If the interference is caused by a local broadcaster, try the following before you build a wave trap. Disconnect the aerial from the set, leaving the ground connected. If the interfering station still spreads over the dial, you know definitely that a wave trap will be of no use.

There is another type of station interference that you will encounter, called *cross-talk*. You may, when the receiver is tuned to a distant station, hear a local station in the background; but when you tune off the station, neither one is heard. This may occur when tuning in a few or many distant stations.

This interference may be greatly reduced with a wave trap tuned to the interfering local station.

HOW TO BUILD A BROADCAST WAVE TRAP

Now that I have told you when to use a wave trap, let's see what this device looks like. Figure *1* shows clearly what apparatus is required and how the parts are connected. Simple but effective. A .00035 mfd. variable condenser, a coil which I will tell you how to build, and four binding posts as well as the baseboard on which the complete assembly is mounted are the parts required. Possibly a small wooden box cover may be used to dress up the job.

A coil form 2½ inches in diameter and 3 inches long, a roll of No. 22 D.C.C. (double cotton covered) wire and 4 rivet type lugs are required to build the coil. Drill the holes in the coil form for the rivets and fasten on the lugs. Drill the wire holes as shown in Figs. *2a* and *2b*.

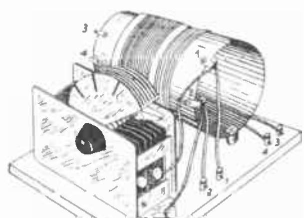


FIG. 1

Wind seventy-five turns of wire on the coil form, starting about one-half inch from one end of the coil form. Run the two leads of this coil to lugs *1* and *2*. Next cut a one inch wide strip of writing paper or, if you wish, you can use insulation tape. Wrap this strip over the lower end (near lugs *3* and *4*) of the coil, making sure that there are at least three thicknesses of paper. If you use paper, it should be shellacked or varnished so it will stay in place. Now wind ten turns of the No. 22 D.C.C. wire over the paper and run the two leads to lugs *3* and *4*. Varnish or wax coat the coil windings. Follow closely Figs. *2a* and *2b*.

Now assemble the coil, condenser and binding posts on a small wooden baseboard as shown in Fig. *1*. Note that lugs *1* and *2* connect to the stator and rotor terminals of the variable condenser. It makes little difference if lug *1* or *2* connects to the stator terminal. Two binding posts are connected to lugs *1* and *2*, while the other two binding posts are connected to lugs *3* and *4*. Now solder all wire joints, using lugs where necessary.

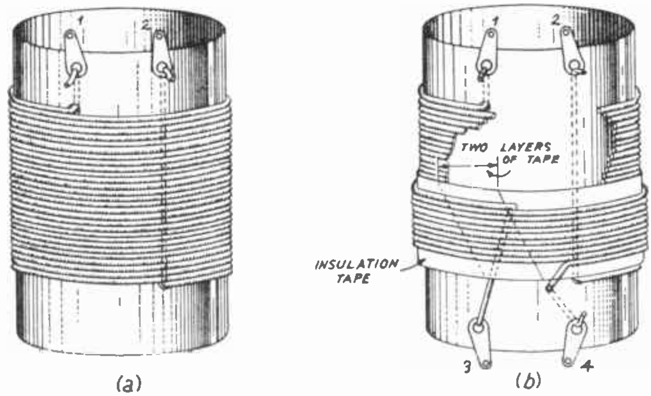


FIG. 2

HOW TO BUILD A SHORT-WAVE WAVE TRAP

On some radio sets you may be called upon to trap out short-wave transmitting stations, such as local police, aircraft, short-wave broadcasts and amateur radio stations. The wave trap for these shorter waves are constructed exactly like the broadcast wave trap, except that a smaller coil is used. The coil connecting to lugs *1* and *2* should have twenty turns of No. 22 D.C.C. wire and the coil connected to lugs *3* and *4* have five turns. The same size coil form and variable condenser may be used.

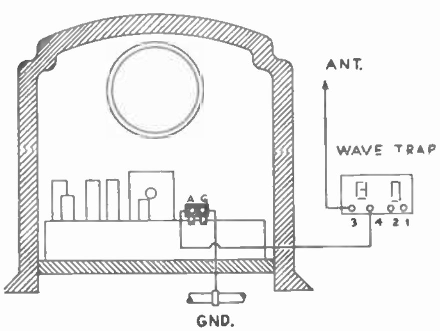


FIG. 3

How To Adjust a Wave Trap.—Connect the wave trap as shown in Fig. *3*. First try connecting binding post *3* of the wave trap to the antenna lead-in and post *4* to the antenna terminal of the receiver. Now tune the receiver to the desired station, and at a normal setting of volume. Adjust the wave trap to the interfering station. You will find that the volume of the interfering station will decrease when the wave trap is tuned properly. Retune the receiver (selector dial only) so the desired station is heard the loudest, and readjust the wave trap for maximum interference elimination.

If interference is still experienced, try connecting binding posts *1* and *2* respectively to the antenna lead-in and the antenna terminal on the receiver. This connection of the trap may be better. The tuning adjustments of the wave trap and receiver are the same.

Finish the job by mounting the wave trap in the rear or in the cabinet of the radio set. Before you leave, instruct the customer that no further adjustments of the wave trap are necessary after setting it once for the interfering signal. If it is disturbed, you may have to make another service call.

How To Make Spare-Time Money Cooperating with a Dealer

When Bill Jones drives up to his front door after work and parks his old, battered, worn-out automobile, any automobile salesman knows that he is a prospect for a new car. When a car owner drives his machine to the garage every five hundred or one thousand miles to change the oil, the garage mechanic has a chance to recommend repairs or some other improvement; that is, provided the mechanic is interested in your car service and is on his toes looking for your business.

Radio dealers wish they had an equal opportunity to know what they could do for their customers. And they can, if they will use their radio servicemen in the proper manner. So will you, when you go into the radio service business.

What can you do now to bring business your way? Take advantage of the advertisements and business-getting methods promoted by wide-awake vacuum tube manufacturers. The public is constantly told through various mediums—newspapers, magazines, and even over the radio—that tubes must be periodically checked and replaced. Only a very few people are willing to take tubes out of their radio sets and bring them to a dealer. Others even neglect to call a serviceman to their homes to have the tubes checked. Too much trouble, why bother while the set plays, is the thought in their minds.

Suppose you were to knock at a front door and say that you are on a special tube checking visit. Do you think you would get in? Perhaps! If they know you personally, you have a fair chance of getting in. If you say that you are a representative of some reliable local department store or radio shop, you again have a good chance of getting in. You must inspire confidence, as this door-to-door campaigning has been overdone. You may make your calls more welcome if you inform the people in advance that you are coming.

Getting Dealers' Cooperation.—If you are going to test tubes, replace the worn out with new ones, you must carry with you a tube tester and a stock of tubes. Naturally, this involves expense which you may or may not wish to incur at this time of your radio career. Of course, when you finish your radio training and choose a campaign of this sort to build up your business, this expense is justified.

So, at this time, why not go to some reliable radio dealer in your locality and suggest a tube checking campaign? Explain that you will call on his customers who have not been heard from for over a year and check their tubes. He will recognize that not only can you sell tubes for him, but you can get him additional service jobs, sell radio attachments, put up new antennas, repair marred cabinets, or give him leads for the sale of new radio sets. Most of these jobs you know how to do. You can even sell radio sets if you will only try.

You can work out a commission plan for every job you turn in to the radio dealer. Some commission basis can be worked out for tubes and new radio sets sold. He will gladly arrange to pay you for your time on any job that is turned over to you to do.

Have the dealer furnish a tube tester and a group of representative replacement tubes. Of course, you could not carry all the types of tubes used in radio sets, but the dealer will be able to recommend from his experience the types most commonly replaced. After you have made a number of calls, you too will know which types to carry. Even if you don't have the right one with you, you can test a tube, label it defective, and return later with a good one.

The tube checker should be a modern one, suitable for testing any of the old or new tubes. It should have a professional appearance, as the customer will not have confidence in any makeshift tester.

Getting the Dealer To Help.—The success of this campaign is as much the dealer's concern as it is yours. He can go a long way to help you, and he will if you "mean business." Have him give you the name and telephone numbers of his customers. Call them on the phone. All you need to say is: "Madam or Mr. —— this is —— (give the dealer's business name) calling. This week we are checking

the radio tubes in our old customers' radio sets right in their homes, free of charge. You need not buy new tubes unless you wish. May we send a serviceman over tomorrow?" If the dealer prefers to keep his list of customers to his own staff, have one of his clerks call the customers.

Later, when you are able to service receivers, you can get the dealer to send a card to each customer telling him that he is planning to have a radio serviceman at work in their locality and will gladly send him (meaning you) to test tubes and give their radio set a general inspection for a modest sum. Figure 4 shows a well-planned card, prepared by one tube manufacturer for their dealers; worth considering.

When the list of customers has been exhausted, you can start to work systematically on the various sections in your locality. Have a card printed, explaining that you will call on the following day to inspect and check their tubes. Distribute the cards in the morning, and follow up these cards the next day with a personal visit. If you have something to give, a radio log book, as the door is opened, you will get a better reception. All you need to say is, "I am the radio serviceman from (give name of dealer). Won't you have, with our compliments, this radio log? May I test the radio tubes in your radio set? There is no charge for this service and you need not buy new tubes if you do not wish to! This is a get-acquainted campaign."

The card left the previous day has focused their attention on your personal call. If they have any doubt about the company you represent, they will have had a chance to investigate.

If the firm you are working with is reliable, you will have a good chance in getting acquainted.

Fig. 4

Some successful radio servicemen do not bother with the scheme of letting a prospect know that they are coming. They work one street one day, another one the following—"cold turkey," they call it. Perhaps you would prefer to work this way too. It is a fair scheme in a small town, where you are known.

Inspiring Confidence When You Are Allowed in.—What should you do when you are shown their radio set? It goes without saying that you are to behave as a gentleman, remove your hat and be courteous. Turn on the power to the radio set and try tuning in several stations. If the receiver works, tune in a distant station. Notice how loud it is. Turn the set off and remove the tubes, one at a time, from the receiver. Check each tube as it is removed, in the tester, and replace the worn-out ones with new ones. Be sure the tubes you put in have a label on them to distinguish them from the old tubes. After all tubes have been checked, again tune in the distant station and prove to yourself with your customer listening that the receiver operation has been improved. Not only will its tone or clarity improve but its volume will be louder.

Be sure you point out these facts to the customer who, no doubt, will be with you all the time. Say, "This sounds much better. Shall I leave the new tubes in? They will only cost you ——. Furthermore, we guarantee them for ninety days." If the customer accepts, offer to leave the old tubes or ask the customer to throw them away. This will convince them that you are on the level.

Be just as ready to say that the tubes already in the set are good, if you find this to be the case, as you would say that some are worn out. If some appear weak, as indicated by your tube tester, call this to the attention of the customer. Mark these tubes weak and make a note to call some time later, when replacement will be needed.

Before you leave it would be a good plan to polish the cabinet, although I would first ask permission. Now is your chance to look around. Would a new antenna system improve reception? Would a wave trap remove interference? Does the chassis need an overhauling? Do the power, ground, and antenna extension leads need repairing? Is the cabinet marred? Maybe you can suggest some job or improvement already mentioned or to be explained to you in these practical job sheets. If there is anything wrong with the receiver, you will probably be told what it appears to be. Perhaps, when you are first asked in the house, the customer may say, "I am glad you called. Our radio hasn't been right for over two weeks."

General Helpful Hints.—If no one answers your call, leave a self-addressed postal card indicating that you called. On the card mention that if the card is mailed, you will be glad to come at their convenience. The card should have space for the customer's name, address and the time at which they would like to have you call again.

Many men who have made a success in this tube checking campaign prefer to call in the late afternoon or early evening, an excellent time for you if you are occupied during the day. Be sure that you do not disturb them at their evening meal. Never call after 8:30 in the evening, as most people have settled for the evening. Do not call on stormy days, especially during a heavy rain or snow, as you are bound to track in dirt and water.

All of these ideas can be used in your own business after you have finished your course of radio training.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

How To Select and Use a Tube Tester

Although vacuum tubes are now better made than ever before they are still fragile devices having only a limited life. Tubes—that is, the filaments—burn out and the receiver is silent; or the other inside elements of the tubes become worn or partially defective through use and the set plays incorrectly. Here are a few troubles that you will encounter, where a tube or tubes may be at fault.

The set plays, stops for a few seconds, then continues to play. Inspect the tubes while the set is turned on and locate the tube that burns brightly, dims or dies out and then brightens again. That tube should be replaced.

The set may play, but a loud crackling noise is heard. Tap each tube, one at a time, with your finger tip. The defective tube is located when upon tapping a tube the crackling becomes more violent. To make sure it is defective, try a new tube.

If the receiver is silent, and you locate one or more tubes that do not light, one or all may be defective. Try new ones.

If the receiver is silent and no tube lights, the chances are that some other piece of apparatus in the set is defective, or the power line is dead.

If the set hums, this may be caused by a poor tube. All tubes should be checked.

Even if the set apparently plays satisfactorily, it may not be giving its best performance due to weak or partially worn-out tubes. Each and every tube must be checked, the poor or weak ones replaced. And what a difference good tubes make in radio reception. That is why tubes should be checked every six months. If the receiver is used constantly, each and every day, they should be replaced at least once a year.

Now, what constitutes a good tube checker? First it should be made by a reliable instrument maker, because you will need further service from the manufacturer as new tubes appear on the market. Furthermore, the tester must be well made and have a professional appearance. The customer will not be convinced that the checker is reliable if it has a crude, makeshift appearance. A modern tube checker should show *Bad* or *Good* readings; you must not confuse the customer with technical terms. It should be so designed that tests are quickly and easily made and it must not go out of date as soon as new tubes are announced by tube manufacturers.

A modern tube checker should test all the octal base tubes regardless of whether they are all metal, metal equivalent, or special glass tubes with an octal (8 prong) base. Even if the instrument is a previous year's model, it should be easily converted by the use of adapters for the testing of the new octal tubes.

A satisfactory tube checker should test tubes for:

1. Shorts or leakage between elements.
2. Its merit. This is often referred to as its quality, worthiness, or mutual conductance. As far as you are concerned, the tube is either *good* or *bad*.

FIG. 1. *A Readrite Tube Checker, inexpensive yet trustworthy. One of the many tube checkers you can use*

Tubes, as you know, are either amplifiers or rectifiers. The test for one differs from the other. In some cases, we have an amplifier and a rectifier in the same glass envelope, and two separate tests are made. You never need worry how a tube should be checked, for every tube tester manufacturer supplies detailed information on how to test all tubes in common use.

Figure *1* is a typically modern, almost obsolescence proof tube checker. A discussion of its use will explain how most checkers work.

First, you always refer to the chart supplied with each tube checker. This chart lists the various types of tubes and the position of all switches and the use of the push buttons on the tube checker. With the tube checker of tester shown in Fig. *1*, you plug the power cap into the wall outlet. Turn the switch marked *A.C. VOLTS* to the right. The line voltage indicator above the meter will become lighted. Continue to adjust this switch until the shadow is just under the line indicator provided. This assures you of correct transformer secondary voltages. Then by reference to the tube chart, set the *FILAMENT SELECTOR* switch for correct tube filament voltage.

Be sure the *TUBE SELECTOR* switch is at the *OFF* position. Place the tube to be tested in the proper socket (4-prong tube in 4-hole socket, 5-prong tube in 5-hole socket, 8-prong tube in 8-hole socket, etc.) and connect the top cap terminal, if any, to the top cap pin jack and allow the tube to assume proper operating temperature. Readjust for correct line voltage. Now, slowly turn the *TUBE SELECTOR* switch to positions *S, H, O, R, T,* and while doing this, your eyes should be on the meter. On each of these positions the meter should show no deflection. A momentary needle kick-over while making a change does not indicate leakage or short. A steady or flickering reading indicates a defective tube requiring replacement.

The next step, if the tube checks O.K. so far, is to set the *LOAD* and *TUBE SELECTOR* switches to the positions indicated in the tube chart sent with the tube checker. Pressing the button marked *VALUE* will cause the meter needle to indicate on the *GOOD—?—BAD* scale. If the indicator shows "?" then the tube is weak and its usefulness is questionable.

Although the procedure for this tube checker is quite simple, it will differ in a checker of a different make. Always follow the instructions supplied with the tube tester which you may be using.

HINTS ON CHECKING AND REPLACING TUBES

1. Always replace with a tube of reliable make and preferably one whose manufacturer is well known. This reduces sales resistance and future service trips.

2. Tubes that show a purple glow between their parts when in the receiver may not act this way in a checker. The replacement tube should be watched carefully when tried in the receiver. Be ready to turn the receiver power switch off if the new tube shows a purple glow; this means that the set is defective.

3. To be sure you get the tubes back into the proper receiver sockets, mark the socket with the tube type number, using colored crayon.

4. Tubes used in A.V.C. (automatic volume control) type receivers should be tested for gas. You will learn more about A.V.C. in your regular radio Course. If your tester does not have a gas test, try various good tubes in the R.F. section and the ones that do not cause the volume to creep up gradually when the set is on a few minutes are good.

What To Do When Tubes Test O.K. and Set Does Not Play

Don't lose your nerve when you are on a service or tube checking call and told that the receiver does not play. Develop confidence. The trouble is either due to tubes, an external defect, or a break inside the chassis. In the latter case, you, in fact any serviceman, will have to take the chassis and speaker out of the cabinet to make a repair. If you don't find a broken wire or connection, take the "works" to your service bench and overhaul it. As you learn more about radios from your radio Course, you will find more and more of the hidden defects, and know how to service same. For the time being you can call on your friend, the serviceman in the other end of the town, for help. You will gradually need his services less and less. But I am getting ahead of my story.

Turn on the power to the set, and see that the pilot light illuminates the dial. If it does, you know that the supply is active. If you don't see the lamp light, look at the chassis, for, if the tubes light, the pilot lamp may be burned out. Suppose neither shows "life." Then the next step to take is to see if the power outlet is active. This is easy to check. Every home has a table or bridge lamp. Turn

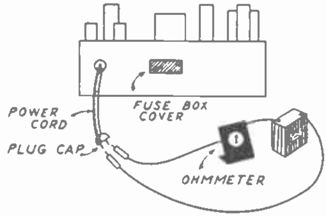


Fig. 2

it on to see that it works and, when satisfied that it does, try it in the outlet that you question. No light means a defective outlet or a fuse blown in this section of the wiring system. An outlet defect is a job for an electrician. When repaired, the chances are that the receiver will play.

What should you do if the test lamp lights? Merely test the power input system of the receiver with the ohmmeter you make with your Home Experimental Outfits. Figure *2* shows you how. Leave the power switch of the receiver in the ON position. Connect the probes of the ohmmeter to the prongs of the power cap as shown. A low ohm reading indicates that the defect is in the receiver further along in the system. No reading may indicate a blown-out fuse, if the receiver has one; or an open in the primary circuit of the power transformer, in the switch, in the plug cap or in the power cord.

FIG. 3

First check the fuse. If it is on the chassis, remove it; if it is inside the chassis, you will find a fuse box cover as shown in Fig. *2*. Unscrew the cover, take the fuse out and test. All you have to do is to place the prongs of the ohmmeter to points *1* and *2*, indicated in Fig. *3*. A reading on the meter shows that it is O. K. and you must take the chassis out for further check.

Going back, let us assume that the tubes and pilot lamp are active. Now you have to use your eyes. Are the aerial and ground leads properly connected to the chassis; are all tubes firmly in place; are the top cap connections, used with some tubes, on their tubes; do any of the top caps touch the tube shields? They shouldn't. Is the cable from the speaker to chassis plugged in firmly; can you see any broken wires? Yes, a lot of trouble can be traced to these obfious, simple defects. I know you won't overlook them. Finally, test the antenna system with your ohmmeter. You know how this is done, so I need not repeat the procedure.

Now, test each and every tube with your tube checker, and look especially for tubes with shorted elements, or tubes that are plain "dead." A tube may light and yet be useless. Usually this shows up as poor or weak radio reception.

If you master what I have already told you, you are in a position to correct about 50 per cent of all the service calls you get. It's the other defects that call for a mastery of radio, which you will get in this Course.

Now you can tell the customer you have to take the chassis and speaker out and perhaps to your work bench. But, before you do the latter, inspect the chassis, which you may turn upside down on the floor. Look for open wires, poor connections or any of the other defects that your studies will suggest to you. At the shop, overhaul the receiver and check each and every part. But this is a subject for another job.

How To Test Coils, Condensers and Resistors When in the Chassis

From your own study of radio receivers, try to answer the question: "What is probably wrong with a receiver, if all possible surface defects have been checked, good tubes are used, and still the receiver does not play?" Let me answer it in this way. In nine cases out of ten, it is probably due to either an open circuit or a short circuit in some part of the receiver. Shorts are usually found in condensers; while resistors, chokes, transformers and wiring become open. Therefore, when the chassis is brought to your bench and after you have overhauled it, without getting the receiver to play, check each part and connection with an ohmmeter.

The average radio serviceman has a "hunch" that this or that part has become defective and checks those parts at once. The expert serviceman also has his opinion, derived from experience and certain tests and knows just where to test. But you can only do the work of an expert when you get further along in your radio Course and know more about radio receivers and service technique. You can, however, do what the average serviceman does—test the parts in the receiver for opens or shorts. Let me show you how this is done.

May I suggest that you assemble the parts sent with your experimental outfits

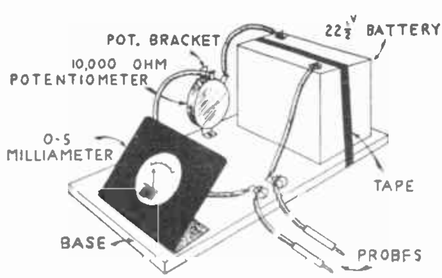


FIG. 4

as shown in Fig. *4*. This set-up is easier to use because of its compact assembly. You need the 0-5 milliammeter, the 10,000 ohm potentiometer, the two probes, two

Fahnstock clips, and a 22½ volt battery. I suggest that you buy a small C battery. Connect these parts in series as shown.

There is no secret in using this ohmmeter. Bring the two probe leads together and adjust the potentiometer so the meter needle reads *5*. Should the meter read down scale (below zero), merely reverse the connections to the meter. Now connect the two probe leads to the coil, resistor, condenser or wiring leads which you wish to test. If the needle reads *5*, the part has an extremely low or no resistance, in which case it might be either shorted or O. K. Experience with the type of part in question will enable you to arrive at a satisfactory conclusion. All resistors and chokes will have a visible amount of resistance and the ohmmeter will read less than *5*. R. F. transformers have a very slight resistance which may not register on the meter. You should not obtain a resistance reading less than *5* when checking for a good connection.

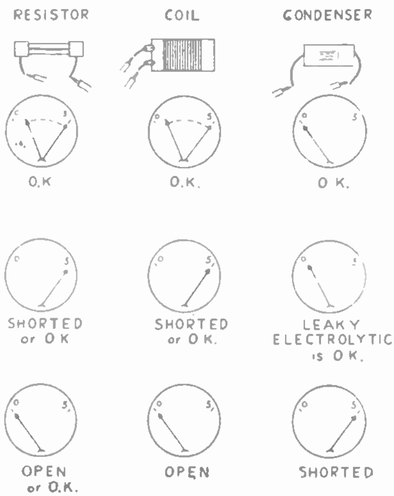


FIG. 5

Now, if the needle points to zero, the circuit is either open or has an extremely high resistance. Again experience will help you make the right decision. A very large resistor might result in a natural reading of zero. If transformers, ordinary resistors or chokes read zero, they are open—burned out, and must be replaced or repaired.

When we first connect the ohmmeter leads across a good paper condenser, the needle will flick toward *5* and gradually drop back to zero. This shows that the condenser has taken a charge and is not open. If the needle goes all the way back to zero, the condenser is not leaky or shorted. If the needle does not go back to zero, the condenser is leaky and should be replaced. In the case of electrolytic condensers, some reading is natural. By reversing the ohmmeter probe connections, the reading will change if the electrolytic condenser is in good shape. The reason for this is that the electrolytic condenser has rectifying properties—that is, current

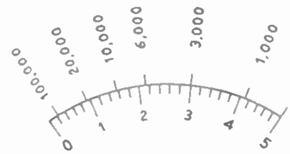


FIG. 6A

flows through it easier in one direction than in the other.

One important point to remember when testing parts is that you must disconnect at least one of the leads across which you intend to test. Suppose, for example, you have a coil connected across a tuning condenser and you wish to check the tuning condenser for a short circuit. You place the ohmmeter leads across the rotor and stator plates of the condenser and obtain practically a full scale deflection. If you did not know that the coil was across the condenser, you would think that you were getting the reading through the condenser and that it was shorted, whereas all that you are really doing is testing the coil. The same applies to other parts such as by-pass condensers, shunting (in parallel with) resistors, etc.

In checking the parts of a chassis, start with the resistors, then the condensers, and finally the transformers, coils and wiring. The parts are listed according to the amount of trouble they cause.

It takes experience to do this quickly, so I suggest that the next time you work on a chassis of a receiving set you measure the resistance of all parts. Figure *5* will help you, at the start, to correctly interpret the readings you will get with the ohmmeter suggested.

Figure *6A* is a rough and Fig. *6B* is a more exact resistance calibration for the

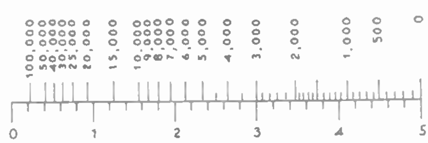


FIG. 6B

ohmmeter set-up shown in Fig. *4*. Whenever possible, have a wiring diagram of the receiver available giving the resistance values of parts. This, too, will enable you to interpret your readings.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE • WASHINGTON, D. C. • PRACTICAL JOB SHEET

What Is the Best Receiver?

As long as there are radio experts, the question "What is the best radio receiver" will be asked them. *You*, too, will be asked this soon after you tell your friends that you are studying radio, after you start on these radio jobs and get into set repairs. I'll wager you have asked the same question yourself.

If you were to put that question to me, I would probably say—"Of course, you don't mean the make." I would want this point cleared away first. Why? Because all reliable radio manufacturers make good receivers and they are fairly priced. You get what you pay for. I would probably ask you what you expected from a radio, where you would use it, how much you wanted to spend, whether you were a music lover, liked sports, or would be interested in long distance reception. If you were on a service call, many of these questions could be answered by looking around. Another important thing to know before answering such a question is what kind of electric power supply (direct or alternating current) is to be used to operate the radio receiving set.

The customer should put the question as follows—"What kind of radio receiver would best serve my needs"—people do not say this, yet that is the only way you can interpret their question.

Why can't manufacturers make one radio to satisfy everybody? In the early days of broadcasting, set makers thought they could, but have since given up the idea. The perfect all-purpose radio receiver has not been developed and probably never will be.

When a radio engineer designs a receiver to be sold for a definite price, he must make compromises. If the set is to have extreme selectivity or distance getting properties, he must slight the tone quality. If the set is to have good fidelity, and the set is to be popularly priced, then selectivity and sensitivity must suffer. If price is no object, then a real high fidelity receiver with good selectivity and sensitivity is possible.

If he is designing a midget or cigar box receiver, then everything: tone, sensitivity, selectivity and ruggedness must be sacrificed for size and compactness. A universal receiver to work on either a D.C. or A.C. power supply cannot have the degree of perfection that a well designed A.C. receiver usually has. Some people want consoles or cabinets to meet their peculiar taste, others want compact receivers. All of these desires demanded by the public have prompted 69 manufacturers in one year to bring out about 680 different models.

The popularity of radio reception has been keyed to such a pitch that the public wants to have radio reception in the home; in the automobile; on boats and in several places in the home, as in the kitchen,

All-Wave Console Receiver
A.C. socket operated

bedroom or recreation room. The travelling man carries his personal set right along with him and operates it on any kind of supply, anywhere and at any time.

I want you to get a clear picture of what is available, so you will be able to answer the question "What is the best receiver?" Furthermore, your knowledge can be turned into money. When you are on a radio job or service call and the customer needs a receiver and is inclined to consider one, study the situation and make a recommendation. You can make a deal with a local dealer to sell on commission, or eventually tie up with a set distributor. If there is a need for a second receiver in the home, or for an auto receiver or a universal (A.C.-D.C.) receiver, sell one.

Remember, as a service technician, repairs come first. Don't push a sale in place of a repair and don't sell a receiver just to get a commission or profit. Be on the level and tell the customer the straight facts. It pays in the long run. Now let

High Fidelity Console Cabinet

me tell you the kind of receivers that are considered standard.

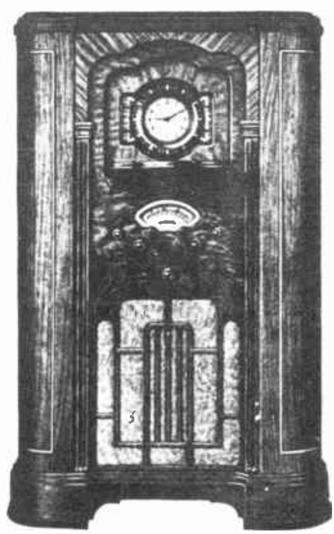
Circuits. Receivers are classified as to the circuit they employ and the wave range they cover. Only two circuits are in general use. One is called the "tuned radio frequency," abbreviated "t.r.f."; the other is the "superheterodyne," usually called a "super." As you probably know, they differ only in the manner the weak radio incoming signal currents are amplified. Out of the six-hundred and eighty kinds of receivers we mentioned only forty-seven were t.r.f. sets. Nowadays you will usually find tuned radio frequency receivers are the inexpensive, smaller types. T.R.F. sets use 4 to 6 tubes, while supers may have from 4 to 16 tubes. For any reliable make the more tubes there are, the more sensitivity, selectivity and power output we can expect.

Again receivers are made to tune to various wavelengths or frequencies. They fall into three classes: broadcast band, dual wave, and all-wave reception. A broadcast receiver usually covers the 540 to 1570 kilocycle band which includes the recent extension of the broadcast band. A dual wave receiver covers the broadcast band and some other band in the 4,000 to 20,000 kilocycle range. The second band will depend on whether foreign short wave stations, police and aircraft signals, or low frequency (less than 540 kilocycles) are to be available. The all-wave receiver can pick up any station within its sensitivity in a range of 540 to 18,000 kilocycles. The change from one range to another is made merely by twisting a range selector switch.

Stated another way, an all-wave receiver can pick up signals from practically any transmitting station on the air; the dual wave picks up American broadcasts and a few foreign short wave signals; while the broadcast receiver is limited to regular American broadcasts. The dual wave receiver providing broadcast and low wavelength reception is made solely for export purposes and is not recommended for America's needs.

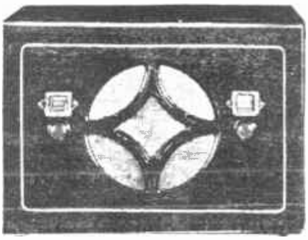
Broadcast Band Console. Until the all-wave receiver became popular the broadcast band receiver (chassis and speaker) housed in an attractive cabinet or console was the most widely purchased product. They average about 3 feet high, 30 inches wide and 2 feet deep. Various designs are offered so that one cabinet of the group will please the customer. The receiver is intended for general use to receive U.S.A., Canadian and Mexican broadcasts. It still is a popular model and is to be recommended where entertainment is the paramount idea. These receivers in addition to the usual station selector knob, have a control for volume, a tone control, and an OFF-ON power switch. The better receivers have an automatic volume control built into the circuit to prevent station fading and to prevent blasting of the signal when tuned from weak to strong stations.

A High Fidelity receiver is a broadcast



Console Radio Receiver with Automatic Clock Control

receiver designed in such a manner that it reproduces the entertainment so that you actually feel you are with the performers. It is housed in a large console, is high priced and some makes have an additional control called a side-band compressor. The latter is an interesting device as it permits you to control the selectivity of the receiver. This is important when you wish to separate signals coming from stations operating at or near the same frequency. You also use it to tune properly to a given broadcast. The set does not have high fidelity when this compressor



Cigar Box Receiver Broadcast Band. A.C.-D.C. Operated Circuit-Super

control is set at higher selectivity. Here is an example where the designer allows you to make compromise between good tone quality and poor selectivity or good selectivity and poor tone quality.

Today, the majority of radio stations are not as good as the high fidelity sets and if you do not have a high fidelity local station, don't sell the customer on the idea of a high fidelity receiver. Of course, he may wish to make an investment because sooner or later most broadcasting stations will have high fidelity.

Mantel or Table receivers are generally sets with 5 to 9 tubes, housed in a small cabinet which can be placed upon a shelf, desk, table or end table. Such a set will cost less than the same receiver in a small console cabinet and, outside of the cabinet, the only difference noticed will be in the tone quality. It takes a large cabinet to get the best sounds out of a speaker. Mantel receivers are preferred by people who desire reliable reception at a reason-

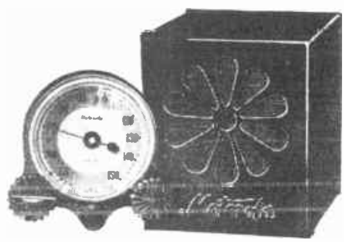
Typical Midget T.R.F. Circuit

All-Wave Table Model

ably low cost; who dislike or have little room for a large cabinet. The controls are the same as on a regular console job. They are made in broadcast, dual-wave or all-wave styles.

The *Midget Receiver* really falls into two classes; one is the very small mantel or table model rarely having over 6 tubes, and the other is the tiny, so-called cigar box receiver. Fortunately they are losing favor, for they have none of the qualities of good tone, selectivity or sensitivity. If a customer wants one, be sure you explain its limitation. If you don't you will get calls to "make them sound like a big receiver,"—"to stop the stations from getting mixed up"—"to get some small station hundreds of miles away." You cannot promise the latter even on a full size machine.

These sets, however, are usually purchased because of their low cost and portability—the customer in most cases understands that they are only good for local reception and are most satisfactory on talks, sports, news flashes, etc. These sets have reached a wide popularity as second receivers. That is, a man will buy a cigar box receiver so that different members of the family who have different program preferences can listen in at the same time. These receivers are generally made for the broadcast band and in some cases provide for local police calls.



Automobile Radio

The *Pocket Radio* is, in my opinion, only a novelty. It consists of 4 tubes in 2 glass envelopes, can be carried in the coat pocket or in a traveling bag. It is used mainly by people who travel, replacing the cigar box radio for this purpose to some extent. Its cost is very low, but it has no place in the home. Only local broadcast signals can be received and only the voice is understandable.

The *All-Wave Receiver* is of sufficient importance to receive special attention. As stated before, it generally covers 540 to at least 18,000 kilocycles. Some of these sets go as high as 25,000 kilocycles. There are usually four separate ranges for this wide frequency coverage controlled by the wave band selector. It is considered the most desirable of all the receivers for the man who wants to receive signals from all parts of the world. Good all-wave receivers can be had in either console or mantel cabinets. They always cost more than a regular broadcast band set. Foreign reception cannot be compared to the results obtained over domestic stations but the distance fan is willing to overlook this to bring in signals from Germany, London or Australia, etc. On the broadcast band, however, they are excellent.

Power Supply. Any of the models so far explained, except the high fidelity receiver, can be purchased to operate from an A.C. or D.C. power socket or from batteries.

Power socket receivers are usually made to work on 110 volt 60 cycle power or on 110 volt D.C. power. Any of these receivers may be made to work on any other voltage, frequency or type of power, as will be explained elsewhere in the N.R.I. Course. Special receivers can be purchased to operate on any power available, although they are purchased at extra cost.

The battery type will always use two or three 45 volt B batteries and the filaments of the tubes may be heated by a dry cell, a special block of small dry cells, or an air cell. Special tubes are employed in battery receivers, except in the case of auto sets, which we will describe next. One manufacturer has brought out a battery set which operates from a single storage battery—working on the principle of the auto sets and not using B batteries.

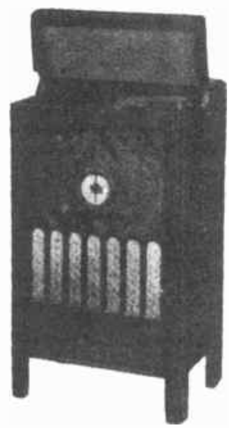
Most of the midget and pocket radios are made to work on A.C. or D.C. power. Some, however, may be changed to work on batteries. These receivers are called universals and are in common use as portable sets.

Auto Radios are compact devices made to stand lots of hard road knocks and abuse. They are very sensitive to signals —they must be, because of the short antenna with which they are used. As their name implies, they are used in automobiles, trucks and buses. Sets of this type are also employed in motor boats. They may operate from the car storage battery and a group of B batteries or they may operate entirely from the car battery. A special vibrator system or a midget motor-generator, either one connected to the car battery, is used to replace the B batteries. Quite often the generator is coupled directly to the car motor. In this case, of course, the radio only works when the motor is running. People like auto receivers and you will learn in your Course how to make them more acceptable by their proper installation and the removal of noises caused by the auto ignition system.

One manufacturer has brought out a portable auto receiver which can be used from the car storage battery or which can be operated from an A.C. or D.C. power source.

The *Phonograph-Radio* is an important instrument. It is usually found in the homes of music lovers who like to choose their own programs. These combinations contain an electric turntable, pickup and record storage space. The records are played and amplified through the audio system and speaker of the receiver. They are usually large, costly affairs although they are available in table or mantel forms.

Special Features in Radios. Some manufacturers offer with their higher priced models one of many special features, to simplify tuning or make the tuning of receivers more or less automatic. *Remote* control is a popular addition to a receiver. Usually the receiver and its speaker is placed in the best acoustical position, where the best sound is obtained, and the remote or extended tuning control placed near an easy chair, desk or table. The receiver is controlled by midget electric motors. A very popular scheme is to have the receiver in a midget case, or in an end table placed near an easy chair, the output of this affair fed through wires to a large console speaker placed elsewhere in the room.



Dual-Wave Radio Receiver with Phonograph

A number of these remote controls are so designed that the operator can push a button and automatically the desired station is obtained. Usually you are allowed a selection of six stations, the tuning prearranged and set-up for by the service or installation man. These gadgets are called *automatic tuners* and are a favorite with women.

A recent improvement of the automatic tuner includes an electric clock and a switching system so that the operator may select in advance the programs desired over a period of 12 hours. Changes are made every 15 minutes starting on the hour, and you may shut the radio off for any desired time. Some of your friends and customers will like these innovations and why shouldn't they? They help make radio a real pleasure.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

How to Eliminate Line Noise with a Filter

"My set is very noisy," is a frequent service complaint. Elimination of noise is important and you will study this subject often before you finish your complete training. Now I want to show you how to handle the general case.

Noise originates either in the receiver or is picked up by the antenna system. Therefore, first you should determine whether it is due to some defect in the receiver or if it is picked up by the antenna. Here is how I go about this kind of a job. It is quite simple.

FIG. 1A

FIG. 1B

I reason to myself: If the antenna system is at fault, all I have to do is to disconnect the aerial and ground leads, that is, remove the pick-up system and if it is at fault then the noise will stop. This test is, of course, made with the receiver turned on. As an added assurance that there can be no input pick-up, I usually take a short piece of wire and connect it to the ANT and GND posts of the receiver; that is, short circuit the input. If the noise stops, I take certain steps which I will shortly explain.

Suppose I find that the noise does not disappear or its loudness is only slightly reduced. Do I immediately condemn the set? No indeed. The noise signal may be picked up by the chassis or come in through the electric power system.

If the parts in the receiver are exposed, that is, are not covered by shielding cans, I suspect that they pick up the noise. Unfortunately, there is very little that you can do about this. If the set is old, and it probably will be, I suggest a new one. Receivers made since 1932 are, as a rule, well shielded and this condition is rarely experienced.

How can I tell whether the noise gets in through the power line? Simply by connecting a so-called "noise filter" in the line. They generally take the noise out if this is the source of trouble.

Figures *1A* and *1B* show two typical noise filters. Figure *1A* is a simple and inexpensive filter and less effective than the one shown in Fig. *1B* which is a more elaborate affair; therefore more costly. When you go into service work as a full time job, I suggest that you carry both types with you on all calls where noise is the customer's complaint. For the time being, a small one is sufficient. Incidentally, many modern receivers have a simple line noise filter built into the chassis.

The typical line filters shown in Figs. *1A* and *1B* are comparatively easy to install. First, pull out the power cord going to the radio and then plug the filter unit (see Fig. *1A*) or cord (see Fig. *1B*) into the wall outlet. Now put the power cord plug of the receiver into the outlet provided on the filter unit. Connect a lead from the binding post on the filter to the ground, or to the receiver GND post if you wish. This wire may be run parallel to the power lead to the receiver ground. A typical connection is shown in Fig. *2A*.

Let us now consider a condition where none of the ideas or remedies tried so far reduce or eliminate the noise. The trouble is then probably due to a defect within the set. I usually slap the side of the chassis or cabinet of the receiver while the set is turned on. If the noise becomes more violent, I know that I am at the root

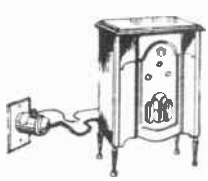


FIG. 2A

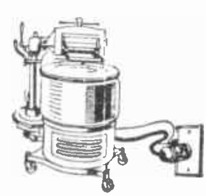


FIG. 2B

of the trouble. I take the chassis and speaker out of the cabinet and remove it to my work bench. I overhaul the set, looking for bad connections or rubbing metal contacts. If this does not solve the trouble I start a trouble shooting procedure. To do this, you must master your radio Course of practical theory and study the texts on Servicing Technique. This information you will eventually get. At this stage of your training, I suggest that you take the chassis and speaker to a friendly service man.

Going back, let me say that I have been convinced that the pickup system is to blame. Every up-to-date service man knows that a special antenna called a noise-reducing antenna will help eliminate what we radio men call "man-made" static. In the next job I take up these antennas, but now I want you to get clearly in your mind the difference between man-made and natural static.

You can't do a thing about natural static, and you should explain this to the customer in the following manner. Explain that there are two kinds of static: man-made and natural static. Man-made static is made by electrical devices such as electric motors, bells, fans and pumps. Fortunately, man-made static is localized and its effects can be greatly reduced or eliminated if he will permit you to do so. In fact, it will be rather inexpensive.

Natural static is a more general interference resulting from conditions in the atmosphere. This type of interference to radio reception is usually more pronounced during thunderstorms than at any other time. Humanity has no control over such interference, although the effects from such interference can be greatly reduced by increasing the power of the transmitting station. This usually explains why local stations come in better than the more distant ones and he should rely on them during times of severe natural static.

Convince the customer of the need for a special noise-reducing antenna. Tell him, frankly, that it will cure man-made static 90 per cent of the time or reduce it considerably. Furthermore, this antenna system will improve reception.

Suppose that you erect one of these antenna systems and the noise does not disappear? You then have to trace down the appliances, like the electric toaster, ventilators, sewing machines and the lights and insert a noise filter in their sockets as shown in Fig. *2B*. You can usually recognize where the noise is originating by the sound. Turn the various appliances used in the home *on* and *off*, one at a time, until you locate the offender. This subject is studied completely in your service course where special and more involved cases of trouble are taken up. But don't be discouraged if you can't handle these cases now, for the majority of the service men today don't know how to either. When you finish your complete training you will know.

Installing Noise-Reducing Antennas For Regular Broadcasts

Noise-reducing antenna systems are becoming more and more popular as they eliminate or reduce man-made static, improve the operation and entertainment value of a receiver and allow better placement of the receiver in the home. They are indispensable in apartment houses where long antenna lead-ins are required. Owners of radios in apartment houses as well as those living in industrial areas can be interested in these noise reducing antennas.

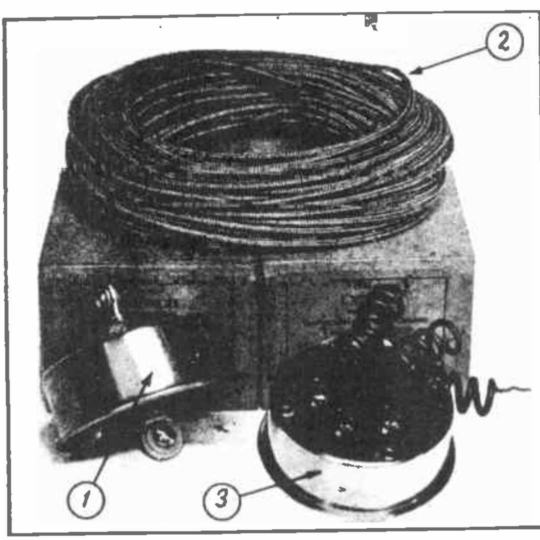


FIG. 3

There will be two conditions where noise reducing antennas will be considered. First when you install a receiver; secondly, when you are out on a service call and man-made static is heard. When a new antenna is to be erected, by all means recommend the noise-reducing type. If the customer questions its need, install the receiver and the ground; use about 20 feet of wire hanging out of the window as an aerial and test for noise as explained in another job. If noise is picked up with this in the temporary aerial system, sell the customer on the idea that a good deal of it will be reduced by the correct antenna system. The same test will tell you whether the old aerial system should be replaced by a noise-reducing system. Remember that a noise-reducing antenna is not a "cure-all" but you never make a mistake by installing them.

Kits of the necessary parts for the installation of the noise reducing antennas can be purchased at reasonable prices. A typical commercial kit is shown in Fig. 3. It contains:

1: About 50 feet of shielded lead-in wire; a flexible rubber covered wire with a sleeve of braided tinned wire over the insulation.
2: An antenna transformer, and
3: A receiver transformer.

Of course, additional parts are needed which you will be required to supply from your own stock; a suitable length of aerial wire, ground lead wire, a ground clamp, stand-off insulators, insulated staples and a lightning arrester. These parts are not usually supplied in the kit as the amount of material you will need will vary with each installation. If you need more than 50 feet of shielded lead-in wire, order the kit with the proper length.

Installing the system. The first and most important step to take is to select the place for the straight-away. It is the only part of the antenna system that is electrically exposed and will, unless properly placed, reduce the effectiveness of the noise-reducing feature. Here are a few simple rules to follow:

1: Place the straight-away as far above all other objects as you can, particularly the house, 10 to 25 feet.
2: The straight-away should be remotely situated from power or telephone lines, and if this is not feasible run it at right angles to them.
3: Keep the straight-away as far as possible from the elevator penthouse, usually found in apartment houses.
4: You may consider a better location even if it makes the lead-in over 100 feet long.

After selecting the most desirable location for the straight-away erect or prepare its two supports and string the aerial wire. The lead-in end should preferably be held in place by a rope going through a pulley. Connect a suitable length of aerial wire to two antenna insulators, anchor one end to the remote support and fasten the other end to the rope on the pulley. Before you pull it into place, connect the antenna coupler of the system.

Figure *4* is a typical apartment house installation. Here is how you would go about connecting this antenna transformer or the top one in the figure. Remember if

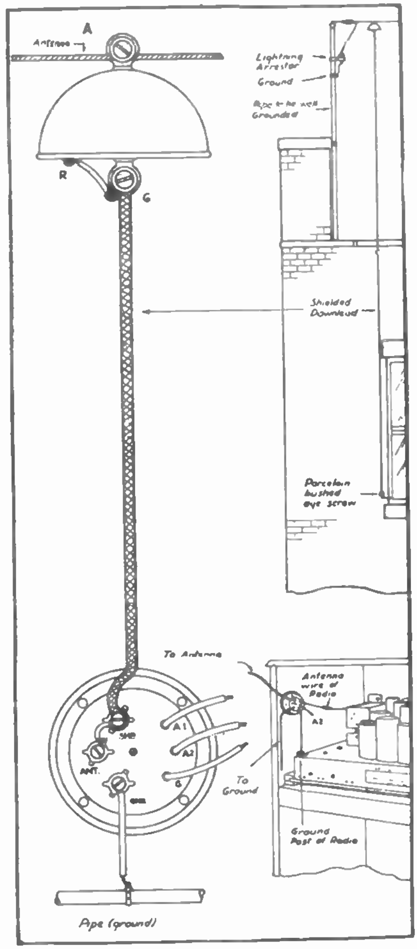


Fig. 4

you use a different kit, the details will differ. Be sure to read the instructions supplied with the kit. In this case push the shielding on the lead-in back about three inches. Unscrew post *G*, see Fig. *4* as wide as you can and after looping the shielding under the washer provided, clamp the post tightly over the lead wire. Be sure that only a small part of the free end of the wire shield extends from the post. Now only a rubber covered lead wire extends and about an inch of the insulation is removed from the end. The bare wire is looped clockwise under screw post *R*. Now unscrew post *A* as wide as you can and hook it onto the straight-away at a point that has been thoroughly cleaned of any corrosion or insulation. In this coupler a deep slot is provided into which the aerial wire fits. Lock the contact tight. Personally, I like to cover the connections with electrical friction tape so that there is less chance for moisture to get in. Now you are ready to pull the straight-away into position.

If you plan to use a lightning arrester on the roof, the lead to the arrester must

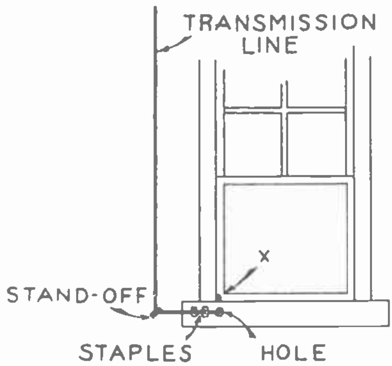


Fig. 5

be attached before the straight-away goes up. This lead should be short, and this means that the arrester should be well up on the pole, as shown. Instead of connecting an extra length of wire to this end of the straight-away, it would be wise to make the aerial wire long enough so when looped around the insulator, the free end will reach the ANT post of the arrester. The GND post of the arrester must be grounded to a vent pipe or to the metal flashing.

Anchoring the lead-in or transmission line as you will eventually call it, is your next step. Make the path from the straight-away to the lead-in window as short as you can. Under no conditions should the lead-in wire rub against an object, for if the shielding breaks, the effectiveness of the system is destroyed. Stand-off insulators (porcelain bushed eye screws) are the ideal supports, as shown in Fig. *4*. I usually wrap a small piece of friction tape around the transmission wire, where it passes through the porcelain bushing. This trick holds the line in place and prevents the shielding from wearing through by swaying and rubbing against the insulator.

The transmission line is then brought through the lead-in window. Of course, if the lead can be wedged into the casing, as at *X* in Fig. *5*, this would be the simplest procedure. Try it but be sure the window closes easily. I would wrap a layer of electric tape around the wire where it crosses the window casing. If this is not feasible, drill a hole as shown. It need be only large enough to allow the line to get through. Be sure you staple the lead to the frame both outdoors and indoors. You do this to prevent wearing the shielding away at the lead through hole.

Indoors, the transmission line is tacked to the window casing, led to the baseboard and anchored in back of the receiver with insulated staples. Enough free shielded wire is allowed to reach the receiver transformer which is screwed to the inside of the radio cabinet as close as you can place it to the ANT and GND posts of the chassis. A ground connection is made in the usual way and connected to the transformer.

The proper connections are shown in Fig *4*. The ground lead is connected to GND terminal of the transformer whereas the *G* lead from the transformer connects to the GND post of the chassis. About three inches of the shielding is pushed back on the transmission line, the shield looped under the SHD terminal of the transformer. After stripping about an inch of the rubber off the lead, the bare wire is connected to the ANT post of the transformer.

Turn on the receiver and try the *A1* and the *A2* wire leads on the ANT post of the chassis. The lead that gives you the strongest signal is selected and connected firmly to the aerial post of the receiver. The job is now completed.

How to Check the Transmission Line. You may have to check the line in an old installation for an open or a short. Here is how you make the tests.

Disconnect the lead of the line from the ANT terminal of the receiver transformer. Connect an ohmmeter (the one you build with your Home Experimental Outfits), to the disconnected lead and the SHD post of the receiver coupler. A low reading, less than 100 ohms indicates a completed circuit, that is, no open.

Do not reconnect the lead to the transformer. Take the ohmmeter to the roof and after disconnecting the line from terminal *R* of the antenna transformer, connect the ohmmeter to this free lead and terminal *G*. The ohmmeter needle deflection should be extremely small and in a new installation no ohmmeter deflection should be indicated. If the ohms indicated when checking an old installation is less than 25,000, I suggest replacing the line with a new one.

Pigtail Lightning Arrester. Where it is not convenient to erect a lightning arrester on the roof, a small pigtail arrester, which looks like a grid resistor with pigtails may be used. Merely connect one pigtail to the ANT and the other lead to the SHD terminals of the receiver transformer.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

Where To Place the Receiver in the Home and the Best Antenna To Use

As the tone of a radio receiver or the fidelity, as we Radio-Tricians call it, has become one of its most important characteristics, good judgment is required in the proper placement of the receiver in the home. Why should a radio manufacturer build receivers with high fidelity (one capable of handling the wide band of audio frequencies with a low percentage of distortion), if the customer's enjoyment of it is lost by improper installation?

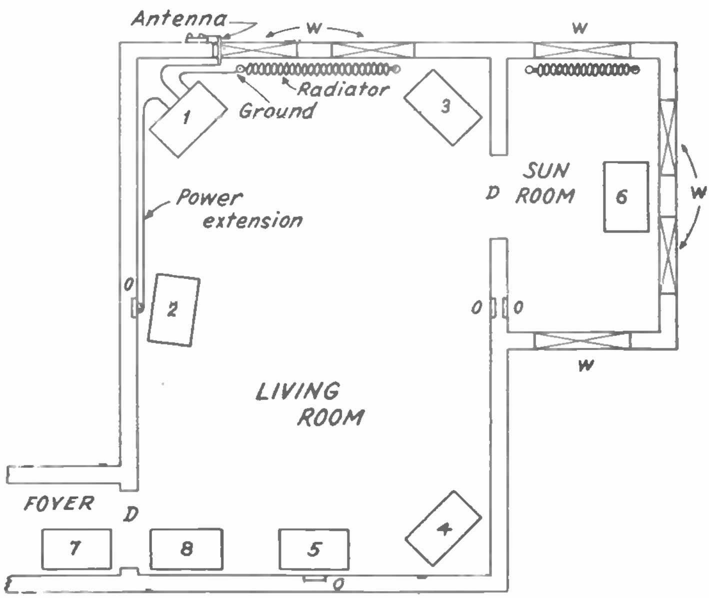


FIG. 1

Just so long as a radio set is considered as a source of family entertainment, just that long will tone, fidelity, quality, richness in sound, or whatever description the customer wishes to give it, be an important installation and service problem. I want you to develop your ability in this respect.

The position of a receiving set in the home is governed first by the desire of the housekeeper and secondly by the location for best acoustical (sound) effects. Regardless of what you think is the proper location you must either convince your customer that you are right and this must be done with all the tact that you can muster, or you must place the set where the housekeeper wishes. In the latter case you should explain the results of such a move.

Usually there are several acoustically good positions in a room, but the most desirable of these places is the one that makes the power, antenna and ground leads as short as possible and away from each other. This last rule should be followed whenever you are using an ordinary antenna system. When a noise reducing antenna is used, you may employ any of the acoustically desirable positions and the length and position of the lead-in will not cause trouble. Let me make these facts clear with a few examples.

Consider a possible room arrangement as shown in Fig. *1*. Windows are marked *W*, doors marked *D*, and power outlets marked *O*. From an acoustical (sound) viewpoint, the radio receiving set in its cabinet may be in positions *1*, *3*, *4* or *5*. In position *5* you should be careful to keep the cabinet of the radio set away from the wall. From an electrical point of view, position *1* is to be preferred. The radio is situated conveniently near the aerial, ground and power outlet. Position *3* is less desirable, as this location would entail a long power extension cord. If the customer should want the radio at this point, and you are erecting the aerial, bring the lead-in at this side of the window.

Positions *4* and *5* are the least desirable. If you are requested to place the radio at such points, I would recommend a noise-reducing antenna employing a shielded lead-in. In this case you would have to lead the transmission line around the door casing of the living and sun rooms. Of course, you could bring the leads up through the floor from the basement. At the nearest point to a good ground, make a connection to the shielding of the transmission line. In noise-reducing antenna systems where a ground on the roof is used, you naturally need not worry about an indoor ground.

FIG. 2.—*The console speaker is acoustically treated, so it may be placed against the wall.*

Position *2* is quite a favorite with home owners, but should not be recommended. Sound will be directed back to the speaker from the opposite wall. Remember that the speaker of the radio set should be pointed to the farthest wall or corner. Position *6* is another favorite and it too is not to be recommended. To begin with, this room is too small and the radio is back to the wall. The sound reaching the living room will be distorted. It might be a more desirable position if the connecting door was extremely wide. When placed in this position, the antenna lead-in should come in at the nearest window.

Surprising as it may seem, radios are placed in the foyer, position *7*, a wrong place from every point of view. It would be far better to locate the receiver at position *8*.

Although the serviceman can only recommend the most desirable location for the receiver, remember that the customer will live with the radio. They have as a rule definite ideas about placing their furniture, and may resent being told how to arrange their home. Suggest the ideal position. Don't force your idea.

If you are compelled to back the receiver against the wall, leave at least 2 inches of air space. If permitted, place the back at a slight angle as shown in position *2*. The sound from a receiver placed against the wall may be improved by lining the inside of the speaker compartment with thick wool padding and employing a wood padded back. Two or three 6 inch holes in the bottom and back of the speaker compartment will help take out the *boom, boom.* Both of these plans are employed in some high priced receivers.

When called upon to repair, service or improve a radio, you should suggest a better position for it, if it is not well placed already. Often a marked improvement will be realized. It is worth knowing that a radio sounds best when heavy rugs, drapes, and overstuffed furniture are in the room. A radio will sound a little hollow in a "summerized" room—rugs and drapes taken out.

Some of the higher priced receivers are made into two sections. You may find the receiver chassis in a small low-boy which can be placed alongside an easy chair, while the speaker may be removed 15 or 20 feet and in this case is usually placed in a large console cabinet, as shown in Fig. 2. In such a case, you have two things to consider. In this installation you will be better off if you use a noise-reducing antenna. The easy chair selected should be near a power outlet. The console containing the speaker may now be placed in a position which is acoustically desirable. A long flat cable connecting the chassis and the receiver which can be run under a rug is a part of the equipment supplied. Now you may choose any of the good acoustical positions to place the speaker.

Receivers operated with a remote control mechanism in which the speaker is built into the receiver cabinet, must be treated in exactly the same manner as an ordinary set which is tuned and operated by hand.

Battery receivers eliminate the necessity of considering the power lead—just keep the aerial and ground leads separated. Midgets and mantel receivers need not be included in this discussion as they do not produce excellent tone quality and their placement in various positions will have little effect upon their sound.

Be careful, however, to listen after all installations, with the volume turned up fairly high. Sometimes there are objects in the room which may be thrown into vibration by the speaker, causing rattling noises. In some homes you may find large pieces of tin behind the radiators, used as heat reflectors. These may vibrate with strong signals, producing an annoying buzz or rattle. The sound from the receiver should be directed away from such objects.

Also on very small sets, the hum may seem to be intensified by their position. Experiment until you find the best position.

How To Install a Noise-Reducing Antenna for 1 to 4 Receivers

Here is a job that the landlord or owner of a house with two or more tenants will welcome if you suggest it in the right manner. Look around and see the number of homes which have two or more families. Observe the unsightly antenna set-ups. No wonder that some landlords balk at poor antenna installations. You would, too, if you were in their places.

Before I go into the actual installation of an aerial that will serve for 1, 2, 3 or 4 receivers, let me tell you where and how to get this sort of a job. If any of your relatives or friends live in a house or apartment, where there are two or more aerials, suggest to them a modern multiple receiver antenna. Explain that one straight-away, that is, one aerial on the roof will serve up to four receivers, give better radio reception, and above all reduce man-made static. If you get one of these installations working, you can point to it as an example of what a well planned system will do for the appearance of the house and how it improves reception.

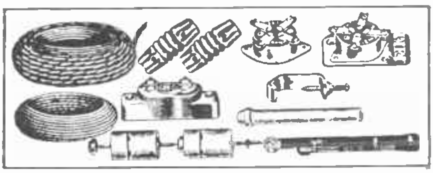


Fig. 3

With this as a lead, have your friends tell you who of their friends have two receivers in their home. Make a survey of houses that have several aerials on the same roof and through your town records find the name and address of the house owner. Write to him or, better still, call on him. Explain that you can improve the appearance of his property and satisfy the tenants with this modern installation. Maybe he will pay for the entire installation and maybe he will pay a portion of it with his tenants paying the rest.

Keep your eyes on the homes that are being put up. Many jobs will come from this source. It helps rent a house if the radio antenna system is already erected. When you go into the radio service business, this and many other jobs will suggest themselves.

The system that I am to describe has been designed and is manufactured by the Philco Radio and Television Corporation. A kit of parts suitable for one receiver is sold through their distributors or mail order houses and there are many of them throughout the country. This kit, shown in Fig. 3, contains two coupling transformers, a lead-in strip, two nail-it-knobs, a lightning arrester, a ground clamp, two aerial insulators, a porcelain tube, a roll of aerial wire, a roll of transmission cable, and a roll of ground wire.

For multiple receiver operation you buy an extra receiver transformer for each extra set to be operated, and sufficient transmission wire to make the extensions.

Single Receiver Connection. Figure 4 shows how a single receiver installation would be made. The straight-away should be as high as possible and the lead-in support should be near a ground. This antenna system depends to a large extent for its efficiency upon the ground, conveniently obtained through a connection to an outdoor vent or indoor overflow pipe. The connection to the overflow pipe in the attic will provide a ground of fairly low resistance. A connection to a tin roof that is fairly well grounded will also be suitable. Under no circumstances should a ground wire be run from the roof down to the actual ground level, since this connection will afford no better performance, as far as noise elimination is concerned, than if the antenna transformer were mounted at the ground level.

The antenna lead wire connects to the ANT post of the arrester and to the ANT post of the antenna transformer. Make a lead connection from the GND post of the transformer, to the GND post of the arrester, to the ground chosen; use the window lead-in strip if you have to go inside the house to reach a ground. The transmission cable which contains a red covered and a black covered wire is clamped to the antenna transformer and the red lead connected to the post marked RED while the black lead connects to the post marked BLK, of the transformer.

Now the transmission line is led down in the most convenient manner, using the nail-it-knobs, directly to the lead-in window; through the porcelain tube or hole in the window casing; around the baseboard or under the floor to the receiver, employing insulated staples to hold the cable in place. The set transformer is screwed down inside the radio cabinet and near the antenna and ground posts. The red and black covered wires are connected respectively to the set transformer posts marked RED and BLK. The ANT and GND posts of the transformer are connected with the shortest possible wires to the respective ANT and GND posts of the receiver. Note that a ground connection is not needed at the receiver. Therefore when installing a receiver with this antenna system, only the power socket and the most desirable acoustic position will govern the location of the set.

Multiple Receiver Operation. Parallel connections or extensions may be made to the main transmission line and each lead connected to a set transformer, the latter, of course, located at its respective receiver. This is shown schematically in Fig. *5*. More than four parallel connections are not recommended. Furthermore a second, third or fourth set connection may be made at any time. Each connection to the main transmission line should be made by using extra lengths of transmission wire. The red lead of the extension is soldered to the red lead of the main transmission line, and the black lead to the black lead of the main line. Be sure that a red lead does not short (touch) a black lead. Tape the joint to prevent corrosion and possible future shorts.

Hints: Needless to say, the antenna should be away from any probable source of interference. The total length of the transmission line, including extensions, should not exceed 400 feet. The antenna need only be 50 feet long for a single receiver connection, but 75 to 100 feet will be best for a multiple set connection.

Note in Fig. *4* that the antenna coupler is not placed directly at the aerial. For best reception of locals a small vertical down lead such as shown in the illustration is a big help. This need only be a few feet in length.

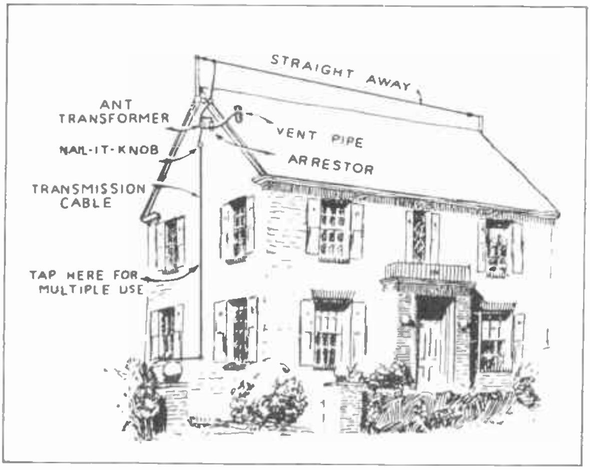


Fig. 4

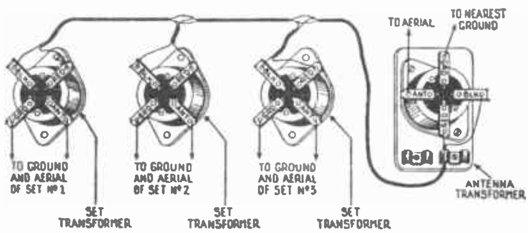
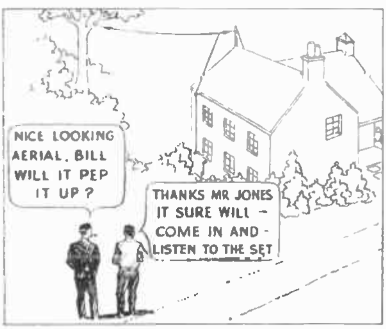


Fig. 5

How to Get Started in Radio

You can start, just as soon as you want, to do a large number of different Radio jobs. Some of these jobs are very simple. You will be able to do them easily.

Some of the early jobs these "Practical Job Sheets" will show you how to do, are so simple they are neglected by many Radio servicemen. Do not make this mistake. They are very important. Master them thoroughly. Handle all of this work you have time for. It gets you into



real Radio work at once; gives you practical experience—starts you making money.

Most people take it for granted that if a Radio set plays at all, it is in good condition. That is absolutely wrong.

But when the set owner comes to realize that a carelessly installed aerial, strung up in the attic, is not as good as a real aerial installation on the roof, he will want a good outside aerial. When he realizes that there is a proper position in his home for his set, a position which will make it sound more lifelike, he will welcome the opportunity to have you move his set to the best location. Even the most indifferent set owner will ask you to install a lightning arrester in his aerial system, if you call to his attention that the fire insurance policy on his house says it must be there.

Of course, before people will let you do these and the many other jobs about which we will tell you, they must be sold on the idea that they need what you have to offer. Furthermore they must be convinced that you can do a good job.

These Practical Job Sheets have been prepared to show you how to do the jobs and how to convince others that you can do them. Here's what they show you:

1. What the jobs are and how to do them.
2. What they will do for the set owner —in other words how he will benefit and consequently *why he will want them done.*
3. Ways of showing the set owner what he needs, and in such a way that he will realize *you are the one to do the job.*

The best way to start is on your own Radio—then on that of some relative or friend. Help your friends and relatives get the most out of their sets by using just as many of these ideas we give you as you possibly can.

Point out these benefits and improvements to them. Make sure they understand and appreciate the improvements in performance that your work is getting for them.

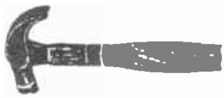
Radio is a great mystery to those who know nothing about it and you'll be surprised how glad your relatives and friends will be to see you progressing so rapidly.

A good Knife is required

They'll like to brag about your ability and they are also interested in seeing you get ahead. They'll be quick to tell *their* friends about what you are doing. These people will in their turn want the same improvements made to give them better reception in their Radio, and will be calling you up and coming around to get you to do jobs for them.

All the time you will be learning to handle an increasing number of jobs.

Naturally, some of them will be a little more difficult than others. BUT REMEMBER THIS: you will be learning more and more about Radio from your regular lesson texts in the Course. The lessons will make the more advanced jobs seem very easy—because you will be trained to a point where you will know how to do them.



Get a good Claw Hammer

Read all you can about Radio in the newspapers and magazines coming to your home; talk Radio whenever you get a chance. In other words LIVE Radio and people around you will come to think of you as the "Radio man." Calls for your services will start to come in. If you get jobs that are beyond the ability you have developed at a particular point in your training, remember that N. R. I. is always ready to help you. If these jobs are urgent, there is sure to be some friendly Radio serviceman in your town who will do a good job for you if you take the chassis (the "works" inside the cabinet) to him. Watch what he does with it. You may learn something. If the job is simple he may even tell you how to go about doing it. It will be a good move for you to get on friendly terms with some Radio man on the other side of the town.

Here is another tip. Try to do your job, particularly if it is an outside one like putting up an aerial, when the men folk are around. You will be in the limelight and if your job has a good workmanlike appearance, they are bound to be favorably impressed. Get them interested and be sure to point out the advantages and important points of the installation. If neighbors or visitors happen to be about, so much the better. Get permission to invite them to listen to the improvements in reception that your installation or job has produced. Be friendly, courteous and tactful—but be very sure that everyone who sees the job or listens to the improved reception understands what you have done, and that you would welcome the opportunity to do the same thing for them.

A Side Cutter

Before taking up individual jobs, *let me stress the importance of your regular lessons.* Without them you will never be more than just a "tinkerer"—a "fixer." The Radio Industry is cluttered up with "half-baked" Radio men of this kind and most of them can't make a living because they just don't know what it's all about. Master your lessons thoroughly so you will KNOW Radio, know it *through and through.* Then the jobs in these bulletins will become second nature to you and a single reading of one will set you on the right track to make money.

Collecting Simple Work Tools

You don't need many tools to start in Radio work. Most of those you do need at first are already about the house. Any which must be purchased should be obtained as inexpensively as possible. You can get some very practical tools in the five and ten cent stores, chain stores, or from mail order houses.

A medium and midget Screw Driver

Do not spend much money for high grade tools until you are doing plenty of service work and have extra money to spend. Remember this—a good workman will do a satisfactory job with whatever tools he has. Even though you may not have had much experience with tools, you will find it easy to acquire good mechanical skill *if you learn to recognize a well-finished job when you see it.* Experiment with your methods until you can depend upon yourself to turn out a neat, clean piece of work. Arrange to watch some good mechanic, better still, a good Radio man, handling his tools. Get the knack.

The tools you will use most are an electrician's pocket knife; a claw hammer; a medium size and a midget size screwdriver; a pair of side cutting pliers, a pair of expanding combination pliers; a file and some sandpaper; an electric soldering iron; and eventually a small hand drill with a number of steel cutting drills to fit it. A small steel utility or tool box is a very handy thing to keep these tools and small Radio parts in. Let's see what these simple tools are like.

Electrician's Pocket Knife. Any heavy pocket knife with a strong steel blade will do. However the electrician's pocket knife is particularly handy, as it IS very sturdy, will stand up well. Also because it has a screw-driver blade and wire stripper. Often when making an electrical connection you need a screw-driver for just a moment, and having it already in your hand saves time in laying down the knife and picking up your regular screw-driver.

These Combination Pliers are indispensable

Any knife blade can be used to cut off insulation. At the same time you will use it to scrape wires clean which is necessary for properly soldering joints. You will use this knife hundreds of times so keep one handy. *Always close the knife when you put it away.*

Hammer. Probably you have a hammer or two already. Almost everyone does. Personally I like a claw hammer of medium weight. You will use it frequently. Not only will you use it to drive and pull nails, but you will use it to rip off external extension wires; hence the need for the claws. You will use the hammer and a nail to start screw holes and you will often use the hammer to fix a rivet or a screw so it will stay put.

Screw-drivers. Machine screws, wood screws, and set-screws are so extensively used in building Radio apparatus, that when you do installation, repair, and replacement work, you will be constantly in need of good screw-drivers.

I find that all my needs are answered by an eight inch heavy duty, and small midget screw-driver. The heavy screw-driver is grasped with the palm of the hand and fingers and turned with a wrist motion. The small screw-driver is held between the thumb and first two fingers and the handle rolled with thumb and fingers.

A File is mighty handy

Never turn the screw-driver until its blade is set firmly in the groove of the screw.

Combination Pliers. Your fingers are really remarkable things with which to grip, bend or twist wires or nuts. But you should learn the useful limit of your fingers and know when to resort to a pair of pliers. Increase the effectiveness of your fingers by getting and learning to use a pair of combination pliers. You very likely have a pair around the house.

With these pliers, you can grip an object of any shape and hold it firmly while you twist or pull. The flat jaws are just about right for flat surfaces, the alligator like jaws permit you to grab round objects such as a pipe. The expanding jaw allows you to get a good hold on objects up to an inch and a quarter thick. Many combination pliers have a wire cutter, just the thing to cut heavy aerial and lead-in wires. At the end of one of the grips you will usually find an emergency screw-driver. This is also good to pry with.

For Radio work these pliers can be used to tighten bolts, or unscrew nuts. Nothing could be better to finish curling the end of a wire which has to be wrapped around itself. And they make a fine hand vise. You'll agree with me that a pair of combination pliers is a very handy tool.

Side Cutters. A Radio man cuts wires so often a wire cutter is constantly in his hands, even as much as the soldering iron, the use of which I am going to explain shortly. Radio men prefer side cutting pliers.

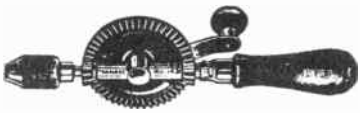
A good electric Soldering Iron

I never saw a good Radio serviceman who would venture out on a job without a pair of side cutters. Get a pair of 6-inch side cutters and learn to use them. Cut small wires with the tip of the cutter, but when you cut heavy wires *be sure* the wire is set well into the jaw. This is just a caution as you will do this naturally.

There are all kinds of pliers with side cutters on them but I recommend a pair of regular side cutters for Radio work. You can cut wires when they are in the chassis. You can get the jaws under a loose rivet or bolt to snip it off. You can cut close to a flat surface as the handles, when the pliers are set for cutting are off the surface, allowing enough for your knuckles underneath. Radio men use their side cutters to strip the insulation off wires. Try it. Grasp the insulated wire in the left hand (if you are a right hand worker) and with the side cutters in the other hand, use the little finger of the right hand to push open the handle and consequently to open the jaws. Cut into the insulation only. Don't cut into the wire. Pull the jaws against the insulation, and off it comes. Try it a number of times and you'll get the knack.

File. A clean r urface makes a good electrical con on, and makes soldering easy. Keep your soldering iron in good shape by filing the tip clean. Use your file to clean the water pipes which you use as ground connections in aerial systems. You will need a file to trim down parts, to finish off a screw after you bite it off with side cutters.

An eight-inch flat bastard file will serve your purposes. If you wish you can drive the pointed end into a wood handle. Small round, and half round files may eventually come in handy, but I suggest that you do not get them until you learn more about your requirements.



You'll be proud of your Hand Drill

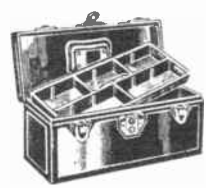
Sandpaper. Don't try to clean a round wire, or remove the enamel from wire with a file. Use sandpaper. For large round surfaces cut your sandpaper into strips: hold the ends firmly between the fingers of each hand and use a motion like a bootblack polishing a shoe with a cloth. You should carry several grades of sandpaper. A package of assorted grades can be purchased in 5 and 10 cent stores or hardware stores, for about a dime.

Hand Drill. I distinctly remember how proud I felt when I purchased my first hand drill. I knew that steel, brass and aluminum were no obstacles. But while most servicemen carry hand drills and although they are not expensive, I personally find drills are rarely needed in present day Radio service work, except when replacement parts must be riveted to the frame of the receiver and are not exact duplicates, requiring new holes to be drilled; or where a receiver is to be completely rebuilt; or you are building a special receiver or transmitter.

When you get to an advanced point in your service work it will be plenty of time to get a small hand drill, one capable of taking an assortment of twist drills.

Soldering Iron. Get a soldering iron as soon as you start doing service and repair work—learn to use it—and use it! I couldn't express myself more forcefully. Every permanent connection *must* be *soldered,* and even if the connection may not be permanent, I would say solder, if you are in doubt. All joints subject to corrosion, and that includes all outdoor connections must be soldered. I'll explain what connections should be soldered as I take up the various jobs.

The best size to get is a 50 to 75 watt electric soldering iron. You will not need a large one, as most soldering joints will be small. If you can afford it, get a good one as they are the only kind that can take punishment. It is wise to have a steel table soldering iron rest, so you won't burn holes in the furniture. Never heat the iron unless the tip is in place, and never let the tip get too corroded while in the iron. All of which suggests that you get an electric soldering iron with a tip that is easily replaced. I am going to tell you more about soldering in another job sheet.



Keep them in a tool box

Tool Box. If you value your tools, want to keep them in an orderly manner, and not go on a job minus an important tool, *use a tool box.* I find that one about 15 inches long, 6 inches wide and 6 inches deep, with a tray is just the right thing to use. And every tool goes back into that box when I finish using it.

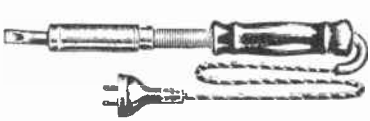
Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

Learning How to Solder

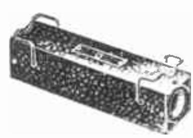
When you solder an electrical connection you insure and prolong its useful life. Think this over: what good is it to locate a broken wire or a defective connection and repair this damage with poor soldering? Trouble is bound to recur. Good soldering is easy, if you will pay attention to details. Learn to solder correctly and your work will be easier and the job quickly finished. In a short time you will solder well without even thinking about it.

Tools You Need. A moderately priced electric soldering iron with a removable tip which works equally well on A.C. or D.C. current is a first necessity. You need a 50 to 75 watt, 110 volt iron. I prefer an iron that uses a round copper rod ⅜ inch in diameter for the tip. This tip slips into the heater of the iron and is held in place by a set screw.



My Choice for Radio Work

Get a soldering iron stand. The one shown is also a soldering iron holder. When you are through with the iron and ready to put it back in your tool box, slip the iron, tip first, into the holder, and your hot iron will not burn or overheat the other tools. When you are using the iron, keep it on the two curved wire arms of the stand, the tip free in the air and plug the wire cord into the power socket.



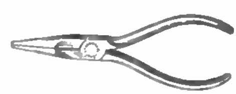
A practical Soldering Iron Holder and Stand

Soldering Iron Brick to keep your Iron bright

To keep the tip of the iron in a condition for perfect and quick soldering, you need a ½ pound cake of *sal-ammoniac*, (called a "soldering iron brick") to clean the tip—keep it bright and shiny.

Now we come to the solder itself. There are many kinds of solder, but ONLY ONE KIND FOR A RADIO MAN. When you buy this material, simply ask for *Radio Rosin Core Solder*. It comes rolled or on spools; looks like lead wire about ⅛ inch in diameter and has a yellowish brittle material in the center, its core, which is nothing more than rosin.

Use only Rosin Core Solder



Long Nose Pliers

In addition to the iron, the brick and the solder, you will use your side cutters, your combination pliers, your file, sandpaper and a piece of cheese cloth. Nothing elaborate you will agree. Later on as you get to doing repairs inside the chassis (the frame-work, conductors and electrical apparatus of a radio set) long nose pliers will be a mighty handy addition to your existing collection of tools. Long nose pliers will allow you to pull wire through the mass of chassis wiring, or bend the wire around a joint. Because they have a long nose, you can work in tight quarters. After the wire is bent and in place, surplus wire can be snipped off with the side cutters.

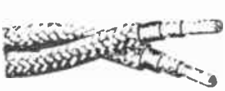
Preparing the Soldering Tip. Your iron will probably come to you with its tip shaped to a dull point. More than likely it will be a four sided point, the tip coated with solder. Heat the iron until you can wipe the solder off with the cheese cloth and then notice how bright the tip becomes. Take a foot length of solder, wind one end into a small compact roll, with about two or three inches of it sticking out straight, and hold the roll in your left hand. Holding the soldering iron by the handle, in your right hand, apply the

Stranded Copper Wire. Rubber Covered

Solid Copper Push-Back Wire. Cotton Covered

end of the rosin core solder to the tip of the iron. How can you tell if the iron is in a fit condition? If the iron is hot enough, it will melt off a slight amount of solder, and if you point the tip of the iron towards the floor the solder will run to the extreme tip. If the iron is not perfectly coated with solder, the solder will form a small ball and roll off the iron.

In time the bright coating on the tip will disappear and you must recoat or, as it is called "tin" the tip. Here is how you do it. While the iron is cool, file the four faces of the tip. No black or dark brown spots should show. Only bright lead



Twisted Lamp Cord Wire. Cotton or Silk Covered

Parallel Lamp Cord Wire. Rubber Covered

or a sunset copper color surface should appear. Be sure there are no burrs or very sharp points. Now heat the iron and when it gets hot, place the tip in one of the grooves of the sal-ammoniac brick. Melt a bit of solder into the groove of the brick and rub the solder well into the tip of the iron, while in this groove. When the tip is properly tinned you will find, on wiping it off with the cloth, that there will be a bright surface. Always be sure that it is well tinned before you go out on a job.

Preparing Electric Wires for Soldering. The wire used in radio is usually made of copper, varying in diameter. It may be "solid," that is, one piece; or there may be five or more strands twisted together,

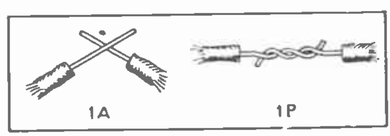
Parallel Lamp Cord Wire. Silk Covered

Single Wire. Rubber Covered

called "stranded" wire. If the wire is not already tinned, you will have to apply a coat of solder to it before you can solder it to another wire or surface.

The portion of the wire that is to be soldered should be made bright and clean with sandpaper. In the case of stranded wire, unravel (separate) the strands and with a folded piece of sandpaper, grasp the wire and draw the sandpaper off. Repeat while turning the wire.

With the hot iron resting on the stand, bring the wire to the iron and while you draw the wire across one face of the soldering iron tip, apply the wire solder to the tip pressing the wire to the iron with the solder. In this way the rosin is not burned but used immediately to cause the solder to adhere to the wire. Now retwist the stranded wire and run it across the tip of the soldering iron to permit the wires to adhere to each other.



The Most Fundamental of Joints

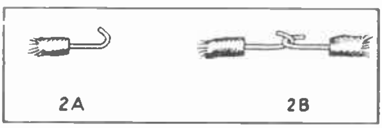
Several kinds of insulated magnet wire are used in radio devices. As a rule you will find non-tinned copper wire covered with one or more layers of cotton, or wire covered with enamel, which may or may not be covered with cotton or silk. When these wires break they have to be reconnected. Quite often you will find several strands of enamel wire covered with silk. This wire is called *Litz* wire. In any case scrape the insulation off with your knife, and clean the wire or individual strands. In the case of Litz wire use sandpaper. Tin the wire as explained.

Turning now to electric power and aerial lead-in wire, you will find that they are generally plain copper or tinned copper wire with one or more strands covered with rubber and finished with a cotton or silk outer covering. Before you can make an electrical joint to an insulated wire, peel off or cut off with your knife or side cutter, the entire insulated covering at the point you want to make a connection. Tin the wire or individual strands at this point.

Finally we come to *hook-up* wire. In general it looks like bell wire. Use only tinned hook-up wire. It will save you a lot of time, when you are connecting wires or making a wire change in a chassis. The insulation on hook-up wire is obtainable in assorted colors so that you can readily identify the connections that are made. Red, black, green and yellow are standard.

Hook-up wire is easy to use. Slip the insulation back on the wire. It slips back readily and stays put and is ready for soldering.

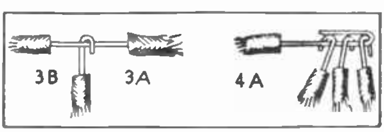
Joints used in Radio. Before we consider the final step in the art of soldering a good electrical connection, let us consider the various possible joints. This is important. No matter what kind of a joint or connection you make, the connection must be a good clean one before you solder. Furthermore it must stay put, that is, be a reasonably permanent mechanical connection, too, so it won't pull loose easily. The Radio should work with the connection as made without soldering, but never *leave it without soldering.* What type of connections will be acceptable?



Hook and the Double Hook Joint

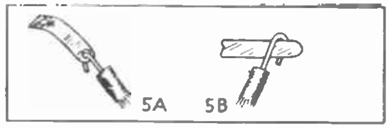
First we will consider the twisted leads. Remove the insulation from the ends of the two wires that are to be connected. Be sure they are tinned. Cross them as in *1A* and twist the two wires in opposite directions with both hands, using your thumb and first finger, until it appears as in *1B*. This is the most fundamental of all wire connections and is universally used for heavy wires. To insure a permanent connection, solder the twisted leads. I will come to that shortly.

The next type, especially useful in radio work, is the hook joint. Remove the insulation, tin the wire and form with your fingers or with your long nose pliers a hook as in *2A,* on each lead. Hook the wires and close each hook with the pliers. Press on the hook, below the actual point of contact. Solder.



A "T" Joint   The Multi Hook-Joint

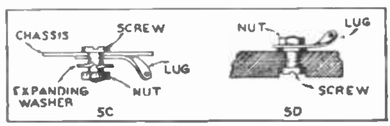
A "T" connection is very often used. In this case the wire *3A* is stripped of its insulation at the point where contact is to be made. A knife is the proper tool to use. The exposed wire is tinned if necessary and the other wire prepared as in *2A,* is hooked on as in *3B*. Solder. Of course, there is no reason why two or more wires cannot hook on at the same point. In fact, it is often done.



Two typical lug joints

Where two or more wires are to be connected at their ends, follow the scheme shown in *4A*. One wire is used to hold the other hooked wires and is itself finally bent into a hook. Then the joint is soldered. After the ends are soldered you can lead the wires away in any desired direction.

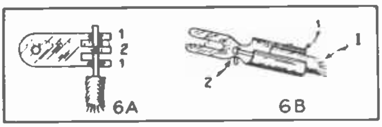
Metal projections called "lugs" are extensively used to simplify the electrical connections of two pieces of Radio apparatus. They are used because designers realize that you should not solder to a large frame, to aluminum, to binding posts or to connections which may have to be disconnected. Instead a lug is used which is either bolted or riveted to the part. Observe that in *6A*, the wire is hooked into the hole and pressed tight against the lug. In *6B* the wire is hooked around the lug, which has no hole. Solder the wire to the lug. If you ever have to make a connection to a large surface or permanent connection to a post, follow the lead of expert designers. Illustrations *5C* and *5D* show how lugs are bolted to a flat surface. Be sure that you use lugs that are tinned, or tin them if necessary. Assorted lugs may be purchased inexpensively and should be in every serviceman's tool kit.



You should use lugs when necessary

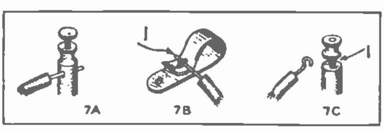
As you do more and more service work you will run into a large variety of soldering lugs. Manufacturers of radio apparatus use lugs that facilitate their work and insure good permanent connections. Illustration *6A* is a crimp type lug. The tinned wire lies between extensions *1* and *2*. The extensions are squeezed together with pliers. You then have a good electrical connection whose permanence is insured by soldering. Another type of lug is shown in *6B*. Observe that the tinned wire rests in trough *1* and is inserted in hole *2*. Usually the wire insulation *I* extends into the trough. The wire is soldered at the hole and the trough *1* is crimped over the wire and insulation. This type of lug is used to prevent the insulation on the wire from fraying or unraveling.

Other Types of Connections. Illustrations *7A, 7B* and *7C* show a number of temporary connections, often found on Radio apparatus. They are called binding posts. Connections of this kind are used on receivers as *aerial* and *ground* (ANT and GND) connections. In spite of the fact that they are used for temporary connections the wire which connects to them should be well cleaned of its insulation and the wire or strands tinned. The pillar type shown by *7A* is now rarely used. The tinned wire is passed through



Lugs to suit any need

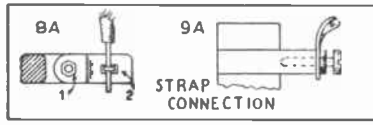
a hole and the wire is wedged into the hole by screwing down with the thumb screw. Connection *7B* is more frequently used and is referred to by its trade name, a "Fahnstock clip." In this case the tab marked *1* is pressed and the tinned wire passed through a curved tongue which appears as the tab is pressed. Release the pressure on the tab and a good connection is obtained. An old binding post connection still used, especially on some "B" batteries is shown in *7C*. The tinned wire is shaped into a curl and placed under the round nut, point *1*, and the nut screwed tight. Remember this: Be sure that the wire is placed under the nut in such a manner that the free end of the wire points in the direction that you turn the nut. If you place it the other way, the wire will be turned out of the post.



Radio apparatus employs binding posts

In some installations you will see a connection similar to illustration *8A*. Here you observe a Fahnstock clip which is riveted to an object. It is wise to insure a permanent connection by soldering at points *1* and *2*.

Where you have to make an electrical joint to objects that cannot be drilled, as for example a water pipe, it is customary to use a metal strap around the object which is held firmly in place by a pointed screw. Such a joint is shown in *9A*. Of course, the strap is clean, or made so by sandpaper or a file. The surface on the pipe where the strap is placed is sanded

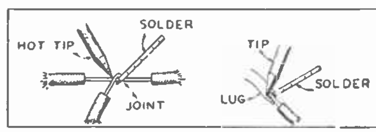


Typical connections used in Radio

clean. A solder lug is placed on the screw and held rigid by a nut. The connection is then completed by soldering to the lug.

As a future serviceman, you should remember that temporary or pressure contacts such as Fahnstock clips, etc., get dirty or corrode. Such connections should be inspected and if they look doubtful should be remade.

Soldering the Joint. And now we come to the final step of insuring a permanent connection, soldering the joint. If you have made a good mechanical joint, soldering will be easy. If the joint is poorly made you may find it difficult to solder and the connection may open eventually.



How to solder two wires — *Apply solder and iron tip in this manner*

Take the hot soldering iron off the stand, holding it in your right hand. The small coil of rosin core solder should be in the other hand. Place the hot tip of the iron on the lug or on the main wire, not on the joint but to one side, pressing gently sidewise on the joint. In about three or four seconds bring the extended solder wire to the other side of the joint and hold both iron and solder there until the solder starts to flow *into* and *around* the joint. Remove the solder first and a second or two later the iron tip. Be sure that you do not push or hit the joint. If you do, you will break the perfect solder seal. Do not touch the soldered joint or the wires to it until the solder hardens. You can tell when this happens by watching the surface of the solder harden.

Extra Money Jobs
and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

Overhauling Radio Receivers

How to take the chassis out of the cabinet—tighten parts—resolder poor connections, and get better results from a radio receiver.

Every radio receiver should get a general overhauling every once in a while. If you or some relative or friend has a receiver 2 or 3 years old, here is an opportunity to take the "works" out of the cabinet, and give it a thorough inspection and cleaning. You can do it no harm; and if you follow my instructions, you will improve the radio reception and prolong the life of the machine. To you, as a beginner, this work is very important. You will become acquainted with the construction of radios; you will see before you the various parts that are used in the many radio circuits explained in the lessons of your Course. Furthermore, the first step in any radio service job is to look for plainly exposed causes of trouble and that is what you will be doing. You are actually doing radio service work.

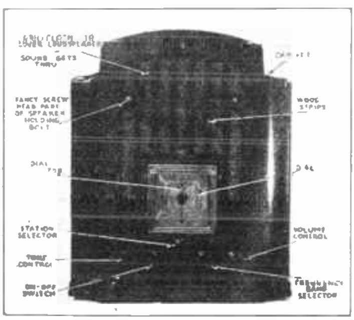


Fig. 1. The front is quite familiar to you
Courtesy of G. E. Co.

Let's now take as our example a midget model receiver as shown in Fig. *1*.

Since we are going to work on this receiver we first pull the power cord plug from its wall receptacle. There is now no power whatever in the set. Next disconnect the antenna and ground leads marked "ANT" and "GND." These parts are shown in Figure *2*.

Taking Out the Tubes. Tubes are numbered either on the base or on the glass envelope, as indicated in Fig. *3A*. You *may* find the tube socket marked with a number indicating what type of tube goes into it or you *may find no number.* In just a minute I am going to show you how to remove these tubes and be sure of getting them back where they belong. But before I tell you this, I want to tell you more about the tubes and their sockets.

The first chance you get, inspect a

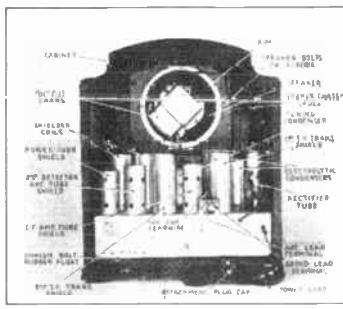


Fig. 2. The rear of set should be studied

vacuum tube. Note that the parts inside the tube are connected to reddish wires leading through the glass into the base. These leads connect to the prongs on the base of the tube and are soldered to them. In order to extend these tube leads into the receiver circuit, a tube socket is used. There are different types of tubes having 4, 5, 6 or 7 prongs on the base. Consequently, there must be particular sockets for each of these tubes. A socket is just an arrangement of spring contacts. The contacts to the tube prongs are made by pressure. The connections to the inside

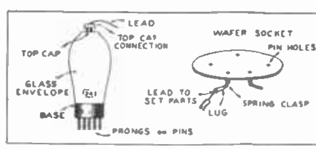


Fig. 3A. Tube, its socket and top Cap

of the receiver are made by wires soldered to the spring contact usually in the form of a lug. In some tubes you will find another connection on top of the glass envelope. It looks like a cap and is called a "top cap." A spring cup soldered to a flexible lead wire is the connector. (See Fig. *3A*.)

Quite often the tube itself is surrounded by a metal can, called a tube shield. To remove this shield, take off the top cap connection, if one is used; then pull off the tube shield from its base. The tube can then be easily pulled out of its socket.

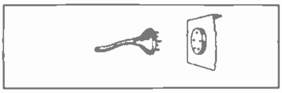


Fig. 3B. Speaker to chassis connection

Now how can you make sure that each tube goes back into its original socket? Get a soft green or red crayon pencil and mark the first tube you take out number 1, write the same number on the socket. The next tube and its socket will be numbered 2, and so forth. You will have no difficulty in getting the tubes back in their right places. The tubes taken out should be kept in a box, having a soft cloth on the bottom.

Taking Out the Chassis. Study Figs. *1* and *2* carefully. It is evident that the chassis was slipped into the cabinet from the open back: bolted or screwed to the bottom of the cabinet. It is also evident that after you free the chassis, the knobs on the front would prevent the chassis from sliding out.

Look again at the speaker. It too must be supported. Perhaps 4 or more wood screws or bolts passing through its rim holds it to the inside of the front panel. When bolts are used, the heads of the screws show on the front and are generally fancy, finished to match the color of the wood. To take the speaker out remove the screws or nuts of the bolts. Hold the speaker before you take the last two screws out so the speaker will not fall on the chassis. If bolts are used, you will be able to pull the speaker off the four screws.

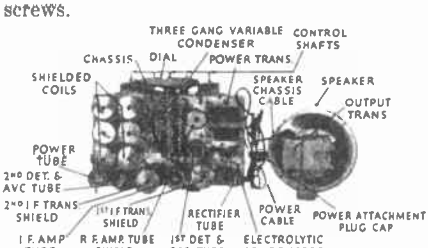


Fig. 4A. Most of this you can see without removing the chassis from the cabinet

You will find a cable (2 or more wires inside a cloth covering) attached to the speaker and connecting it to the chassis. It is the electrical connection between the two. Generally, you will find a 4 or 5 prong plug at one end of the cable pushed into a socket. See Fig. *3B*. You need have no fear in opening this connection because it is made so it will only fit back in one (the proper) position. If the connection has no such plug and socket, lay the speaker on the bench and proceed to take out the chassis.

To do this, remove the bolts or screws holding the chassis to the cabinet, then take off the control knobs from the front of the cabinet. With your midget screwdriver, loosen the screw on the knob. Pull the knob off the shaft. Should you find no set screws, you will know that it is merely held by friction and a pull will get it off.

Look for Loose Parts. Carefully examine all the parts bolted on the upper and under side of the chassis. Study their construction, learn to call them by name and which devices have 2 leads, 3, 4, or more. Figures *4A* and *4B* will help you recognize the parts.

Grasp each part with your thumb, fore and middle finger and shake it slightly. If the part appears to be loose, decide at once the best way of tightening up.

If it is held down by a bolt use your

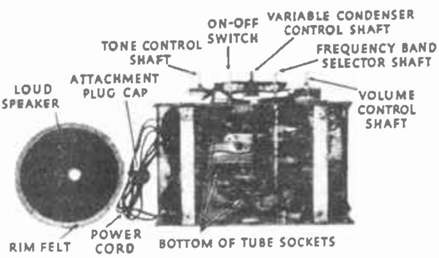


Fig. 4B. The under side of chassis is new to you

screw driver and combination pliers. Set the chassis on the bench on one of its ends, leaning it against a small box or some other object if necessary so it won't fall over. The pliers in one hand grasp the nut; the screw driver in the other hand is set in the groove of the screw. Turn the nut tight with the pliers, the screw driver on the other side holds the screw still. Or you may hold the nut still and turn the screw. (See Fig. *5*.)

For tightening bolts with hexagonal nuts, I prefer a set of socket wrenches (shown in Fig. *6*). The various wrenches slip onto a steel rod having a wood handle. Be sure that the wrenches you buy are for hexagonal nuts. I like a socket wrench better than pliers because they don't slip off the nut.

In addition to bolts (Fig. *7A*), special self-locking metal screws as shown in Fig. *7B* are used. A twist of a socket wrench, and loose metal screws can be made tight. Some manufacturers rivet some parts to the chassis, as in Fig. *7C*. The only way to tighten a loosened rivet is to set the head of the rivet on the head of a hammer and gently tap the hollow or "curled-over" end of the rivet with another hammer. Be sure that the blow is taken up by the back hammer and not by the chassis.

If a screw or bolt is missing, put one in. The nut should be preceded by an expanding or shakeproof washer to insure a permanent hold.

Drying the Chassis and Speaker. When a radio has been to a camp or the seashore, has been through a long siege of rainy weather, or carelessly exposed to rain or water, it loses its vitality. If you find the dust in a set is sticky and if wiping the parts with a cloth only smears the dirt, consider baking out the moisture.

All you need is a small electric fan, and a portable electric heater. Set the chassis on one end, point the heater and fan towards it, as in Fig. *8A* and let the drying process start. Change the position of the

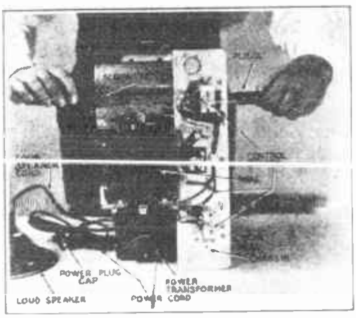


Fig. 5. Learn to handle a chassis like this

chassis so that heat can get at the various parts and the fan can drive off the water vapor. Don't let the heater get too close, or it may melt some of the waxed parts. If you don't have a radiant heater, use a 100 watt lamp in a goose neck desk reflector.

Cleaning the Chassis. Start cleaning a dry chassis with a two inch paint brush. The stiff bristles will loosen the dirt sticking to the parts; get into corners; under wires without disturbing them; and allow you to brush the connections. Go over all surfaces of the chassis and speaker, and don't use force where there are delicate parts or connections. Don't change the position of any wire.

Take the chassis to an open window and blow off the freed dust. You can use a

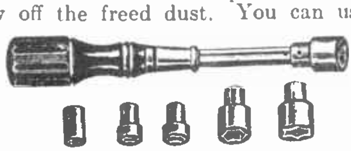


Fig. 6. Another handy tool to add to your collection

hand bellows, a tire pump or a vacuum cleaner attachment. Go over the chassis and speaker with a dry cheese cloth. Shake the dust out of the cloth often. See Fig. *8B.*

The variable condensers are the most important part to clean thoroughly. I use a pipe cleaner, with the condenser open, run the cleaner between the plates as shown in Fig. *9.*

Checking and Resoldering Connections. When you look at the under side of the

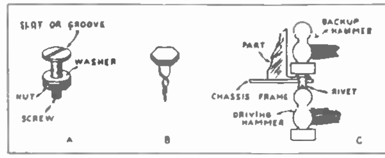


Fig. 7. Bolts, Metal Screws and Rivets

chassis, you will see many leads, connections and parts. The leads may be orderly grouped, tied together by a waxed string, or they may go from one point to the other without any definite order. Don't try to improve on the wire arrangement. Wait until you know more about radio circuits.

Inspect every connection, and each wire lead. Do this in an orderly manner; for example start at the upper left hand corner, go across as if you were reading a printed page, come down a couple of inches and go across once more, and so forth. Every joint should be firm, and properly soldered.

You can tell which connections need resoldering, because they stand out. Some of them are green with a sticky corroded appearance; other joints are sharp and lumpy; in others, the solder is formed in a ball. Look for the joint with excessive rosin, for it may be the only holding material. I generally test joints by pulling on the lead with a long nose plier, or push on it with an orange wood stick, which you can buy in any drug store.

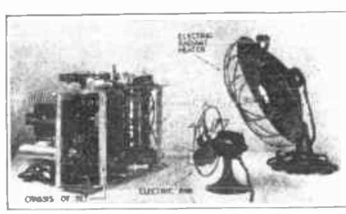


Fig. 8A. Simple and effective

To resolder, first apply a clean, hot iron tip which has no solder on it. (Snapping the hot iron down and away from you removes the solder.) The solder on the joint will either spread as it should or will be picked up by the iron. In the latter case, clean the joint with a cloth, and if necessary with a cloth dipped in wood alcohol. Clean the lead ends with sandpaper, or with a knife blade; tin; reform a good mechanical joint; and solder.

Be sure that the insulation on the wires have not been bruised or cut. Rubbing on some sharp edge or on a chassis hole will break the insulation. If you find this condition, unsolder the wire and connect a new one; or unsolder one end and slip on a piece of varnish cloth tubing, called by radio men "spaghetti." Position the in-

Fig. 8B. Brush, bellows and cheese cloth—enemies of dust and dirt

sulation tubing so that it covers the insulation break, and resolder the lead.

Inspect the power cord. Constant pulling on it may have weakened the solder connections, although in modern machines you will find the inner portions of the cord tied into a knot, so the pull is on the knot and not on the joint. Nevertheless inspect the soldered connections.

Turn the chassis over, so the top of the sockets are in full view. Check all the connections to the parts. Especial attention should be given to the flexible lead that connects to the top cap connector. The insulation on the lead should be intact, the lead should be firmly soldered to the cap, and the cap should be clean and actually make a firm contact on the tube. Try it on a tube.

Testing the Chassis. Before returning the receiver to the cabinet, a wise radiotrician checks its operation.

Place the tubes in their proper sockets. If you were careful not to rub off the identification numbers, this task will be simple. Reset the tube shields and connect the top cap connections wherever indicated. Reconnect the speaker, leaving the latter with the cone pointing towards the bench. Attach the aerial and ground leads to the receiver terminals marked "ANT" and "GND." Temporarily slip on the control knobs. Plug the cord into the power socket and turn the radio *ON*. Tune in the local stations, and try a few distant stations. If you remember what the machine could do before you overhauled it, there should be no doubt in your mind whether an improvement has been made.

When you become versed in radio, and you will as you continue your regular lessons, you will be able to make other adjustments and tests before the chassis goes back into the cabinet. Here are a few. You will test the tubes, interchange the position of similar tubes for best results, prevent certain types of receivers from squealing, check the supply voltages, and adjust the radio stages so that the receiver is at its peak of efficiency. All this will take but a few minutes more when you master the procedure. I will tell you about them later.

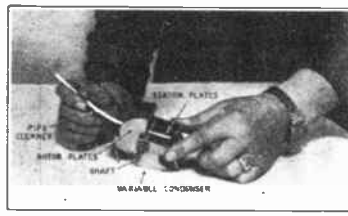


Fig. 9. Another use for a pipe cleaner

Back into the Cabinet. Take off the control knobs, and without touching any other connection, except perhaps where it is easy to remove the speaker connection, slip the chassis into the cabinet. Take it easy until the shafts of the controls pass through the holes in the front of the cabinet. Screw the chassis to the cabinet, but before you tighten them, slip the controls on, see that the dial and the controls are in position. If the chassis is supposed to rest on springs or rubber, be sure that the chassis floats. Now rebolt or screw on the speaker. Be sure that the rim is flush against the cabinet. Connect the speaker and give the receiver a final test.

How To Get Practical Servicing Experience At Home

THE question of getting practical experience in radio servicing has been given serious consideration by the instruction staff at N. R. I. We have found unnecessary the long-drawn-out method of apprenticeship whereby a beginner works for a radio man at little or no salary for a long period of time to secure experience, for we have developed a method which allows you to secure this same experience right in your own home while you are studying your regular Course.

The N. R. I. Plan. Briefly, our plan involves concentrating on one radio receiver chassis the experience which you would normally get from the successful servicing of scores of different receivers. This experience-getting procedure is divided into thirty-four main steps; the first eight you can well carry out while completing your Fundamental Course and laboratory experiments, and the remaining steps can be performed while you are studying the Advanced Course. Naturally you will have to spend considerable time on this plan; by dividing your time properly between study and experiment, you can complete the N. R. I. plan and the Course at the same time, and be ready to start actual radio service work as soon as you receive your diploma. (If you want to begin actual radio servicing work as soon as possible, you can concentrate on this plan and finish it long before you complete your Course.) This plan will also help you to master the Course, for you will actually be practicing the various service techniques at the same time that you study them.

1. *Secure A Suitable Receiver.* For the first part of the N. R. I. Experience-Getting Plan, you will need the chassis and loudspeaker of a broadcast band A.C. superheterodyne receiver *which is in good operating condition* and has from five to eight tubes.

If you have A.C. power, the receiver should use a power transformer. If A.C. is not available, get a 6-volt receiver using a vibrator, as this will give you the same experience as an A.C. receiver. When possible, A.C.-D.C. sets, battery sets using 1.4-volt tubes, and three-way (A.C.-D.C.-battery) receivers are to be avoided.

A recent model is not necessary; in fact, a set from three to five years old will be better suited to your needs. Try to get a well known make, such as Philco, RCA-Victor, General Electric, Zenith, Grunow, Silvertone, etc.; one of the first three models is preferable, for we can then supply complete service information on your set, including pictorial layout diagrams.

2. *Get Service Data On Your Receiver.* Having secured a suitable chassis, write to us giving the make, the model number, and the type numbers of the tubes in it, and state that you intend to use this chasis for training purposes. We will then send you all available service information.

3. *Get Acquainted With The Circuit Diagram.* When you receive the service information, go over the circuit driagram and note the various stages of it. Now trace the signal from the antenna terminal to the loudspeaker, remembering that a change in carrier frequency occurs at the mixer-first detector, and that demodulation takes place at the second detector. Trace through the power supply circuits to see how each tube gets its electrode voltages, and trace through special control circuits such as A.V.C., A.F.C., tuning indicator circuits, tone control circuits, etc.

4. *Redraw The Circuit Diagram.* On a large sheet of paper redraw the schematic circuit diagram of your receiver, two or three times the original size, in the following manner: First draw all of the tubes in their usual schematic form, in the same relative positions as they are on the diagram sent you. Now put in the signal circuit parts and connections, working from the antenna toward the loudspeaker. Use schematic symbols just as on the original diagram. Do this slowly, visualizing the function of each part and circuit as you draw it.

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Alongside each part indicate its electrical value; sometimes you can get this directly from the original circuit diagram, and sometimes you will have to refer to the parts list. Put in the power pack next, then draw each electrode supply circuit. Insert the condensers which keep signal currents in their correct paths, add all special control circuits, then check your enlarged diagram against the original.

5. Trace Electrode Supply Circuits On The Circuit Diagram. On your enlarged circuit diagram, locate the cathode (or filament) of the rectifier tube, for this is the highest positive terminal in an A.C. receiver. Now locate the center tap of the power transformer secondary, for this is the lowest negative terminal on the chassis. See if there is a direct conductive path from this negative point to a rectifier plate or to the chassis. Next trace continuity through each electrode supply circuit on your enlarged circuit diagram.

6. Imagine Various Parts Are Defective, and Determine How You Would Check Them With An Ohmmeter. Select a part at random on your enlarged circuit diagram and imagine it to be shorted, open or leaky (if a condenser). Determine how you would check this part to prove that it was defective. Would you have to unsolder any leads to make an ohmmeter test? Would the defect cause any change in voltage which could be detected with a voltmeter? Repeat this process of reasoning for at least twenty parts on your circuit diagram.

7. Make A Tube Socket Connection Diagram. Draw an actual-size bottom view of each tube socket in the receiver, showing the terminals and tube prongs in their proper relation to each other. Label the terminals P, K, CG, SG, SP and H, for plate, cathode, control grid, screen grid, suppressor grid and heater respectively, and label the electrodes on your enlarged circuit diagram in the same way; use either a tube chart or the socket connection diagram of your receiver as a guide.

8. Identify All Stages On The Chassis. Identify each stage on the chassis, as described in a previous job sheet.

9. Identify All Parts On The Chassis. Locate on the chassis each part which is indicated on your enlarged circuit diagram; use the pictorial layout diagram (if you have one) as a guide when necessary, but try to get along without it as much as possible.

10. Make Electrode Continuity Tests. Make a continuity test of each electrode circuit with an ohmmeter, by connecting the free ohmmeter probe to a tube socket terminal and placing the other probe on the correct common power pack terminal for the test. Referring to the circuit diagram each time, estimate what the resistance should be, then compare your estimate with the observed value. When discrepancies exist, try to figure the reason; remember that variations of up to 20% in resistor values are often permitted during receiver manufacture, and remember that when parts are in parallel, the combined resistance must be considered.

11. Check Electrode Supply Circuits Part By Part With An Ohmmeter. Repeat the electrode continuity tests described in the previous section, but this time move the free probe along the circuit toward the fixed probe, part by part, and observe the ohmmeter reading for each step. Check the reading each time against that which you would expect from the circuit diagram.

12. Check All Resistors With An Ohmmeter. Check the value of each resistor on the chassis with an ohmmeter, and record the measured value either on your enlarged circuit diagram or on a separate chart. When a resistor cannot be checked because it is shunted by another part, unsolder one lead of the resistor and make a direct measurement, then resolder.

13. Check All Coils With An Ohmmeter. Check the continuity of each winding on each coil in the receiver, using the lowest range on your ohmmeter. Look through your service information for coil connection diagrams; if these are not present, use your ohmmeter first to locate the terminals for each winding. Locate the terminals of power transformer windings in the same way and measure the resistance of each winding. Before checking the filament winding, remove all tubes and unsolder one lead of a center-tapped filament resistor if present. Record all readings for future reference, after comparing with the D.C. resistance values specified on the circuit diagram.

14. Check All Condensers With An Ohmmeter. Connect your ohmmeter across each condenser in the receiver in turn, using the highest ohmmeter range, and note the amount of the initial flicker of the ohmmeter pointer. Unsolder one lead when a condenser is shunted by some part; be sure to resolder after the test. For electrolytic condensers, take one reading, then reverse the ohmmeter probes and take another reading; the higher one will be a true indication of the condition of the condenser, but record both values.

15. Measure All Electrode Voltages. Insert the receiver power cord plug in an A.C. wall outlet, turn on the set, set the volume control at its maximum setting (no station tuned in), and measure each D.C. electrode voltage with respect to the cathode (measure with respect to the chassis if the voltage values in your service information are for this connection). Record each measured value.

Measure also the total rectified D.C. output voltage of the rectifier tube by connecting between the rectifier cathode (+) and the center tap of the power transformer secondary (—).

16. Check Performance of Receiver. Tune in local and distant stations at different parts of the tuning dial while the set is connected to a good outdoor antenna, so you become familiar with the sensitivity and selectivity characteristics, then try all controls.

17. Make A Circuit Disturbance Test. With the receiver in operation, carry out the circuit disturbance test ordinarily used for locating the defective stage in a dead receiver. Do this first by pulling out and replacing each tube in turn while the receiver is tuned between stations. Next, touch the control grid terminal of each tube in turn with your finger. Make the test once more, but this time remove and replace each control grid connection to a top cap, or short the control grid to the cathode when there is no top cap. Notice that sometimes you get clear-cut clicks, while at other times there is a squeal.

18. Make A Defective Stage Isolation Test With A Signal Generator. With the receiver operating but the aerial disconnected, make a defective stage isolation test with your signal generator, just as you would for a dead receiver.

19. Make Resistors Defective. Turn off the receiver and introduce a defect in one of the resistors (open one lead, or connect a resistor across or in series with it to change the value). Try to figure what effect this defect will have on the performance of the receiver, then turn on the receiver and see exactly what happens. Now suppose that you were servicing a receiver which had exactly this same effect; figure a servicing technique which would locate the defect in the quickest possible time, then proceed to carry out this technique until you come logically to the defective resistor. Check it with your ohmmeter, then remove the defect and make a final test to be sure you have restored the circuit to its original condition. Repeat this procedure for each resistor on the chassis in turn, opening a resistor lead in most cases since this is the most common resistor defect. Make a record of the defect and the effect on receiver performance in each case.

20. Make Condensers Defective. With the receiver off, introduce a defect in a condenser; you can disconnect one lead to create an open, you can short the condenser terminals to create a short, or you can shunt the condenser with a resistor of about 50,000 ohms in order to create a leaky condition. Turn on the receiver and check performance, then figure out a logical service technique for locating the defective part, and proceed to carry it out. Repeat this procedure for each condenser on the chassis in turn. Caution: Before shorting a condenser, study the circuit diagram to see if the short will damage any part. If smoke or excessive heat is observed when a particular condenser is shorted, try another defect. Do not short electrolytic filter condensers in the power pack; make these condensers leaky by shunting with a 1,000-ohm, 10-watt resistor, or make them open. Make a record of the defect and the effect in each case.

21. Make Coils Defective. Introduce a defect (an open or a short) in one winding of an R.F. coil, then turn on the receiver and check performance. With the observed effect in mind, determine a logical service technique and apply it to the receiver until you find the defective coil. Remove the defect, then repeat the entire procedure for each other coil winding in the receiver. *IMPORTANT:* Do not short power transformer windings; introduce an open in each winding in turn and carry out your tests. Record your results in each case.

22. Make Tubes Defective. Create a low-emission defect in a tube in the receiver by inserting a filament rheostat (about 10 ohms) in series with one filament lead to the tube and setting it to lower the filament voltage for that tube to about 60% of the original value. (For rectifier tubes and for other tubes drawing more than .5 ampere filament current, get about a 2-ohm wire-wound resistor with slider, and adjust until you get the desired filament voltage. Turn off set before adjusting the slider, to avoid a shock). Turn on the set and note the effect on performance. Remove the defect, then repeat this same low-emission test for each tube in the receiver in turn. Starting at the first tube again, create a cathode-to-heater leak by connecting a 1,000 ohm resistor between the cathode and one heater terminal. Turn on the set, check performance, figure a service technique, apply it, then remove the defect and repeat for each other tube.

23. Create a Dead Receiver. Referring to your enlarged circuit diagram, make a list of the parts which, if defective in a certain manner, will cause a dead receiver. Try to do this by reasoning alone, without looking at the records you have previously made. Introduce each defect in the receiver in turn, to prove that it does cause a dead receiver. Apply the circuit disturbance test and the defective stage isolation test with a signal generator in each case, to see if these tests will correctly locate the defective stage.

24. Create Hum. Referring to your circuit diagram, make a list of the defects which you believe will create hum in the receiver, introduce these defects and carry out the tube-pulling test for locating the defective stage, then check operating voltages on that stage with your D.C. voltmeter and locate the defective part with an ohmmeter.

25. Create Distortion. Make a list of the defects which you think will create distortion, then introduce these defects, and for each one apply the defective stage isolation test for locating the defective stage, then determine and carry out a logical procedure for locating the defect in that stage.

26. Create Poor Sensitivity. Make a list of the defects which you think will create poor sensitivity, then introduce these defects to verify your assumptions, and carry out a logical service technique for locating the defect in each case.

27. Create Poor Selectivity. Place a 1,000 to 25,000 ohm resistor across one winding of an R.F. coil to load the coil and create the effect of poor selectivity. Turn on the receiver, check performance, then carry out a logical service technique for locating the defect. Repeat for each other R.F. and I.F. coil winding in the receiver.

28. Create Oscillation. Make a list of the defects which will create oscillation, remembering that feed-back from plate to grid due to an open by-pass condenser is the most common cause of oscillation. Check performance and carry out a logical service technique for locating the defect in each case.

29. Create A Defective Loudspeaker. Introduce in turn the following defects in the loudspeaker: open voice coil; open field coil; shorted field coil; off-center cone; loose spider. Check performance in each case at various volume levels, and try to remember the particular effect on performance which is observed.

30. Replace Parts. Remove from the receiver and replace, one at a time, at least one of each of the following parts: a resistor; a paper condenser; a mica condenser; an electrolytic filter condenser; an R.F. coil; an I.F. transformer; an audio transformer; a volume control; a power transformer. Check the part with an ohmmeter before you remove it, after it is out of the set, and after you have replaced it in the set. In the case of coils and transformers which have more than two leads, draw a pictorial diagram of the connections before unsoldering any leads, so you will be sure to get them back again correctly. This is particularly important in the case of the power transformer.

31. Check Each Alignment Adjustment. Connect your signal generator and output meter to the receiver in the proper manner for realignment, then vary the setting of each alignment trimmer in turn, and note the effect on the output meter; restore the original adjustment before going on to the next trimmer. This procedure will show you just how critical each adjustment is.

32. Realign The Receiver. Refer to your service information for any special alignment instructions, then realign the receiver. Repeat until you can complete the alignment without referring to the instructions.

33. Throw Receiver Completely Out Of Line, Then Realign. Turn each alignment trimmer two or three turns in any direction, or tighten all alignment trimmer screws, then repeat the alignment procedure. This will correspond to the most difficult alignment job which you can encounter in actual practice.

34. Overhaul The Receiver. An overhaul of your receiver, just as if you were going to return it to a customer, completes your work on this one chassis. Replace all parts and wiring which you may have damaged, and resolder joints if necessary.

———oOo———

If you have faithfully followed the procedure just described for a broadcast band receiver, you will be a long way toward securing the experience which you require. If you really want to start out in radio servicing with a confidence equal to that of a Radiotrician with years of experience, get a second and even a third chassis, and repeat the entire N. R. I. plan on these. Choose an all-wave superheterodyne or at least a two-band A.C. superheterodyne receiver having somewhere between five and twelve tubes for your second test. The third receiver can be defective, for by that time you should be able to repair it yourself.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

How to Make a Receiver Serve as a Phonograph and an Announcing System, by Using an Oscillator and By Means of a Chassis Connection

PRACTICALLY any A.C. radio receiver can be converted into a small public address system having either a microphone or a modern electric phonograph (or both) connected to its input circuit; the work can be done at a reasonable cost to the customer, and offers you an excellent chance for extra profits. Two distinct conversion methods are available: *1.* Use of a separate R.F. oscillator which is modulated by the phono pick-up or microphone and which feeds into the antenna and ground terminals of the receiver (this will work with practically any receiver); *2.* A direct connection between the pick-up device and the input of the audio amplifier in the receiver. This will work only if the audio system has sufficient gain.

Prospective Customers. With phonographs rapidly regaining their before-radio popularity, many people will welcome the opportunity to have a modern record player connected to their own radio receivers; the performance will be comparable with that of modern electric phonographs. All clubs, churches and public schools which have good radio receivers are ideal prospects, for whenever more than fifty people are to be addressed or entertained at these places, there is definitely a need for a small public address system. Dancing schools and gymnasiums also have need for phonograph music and voice-amplifying facilities. Stores, restaurants, night clubs, roadside stands, concessions at fairs and carnivals and other similar places can boost business by providing recorded music which is supplemented at times by songs or sales ballyhoo.

Oscillator Connections. The oscillator unit used to convert a radio receiver into a public address system is commonly called a phonograph oscillator; a typical unit of this type as made by RCA is shown in Fig. *1.* Figure *2* shows how it can be mounted inside the cabinet of a console model receiver and connected to a table model electric phonograph turntable. This phonograph oscillator unit is really a miniature broadcasting station, for it contains an R.F. oscillator which produces an R.F. carrier signal at a frequency between 1,400 kc. and 1,700 kc., modulated by the audio signal from the phono pick-up or microphone. Power for the pentode vacuum tube in the oscillator unit is obtained from the receiver by making three simple slip-on connections to prongs

Courtesy RCA Mfg. Co., Inc.

FIG. 1. With this RCA phonograph oscillator, you can convert practically any radio receiver into a small public address system for use either with a microphone or record player. You can secure it at the wholesale price from any RCA distributor if you identify yourself as a serviceman; some mail order radio supply houses also sell it or will procure it for you.

of receiver tubes. These connections are easy to make, since each of the leads coming from the oscillator has a different color of insulation.

After mounting the oscillator unit at some convenient location inside the receiver cabinet, disconnect the antenna lead-in wire from the receiver and splice it to the *BLUE* oscillator wire. Connect the *RED & BLACK* wire to the antenna terminal of the receiver, and connect the *RED & YELLOW* wire to the ground terminal of the receiver without removing the regular ground lead. Next, pull out the receiver rectifier tube, slip the special clip of the *RED* lead over the cathode prong or over either of the filament prongs if there is no separate cathode, and replace the tube in its socket. Now remove any other tube from the receiver, slip the clip of the solid *BROWN* lead over one of its filament prongs, slip the clip of the solid *YELLOW* lead over the other filament prong, and replace the tube. Finally, connect the two terminals at one end of the oscillator chassis to the microphone or phono pick-up terminals. With a magnetic pick-up or a carbon microphone you can use twisted two-wire lamp cord up to 25 feet long, but

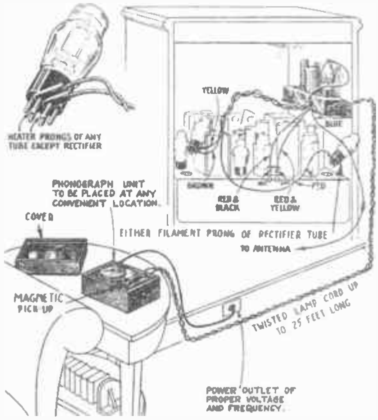

FIG. 2. Diagram showing how the RCA phonograph oscillator and a record player employing a high-impedance magnetic pick-up are connected to a typical A.C. radio receiver.

with a crystal pick-up it is necessary to use one-wire shielded cable not more than 10 feet long.

The oscillator unit is sold without a tube; if the receiver has 2.5 volt filament tubes, order a type 2A7 tube for the oscillator; if the receiver has 6.3-volt filament tubes, order a type 6A7 tube. Insert the proper tube, set the toggle switch on the oscillator to the *PHONO* position, advance the volume control on the record player about halfway, play a record, turn on the receiver, set the receiver volume control for normal volume on a local station, tune the receiver to the highest possible frequency in the broadcast band, and vary the oscillator frequency by turning one or both of the adjustment screws on the top of the cylindrical oscillator coil shield until you hear the recorded music coming from the loudspeaker with maximum volume. (If interference is heard at the high-frequency end of the dial, tune the receiver to a slightly lower frequency at which there is no interference, and adjust the oscillator to this frequency.) Whenever the record player is to be used, the receiver must first be tuned to this high-frequency setting and the receiver volume control set for normal local reception. The volume control on the record player is used to vary the volume of the recorded music.

Selecting a Record Player. Complete record players consisting of a phono pick-up and an electric motor-driven turntable mounted in a suitable cabinet are now available at reasonably low prices. Typical units are shown in Fig. *3;* those which have a cover are to be preferred, for by lowering the cover after a record is started, the amount of needle scratch noise which can be heard directly is reduced to a minimum. Any crystal pick-up or high-impedance magnetic pick-up intended for ordinary phonograph records will work satisfactorily with a phono oscillator.

Wireless Record Players. Some of the table model record players now on the market include a built-in phonograph oscillator which is so designed that no connection whatsoever is required between the record player and the receiver, provided the distance between the two is not too great; the signals are transferred either by direct radiation, by induction, or through the power line. With some units improved operation will be secured by reversing the power cord plug or by connecting a terminal on the record player to the antenna terminal of the receiver. The oscillator unit has its own power supply system, usually consisting of a half-wave rectifier arranged for universal A.C.-D.C. operation. Receiver and oscillator must be tuned to the same frequency.

Connecting a Microphone to an Oscillator. A double-button carbon microphone will deliver sufficient audio power to modulate a phonograph oscillator. In addition to this microphone, you will need one microphone-to-grid matching transformer designed for a double-button microphone, one 250,000 ohm potentiometer, one 4.5 volt battery, one S.P.S.T. switch, and suitable lengths of one-wire and three-wire shielded cable. The connections are shown in Fig. *4;* this diagram also shows how both a microphone and a crystal pick-up may be connected permanently to the phonograph oscillator. Both units are in series, feeding into a single-wire shielded cable (not over 10 feet long) which connects to the input terminals of the oscillator. The microphone control unit should either be built into the record player or placed in a small box located near the record player. The shielded three-wire microphone cable can be any desired length up to 1,000 feet. The metal housing of the microphone is connected to the shield on this cable, as also is the positive end of the C battery and the housing of the matching transformer. These shield connections are essential to keep hum at a minimum.

FIG. 3. Typical record players. Note that each has a volume control for the phono pick-up.

Since the average microphone will have less output than the average phono pick-up, the microphone will determine the proper setting of the receiver volume control. Reduce the output of the phono pick-up to zero by setting the movable arm of the phono volume control at point *A*, set the microphone volume control to about two-thirds of the full output value, talk into the microphone in a normal manner, and adjust the receiver volume control until very nearly the maximum desired volume is secured. Further changes in volume are now made with the microphone and phono pick-up volume controls.

Direct Connection of Pick-Ups. If the receiver in question has sufficient audio gain, it is always better to connect the microphone or phono pick-up directly into the input of the audio amplifier. You can consider this direct connection whenever the receiver has one of the following detector-A.F. amplifier combinations: *1.* A triode detector followed by a pentode output tube; *2.* A duo-diode-triode or duo-diode-pentode detector followed by a pentode output tube or a pair of pentodes in push-pull; *3.* A screen grid detector followed by a pentode output tube; *4.* A diode detector (either a duo-diode or a triode connected as a diode), with at least one voltage amplifier stage (usually a high-gain tube) ahead of the output stage. Receivers which have a triode second detector of the C bias type, followed either by a single-tube or push-pull triode stage, cannot be successfully adapted to a direct pick-up connection.

The microphone and phono pick-up circuits for a direct connection are exactly the same as is shown in Fig. *4* for the phonograph oscillator. Leads *1* and *2* of the shielded one-wire cable are connected to some section of the detector circuit rather than to the phonograph oscillator terminals; methods of making these connections for four different typical detector circuits are illustrated in Fig. *5*, and will now be taken up.

Case 1. The detector tube has a control grid (a triode or screen grid tube), and is followed by a pentode output tube. This audio amplifier will have sufficient gain for our purpose if the detector is converted into an A.F. voltage amplifier stage. The

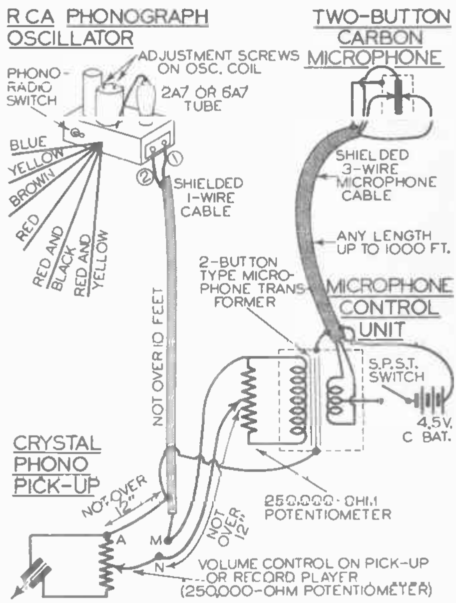

FIG. 4. With this connection, both phonograph and microphone may be used simultaneously and controlled independently. Music can be used as a background for an announcement, and increased in volume as the mike is faded out, just as in large public address systems. If the microphone connection is not desired, connect together points *M* and *N*.

original circuit is as shown by the light lines in Fig. *5A*, with points *A* and *B* connected together. The following additional parts are required: One double-pole, double-throw toggle or rotary switch (*SW*) which can be mounted on the receiver front panel; one .001 mfd. mica condenser (*C2*); one resistor (*R2*)—3,000 ohms for a triode detector and 1,000 ohms for a screen grid tube. Break the ground lead to coil *L2* between points *A* and *B*, and insert condenser *C2* as shown in Fig. *5A*. Connect switch *SW* and resistor *R2*, then connect leads *1* and *2* in Fig. *4* to points *1* and *2* in Fig. *5A*. When switch *SW* is at the right, the original circuit will be restored and normal reception secured; when switch *SW* is at the left, resistor *R2* will change the bias sufficiently to convert the detector into an amplifier, blocking radio reception (it is best to detune the receiver), and allowing the phono pick-up or microphone to feed into the grid circuit of the former detector stage.

Case 2. The receiver has a duo-diode-triode (or pentode) tube acting as a second detector and first audio amplifier tube, with the C bias for the audio amplifier tube supplied from a point outside of this stage. Revisions required are shown in heavy lines in Fig. *5B;* the only new part is the single-pole, double-throw switch *SW*. The conversion simply involves cutting the lead to the movable arm of the volume control and connecting the resulting two wires to points *A* and *B* on the switch. With the switch at the right, the original circuit is restored and normal radio reception is secured; the switch is set at the left for phono pick-up or microphone operation.

Case 3. A duo-diode-triode (or pentode) tube is used as the second detector and first audio amplifier stage, with a self-biasing arrangement for the amplifier section. In the original circuit, shown by light lines in Fig. *5C*, points *A* and *B* are connected together; the lead connecting these points must be broken and single-pole, double-throw switch *SW* connected as shown. With switch *SW* at the right, the audio signal from the pick-up device is fed directly into the grid of the first audio amplifier stage in the receiver.

Case 4. The detector stage in the receiver employs a triode tube connected as a diode detector, with a voltage amplifier stage ahead of the output stage. The connection between points *A* and *B* is broken and a single-pole, double-throw switch *SW* is inserted as showin in Fig. *5D*. Leads *1* and *2* of the pick-up device are connected to points *1* and *2* in Fig. *5D*. With the switch at the right, the output of the pick-up device feeds directly into the input of the A.F. amplifier in the receiver.

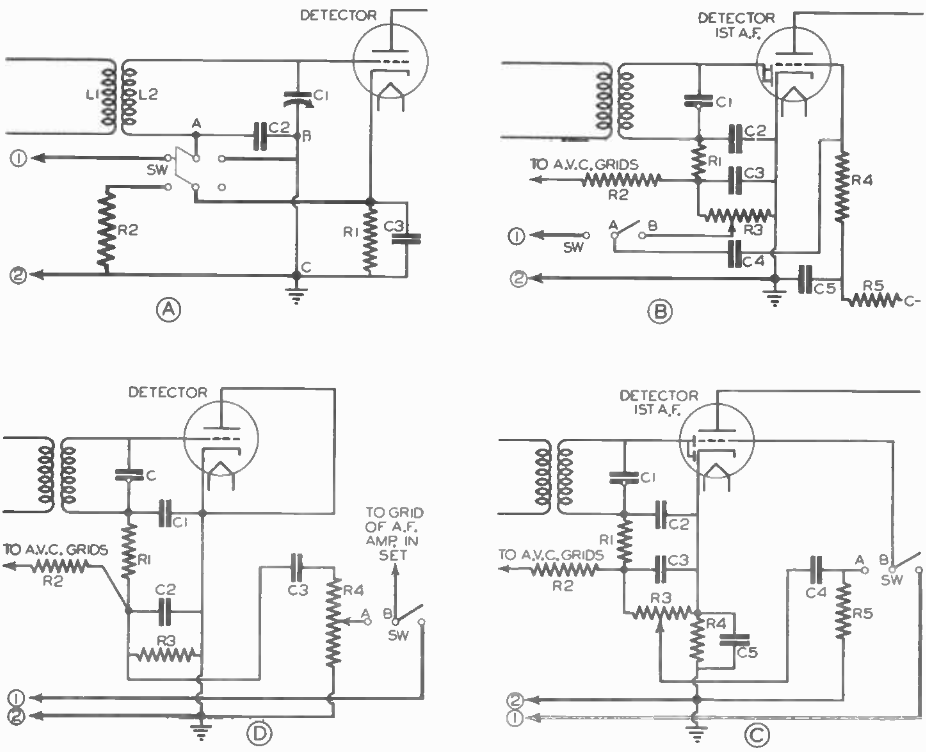

FIG. 5. Four typical detector circuits; changes required to make a direct pick-up connection are indicated in heavy lines. The leads from the pick-up device should go to points *1* and *2*.

Extra Money Jobs and how to do them

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How to Install Headphones, Pillow Loudspeakers and Extension Loudspeakers

OFTENTIMES some member of a family will want to listen to distant stations during the late hours of the evening or the early hours of the morning; the blasts of noise which inevitably occur when "fishing" for distant stations are most annoying to others who may be trying to sleep. It is for this reason that many apartment owners prohibit the operation of radio receivers after 11 P. M. When you come upon a situation like this, you have an excellent chance to make extra profits by connecting headphones to the receiver and providing a means for silencing the loudspeaker.

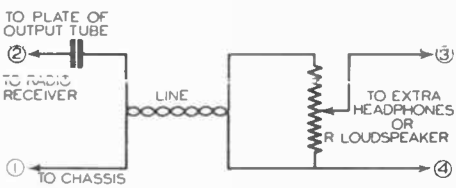


FIG. 1. Circuit for connecting a high-impedance reproducing unit to any radio receiver.

When one person in a family is "hard of hearing," that person must either forego radio entertainment or advance the receiver volume control so far that the excessive loudness becomes irritating to other members of the family. An extension headphone connection with a separate volume control for the person requiring higher volume will solve the difficulty.

A housewife may want to hear radio programs while working in the kitchen, in the sewing room, or in the garden. If the main receiver is so located that sound will have to go around corners or through walls to reach these locations, an extension loudspeaker should be installed. In other homes, an extension loudspeaker may be desirable in a den or recreation room, with provisions for silencing the main loudspeaker when the extension unit is in use. Extension loudspeakers are not difficult to install, but offer excellent opportunities for extra profits to the alert Radiotrician.

Here is another job which is easy to install and which can be a means for making extra money in radio servicing; when a small table model receiver is being used in the master bedroom and one person wants to listen to radio programs while in bed without disturbing others, you can either provide for a headphone connection or for the more comfortable modern pillow loudspeaker, with a switch for silencing the regular loudspeaker.

Analyzing the Job. The circuit used for connecting an extra reproducing device to a radio receiver depends primarily upon whether the device being added has a high impedance or a low impedance. Headphone units, pillow loudspeakers (also known as "hushatones"), magnetic loudspeakers without impedance-matching transformers, and dynamic loudspeakers with transformers intended to match a tube impedance all come under the classification of high-impedance devices, and use one type of connection. Dynamic loudspeakers without matching transformers are low-impedance devices, and use an entirely different type of connection.

FIG. 2. Adapter for connecting to a tube prong.

How to Connect High-Impedance Devices. A high-impedance reproducing device should always be connected between the chassis and the plate of an output tube, using the circuit shown in Fig. *1*. The audio output voltage of the receiver is applied to potentiometer *R* through D.C. blocking condenser *C*, and any desired portion of this output voltage can be transferred to the extra headphones or loudspeaker by adjusting the setting of *R*. In the case of an extension loudspeaker, *R* should be a 10,000-ohm wire-wound potentiometer having a power rating of at least 4 watts. With headphones and pillow loudspeakers, however, *R* should be a 50,000-ohm wire wound potentiometer (the power rating is unimportant in this case). Condenser *C* should be a 600-volt paper condenser of between .5 and 2 mfd., mounted

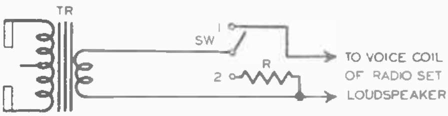


FIG. 3. Circuit which provides optional silencing of receiver loudspeaker when an extra reproducing device is used.

on the receiver chassis; the higher values are used with large loudspeakers. Lead *1* should be connected to the chassis; lead *2* may either be connected directly to the correct tube socket terminal under the chassis or to the plate prong of the output tube by means of an adapter like that in Fig. *2*. The line can be a 2-wire twisted lamp cord, up to 100 feet long. With a headphone or pillow loudspeaker connection, potentiometer *R* may be mounted on the receiver cabinet or chassis, with the headphone or loudspeaker cord serving as the extension line. With loudspeakers, potentiometer *R* should be on the cabinet of the extra loudspeaker.

If triode tubes are used in the output stage, the load placed on them by potentiometer *R* in Fig. *1* will ordinarily be sufficient to prevent a dangerous rise in voltage when the receiver loudspeaker is silenced by opening its voice coil. With pentode output tubes, on the other hand, some additional loading is required; the circuit ar-

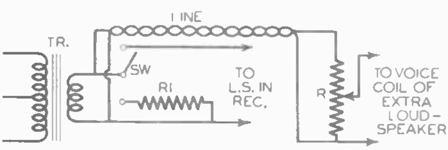


FIG. 4. Circuit for connecting a low-impedance reproducing device (dynamic loudspeaker without matching transformer) to a radio receiver.

rangement shown in Fig. *3* may be used for this purpose. This circuit will also serve to prevent an annoying increase in the volume of the extension loudspeaker when the receiver loudspeaker is silenced. Resistor *R* in Fig. *3* should be a 10-ohm wire-wound unit rated at 10 watts; switch *SW* is an ordinary single-pole double-throw toggle switch mounted either on the chassis or the cabinet of the receiver. Load resister *R* should not be mounted near the loudspeaker cone, for this resistor will radiate a certain amount of heat.

How to Connect Low-Impedance Units. When a dynamic loudspeaker without a matching transformer is to be used as an extension loudspeaker, it should be connected as shown in Fig. *4*. Potentiometer *R* is a 30-ohm wire-wound unit rated at 10 watts, mounted on the front of the cabinet for the extra loudspeaker. The line from this extension loudspeaker may be a 2-wire twisted cable up to 100 feet long; No. 18 flexible twisted lamp cord is best. This line is connected to the secondary terminals of the receiver output transformer.

Quite often both loudspeakers will be operated at the same time, at normal volume level. If the receiver loudspeaker is silenced now, more than normal power will be forwarded to the extension loudspeaker, and the resulting increase in volume may be

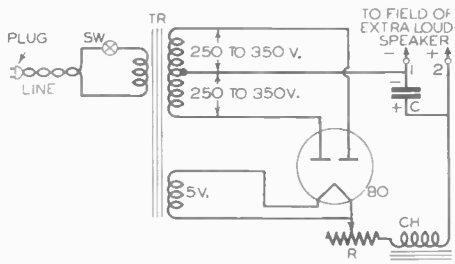
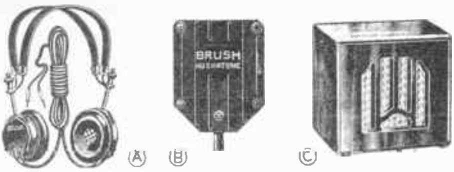


FIG. 5. Power supply circuit suitable for providing field excitation for an extension electrodynamic loudspeaker.

annoying. To provide a means for silencing the local loudspeaker without having to rush to the extension loudspeaker to reduce volume, a 10-ohm, 10-watt resistor *R1* and single-pole, double-throw switch *SW* may be connected as shown in Fig. *4*. Resistor *R1* acts as a dummy load which replaces and duplicates the receiver loudspeaker when this loudspeaker is to be silenced. Resistor *R1* also serves to protect the extension loudspeaker if it has a low power-handling rating and the receiver is capable of delivering high power output.

Field Excitation for Extension Loudspeaker. If a new loudspeaker is to be purchased for the remote location, order a permanent magnet type dynamic loudspeaker; no field power supply will then be required. If the electrodynamic loudspeaker from a discarded radio receiver is to be used, the power pack of this receiver can provide the required field power. When you are installing a new receiver for a customer, you can recommend that the old receiver be modified for use as a self-powered extension loud-



A—headphones for the late-at-night listener and for those who are hard of hearing; *B*—typical pillow loudspeaker or "hushatone"; when placed under a pillow or cushion, anyone with head resting on the pillow can hear the sounds by conduction through pillow; *C*—extension loudspeaker in table model cabinet; they are also available in floor model cabinets.

speaker. From the old receiver you will need the cabinet, power transformer, rectifier tube and socket, filter choke (if present), filter condenser, line cord and plug, and power switch. Mount these units either on a baseboard or on the original chassis after stripping off all other parts. Connect the parts as shown in Fig. *5*. The only additional part required will be a rheostat *R*, a 2,500-ohm wire-wound resistor rated at 25 watts, with an adjustable tap or slider; this serves to control the amount of power which is fed to the loudspeaker field coil. Set *R* to have maximum resistance, connect a D.C. voltmeter across terminals *1* and *2*, then turn on the power pack. Adjust *R* until the D.C. voltmeter indicates the desired output voltage. This voltage will depend upon the power requirement of the field coil (a normal value is 7.5 watts), and upon the resistance of the field coil (measure this with an ohmmeter). The correct D.C. output voltages for various field coil resistances are: 500 ohms—60 volts; 1,000 ohms—85 volts; 1,500 ohms—115 volts; 2,000 ohms—125 volts; 3,000 ohms—150 volts; 4,000 ohms—170 volts; 5,000 ohms—195 volts; 6,000 ohms—220 volts.

How to Build and Install a Remote Electronic Control Switch

Remote control of electrical equipment is becoming more and more a part of our daily life. Pressing a button at one point in a home or factory can send over the power line a radio signal which will actuate a switching unit connected to any other point on that power line, causing an electrical device to be turned on or turned off. Of course, the same results can often be secured more economically by means of an ordinary system of wires between the two locations, but sometimes it will be undesirable to run extra wires through walls and from one building to another. In cases like these, a remote control system like that now to be described can be constructed and installed by the Radiotrician; this system consists essentially of a switching unit at the location of the electrical device being controlled, and an oscillator at the remote location from which the device is to be controlled.

Switching Unit. The circuit diagram for the switching unit of a remote control system is shown in Fig. *6*. The tube used, a type 0A4-G cold cathode gaseous triode, is conductive between cathode *K* and plate *P2* only when starter anode *P1* is more than about 70 volts positive with respect to cathode *K*. Potentiometer *R2* is normally set to apply less than this starting or "trigger" voltage to *P1*, and consequently no current flows from the A.C. line through relay coil *RL* and the plate-cathode path of the tube. Coil *L* and condenser *C1* form a series resonant circuit which is adjusted to have a resonant frequency equal to the frequency of the R.F. oscillator at the control location; when an R.F. signal enters the switching unit by way of the power line, it develops across *L* a large A.C. voltage which period-

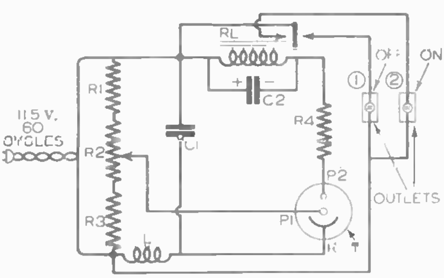


FIG. 6. Circuit of switching unit for a remote control system. *R1*—10,000 ohms, ½-watt; *R2*—10,000-ohms wire-wound potentiometer (wattage rating is unimportant); *R3*—10,000 ohms, ½-watt; *R4*—1,000 ohms, 2 watts; *C1*—.002 mfd. variable condenser; *L*—75 turns of No. 26 D.C.C. wire wound on a 1¾" diameter coil form; *T*—type OA4-G gaseous triode control tube with octal socket; *RL*—20 ma. D.C. relay, not over 200 ohms D.C. resistance with single pole, double-throw contacts; *C2*—8 mfd. electrolytic condenser, connected with polarity as indicated.

ically adds to the voltage between *P1* and *K*, causing a glow discharge which makes the cathode-anode path conductive and sends current through the relay. Relay and tube current is thus drawn from the power line only when an R.F. signal is present. The relay contacts are connected to two outlets; if the device to be controlled is plugged into outlet No. *1*, it will normally be in operation and an R.F. signal from the remote location will cause it to be turned off; with the device plugged into outlet No. *2*, it will normally be off and an R.F. signal will cause it to be turned on.

Connect the circuit exactly as shown, referring to Fig. *7* for socket connections for the OA4-G tube. Mount the parts in a neat

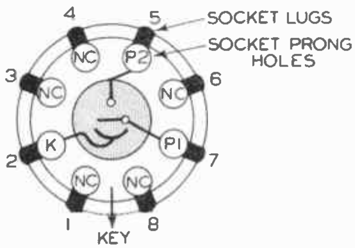


FIG. 7. Socket connections for type OA4-G tube as viewed from the bottom of the standard octal socket.

metal box having ventilating holes on the side or top; a switch box, obtainable from any electrical jobber, is satisfactory. The .002 mfd. variable capacity of *C1* is secured by connecting a fixed .001 mfd. mica condenser, a fixed .00025 mfd. mica condenser and an adjustable .0005-.001 mfd. trimmer condenser all in parallel. The 8-mfd. electrolytic condenser *C2* across the relay coil serves to prevent chattering due to the flow of pulsating D.C. (the OA4-G tube acts as a half-wave rectifier when conductive).

The circuit diagram of an oscillator unit which can be used at the remote location to feed the required R.F. signals into the power line is shown in Fig. *8*. Coil *L* in this circuit is identical with coil *L* in Fig. *6*, except that there is a tap 25 turns from one end; you can wind these coils yourself. Coil *L1* has three turns, wound directly over coil *L* at the location of the tap, after first placing varnished cloth or paper over coil *L* for insulating purposes and connecting one end of *L1* to the tap. Coil *L1* feeds the R.F. energy of the oscillator into the power line.

Adjustments. The power cord of the switching unit shown in Fig. *6* is plugged into an A.C. outlet, and the power cord of the device to be controlled is plugged into the proper outlet on the switching unit. Advance the setting of *R2* until the OA4-G tube glows, then reduce the setting just enough to stop the glow. Plug the oscillator unit into an A.C. outlet at the remote control location, turn on the oscillator, and return to the switching unit to adjust condenser *C1* in it, until the OA4-G glow tube glows with maximum brilliancy; if no glow appears, reverse the plug to either the oscillator or the switching unit and repeat the adjustment of *C1*. Now measure the D.C. voltage across *R4*; it should be about 20 volts. If this voltage is greater than 25 volts, increase the ohmic value of *R4* until the voltage drops to 20 volts, in order to keep the normal current through the glow tube at a safe value. If the amount of oscillator signal reaching the switching unit is insufficient to start the glow tube and actuate the relay, try increasing the number of turns on coil *L1* in Fig. *8*, adding about 2 turns at a time up to a maximum of 10 turns.

The filament in the type 30 tube in the oscillator circuit will reach operating temperature in a few seconds; if this delay is undesirable, it will be necessary to keep the oscillator in operation continuously and insert a key or push-button switch in series with *R2* in Fig. *8*. With the key open, the oscillator will be blocked. Closing the key will send an R.F. signal almost instantaneously to the switching unit.

The maximum safe value of direct current which can be handled by the OA4-G tube is 25 ma.; the relay ordered for the switching unit should therefore operate at about 20 ma. Furthermore, the relay contacts must be designed to handle the voltage and current requirements of the electrical device being controlled. With a single-pole, double-throw contact arrangement like that in Fig. *6*, the oscillator must be in operation for the

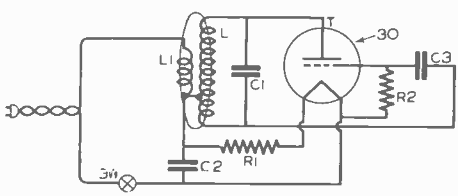


FIG. 8. Oscillator unit of a remote control system. *T*—type 30 tube in 4-prong socket; *SW*—S.P.S.T. toggle switch; *R1*—2000-ohm, 10-watt resistor or 7.5-watt, 110-volt lamp; *R2*—10,000-ohm resistor; *C1*—.002 mfd. mica condenser; C2—.5 mfd., 600-volt paper condenser; C3—.001 mfd. mica condenser; *L*—75 turns of No. 26 D.C.C. wire wound on a 1¼" diameter coil form, tapped 25 turns from grid end; *L1*—3 turns of No. 26 D.C.C. wire wound over varnished cambric at location of tap on coil *L*.

entire period during which the relay is to be pulled up; if a latch-in type of relay is used in place of the conventional relay, however, a single pulse from the oscillator circuit will lock the relay in its closed position, and neither the oscillator nor the switching unit will be drawing current from the power line. With a latch-in relay, it will be necessary to go to the switching unit and reset the latch in order to release the relay.

How To Get Practical Servicing Experience At Home

THE question of getting practical experience in radio servicing has been given serious consideration by the instruction staff at N. R. I. We have rejected the method involving the building of a radio receiver from a kit of parts, for the mere assembling of a receiver gives little experience in actual servicing problems. We have found unnecessary the long-drawn-out method of apprenticeship whereby a beginner works for a radio man at little or no salary for a long period of time to secure experience, for we have developed a method which allows you to secure this same experience right in your own home while you are studying your regular Course.

The N. R. I. Plan. Briefly, our plan involves concentrating on one radio receiver chassis the experience which you would normally get from the successful servicing of scores of different receivers. This experience-getting procedure is divided into thirty-four main steps; the first eight you can well carry out while completing your Fundamental Course and laboratory experiments, and the remaining steps can be performed while you are studying the Advanced Course. Naturally you will have to spend considerable time on this plan; by dividing your time properly between study and experiment, you can complete the N. R. I. plan and the Course at the same time, and be ready to start actual radio service work as soon as you receive your diploma. (If you want to begin actual radio servicing work as soon as possible, you can concentrate on this plan and finish it long before you complete your Course.) This plan will also help you to master the Course, for you will actually be practicing the various service techniques at the same time that you study them.

1. Secure A Suitable Receiver. For the first part of the N. R. I. Experience-Getting Plan, you will need the chassis and loudspeaker of a broadcast band A.C. superheterodyne receiver *which is in good operating condition* and has from five to eight tubes. A recent model is not necessary; in fact, a set from three to five years old will be better suited to your needs. Try to get a well known make, such as Philco, RCA-Victor, General Electric, Zenith, Grunow, Silvertone, etc.; one of the first three models is preferable, for we can then supply you with complete service information on your set, including pictorial layout diagrams. You can either borrow this chassis from a friend or purchase it from a radio dealer for a few dollars.

2. Get Service Data On Your Receiver. Having secured a suitable chassis, write to us giving the make, the model number, and the type numbers of the tubes in it, and state that you intend to use this chassis for training purposes. We will then send you all available service information pertaining to your receiver.

3. Get Acquainted With The Circuit Diagram. When you receive the service information, go over the circuit diagram and note the various stages on it. Now trace the signal from the antenna terminal to the loudspeaker, remembering that a change in carrier frequency occurs at the mixer-first detector, and that demodulation takes place at the second detector. Trace through the power supply circuits to see how each tube gets its electrode voltages, and trace through special control circuits such as A.V.C., A.F.C., tuning indicator circuits, tone control circuits, etc.

4. Redraw The Circuit Diagram. On a large sheet of paper redraw the schematic circuit diagram of your receiver, two or three times the original size, in the following manner: First draw all of the tubes in their usual schematic form, in the same relative positions as they are on the diagram sent you. Now put in the signal circuit parts and connections, working from the antenna toward the loudspeaker. Use schematic symbols just as on the original diagram. Do this slowly, visualizing the function of each part and circuit as you draw it.

Alongside each part indicate its electrical value; sometimes you can get this directly from the original circuit diagram, and sometimes you will have to refer to the parts list. Put in the power pack next, then draw each electrode supply circuit. Insert the condensers which keep signal currents in their correct paths, add all special control circuits, then check your enlarged diagram against the original.

5. *Trace Electrode Supply Circuits On The Circuit Diagram.* On your enlarged circuit diagram, locate the cathode (or filament) of the rectifier tube, for this is the highest positive terminal in an A.C. receiver. Now locate the center tap of the power transformer secondary, for this is the lowest negative terminal on the chassis. See if there is a direct conductive path from this negative point to a rectifier plate or to the chassis. Next trace continuity through each electrode supply circuit on your enlarged circuit diagram.

6. *Imagine Various Parts Are Defective, and Determine How You Would Check Them With An Ohmmeter.* Select a part at random on your enlarged circuit diagram and imagine it to be shorted, open or leaky (if a condenser). Determine how you would check this part to prove that it was defective. Would you have to unsolder any leads to make an ohmmeter test? Would the defect cause any change in voltage which could be detected with a voltmeter? Repeat this process of reasoning for at least twenty parts on your circuit diagram.

7. *Make A Tube Socket Connection Diagram.* Draw an actual-size bottom view of each tube socket in the receiver, showing the terminals and tube prongs in their proper relation to each other. Label the terminals P, K, CG, SG, SP and H, for plate, cathode, control grid, screen grid, suppressor grid and heater respectively, and label the electrodes on your enlarged circuit diagram in the same way; use either a tube chart or the socket connection diagram of your receiver as a guide.

8. *Identify All Stages On The Chassis.* Identify each stage on the chassis, as described in a previous job sheet.

9. *Identify All Parts On The Chassis.* Locate on the chassis each part which is indicated on your enlarged circuit diagram; use the pictorial layout diagram (if you have one) as a guide when necessary, but try to get along without it as much as possible.

10. *Make Electrode Continuity Tests.* Make a continuity test of each electrode circuit with an ohmmeter, by connecting the free ohmmeter probe to a tube socket terminal and placing the other probe on the correct common power pack terminal for the test. Referring to the circuit diagram each time, estimate what the resistance should be, then compare your estimate with the observed value. When discrepancies exist, try to figure the reason; remember that variations of up to 20% in resistor values are often permitted during receiver manufacture, and remember that when parts are in parallel, the combined resistance must be considered.

11. *Check Electrode Supply Circuits Part By Part With An Ohmmeter.* Repeat the electrode continuity tests described in the previous section, but this time move the free probe along the circuit toward the fixed probe, part by part, and observe the ohmmeter reading for each step. Check the reading each time against that which you would expect from the circuit diagram.

12. *Check All Resistors With An Ohmmeter.* Check the value of each resistor on the chassis with an ohmmeter, and record the measured value either on your enlarged circuit diagram or on a separate chart. When a resistor cannot be checked because it is shunted by another part, unsolder one lead of the resistor and make a direct measurement, then resolder.

13. *Check All Coils With An Ohmmeter.* Check the continuity of each winding on each coil in the receiver, using the lowest range on your ohmmeter. Look through your service information for coil connection diagrams; if these are not present, use your ohmmeter first to locate the terminals for each winding. Locate the terminals of power transformer windings in the same way and measure the resistance of each winding. Before checking the filament winding, remove all tubes and unsolder one lead of a center-tapped filament resistor if present. Record all readings for future reference, after comparing with the D.C. resistance values specified on the circuit diagram.

14. *Check All Condensers With An Ohmmeter.* Connect your ohmmeter across each condenser in the receiver in turn, using the highest ohmmeter range, and note the amount of the initial flicker of the ohmmeter pointer. Unsolder one lead when a condenser is shunted by some part; be sure to resolder after the test. For electrolytic condensers, take one reading, then reverse the ohmmeter probes and take another reading; the higher one will be a true indication of the condenser, but record both values.

15. Measure All Electrode Voltages. Insert the receiver power cord plug in an A.C. wall outlet, turn on the set, set the volume control at its maximum setting (no station tuned in), and measure each D.C. electrode voltage with respect to the cathode (measure with respect to the chassis if the voltage values in your service information are for this connection). Record each measured value.

Measure also the total rectified D.C. output voltage of the rectifier tube by connecting between the rectifier cathode (+) and the center tap of the power transformer secondary (—).

16. Check Performance of Receiver. Tune in local and distant stations at different parts of the tuning dial while the set is connected to a good outdoor antenna, so you become familiar with the sensitivity and selectivity characteristics, then try all controls.

17. Make A Circuit Disturbance Test. With the receiver in operation, carry out the circuit disturbance test ordinarily used for locating the defective stage in a dead receiver. Do this first by pulling out and replacing each tube in turn while the receiver is tuned between stations. Next, touch the control grid terminal of each tube in turn with your finger. Make the test once more, but this time remove and replace each control grid connection to a top cap, or short the control grid to the cathode when there is no top cap. Notice that sometimes you get clear-cut clicks, while at other times there is a squeal.

18. Make A Defective Stage Isolation Test With A Signal Generator. With the receiver operating but the aerial disconnected, make a defective stage isolation test with your signal generator, just as you would for a dead receiver.

19. Make Resistors Defective. Turn off the receiver and introduce a defect in one of the resistors (open one lead, or connect a resistor across or in series with it to change the value). Try to figure what effect this defect will have on the performance of the receiver, then turn on the receiver and see exactly what happens. Now suppose that you were servicing a receiver which had exactly this same effect; figure a servicing technique which would locate the defect in the quickest possible time, then proceed to carry out this technique until you come logically to the defective resistor. Check it with your ohmmeter, then remove the defect and make a final test to be sure you have restored the circuit to its original condition. Repeat this procedure for each resistor on the chassis in turn, opening a resistor lead in most cases since this is the most common resistor defect. Make a record of the defect and the effect on receiver performance in each case.

20. Make Condensers Defective. With the receiver off, introduce a defect in a condenser; you can disconnect one lead to create an open, you can short the condenser terminals to create a short, or you can shunt the condenser with a resistor of about 50,000 ohms in order to create a leaky condition. Turn on the receiver and check performance, then figure out a logical service technique for locating the defective part, and proceed to carry it out. Repeat this procedure for each condenser on the chassis in turn. Caution: Before shorting a condenser, study the circuit diagram to see if the short will damage any part. If smoke or excessive heat is observed when a particular condenser is shorted, try another defect. Do not short electrolytic filter condensers in the power pack; make these condensers leaky by shunting with a 1,000-ohm, 10-watt resistor, or make them open. Make a record of the defect and the effect in each case.

21. Make Coils Defective. Introduce a defect (an open or a short) in one winding of an R.F. coil, then turn on the receiver and check performance. With the observed effect in mind, determine a logical service technique and apply it to the receiver until you find the defective coil. Remove the defect, then repeat the entire procedure for each other coil winding in the receiver. *IMPORTANT:* Do not short power transformer windings; introduce an open in each winding in turn and carry out your tests. Record your results in each case.

22. Make Tubes Defective. Create a low-emission defect in a tube in the receiver by inserting a filament rheostat (about 10 ohms) in series with one filament lead to the tube and setting it to lower the filament voltage for that tube to about 60% of the original value. (For rectifier tubes and for other tubes drawing more than .5 ampere filament current, get about a 2-ohm wire-wound resistor with slider, and adjust until you get the desired filament voltage. Turn off set before adjusting the slider, to avoid a shock). Turn on the set and note the effect on performance. Remove the defect, then repeat this same low-emission test for each tube in the receiver in turn. Starting at the first tube again, create a cathode-to-heater leak by connecting a 1,000 ohm resistor between the cathode and one heater terminal. Turn on the set, check performance, figure a service technique, apply it, then remove the defect and repeat for each other tube.

23. Create a Dead Receiver. Referring to your enlarged circuit diagram, make a list of the parts which, if defective in a certain manner, will cause a dead receiver. Try to do this by reasoning alone, without looking at the records you have previously made. Introduce each defect in the receiver in turn, to prove that it does cause a dead receiver. Apply the circuit disturbance test and the defective stage isolation test with a signal generator in each case, to see if these tests will correctly locate the defective stage.

24. Create Hum. Referring to your circuit diagram, make a list of the defects which you believe will create hum in the receiver, introduce these defects and carry out the tube-pulling test for locating the defective stage, then check operating voltages on that stage with your D.C. voltmeter and locate the defective part with an ohmmeter.

25. Create Distortion. Make a list of the defects which you think will create distortion, then introduce these defects, and for each one apply the defective stage isolation test for locating the defective stage, then determine and carry out a logical procedure for locating the defect in that stage.

26. Create Poor Sensitivity. Make a list of the defects which you think will create poor sensitivity, then introduce these defects to verify your assumptions, and carry out a logical service technique for locating the defect in each case.

27. Create Poor Selectivity. Place a 1,000 to 25,000 ohm resistor across one winding of an R.F. coil to load the coil and create the effect of poor selectivity. Turn on the receiver, check performance, then carry out a logical service technique for locating the defect. Repeat for each other R.F. and I.F. coil winding in the receiver.

28. Create Oscillation. Make a list of the defects which will create oscillation, remembering that feed-back from plate to grid due to an open by-pass condenser is the most common cause of oscillation. Check performance and carry out a logical service technique for locating the defect in each case.

29. Create A Defective Loudspeaker. Introduce in turn the following defects in the loudspeaker: open voice coil; open field coil; shorted field coil; off-center cone; loose spider. Check performance in each case at various volume levels, and try to remember the particular effect on performance which is observed.

30. Replace Parts. Remove from the receiver and replace, one at a time, at least one of each of the following parts: a resistor; a paper condenser; a mica condenser; an electrolytic filter condenser; an R.F. coil; an I.F. transformer; an audio transformer; a volume control; a power transformer. Check the part with an ohmmeter before you remove it, after it is out of the set, and after you have replaced it in the set. In the case of coils and transformers which have more than two leads, draw a pictorial diagram of the connections before unsoldering any leads, so you will be sure to get them back again correctly. This is particularly important in the case of the power transformer.

31. Check Each Alignment Adjustment. Connect your signal generator and output meter to the receiver in the proper manner for realignment, then vary the setting of each alignment trimmer in turn, and note the effect on the output meter; restore the original adjustment before going on to the next trimmer. This procedure will show you just how critical each adjustment is.

32. Realign The Receiver. Refer to your service information for any special alignment instructions, then realign the receiver. Repeat until you can complete the alignment without referring to the instructions.

33. Throw Receiver Completely Out Of Line, Then Realign. Turn each alignment trimmer two or three turns in any direction, or tighten all alignment trimmer screws, then repeat the alignment procedure. This will correspond to the most difficult alignment job which you can encounter in actual practice.

34. Overhaul The Receiver. An overhaul of your receiver, just as if you were going to return it to a customer, completes your work on this one chassis. Replace all parts and wiring which you may have damaged, and resolder joints if necessary.

———oOo———

If you have faithfully followed the procedure just described for a broadcast band receiver, you will be a long way toward securing the experience which you require. If you really want to start out in radio servicing with a confidence equal to that of a Radiotrician with years of experience, get a second and even a third chassis, and repeat the entire N. R. I. plan on these. Choose an all-wave superheterodyne or at least a two-band A.C. superheterodyne receiver having somewhere between five and twelve tubes for your second test. The third receiver can be defective, for by that time you should be able to repair it yourself.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

Service Hints for Universal Receivers

MANY thousands of midget universal A.C.-D.C. receivers have been and are still being sold to the public. In most cases no service information whatsoever can be secured. Fortunately, however, these receivers all have more or less the same T.R.F. circuit with four or five tubes, and minor variations in the circuits are quite easy to recognize. This job sheet gives you the basic circuits and the common variations, then shows how you can service these universal T.R.F. receivers without the aid of circuit diagrams.

Signal Circuits. As a general rule, the signal circuits in a universal T.R.F. receiver are extremely simple; the typical circuit has one R.F. amplifier stage, a detector stage, and an audio output stage, as shown in Fig. *1*. The R.F. amplifier tube is usually a super-control pentode such as the 78, 6D6 or 6K7, having a 6.3 volt filament. There are two tuned circuits, controlled by a two-gang variable condenser; one couples the antenna to the input of the R.F. stage, and the other couples the R.F. stage to the detector. The volume control circuit simultaneously varies the antenna input voltage and the gain of the R.F. tube. A regular R.F. pentode tube such as the 6C6, 77, or 6J7 is used in the high-gain detector circuit. The detector feeds through resistance-capacitance coupling into a high-gain power audio amplifier tube, which may be a 38 or 43 pentode or a 25L6 beam amplifier tube. An electrodynamic loudspeaker coupled to the audio output by an impedance-matching transformer is most common, but you will also encounter magnetic loudspeakers which are connected directly into the plate circuit of the power tube.

Universal receivers usually have an antenna consisting of about twenty feet of flexible insulated wire which comes wound on a fiber card and connected to the receiver input circuit through a small tubular or mica condenser; this wire should be unwound and dropped out of a window, tacked around a window or wall, or placed under a rug. Satisfactory reception can often be obtained simply by connecting this aerial wire to a radiator or other ground.

Two distinct types of grounding systems are employed in universal receivers. In the type represented by Fig. *1*, the chassis is not an electrical part of the circuit; the ground symbols in the diagram simply indicate a connection to a common wire which serves as the return path for signal currents. In the second type of grounding system, the chassis is the common return path for signal currents. One side of the power line is directly connected to the chassis, so for one position of the power cord plug, the chassis

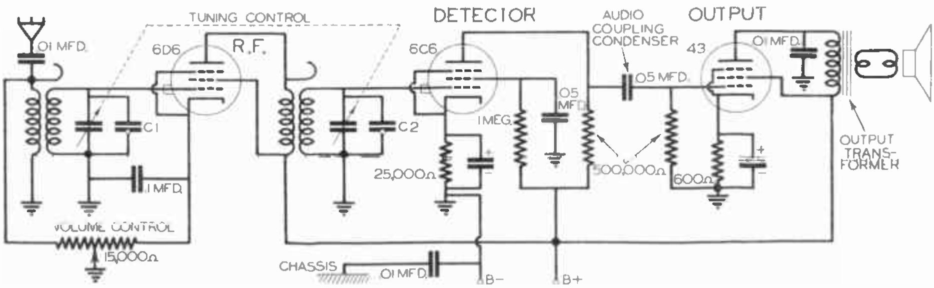


FIG. 1. Signal circuits of a typical universal T.R.F. receiver. Alignment simply involves tuning in station, then adjusting trimmer condensers *C1* and *C2* (mounted on the gang tuning condenser) for maximum output volume.

will be "hot" (connected to the ungrounded side of the line). Under this condition a shock may be felt if some part of the body is grounded when the chassis is touched. Never connect the chassis to an external ground, for this may short-circuit the power line.

Power Supply Circuits. In a universal receiver, the power pack must rectify the A.C. line voltage and deliver the maximum possible rectified voltage to the tubes. Furthermore, since the tube filaments in these receivers are always connected in series, and since the sum of the required filament voltages for the tubes is considerably less than the A.C. line voltage, the power pack must limit filament current to the correct value. Rectifier tubes having 25-volt filaments, such as the 25Z5 and 25Z6, are quite popular, as also is the 12Z3 tube which employs a 12-

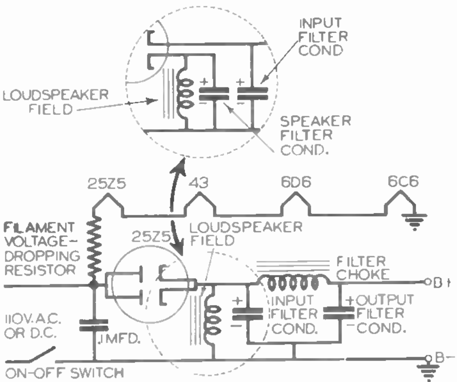


FIG. 2. One type of power supply circuit commonly found in universal receivers. Alternative loudspeaker field coil connections are shown inside the dotted circles.

volt filament. Sometimes a "dummy" tube is used to reduce filament current and give the added sales appeal of an extra tube, even though this is not good engineering practice. Dummy tubes are easily identified by their socket connections; only the filament terminals will be connected into the receiver circuit.

A typical power supply circuit for a universal receiver is shown in Fig. 2. A 25Z5 tube is connected as a half-wave rectifier; the unfiltered output is fed directly to the loudspeaker field coil, while the output of the filter system is fed to the tube electrode circuits. The 25Z5 and 43 tubes each have 25-volt filaments, while the other two tubes have 6.3-volt filaments, making the total filament voltage requirement about 63 volts. The filament voltage-dropping resistor must therefore drop 115—63, or 52 volts, in order to keep the current at the correct value of .3 ampere. Knowing the voltage across the resistor and the current through it, Ohm's Law gives the correct resistor value as 52 ÷ .3, or 173 ohms; increases of up to 10% in this resistance value are permissible when an exact-size resistor is not available. This resistor may be a wire-wound resistor mounted on the chassis, a ballast tube (a resistor in a glass or metal envelope), or a line cord resistor having resistance wire imbedded in asbestos and placed in the receiver power cord along with the usual two copper wires. Ballast tubes are favored by most manufacturers, for they give the impression that the set contains an additional tube.

A resistor is sometimes used in place of the filter choke in Fig. 2, but when this is done the plate D.C. voltage for the power tube is obtained ahead of the filter system by a direct connection to the cathode of the rectifier tube. The field coil of the dynamic loudspeaker is occasionally used as a filter choke, in which case its D.C. resistance is made sufficiently low to prevent excessive drop in the rectified voltage. Sometimes the two diode sections of the 25Z5 tube are used separately, one section for the tube circuits and the other to supply field coil excitation; in this case an extra filter condenser is connected directly across the loudspeaker field coil, as indicated in the dotted circle in Fig. 2. There will usually be a condenser (about .1 mfd.) across the power line to keep out line noise.

A type 37 triode tube with gride and plate connected together is sometimes used in the power pack as a half-wave rectifier; with this arrangement or with a single 12Z3 rectifier tube there will usually be a magnetic loudspeaker, for these tubes cannot supply sufficient current for field excitation of a dynamic loudspeaker without failing prematurely.

When a filter choke is used, the drop across this choke is often made to serve as the C bias for the power tube. The choke would in this case be located between the negative lead of the output filter condenser and the on-off switch, with the grid circuit of the power tube connected to the switch terminal.

The screen grid and plate of the R.F. tub usually get the same D.C. voltage, but sometimes a resistor is inserted in the screen grid lead to lower the D.C. screen grid voltage.

The screen grid voltage on the detector tube must be lower than the D.C. plate voltage; this lower voltage is secured either with a series resistor as indicated in Fig. *1* or by connecting the detector screen grid to the positive end of the cathode resistor for the audio output tube in the manner indicated in Fig. *3* (this point is sufficiently positive with respect to the detector cathode to meet detector circuit requirements).

If a magnetic loudspeaker (or a dynamic loudspeaker having the field coil connection shown in the dotted circle in Fig. *2*) is used with the detector arrangement in Fig. *3*, there will be no continuity between the detector screen grid terminal and the cathode of the rectifier tube. All other plates and screen grids will trace to the cathode of the rectifier tube, however, and the control grid, cathode, and suppressor grid terminals will trace to the power switch, which is the B— terminal. Remember these facts when checking continuity of electrode circuits in universal receivers.

Pilot lamps used in universal receivers are generally connected in series with the tube filaments; the lamps are not designed to handle the usual filament current, and hence are shunted by a resistor in the manner indicated in Fig. *4A*. When a ballast tube is used, a tap is provided at the proper point on its resistor for a pilot lamp connection, as indicated in Fig *4B*. When a pilot lamp burns out, replace it with a lamp having the same voltage rating and the same color of glass bead around the filament supports. When a ballast tube burns out, replace it with one having the same code number.

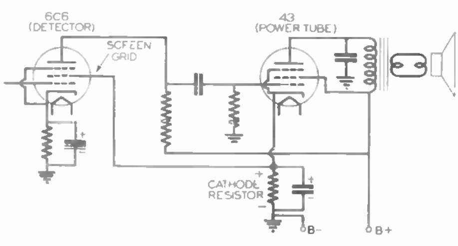


FIG. 3. Detector and output stage of a universal receiver, showing a simple but entirely satisfactory method for getting a low positive screen grid voltage for the detector tube.

Replacing Filter Condensers. Electrolytic filter condensers are more likely to become defective than any other part in a midget universal receiver. All electrolytic filter condensers are usually grouped in a single block. When one condenser in a block becomes defective, it is advisable to replace the entire block, as the other sections will very likely fail in the near future. Whenever an exact replacement filter block can be obtained, it should be used. Ordinarily there will be no identifying numbers on the condenser filter block; in this case the following procedure will enable you to order a suitable replacement.

Make a sketch of the old condenser block, showing all of its leads. Trace each of these leads in the receiver and determine the type of power pack circuit used. Now draw in the internal connections for the condenser block (this will be easy once you become familiar with the power supply circuits used in these sets), and indicate on your diagram the polarity of each lead and the condenser section to which it belongs. Now you can

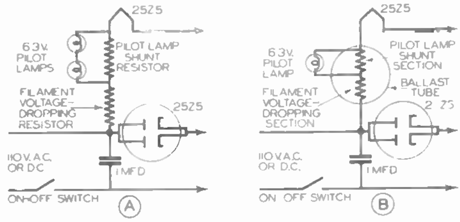


FIG. 4. Pilot lamp connections for power supply circuits employing a filament voltage-dropping resistor (*A*) and a ballast lamp (*B*).

place on your condenser block sketch the approximate capacity values for each section. Use the following general rules as your guide: *Input Filter Condenser*—any value between 10 mfd. and 20 mfd., rated at 200 volts D.C. working voltage or higher; *Output Filter Condenser*—any value between 8 mfd. and 16 mfd., rated at 200 volts D.C. working voltage or higher; *Loudspeaker Field Coil Filter Condenser*—between 4 mfd. and 8 mfd., rated at 200 volts D.C. working voltage or higher; *Cathode Resistor By-Pass Condensers*—about 5 mfd., rated at 25 volts D.C. working voltage or higher.

Your condenser block sketch now gives you the necessary data for ordering a replacement unit. First try to secure a single condenser block to replace the defective unit; if this cannot be secured, order a block to replace some sections and use individual midget electrolytics for the remaining sections, or build up the complete assembly with individual units. Before ordering, make sure the replacement units will fit in the available space. Three examples of condenser block sketches are shown in Fig. *5*. That at *A* is for the power pack circuit in Fig. *2*, while the diagram at *B* is for the circuit in Fig. *2* when the loudspeaker connections are as indicated in the upper dotted circle. When the choke coil is in the negative power supply lead and provides C bias for the output tube, the condenser block diagram may take the form shown at *C* in Fig. *5*.

Performance of Universal Receivers. As you become familiar with midget universal receivers, you will learn for yourself that there is a definite limit to what can be expected from these sets. They give reliable reception only on local stations; they have little selectivity and consequently should not be used on long antennas; they will overload and distort if the volume control is advanced too far when tuned to a local station; fidelity of reproduction, especially as regards bass notes, is poor. This lack of fidelity is inherent in these sets because low-power output tubes are used, because the loudspeaker is small, and because the baffle is small. Be on the lookout for complaints which indicate that the customer is expecting more from a universal set than it can possibly give.

Because of the limitations in size and circuit design of universal receivers, circuit defects tend to be concentrated in a few critical parts. Short-cut methods for locating these common defects will now be considered; conventional servicing techniques as presented elsewhere in the Course can be applied whenever these short-cuts fail to locate the trouble.

Service Hints for Dead Receivers. A break in the filament circuit is a common cause of a dead universal receiver, for a defect in one part or lead in this circuit will block filament current to all tubes. Check all tubes with a tube tester, then check continuity in the filament circuit with an ohmmeter.

A defective (open, leaky or shorted) electrolytic filter condenser is another common cause of a dead universal receiver. A shorted filter condenser can damage the rectifier tube, so check this tube after replacing a filter condenser. A measurement of the rectified output voltage of the rectifier tube will often give a clue to the trouble. With the set plugged into an A.C. outlet, the D.C. voltage as measured between the rectifier tube cathode (B+) and the tuning condenser frame (B−) should be between 90 and 120 volts; if lower, a filter condenser is very likely defective. When making a circuit disturbance test to isolate the defective stage in a universal receiver, remember that you cannot pull tubes; remove and replace each control grid cap or short the grid momentarily to the cathode to produce the disturbance.

Distortion. Excessive distortion may be due to an off-center cone or an open field coil in a dynamic loudspeaker, to improper centering of the armature in a magnetic loudspeaker, to a leaky audio coupling condenser, or to a defective audio output tube. Always try a new output tube when you are unable to find any other cause of distortion, even if the present tube tests okay in a tube tester.

Low Volume. Open filter condensers, defective volume controls, and inadequate antennas are common causes of low volume in a universal set. The antenna wire should be completely unrolled.

Oscillation. A certain amount of oscillation at high volume level is normal and unavoidable in some universal receivers, so if a reduction in volume will stop the oscillation and allow the signals to come through clearly, nothing should be done. If the oscillation cannot be controlled or if the volume must be reduced too much in order to eliminate it, look for a defect. The most common defects are an uncoiled antenna, a misplaced control grid lead, an open by-pass condenser or an open output filter condenser. If a check of all these fails to locate the trouble, try connecting the antenna wire to a radiator or other ground, or try detuning the trimmer condensers which are mounted on the gang tuning condenser.

Intermittent Reception. Experience has shown that the most common cause of intermittent trouble is a defective audio output tube or a defective audio coupling condenser, so check these parts first. Also check for intermittent breaks in the antenna cord.

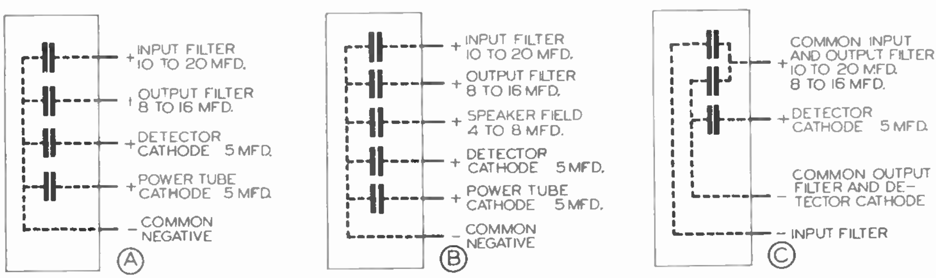


FIG. 5. Typical condenser block diagrams for universal receivers.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

How to Service a Receiver Which Hums

ANY receiver which operates from an A.C. source will have a certain amount of hum current in the output of the receiver. Complete elimination of this hum current is not possible nor is it necessary, for in a normal radio receiver in good condition, the hum will hardly be noticeable even when the receiver is tuned between stations. If you will listen carefully, you can hear this hum on practically any receiver. By listening for this hum in a number of new receivers, you will become familiar with the amount of hum which is considered acceptable to the average radio listener, and you will realize that there is no need to waste time in trying to eliminate hum which normally would be unnoticed by a listener.

Hum is always more pronounced when the radio chassis is in its cabinet, for the cabinet serves to improve the response to low frequency notes. Each time you work on a receiver, listen carefully for the amount of hum when the chassis is still in the cabinet and when the chassis is out of the cabinet; in this way you will learn to determine how loud the hum can be in the chassis alone without making it annoying to the customer when the chassis is returned to the cabinet.

Three Types of Hum. When the hum in a receiver increases to the point where it becomes annoying to the set owner, the customer will call in a serviceman and ask him to "get out that hum." Actually, however, there are three different forms of hum, with a different servicing procedure for each.

1. Hum Due to Mechanical Vibration. When a hum is heard but it does not come out of the loudspeaker, you can be sure that some part on the receiver is vibrating. To check this, place your fingers on the voice coil or cone to prevent it from moving; you should still hear the hum, but will not be able to feel it with your fingers. By listening carefully to various parts, you should be able to locate the one which is vibrating. The procedure for eliminating this vibration was covered in a previous job sheet, and simply involves tightening the part in question so it cannot vibrate.

2. Tunable Hum. This type of hum is heard only when a station is tuned in. If the hum is heard only on one station, it is more than likely originating in the station transmitter. The trouble will undoubtedly be corrected in a few days by the station operator. You can check for this by tuning in the station on other receivers; the same hum should be heard on each set. Tunable hum which is heard on all local stations, however, is due to a receiver defect; the ripple voltages in the power pack are getting into the R.F. system and modulating the carrier of the station which is tuned in. The trouble may be due to inadequate power pack filtering, to misplaced grid wires, to ineffective shields of tubes which are located near power transformers or iron core choke coils, to a direct electrostatic pickup of ripple voltages by the grid leads of R.F. tubes, or to a cathode-to-heater short or leak in an R.F. tube.

3. General Hum. When hum is heard from the loudspeaker at all times, regardless of the setting of the receiver tuning dial, it is definitely originating in the receiver. If the intensity of the hum varies with the manual volume control setting in an A.V.C.-controlled receiver, the hum is probably originating in the second detector circuit. If the volume control has no effect upon the hum, it is originating somewhere in the audio system or in the loudspeaker; it may be due to a defective tube, to a circuit filter system defect, or to a power pack defect.

Common Causes of Hum. In the majority of cases, hum in a receiver is due to one of two common causes: 1, a defective tube; 2, a defect in the power pack. The wise serviceman usually checks these two causes before even attempting to isolate the trouble to a particular section or stage.

When hum is the complaint, your first step can well be a check of all tubes with a good tube checker. Allow each tube to warm up for a minute or so, then check for leakage between the cathode and the filament, for this leakage can allow A.C. voltages in the filament circuit to get into the signal circuit and produce hum. At the same time, check each tube for emission in the usual manner; the indicating meter on the tube checker will indicate whether the tube is good or bad. A bad tube, having low emission, can cause hum trouble. Be sure to make a thorough test of the full-wave rectifier tube; both diodes of this tube should show about equal emission, for the average filter system in a receiver loses its effectiveness when the rectifier diodes become unbalanced.

The power pack filter system should be checked next, for any defect here can relay the hum voltages to any of the stages in the receiver or directly to the loudspeaker, producing either tunable hum or ordinary hum. Locate the power pack filter condensers, and while the receiver is in operation, shunt each one of them in turn with an 8 mfd., 500-volt electrolytic condenser. Be sure that you connect this test condenser with the proper polarity (its red or plus lead should go to the positive terminal of the condenser being tested). If the hum stops or is greatly reduced when a condenser is shunted in this manner, that condenser has either opened up or has lost its capacity, and should be replaced. This shunting procedure will not test for leakage, however; to do this you must unsolder one lead of the electrolytic condenser in the receiver and then measure its resistance with an ohmmeter. Take two readings, reversing the ohmmeter probe for one; if the higher reading is below 50,000 ohms, the condenser is leaky and should be replaced. Some servicemen prefer this simple test for leakage: allow the receiver to heat up for a few minutes, then feel the sides of each electrolytic condenser; if any are warm, they should be unsoldered and checked for leakage with an ohmmeter. Condensers which remain cool have negligible leakage, and need not be checked.

When checking the power pack, be on the lookout for tuned chokes in the filter system. A small-size condenser (about .1 mfd.) shunting a choke coil, or a 1 to 2 mfd. condenser connected to a mid-tap on a choke coil, indicates that a tuned circuit is being used to filter the output current of the rectifier tube. The air gap in the core of the choke coil may have changed, causing the resonant frequency of the filter circuit to change. Try different condensers which are rated at about the same value as that used, in order to locate one which will be sufficiently different in capacity to retune the circuit to the hum frequency and thereby eliminate the hum trouble.

If the preceding checkup of tubes and the power pack filter system fails to reduce the hum sufficiently, the next step is a systematic procedure for isolating the defective stage. It is well to start this by shorting the primary terminals of the loudspeaker input transformer; this prevents any hum voltages from reaching the loudspeaker through this transformer. If hum is heard when this is done, you know that it is either getting into the loudspeaker through the field coil leads (in which case you would look for a defect in the filter system associated with the loudspeaker field coil or for a defect in the loudspeaker field supply if that is separate from the receiver supply) or hum is getting into the loudspeaker by magnetic induction from some nearby part. Remove the short after this test has been made. If the loudspeaker has a hum-bucking coil (a small coil mounted on the central core of the loudspeaker and connected in series with the voice coil), and you suspect that some one may have reversed the connections to this coil. try reversing these connections temporarily. Use whichever connection gives the least hum.

If the preceding tests fail to locate the trouble, you can be pretty sure that the hum is originating in one of the stages of the receiver. If the chassis is still in its cabinet, you can isolate this stage by pulling out the

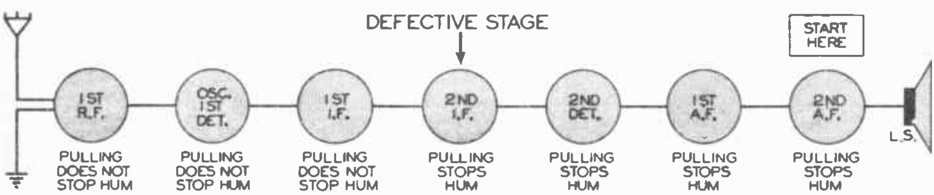


FIG. 1. Example illustrating the professional procedure for isolating the defective stage in an improperly operating receiver when hum is the complaint.

tubes one at a time, working from the output stage to the R.F. input stage, as described in the previous job sheet, and as illustrated in Fig. *1* in this job sheet. If the chassis is on your work bench, it may be easier to short the grid of each tube in turn. In either procedure, when you come to a stage which, even though placed out of action, allows the hum to exist, you know that the trouble is in the following stage. Check tween the tube and the power pack, allowing this metal to touch the chassis; if this reduces or eliminates the hum, try another tube; if this fails, install a shield.

Quite often, tunable hum is due to R.F. current in the power line; it may be produced there by a faulty power line connection which causes rectification and modulation of the A.C. current on the R.F. This

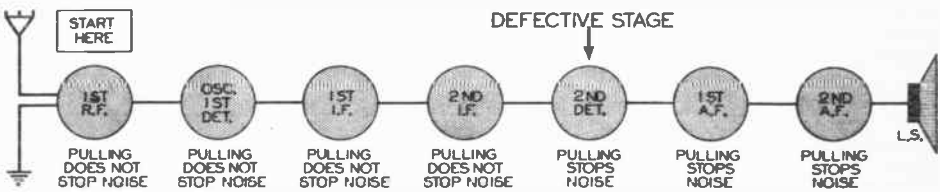


FIG. 2. Example illustrating the professional procedure for isolating the defective stage in an improperly operating receiver when noise is the complaint.

the by-pass condensers in that stage first of all by shunting each in turn with a good condenser of the correct size. Try moving the grid lead away from tube filament leads, to see if this will reduce or eliminate the hum. Check for open grid circuits, as a tube having a "floating" or open grid is very susceptible to hum pickup.

If the receiver in question is an older model having a grid leak-condenser detector, try placing a metal shield around this tube if you have traced the trouble to this stage. These tubes are easily affected by the hum field set up by power transformers and choke coils. For a preliminary test, you can simply place a sheet of metal be- hum-modulated R.F. current enters the receiver through its power cord, and causes tunable hum when it gets into the R.F. stages.

This trouble is chiefly encountered in locations where power lines are on poles rather than underground.

Try this when you encounter tunable hum: Reverse the receiver power plug in its outlet to see if this will eliminate the hum; if it has no effect, connect two .05 mfd., 600-volt condensers in series between the two power line leads, and ground the common terminal of these condensers. If hum is getting in through the power line, these condensers will by-pass it to ground.

How to Service a Receiver Which is Noisy

As you already know, noise in a receiver may be due to a make-and-break connection which intermittently causes a circuit to open or a part to become shorted. The defect may exist in a tube, inside a part, or in an exposed connection. The slightest jarring of the receiver causes the connection to make and break, with the result that we hear noise. This defect can occur in any section of the receiver, as well as in the antenna system. Fortunately, the noise will be most severe when the defective part itself is jarred; this simplifies locating the trouble.

When you are called in to service a noisy radio receiver, make sure that the noise in question is actually receiver noise and not atmospheric noise (static) or man-made interference. Check the antenna system next by shaking the antenna and ground leads. If this does not increase the noise, remove the leads and short the antenna and ground terminals of the receiver; if the noise is still heard, you know that it was not coming in over the antenna system. Now insert a line filter in the receiver power cord; if the noise is still heard now, you are sure that it is internal noise. If a line filter stops the noise, however, you know that it is coming in over the power line. As soon as you have serviced a few noisy receivers, you will find yourself able to detect internal noise almost immediately without making all these checks, simply by slapping the chassis; if noise results, the chassis has a defect.

Before removing the chassis from its cabinet, be sure that there are no surface defects. Carefully examine the chassis for loose parts, wiggling them to see if any one will pro-

-duce noise. See that all tube shields are in place and that top cap connections make firm contact with tube caps but not with shields. Tap each tube to see if any one has loose internal connections which may be causing the noise. Inspect the loudspeaker connections, for if the defect is here there will be no need to remove the chassis. Make this inspection while the receiver is turned on, using a wood stick or bakelite rod to move the wires and jar suspected parts.

Quite often this preliminary checking of a noisy receiver is not necessary. For example, if the noise occurs only when the volume control is adjusted, you know that the volume control potentiometer is defective and should be replaced. The same is true of a noisy tone control. If the noise occurs when the wave band change switch is wiggled, you know that there is a defect in the switch. If noise occurs only when you are rotating the tuning dial, you suspect immediately that the rotor and stator plates of the variable tuning condenser are touching or that there is poor contact between the rotor and the condenser frame. One of the rules of professional servicing is to try first of all to make the effect reveal the defect to you directly or after simple tests.

If the foregoing tests do not locate the defect, take the chassis out of the cabinet. Now make an inspection for surface defects, moving each part and wire with your insulated rod while the receiver is turned on; in the majority of cases, this simple procedure will locate the defect. Give special attention to the power pack system; wiggle all parts in it, including chokes, filter condensers, voltage dividers, power transformers, fuses, etc. Do not be afraid to apply pressure to transformers and chokes when doing this.

The tube-pulling procedure for isolating the defective stage comes next. Proceed to pull out tubes one at a time, starting at the receiver input and working toward the loudspeaker as indicated in Fig. 2. The first stage which stops the noise is the defective stage. Once the defective stage has been isolated, try shorting its grid to the chassis after you have replaced the tube. If the noise is in the input of this stage, this test will very likely stop the noise; if this grid-shorting test has no effect on the noise, the trouble is very likely in an electrode supply circuit. Measure the D.C. plate and screen grid voltages; if either one fluctuates each time the noise exists, you have located the defective circuit.

Having found the defective stage or the defective circuit, push each lead and part in it vigorously. Shielded parts having internal connections should be tapped and jarred in an attempt to open a concealed connection. If you prefer, you can turn the receiver off and connect an ohmmeter across each part or connection in turn while moving the part, noting whether any change in the ohmmeter reading occurs. It will be best to use alligator clips on your test probes while doing this, so you will have your hands free to move the part. This procedure should reveal the defective part or connection.

Radio Servicing Jobs and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

How To Align a Superheterodyne Receiver

Bragging is something I rarely indulge in, but I can align the R.F. system* of a superheterodyne as well as the best of radio experts. With all this personal confidence I think twice before I start adjusting alignment trimmers. There are other defects in a receiver resulting in the same symptoms as poor alignment; if I start aligning a receiver before I am sure other defects are not at fault, I am bound to lead myself into plenty of trouble. To be sure, a superheterodyne with one or two I.F. transformers concerns me less than a receiver with three I.F. transformers and a well-balanced preselector; smaller and older sets are usually simpler to adjust. The better receivers may have band-passed stages, requiring adjustments which demand some experience, which you will acquire.

When Alignment Is Needed.—Broad tuning or lack of sensitivity is often due to poor alignment, but other defects, such as low supply voltages and poor tubes, give rise to the same effects. Moral: Check tubes and supply voltages before you touch an adjustment trimmer. Many more causes of broad tuning and weak signals are given in your reference book on "Radio Receiver Troubles."

On the other hand, certain defects immediately indicate misalignment. For example, if the receiver is sensitive at the low and high frequency dial positions but poor or even dead in the center, and the taper off (of response) from the ends of the dial to the center is gradual, the preselector and the oscillator do not *track*.** For the same reason, a receiver may respond well at one end of the dial, but poorly or not at all at the other end.

If you encounter a receiver which operates satisfactorily except that its dial readings do not correspond to the frequencies of the stations tuned in, the oscillator is not properly aligned with respect to the station dial. Even here it is wise to determine first whether the dial has slipped on the condenser shaft. Better dial frequency agreement is in many cases not worth the time necessary to make the alignment.

Poor selectivity and sensitivity are by far the most common reasons for aligning superheterodyne receivers. The reason is easy to understand. Poor selectivity and sensitivity are the result of natural aging and the effects of the atmosphere (weather); the other radio faults discussed are the result of tampering and poor original design. People as a rule do not tamper with their radios, nor does a reliable manufacturer offer receivers with the glaring defects mentioned.

The Alignment Problem.—Every superheterodyne receiver has three basic sections: *1*, The I.F. amplifier; *2*, the oscillator; and *3*, the preselector (including mixer-detector), all requiring perfect alignment with each other. The all-wave super has, in addition, as many preselector-oscillator sections as there are bands.

I.F. Amplifier Stages.—The I.F. amplifier should always be aligned at the frequency recommended by the manufacturer unless you have a good reason for a change. A change is advisable only to eliminate interference from a local low frequency station operating at the I.F. value of the receiver, or to eliminate harmonic feed-back from the I.F. to the preselector.

I.F. amplifiers with one or two I.F. transformers are always peaked. When three or more transformers are used they are adjusted for band-pass if enough gain remains after this adjustment is made. Only I.F. transformers with *tunable* primaries and secondaries can be band-passed. Later I will explain how peak and band-pass adjustments are made.

R.F. Amplifier Stages.—The preselector or R.F. amplifier is the first section of the super. It may be a simple tuned antenna transformer feeding into the first detector, a single R.F. stage, or a band-pass T.R.F. system. The preselector should follow the dial readings, and for an all-wave receiver each preselector must track with its corresponding dial. The preselector must contribute sufficient undesirable station rejection (selectivity) and gain, if the receiver is to be free of station and converter circuit noise interference. If the I.F. amplifier is band-passed, the preselector must either tune

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* The R.F. system of a super includes: *1*, The R.F. or high frequency amplifier (also called the preselector); *2*, the oscillator; and *3*, the I.F. amplifier.

** It is assumed you have read and mastered the lessons on superheterodyne receivers.

broadly (for simple circuits) or be band-passed (for double resonance circuits).

The Oscillator Stage.—The oscillator invariably operates at a frequency* above that of the station received by an amount equal to the I.F. amplifier frequency. There must be as many oscillator coil systems as there are preselector sections,** and in each range the oscillator must track with its preselector at a frequency difference equal to the I.F. value.

Order of Aligning Stages.—In any alignment procedure, the I.F. system is aligned before the preselector-oscillator is made to track. In an all-wave receiver the broadcast band is always checked and aligned before the other bands.

Although the procedures now to be given are typical of all receivers, the final guide and authority is the service manual of the receiver on which you are working. As you gain experience you will know when special precautions are required, and when the service manual should be consulted.

Be sure you know the purpose of each adjustment on the chassis before you make any changes.

Identifying Trimmers and Adjusters.—To give all the information necessary to identify every adjustment control in any super would be an endless task. However, the following hints will be of real benefit.

In the case of the 550 to 1,500 kc. broadcast band super, the I.F. trimmers are usually inside the can shielding the I.F. transformer. One or two adjustment screws or nuts are clearly visible at the top, side or bottom of the coil shield. If the I.F. transformer trimmers are not in the coil shield, they are on the chassis near the transformer; tracing their leads to the I.F. transformer identifies them. The high frequency trimmer adjustments for the preselector and oscillator are to be found on the variable condenser gang. The other trimmers on the main chassis are either the low frequency oscillator padder, some resonant rejection circuit, acceptance circuit, or regeneration control. With a little study you should have no difficulty in identifying each control.

In the case of an all-wave receiver the adjusters for the I.F. system differ little from the above layout. The greatest difficulty will arise in locating the preselector and oscillator trimmers. With a little experience these trimmers may be identified. If the R.F. transformers and oscillator coils required for all bands in a given stage are housed in a common shield, quite often the high frequency trimmers are inside, the adjusting screws showing at the side. On some sets the trimmers are ganged on a bakelite or ceramic strip near the group of coils. However, the low frequency oscillator padders are always on the chassis and usually on an assembly strip. The trimmers with the greatest number of plates are the low frequency padders. There are as many trimmer condensers in each R.F. coil, oscillator coil and padder group as there are bands.

On all-wave receivers the trimmers belonging to any one band can be identified by tuning to that band, then touching each trimmer in turn with a screw-driver. A change in the operation of the receiver will be noted when each trimmer in use at the time is touched.

Identifying Tubes.—Before you can connect the signal generator to a superheterodyne you must be able to identify the tubes in the radio frequency section. Inasmuch as it is good design practice to locate a tube near its circuit parts, it is possible to check the use of a tube by the parts near it. If the control grid lead of a tube goes into an I.F. transformer, it must be either an I.F. amplifier or the second detector; if the control grid goes to a *stator* of the gang of variable condensers, the tube must be an oscillator or preselector. If the plate lead of a tube (in which the grid goes to the variable condenser) feeds into an I.F. transformer, this tube must be the first detector. A continuation of this type of analysis will identify the tubes in any receiver. Circuit diagrams, either for the radio in question or for one of the same general characteristics, will be of great value for tube-identification purposes.

Apparatus Required.—The same apparatus used for aligning T.R.F. receivers is used to align supers, provided the signal generator covers the I.F. and preselector frequency bands. If you make the multimeter and signal generator described in previous jobs or buy factory-made equipment with similar specifications, you will have no trouble in handling any all-wave or single band super.

In aligning a super you will sometimes have to make signal generator connections directly to the various stages rather than to the antenna and ground posts. The easiest connection is to the control grid of the stage involved, a connection being used which has a minimum effect on the receiver. A standard coupling unit such as that recommended by Atwater-Kent and shown in Fig. *1* should be added to your testing equipment. It is to be used whenever the hot R.F. lead (within the shield of the signal generator cable) is to be connected to a control grid.

STEPS IN ALIGNING A BROADCAST BAND SUPERHETERODYNE RECEIVER.

A. Align the I.F. stages.

1. **Connect signal generator to first detector stage.**
2. **Connect output meter to output stage.**

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* In some receivers the oscillator in the highest frequency band operates below the preselector frequency.

** Quite often you will find a band using the 2nd harmonic of the oscillator circuit of a lower frequency band.

3. Set S.G. at recommended I.F. frequency.
4. Adjust I.F. trimmers for maximum gain, repeating adjustments once.
5. Band-pass I.F. stages (if necessary).

B. Align preselector and oscillator.

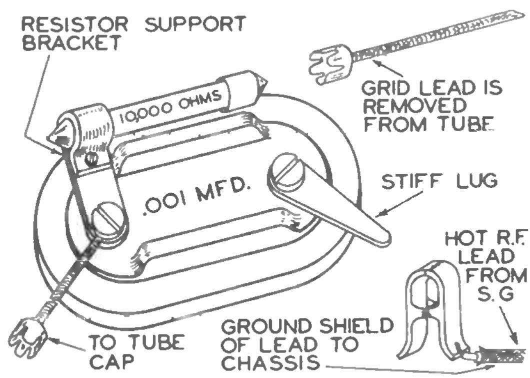
1. Connect S.G. to antenna and ground posts of receiver.
2. Set receiver and signal generator to 1,400 kc.
3. Adjust oscillator trimmer for maximum gain.
4. Adjust preselector trimmers for maximum output.
5. Set signal generator and receiver to 600 kc. Make rocking adjustment of oscillator low frequency padder (if set has one).
6. Realign oscillator high frequency trimmer at 1,400 kc. by rocking the condenser gang.
7. Realign oscillator low frequency padder at 600 kc.
8. Band-pass preselector stages (if necessary).

Connecting the Signal Generator.—For preselector and oscillator tracking adjustments the signal generator is connected to the receiver antenna and ground posts, just as we described in the job sheet on T.R.F. receiver alignment. When it is desired to align the I.F. section, the control grid lead of the *first* detector is removed, the coupling unit shown in Fig. *1* connected, and the output terminals of the service oscillator connected to the coupling unit and the condenser gang frame. The output meter connections are like those for T.R.F. alignment, being made to the output stage.

When the receiver has AVC, the signal generator strength must be kept below the threshold point. However, if the receiver is equipped with some form of visual tuning the output meter may be omitted, the alignments being made for minimum shadow on the shadow tuning meter or electric eye indicator, and for maximum needle deflection in cases where a tuning meter is used. If the set has no visual tuning indicators a milliammeter may be connected into the plate supply circuit of one or more AVC controlled amplifier stages. The meter will then operate in the same manner as a tuning indicator. By using a visual tuning indicator as your output guide, any signal generator strength may be used.

Peaking the I.F. Amplifier.—With the signal generator connected for I.F. adjustments, set its frequency to the value recommended by the receiver manufacturer. With an insulated screw-driver adjust the I.F. trimmers for maximum gain, working from the input of the second detector to the output of the first detector. Reduce the signal strength of the oscillator after each adjustment to bring the output meter below half scale. Repeat the entire alignment procedure once, as there is a certain amount of interlocking between the various circuits and one adjustment may slightly detune a circuit previously adjusted. This completes the *peaking* of the I.F. amplifier.

In receivers using three or more I.F. transformers the amplifier may require band-passing, especially if the high notes seem lacking. After peaking each stage of the I.F. amplifier turn each of the I.F. *secondary* trimmers *out* about ⅛ turn; the *primary* trimmers should be turned *in* an equal amount. Now tune the signal generator slowly through the peak value, watching the output indicator. As the peak value is approached and exceeded the needle should come up quickly, stay fixed and then drop. The band width is easily estimated by reading off the frequency over which the output is fairly constant. If more band-passing is desired turn the primary and secondary each another ⅛ turn. This procedure, though seemingly a makeshift, works out quite well in practice. A more precise method, requiring equipment other than a signal generator, will be described in the regular study texts.



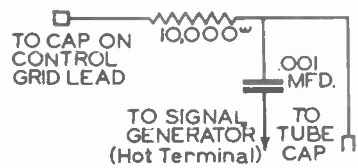


Fig. 1. *Circuit diagram and sketch of standard coupling unit used to connect a signal generator to the control grid lead of a superheterodyne receiver.*

Preselector-Oscillator Adjustments.—Once the I.F. has been adjusted it should not again be touched. Connect the output of the oscillator to the antenna and ground binding posts of the receiver. Tune the receiving set and the signal generator to 1,400 kc.

Before making any adjustments let it be clearly understood that the calibration of the receiver dial is dependent upon the frequency of the oscillator in the receiver. The preselector only contributes sensitivity and selectivity. Therefore, the oscillator trimmer is to be adjusted first. Turn it in or out for maximum gain.* Now, proceed to adjust the preselector trimmers for maximum output, and do not make further changes on them.

Rocking Adjustment for Oscillators.—If the oscillator tuning condenser employs rotor plates shaped exactly like the preselector plates, the receiver will in all probability be equipped with an oscillator low frequency padder. This calls for a special *rocking* adjustment. The low frequency padder enables us to shift the oscillator frequency at the low end of the dial without materially affecting the high frequency oscillator adjustments. The object of the adjustment is to swing the oscillator frequency until it tracks with the preselector. However, the preselector may not be tuned exactly to a 600 kc. signal—remember that the dial setting is controlled entirely by the oscillator. A slight change (one or two divisions) in the receiver dial position is enough to upset or correct tracking. We must therefore do two things at the same time—tune the preselector to 600 kc., and adjust the oscillator to track the preselector.

To make this rocking adjustment, set the receiver dial and the signal generator to 600 kc. Turn the receiver dial knob back and forth across the signal (rock the station selector dial), at the same time changing the receiver oscillator frequency by turning the oscillator low frequency padder slowly *in*. Look for a sudden high point in the output meter swing because then the tracking is exact. If the reading gets less turn the low frequency padder *out*, looking for the greatest swing. A little practice will make this rocking adjustment easy.

After completing the rocking adjustment, realign the oscillator at 1,400 kc. and readjust it at 600 kc. The second 1,400 kc. adjustment is made wholly on the oscillator *high* frequency trimmer (in parallel with the tuning condenser), rocking the gang just as you do at 600 kc. Although other high and low frequencies in the broadcast band may be used. 1,400 and 600 kc. are recommended by most manufacturers.

Now you can band-pass the preselector. This should be done after the I.F. section is band-passed, provided that the preselector is of the band-pass type. Turn one *preselector* stage trimmer *in* and the other out at 1,400 kc. to give band-pass effects, watching the output meter as you swing the signal generator through 1,400 kc. At other frequencies, bend the rotor plates in or out to secure band-pass, but only if the rotor plates are serrated.

ALL-WAVE ADJUSTMENTS.

In the all-wave super we may have as many as five bands, each with its high frequency trimmer and low frequency padder adjustments. On each band the trimmers are adjusted with the gang set to near minimum capacity, in the same manner as we made the 1,400 kc. adjustment in the broadcast band. Then at a near maximum tuning condenser setting the rocking procedure is employed. After you have adjusted one band let it alone and go to the next. Signal generator frequency settings will be suggested by the dial reading of the band under adjustment.

Where the preselector coils are of the open type, so you can run a pencil into the center, a *tuning wand* is quite helpful in the alignment procedure. This simple device is the size of a pencil, having a brass tube at one end and special steel dust held together wth a binder at the other end. Inserting the brass tube reduces the coil inductance, while inserting the end with the steel dust increases the coil inductance. This tuning wand test tells you how to adjust a coil trimmer for maximum output. If introducing the brass tube increases the output, reduce the trimmer capacity; if inserting the steel dust end increases the output, increase the trimmer capacity. If both reduce the output, the trimmer is properly set.

General Notes on Alignment.—If removing the chassis from the cabinet makes accurate setting of the dial at any desired frequency impossible, I suggest that you tune the receiver to 1,000 kc. (using the signal generator), take the chassis out of the cabinet and attach a simple indicator (stiff pointed wire) on the chassis or condenser frame. pointing to 1,000 kc. on the dial (which is left on the condenser shaft). This replaces the indicator on the escutcheon plate.

Trying to adjust the I.F. frequency to exactly the recommended value is not as important as most service men think. Only when interference arises is its exact value important.

When making I.F. adjustments, especially on sets using one tube for a detector-oscillator, a squeal may be heard if a harmonic of the signal generated is tuned in by the preselector. If this makes adjustments difficult, tune the receiver to a position where no squeal is heard.

If correct dial calibration cannot be obtained and the set at one time tracked its dial properly, it may be necessary to replace the fixed condenser shunting the low frequency padder or the oscillator coil for that particular range.

When using a test oscillator, double spot (image) reception may be obtained on the highest frequency range of the receiver. Example: The set has an I.F. of 460 kc., and you are tuning in an 18 megacycle (18,000 kc.) signal from the signal generator. The oscillator in the set should be at 18,000 kc. + 460 kc. (18,460 kc.) to bring in the signal. However, with the signal generator still at 18,000 kc. you may be able to hear a signal when the receiver is set to 17,080 kc. (that is 18,000 — (2 × 400), because the signal generator will feed more signal than the preselector can tune out, and the oscillator will be set at 17,540 kc., which is correct for an I.F. beat. Adjustments should be made with the receiver set at the higher of the two frequencies, or to the stronger of the two positions.

Never, and this is important with all-wave sets. disturb the position of the wiring. Failure to observe this precaution will result in oscillation and inability to make proper alignment adjustments.

Don't turn trimmers back and forth aimlessly—if you don't know what the adjustments are for let them alone.

If better preselector-oscillator alignment is desired, you can adjust the split segments on the rotors, setting the signal generator to the receiver dial frequency at each position where a segment meshes fully with the stator.

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* You may find two settings giving maximum output. Choose the trimmer setting where the least capacity is required.

Radio Servicing Jobs and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

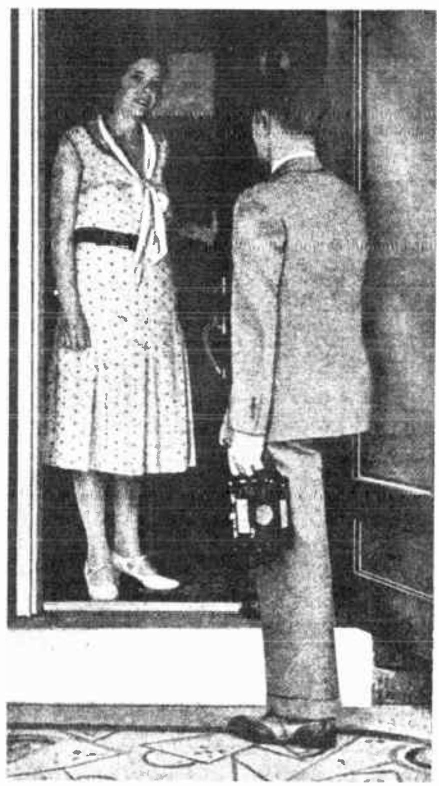
How the Right Approach to a Service Job Builds Confidence

At this time I am going to take you on a trip to a customer's home and back to the shop if the receiver should have to be taken out of the home. What is done in the customer's home will have a lot to do in building up your reputation as a good, reliable and thorough radio technician.

Neatness in personal appearance, professional looking tools and testing equipment inspire confidence. Now, you are not expected to go on a service call in your Sunday clothes, nor should you appear there in overalls or dirty clothes. You should be simply and neatly dressed. Cleanliness is important, for it makes the home owner feel that no damage will be done to his furniture or the radio set. I do not have to stress this matter, for you know that the average housekeeper would hesitate before she would allow the coal delivery man, or the "fashion plate" gentleman to pass her front door.

Whoever answers the door should be told: "I am John Brown, the radio man you sent for," or "I am the serviceman from the Reliable Radio Shop answering your call." He or she understands, and usually without another word you are led to the radio receiver. As you approach the radio receiver, you may ask if you do not already know: "What have you found wrong with its operation?"; or if you know what is wrong you may verify it by saying: "I was told that the receiver no longer plays," or whatever was the information given ahead of this visit. This simple approach to the job is important; you have given the customer a chance to explain what he objects to. What is more important, you at least know the troubles that you must correct; or you are aware of a condition which cannot be helped in which case you must explain why it is a normal action. For example, you must explain that normal atmospheric static cannot be helped; or that a sensitive receiver is noisy when tuned off a station; or the inability to separate stations at the higher broadcast frequencies is something that can only be partially corrected. Of course, you may discover other defects, but the one in the customer's mind comes first.

No matter what happens, or how "shaky" you feel, do not lose your head. Here is the reason why it will be easy to keep a "level head." The defect is either *external*, on the outside of the chassis; or *internal*, underneath the chassis. If it is external, like a defective tube, an im-



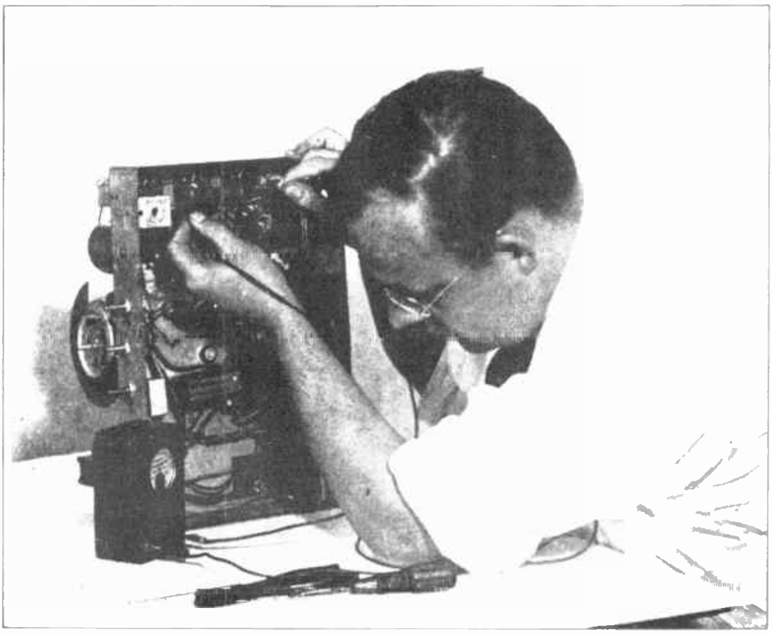
Answering a radio service call

properly connected or erected antenna, some grid cap to a tube off the tube cap, you will quickly locate the trouble. But if no external defects are indicated, the defect is internal and the chassis must be removed from its cabinet, to complete the repair. However, most expert servicemen check for internal defects before they take out the chassis, and I will shortly present the necessary test procedures. If you do not feel like working under the critical eye of the customer, merely ask permission to take it to your service work bench. Explain that you will be able to give the chassis a thorough inspection, after you fix the trouble. In most cases permission will be granted. As you gain more confidence, you will naturally fix more and more internal defects right in the customer's home. Yet, there are thousands of experts who prefer to fix an internal defect at their work bench.

The Technique Worth Developing

Let us get back to our service call. We are at the radio receiver, and instinctively I would turn the power switch on. The pilot light on the dial naturally illuminates the station selector scale. I listen for the characteristic rushing sound or low hum, using the same technique.

First let us assume that we cannot tune in a local broadcast station. Need I say that you should immediately determine whether the receiver is being furnished with power? The fact that the dial light



Service man checking chassis with an ohmmeter

indicating that tubes are heating up. Of course, if I hear any weird sounds, growls or whistles, I would immediately turn the power off, if the tubes appeared to "act up" or the set emits smoke; otherwise I would adjust the volume control to cut down the annoying interference. If no disturbing effects are heard, I would proceed to tune in a local station in order to ascertain just how the radio sounds.

In this limited set of adjustments you have an opportunity to "size up" the situation. You are definitely confronted with two conditions: *1*, the set is dead; and *2*, the set plays unsatisfactorily. Here is how I would handle either case, and I feel sure that you will find most expert servicemen is on, and the characteristic tube warming hiss was heard, answers the question at once. Failing to find these important indications, the next natural thing for me is to look for the receiver power cord, trace it to the outlet (all this by merely looking in the proper direction), and if the power cap is plugged in, I move the cabinet away from the wall (where it is usually placed) and scan my eyes over the tubes. Now if the tubes do not light (this is the usual expression for the dull red glow emitted from the cathode) something is wrong in the power supply system. The trouble may be in the house wiring system, the receiver power cord, the primary of the power transformer, or a fuse or ballast in the primary power transformer circuit. These items I naturally test.

Pulling out the power plug from the outlet, the primary circuit is tested by applying the ohmmeter probes to the two cap prongs. If no meter deflection is observed, check physically the fuse (if it has one) as you are able to get to it while the chassis is in the cabinet. If found in working order you may take the chassis out of the cabinet and test the power switch, the primary of the transformer, the connecting leads and the cord. Each part may be checked for continuity (whether the circuit is complete) by placing the ohmmeter probes to the two end terminals of the part questioned. This procedure quickly locates chassis power input defects and the remedy is to replace a defective transformer, power switch, cord or fuse; and to resolder poor connections.

On the other hand, if we were to find an ohmmeter resistance reading when testing the power plug prongs, the next natural step is to check the supply outlet. Trying a table or bridge lamp in the outlet quickly tells if the house wiring is defective. If it is, maybe a fuse in the house wiring distributing box is burned out. A licensed electrician must repair defective house wiring, in most localities; although a fuse may be replaced by anyone. Never use a fuse having an ampere rating greater than the defective one.

Going back to the original observation and assuming you found the dial light illuminated, the vacuum tubes heated up —what should be your next step? Maybe the antenna is down, or the antenna lead-in and ground wires are shorted; maybe their connections to the receiver have come off. Check these items. Look carefully at the chassis. Has a top cap come off of one of the tubes; or has a top cap been shorted to a tube shield? Feel each and every tube (of course, the set should be set on for a few minutes). Lack of heat will indicate if one is dead or no power is being supplied. Is the cable from the loudspeaker plugged into the chassis? —a very common way of making this connection. Generally you can tell this before you look for this defect. Often the electrolytic condensers will "sizzle." In a few words, examine every possible defect that may be external to the chassis—and then if you wish and you have a tube checker, test each and every tube. You will be surprised to learn how many radios may be placed in operation by this "surface" examination.

If a surface check does not reveal the defect, then obviously something is wrong inside the chassis. You may now take the chassis out of the cabinet and to your work bench for meter checking and repairs. Yet, the customer may want you to indicate what the trouble is, and how much it will cost, before the chassis may be removed; but if you have a reputation for honest dealings and are known, you will not have to go to this trouble. I will explain the procedure of defect isolating in following jobs.

Now let us start all over again. Suppose you were to find the set operating but not to the complete satisfaction of the customer, or you heard these weird growls and squeals. Here is where a complete mastery of your fundamental course will pay large returns. Suppose the receiver should play and cut off—one possibility is that a coupling condenser has opened; perhaps a grid leak is intermittently making and breaking circuit contact; or a lead wire is opening. These are facts that you can picture in your mind if you know radio and the circuit of the set you are working on.

If the set emits a varnish and cloth burning odor, which is traced to the power

Giving satisfactory radio service

transformer; reasoning from radio principles you are pretty sure a primary or secondary turn has become shorted; or an overload exists in the output circuit. Should you find the vacuum rectifier tube glowing blue between the filament and plate (of course, a mercury vapor tube always emits a blue glow), you know from radio theory that the tube has become gassy and this may have been caused by a grounded filter choke, or defective filter condenser, or the tube itself may be defective. Poor selectivity may be due to poor tubes, but more likely to jarring or tampering (by someone else) of the alignment condensers.

Every squeal, howl, noise, hum or rattle has its meaning, which reveals itself to you by coordinating radio theory, the circuit on which you are working, and verifying with past experience. This is where servicing as an *art*, makes its appearance. Study your fundamental course, and you will thank me time and time again for the good it will do. At the start this reasoning from the "effect to the cause," as I call it, will not be readily applied. You will have to search for the cause using testing equipment, in the manner to be explained in later jobs and in the course. The reference text "Radio Receiver Troubles, Their Cause and Remedy," which is now in your possession will be mighty handy. Refer to it until you master its contents.

In the above procedures we have located the trouble; the repair is generally obvious. A part is replaced, or repaired, a connection is soldered, a wire moved, a circuit or radio system aligned, or even one or more new parts added. The trouble uppermost in the customer's mind is rectified. Is the service job completed? Yes and no. Is there anything wrong that you noticed that was not observed by the customer. Should you repair it at once, or get the customer's permission? If the additional work will take very little time, do it at once; and explain what you have done, to the customer. If an appreciable additional expense will be involved, get the customer's consent to go ahead.

Perhaps the set is damp and should be baked out; the chassis cleaned inside and out; the connections need resoldering; the stages require aligning. A moderate amount of overhauling should be done on every chassis that comes to your shop, and the least you can do is to thoroughly clean the top exposed part of the chassis and tighten any loose parts. But if the overhauling will take considerable time, explain what you want to do to the set and get permission from the customer. Every receiver that leaves your work bench should look as if it had been repaired, should work to the best of its ability, considering the amount of money the customer is willing to pay.

Radio servicing requires plenty of common sense, and haste is the surest way of destroying your ability and preventing your reputation for good work from growing.

What Should You Charge the Customer?

When you service and repair a radio receiver, you are entitled to monetary compensation—and the customer expects to pay you. But the customer does not expect to pay more than a reasonable charge. What then are you to charge for a job *satisfactorily* completed? Surely not more than what it would cost if it were done by a good well established radio service technician in your locality. I cannot give exact figures or prices. They vary with localities and the ability of the serviceman. Yet you can arrive at a fair price.

If you plan to service eight hours a day for five and one-half days, you are obviously going to put in forty-four hours of work. How much should you earn a week? What are your expenses; rent, car, tools, etc.? Is your time including all these factors, worth a dollar an hour, or two dollars an hour? Remember you are a beginner. You will consume three or four times as much time on a job as would an expert. Estimate your hourly charge low to start with and then figure up. The cost for similar jobs will always be about the same.

If you replace parts, charge list prices for them. The usual wholesale discount to servicemen is 40 per cent. As you buy at net prices, here is how you figure list prices. Take the wholesale cost, divide by 6 and multiply by 10. Let us say you buy an electrolytic condenser for $0.72. Divide by 6 and you get $0.12; multiply by 10 and you get $1.20. Charge the customer $1.20.

If as a beginner you figure your time as fifty cents, and the job takes two and one-half hours, the labor charge will be 2.5 x .50 equals $1.25. The customer should be charged $1.20 + $1.25 or a total of $2.45. Do not charge $8.00 just because you think you can get it, or because it was the only job that day. Be fair and honest to your customer and business will start to roll in.

I will have more to say about figuring costs, elsewhere in the course, but now let me add the following thought. All repair jobs must be paid for on delivery of the set, do not extend credit. Be sure the customer understands this at the start. One more problem you may run into: Shall you give free estimates, or charge for every call. Frankly I would charge for every call, a minimum charge of $1.00 is the general practice, and you can include this in the final job or render a reasonable amount of overhauling in return. However, if free calls are prevalent in your locality, you may have to do likewise. Yet, I would at first try the minimum charge call. Explain to the customer that your work is reasonably priced, guaranteed to be satisfactory—and that free calls are really not free calls, as the cost is always figured into the final job.

Radio Servicing Jobs and how to do them

How To Test the Defective Stage with a Voltmeter

All radio servicemen do not service alike, and some prefer the voltmeter in checking the defective stage. In the multimeter that, in the next job sheet, I am going to show you how to build, you will have a multi-range voltmeter as well as a multi-range ohmmeter. Therefore, either device may be used. Personally, I believe that the beginner should start with an ohmmeter test and later learn the voltmeter method, for these reasons.

In checking with an ohmmeter, the set is not connected to the power outlet, hence the service technician cannot receive a shock; the meter reading cannot read down-scale or very much more than full-scale. Therefore, the ohmmeter cannot be damaged.* The reason why some servicemen prefer the voltmeter reading is because the service sheets and manuals for receivers give the electrode voltages for a correctly operating stage, making it easier to locate some defects. However, I feel that you should know both methods, as there are a large number of modern radio circuits in which a voltmeter test would so alter circuit voltages that the readings obtained would be meaningless. Learn both methods so that either may be used as is needed. You will not have any difficulty in knowing when one or the other method should be used. An ohmmeter may be used with any circuit, but a voltmeter should not be used in circuits over 100,000 ohms, except for continuity.

Here is how I would use the voltmeter. After isolating the defective stage by the "circuit disturbance test," I would check the tube either by trying a new one, or testing the original tube in a tube checker. If the new tube makes the receiver play, the service job is completed; otherwise an internal defect exists and the chassis is then removed from the cabinet.

However, before the chassis is taken out, some servicemen are required to give an estimate on the repair cost. To do this some men check the plate supply to the tube in the defective stage by pulling the tube out, connecting the —voltmeter terminal to the chassis and the + voltmeter terminal in the plate hole of the socket. If they obtain a reading slightly higher than rated value (and this is normal), they are led to believe that a defect exists in some other circuit such as the input (grid or grid bias). If no reading is obtained, but the power pack checks O.K. then a plate circuit defect is indicated. By referring to the circuit diagram they are in a position to give a rough estimate of the repair. Of course, they must, to protect themselves, quote a price fixed on a breakdown of the most expensive part.

To my way of thinking, it is wiser to insist on removing the chassis from the cabinet and make a thorough check before giving a price. Then if you figure the cost of the job on a fair basis, there should be no objection on its completion. If permission is not granted, an ohmmeter check as explained in another job sheet plus a circuit diagram may give you a closer check on the probable defect.

Assume we are going to do the job the correct way, and have removed the chassis from the cabinet. With the receiver connected to its loudspeaker and its power cord plugged into the power outlet, set the machine on one end so you can see and work on the under-side of the chassis, and with a little effort get to the upper side of the chassis. Turn on the power.

Let us assume that the ouput stage (No. 2) in Fig. 1 is isolated as being defective. How are we going to test the defective stage by the voltage-measuring method? First set the selector switch of the multi-meter in the highest D.C. voltage position. Put the —test lead probe on the chassis and place the + test lead probe on the plate terminal of the output tube (point *a* in Fig. 1). If a reading is obtained, the primary of the output transformer and everything between it and the cathode of the rectifier is conducting a D.C. current, and very likely is in good condition. Should we obtain no reading, put the + probe on the screen grid (b). A reading at this point but not on the plate indicates an open in the output transformer primary, because this is the only thing between the plate, where we obtain no reading, and the screen which is properly supplied with voltage.

In the same manner, a correct reading at +B but not at the screen would indi-

* If you attempt to use an ohmmeter on a receiver whose power is turned on you will destroy the tester.

cate an open in resistor R. Low screen and plate voltage and slightly below normal +B voltage would lead me to believe that C was leaking excessively.

How about the control grid circuit—shall we make a test between the grid and the chassis? If we do we will measure about 1 or 2 volts instead of 30 volts (which is the normal value). The resistors in the grid circuit have a very high value and when our meter is connected, current will flow in the circuit as it is now complete. This will cause a voltage drop to occur across the resistors and we will read a voltage far below normal. A more nearly correct reading will be obtained directly across the bias resistor R_1. Yet, a grid to chassis voltage measurement does have some value. It at least proves that continuity exists.

A positive voltage between the control grid and chassis would indicate a leaky coupling condenser C_1, and a defect here would result in excessive plate current and consequently overheating of the tube.

Suppose stage *No. 1* was isolated as defective. The plate and screen voltage of the detector tube is measured in the same way as on the power tube except that the —probe is placed on the cathode of the tube. If there is no cathode to screen or plate voltage place the —probe on the chassis. If voltages are then available, the bias resistor R_2 is open.

When measuring the plate and screen voltages we again have high value resistors to deal with. However, your reading will be about the same as the manufacturer's specifications if your meter has a resistance of 1,000 ohms per volt or more, as this is the type of meter generally used in making the reference voltage charts.

Suppose we tested from cathode to screen and obtained no voltage and a test from cathode to point D indicates proper voltage. Resistor R_3 is, of course, open. The interesting thing is that a connection of our meter across the defective part will enable the set to play because the meter will complete the circuit.

The control grid voltage is, of course, measured between the control grid and cathode. First, place the negative probe to control grid and the positive probe to the cathode. Now, the same voltage should be measured between the cathode and chassis. If we get no voltage in the grid-cathode test and a voltage in the cathode-chassis check, naturally the grid return circuit to the chassis is open.

In either stage, the voltages applied to the tube filaments are measured with the A.C. voltmeter section of the multi-meter using the lowest voltage range which will take care of the recommended filament voltage for that tube.

Suggestions and Cautions.—The plate, screen, control grid, suppressor grid voltages of any defective stage are checked as we have described, always using the cathode as the reference point. Of course, if we used the circuit disturbance test first we go right to the defective stage, thus eliminating the need of testing stages that are more than likely to be in good condition.

Don't expect your measurements to tally exactly with the service sheet; line voltage variations, *your* meter resistance and part value tolerances will prevent this. Don't expect a voltage test to tell you everything. Associated effects may make the meaning of a certain reading vague. A coupling condenser may be open or a grid input may be shorted and this will have no effect on measured voltages—use your ohmmeter and try new condensers.

When in doubt always use the highest range of your meter. If the reading cannot be easily read you can switch to a lower range. This will prevent damage to your meter. If your meter reads backwards you have your probes in the wrong position—reverse them instantly.

Never connect your milliammeter across a voltage source—this will ruin it. Never probe around aimlessly with your meter—you might connect it across a voltage source too high for the range being used.

One final "don't"—don't be alarmed by the "nevers" and "don'ts" mentioned—they are easy to remember and in a short time your observance of these will become automatic.

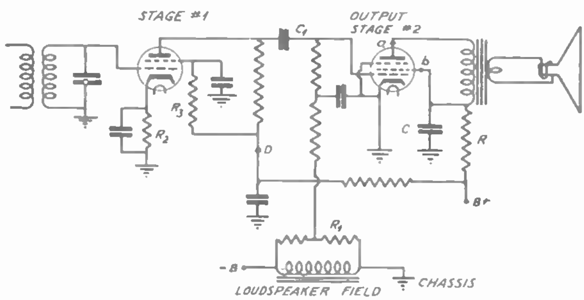


Fig. 1.

How To Isolate the Improperly Operating Stage

The circuit disturbance test is without doubt a valuable procedure in isolating the defective stage of a receiver that does not play. But when a receiver picks up and reproduces a broadcast unsatisfactorily, how are we to isolate the improperly operating stage? By unsatisfactory operation I mean, for example, reception is reproduced with unreasonable distortion, or the set lacks "pep," or the receiver chokes up when tuned to a broadcast. These are only a few of the many things a receiver will do when it works abnormally.

Now the expert learns from a study of radio and radio receivers plus experience the antenna-ground system looks O.K. He does this almost in a slow but thorough visual sweep. It really does not take long to see that there are no surface defects.

If checking for surface defects does not show up the cause, he reasons that perhaps the main D.C. supply voltage is low. So he connects a high range voltmeter (about a 0 to 500 volt range) to two convenient terminals which will tell him something about the power pack output. He could choose the filament of the rectifier and the chassis, or the plate of one of the power tubes and the chassis. Quite often it is easier to check between

FIG. 2. *Service man checking an improperly operating stage with a signal generator.*

what is probably causing the trouble. For example, he recognizes certain distortion as being due to a defective tube, that reception lacks pep because the tuned stages are not aligned, that a receiver may choke up because a grid return connection is open. As you service more and more radio receivers this ability to reason from "effect to cause" will become easier. Earlier in your course you received a reference book containing scores of symptoms of defective receivers and their cause. Study this reference book, because it will improve your ability to recognize the cause of a defect.

What should you do if you cannot reason out the probable cause? Exactly what every expert would do. First, he determines if all of the tubes are working, whether any connection is off or loose, whether the antenna and ground leads are connected properly to the receiver, and if a filter choke terminal and the chassis. It all depends on whether the chassis is in the cabinet or on your bench. It is easier to service an improperly operating receiver when the chassis is on your bench, the bottom of the chassis and the wiring in full view.

Of course, if the voltage is abnormal, then a voltage check on the various stages and the power pack should be started. If the main D.C. supply is normal, and a thorough inspection of the parts in the chassis and the connections suggest nothing that may be at fault, a "stage by stage elimination" test is made. The expert reasons: "If a defect exists it is very likely in some stage; if I connect a *modulated signal generator* to the inputs of various stages starting from the detector ahead of the audio system and proceeding to ANT-GND connection, I will be able to recognize the trouble when I pass through the improperly working stage." To be sure, matters are greatly simplified if he has a circuit diagram and a tube layout of the chassis.

In a following job sheet I am going to show you how to build a service oscillator, but I suggest you buy one of the all-wave type.

Checking a T.R.F. Receiver.—As the tuned radio frequency receiver is simpler than the super, I have chosen it first to show you how to apply the stage by stage elimination test.

The receiver and signal generator (oscillator) are both tuned to the same frequency, say 1,000 k.c. The signal generator is connected, by means of probes, to the input of the detector (grid-chassis) or the plate-chassis of the R.F. tube ahead of the detector. A strong signal is necessary. Now if the modulating tone of the oscillator is heard from the loudspeaker without any of the distortion, noise or choking up that we are looking for, it is natural to assume that the detector and the audio system is in normal working order. But if the trouble exists, we know that there is a defect from the point of signal application to the loudspeaker.

In checking the detector-audio stages for normal operation, the simplest procedure is to employ a head-set with a series protecting condenser, connected first between the plate and chassis of the detector, then the plate and chassis (for single tube stages) or plate and plate (for twin tube stages) of the following audio stages and in proper order. This check may proceed directly to the voice coil or armature coils of the loudspeaker. The defect will quickly show up if it exists in these stages. When the defective stage is located be sure to check the tubes, either by replacement or in a tube checker, before you condemn the parts or connections in that stage.

Let us assume that the detector and audio system check O. K. We discard our head set, and proceed to connect the signal generator to the grid-chassis of the tube ahead of the detector, or the plate-chassis terminals ahead of the tube previously connected. A plate-chassis connection is generally preferred, as this connection produces the least disturbing load on the stages.

As you pass from one stage to the next, the modulation tone of the signal generator emitted from the loudspeaker, should become louder. This shows that the stage just included in the test is contributing its share of R.F. gain. Of course, if you pass through a stage that introduces the trouble you are looking for, as for example, noise, no or reduction in gain, choking up, hum, etc. the defective stage has been isolated.

Now you may proceed to check the tube, and the circuits of the defective stage with an ohmmeter or voltmeter, depending on your preference.

Checking a Superheterodyne Receiver is not very much different. Because it has a different radio frequency system, a little different procedure is taken. In checking the second detector-audio amplifier system, you should adjust the signal generator to the I.F. frequency. And at this setting you may proceed to eliminate the I.F. stages up to and including the first detector.

You may not get an appreciable gain in output when the signal generator, set to the I.F. value, is connected to the grid-chassis of the first detector. But you should get a signal equal to what is obtained by the previous connection; and this is a check on the operation of the first detector.

Now to check the oscillator of the super. Leaving the signal generator connected to the input of the first detector, adjust the generator and the receiver to some broadcast frequency (say 1,000 k.c.). If the local oscillator is working, the sound from the loudspeaker should go up, if no signal is heard or it is very weak, the oscillator is defective.

From this point to the ANT-GND the test is the same as for a T.R.F. receiver.

Suggestions.—In making a grid connection select a top cap, stator section of a variable condenser, or the socket terminal. Plate connections must always be made at the socket.

When the receiver has an A.V.C., remove the control tube, if possible. Gain can only be judged if the signal generator output level is kept low. It is best to judge gain by using an output meter (to be explained in a later lesson), always adjusting the output of the signal generator to get the same output.

The action of special circuits, such as A.V.C., squelch, automatic tone control, and so forth, must be performed after the normal receiver stages are checked. If you know how a certain stage works and what it should do, you will have no trouble in judging its condition.

RADIO RCA N SERVICE SHEET REG. U.S. PAT. OFF.
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NATIONAL RADIO INSTITUTE ~ WASHINGTON, D. C.

Steinite Screen-Grid Chassis No. 10 Used in Models 70, 80 and 95

Tubes used in this receiver are 8 –24, 1 –27, 2 –45 and 1 –80. The schematic wiring diagram is shown in Fig. 1.

Tests for Locating Trouble in Steinite Receivers

Assuming that all voltages are correct, place voltmeter terminals between the plate terminal of detector socket and ground. A click will be heard in the speaker if the circuit is OK from the detector plate to the speaker. If a test shows this portion of the circuit OK, place voltmeter between the plate terminal of 3rd R.F. socket (socket adjacent to detector socket) and ground. If a click is heard, the circuit is correct between the plate of the 3rd R.F. stage and ground. If no click is heard, the trouble lies between the plate of the 3rd R.F. stage and the detector plate. This trouble will then be located in the aligning condenser of the detector stage, open or grounded detector grid coil, or the detector tuning condenser shorted.

If the circuit is found to be operating properly from the 3rd R.F. stage to the speaker, the voltmeter terminals should next be placed between the plate terminal of the 2nd R.F. socket and ground. If the circuit is OK, a click will be heard. If there is no click the trouble is between the plate of the 2nd R.F. stage and the plate of the 3rd R.F. stage. The difficulty will be found in the aligning condenser of the 3rd R.F. stage, open or grounded grid coil, or tuning condenser short circuited.

If the circuit is found correct up to this point, a similar test should be made by connecting the voltmeter to the plate terminal of the 1st R.F. socket and ground. If no click is heard, it indicates trouble between the plate of the 1st R.F. stage and the plate of the 2nd R.F. stage and the difficulty will be found either in the aligning condenser, shorted gang condenser, or open or grounded grid coil.

If these tests have been made and the circuit found correct up to this point, the trouble is between the antenna connection and the plate of the 1st R.F. stage.

Method of Aligning Condensers

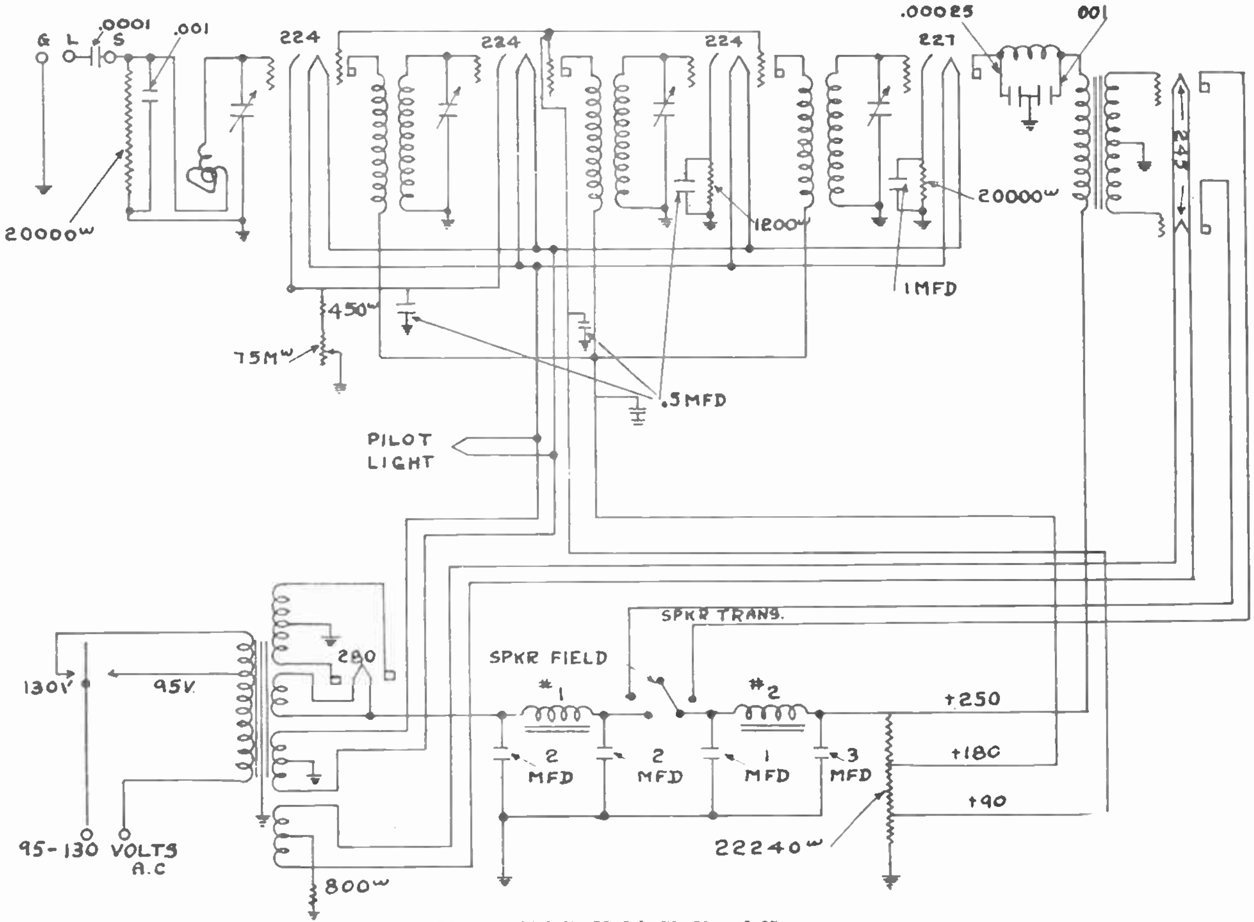
The aligning condensers are mounted on the shield directly back of the screen-grid tubes and are reached through three small holes in the tube shield cover, which must be in place during aligning operations. First production was equipped with machine screws in the aligning condensers and it will be necessary to use a long shaft screw-driver or a bakelite rod with a screw-driver head in aligning these sets. Later production has a hexagon head screw that can be turned with the balancing wrench as furnished for the Model 40 and 50. It will be necessary to cut the head off the 40 balancing wrench and insert a bakelite or other insulating rod of sufficient length to extend through the tube shield, in the head of the wrench. With a modulated oscillator set at approximately 750 A.C. proceed in the ordinary method used in aligning condensers.

Voltage Readings

The readings should be approximately the same as the readings given below.

47 to ground 360 volts.
48 to ground 340 volts.
51 to ground 270 volts.
38 to 59 225 volts 245 plate.
39 to 61 225 volts 245 plate.
38 to 62 45 volts 245 grid bias.
39 to 64 45 volts 245 grid bias.
25 to 19, 26 to 20, 27 to 21, 28 to 22, 38 to 35, 36 to 39 } 2.2 volts filament.
31 to 33 4½ volts rectifier filament.
85 to ground 90 volts (screen grid).
74 to ground 180 volts (R.F. plate).
72 to ground 240 volts (det. plate).
96 to ground 25 volts (det. bias).
91 to ground —3 volts vol. max. —11 volts vol. min.
95 to ground —3½ volts vol. max.

The speaker must be plugged in while taking these readings. Volume control at maximum except when otherwise specified.



Wiring Diagram Steinite Models 70, 80 and 95.

Radio Servicing Jobs and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

How to Assemble a Professional Looking Multimeter

ONE of the most useful of all radio servicing instruments is the multimeter, a compact meter unit which can measure many different ranges of A.C. and D.C. voltages, D.C. currents, A.F. output voltages and D.C. resistances. If you have to service radios for any period of time with only one test instrument, choose a multimeter.

Without a multimeter radio service work must be done by the hit and miss process, which wastes valuable time. Learn to measure and check the important characteristics of receivers with a reliable multimeter.

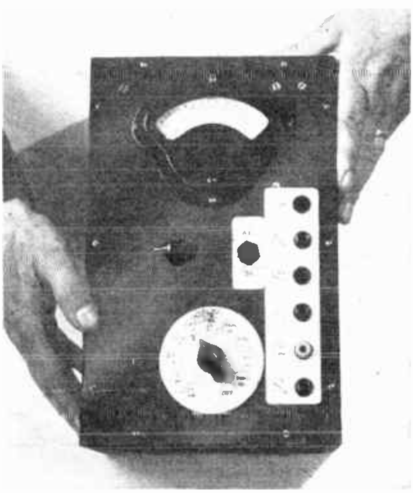


FIG. 1. *Your Completed Multimeter Will Appear Like This.*

Although this job sheet is intended to show how to assemble a reliable professional looking multimeter, frankly, I always recommend that radio service men buy one of the better professional multimeters, which are accurate, dependable, and impressive in appearance. If, however, the few dollars that you will naturally save by building your own unit appeals to you, or you wish to gain valuable experience in assembling test equipment, by all means purchase a multimeter kit. When you purchase all of the required parts in this manner, there will be none of the extra expense and trouble in securing special resistors, and all calculations will have been completed and checked by the manufacturer.

Although I have chosen the Supreme Model 310 Meter, Rectifier and Resistor Kit,* there are many other makes of multimeter kits which might be used. In order to follow through a typical layout it was necessary to select one particular kit.

Your finished Supreme Multimeter will look like Fig. *1*, and will have four ohmmeter ranges—0 to 2,000 ohms, 0 to 20,000 ohms, 0 to 200,000 ohms, and 0 to 2,000,000 ohms. Four ranges are provided for measuring A.C. and D.C. voltages: 0 to 5 volts, 0 to 125 volts, 0 to 500 volts, and 0 to 1,250 volts. D.C. currents may be measured in two ranges: 0 to 5 milliamperes, and 0 to 125 milliamperes.

In any multimeter kit you will find a multi-scale milliammeter, fixed and variable resistors, a fixed condenser and a full-wave copper oxide rectifier unit. Other parts needed, which usually must be purchased separately, include a panel, a box or cabinet for the entire unit, several switches, six or more jacks or binding posts, and several batteries. These parts must be selected and purchased by the individual constructing the service instrument, once he decides upon the style of cabinet to be used. Many men prefer to build test equipment like this right into their work-bench.

The following parts are supplied with the Supreme Model 310 Kit; check against this list when unpacking your kit.

Item #1, Stock #6627: One 5-inch Meter, 0.001-A, 0/5/125 ma. with "OHMS" scale, in fan-shaped case, with 4 meter flange bolts and 4 terminal nuts.

Item #2, Stock #6354: 1 Resistor, attached to meter, series adjustment, to combine with meter resistance, bringing total meter resistance up to 300 ohms.

Item #3, Stock #6650: 1 Rectifier, large full wave instrument, center terminal negative, two end terminals positive, other terminals A.C. input.

* This kit may be obtained from radio parts supply houses or ordered directly from the Supreme Instruments Corporation, Greenwood, Mississippi.

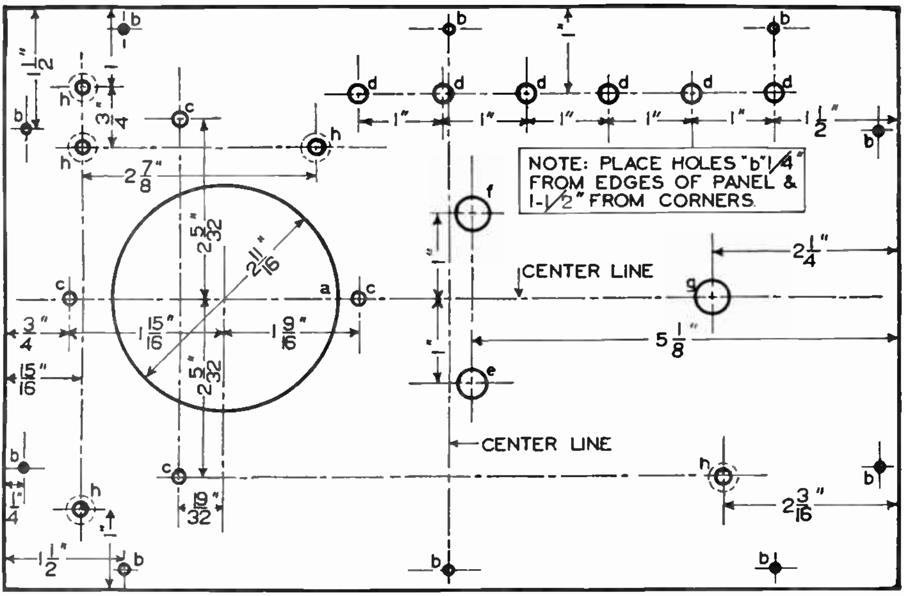


FIG. 2. *Layout of the Front Panel of the Multimeter.*

Item #4, Stock #6715: 1 Resistor, approximately 3,100 ohms, attached to rectifier, used as series adjustment multiplier for 5 volt (A.C.) range.

Item #5, Stock #6736: 1 tubular .5 to 1 mfd. condenser.

Item #6, Stock #822-A: 1 Drawing of Supreme model 310 Meter showing panel layout for panel mounting. (Not needed.)

Item #7, Stock #825-A: 1 Drawing Supreme Meter Kit circuit (Note: this diagram is not used when building this Multimeter).

Item #8, Stock #6333: 1 Potentiometer, 3,600 ohms, with washer and hex nut, but without knob.

Item #9, Stock #6673: 1 Resistor, tapped, containing a 3 ohm and a 72 ohm section, enameled, 5 watt.

Item #10, Stock #6674: 1 Resistor, tapped at 33 ohms, 297 ohms, 700 ohms, 2,698 ohms, and 3,248 ohms. Enameled, 5 watt rating.

Item #11, Stock #6336: 1 Resistor, 4,790 ohms, 1 watt, metallized, for 5 volt (D.C.) range.

Item #12, Stock #6242: 1 Resistor, 20,000 ohms, 1 watt, metallized, for use as rectifier input shunt.

Item #13, Stock #6037: 1 Resistor, 90,000 ohms, 1 watt, metallized, for 125 volt (A.C.) range.

Item #14, Stock #6676: 1 Resistor, 0.12 megohm, 1 watt, metallized, for 125 volt (D.C.) range.

Item #15, Stock #6713: 1 Resistor, 0.28 megohm, 1 watt, metallized, for 500 volt (A.C.) range.

Item #16, Stock #6677: 1 Resistor, 0.375 megohm, 1 watt, metallized, for 500 volt (D.C.) range.

Item #17, Stock #6714: 1 Resistor, 0.56 megohm, 1 watt, metallized, for 1,250 volt (A.C.) range.

Item #18, Stock #6334: 1 Resistor, 0.75 megohm, 1 watt, metallized, for 1,250 volt (D.C.) range.

You will notice that I have numbered each item. These item numbers will be referred to later while describing the assembly of the unit. All of these parts are identified by number on the photographs, to aid you in securing a simple and compact arrangement.

The following additional parts will be required to make the multimeter like that shown in Fig. *1:*

Item #19: 2 Small 22.5 volt "C" batteries, Burgess #4156.*

Item #20: 1 Standard 4.5 volt "C" battery, Burgess #2370.*

Item #21: 1 Double-pole double-throw toggle switch.

Item #22: 1 three-section 11-point rotary non-shorting switch. (The Yaxley #1331 † rotary switch or a switch having the same number of contacts is recommended.)

Item #23: 1—31,500 ohm, 2 watt resistor. (A 30,000 ohm resistor in series with a 1,500 ohm resistor may be used if you are unable to obtain one resistor of the proper value.)

Item #24: 1—50 ohm, 2 watt resistor. (Use two 100 ohm, 1 watt resistors connected in parallel.)

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* Batteries of another make which have the same voltage may be used.

† Yaxley Mfg. Co., 1103 West Monroe Street, Chicago, Illinois.

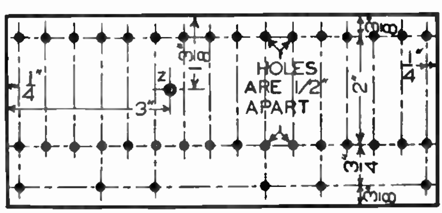

FIG. 3. *Layout for Item #34, a 3½" x 8" bakelite resistor mounting strip.*

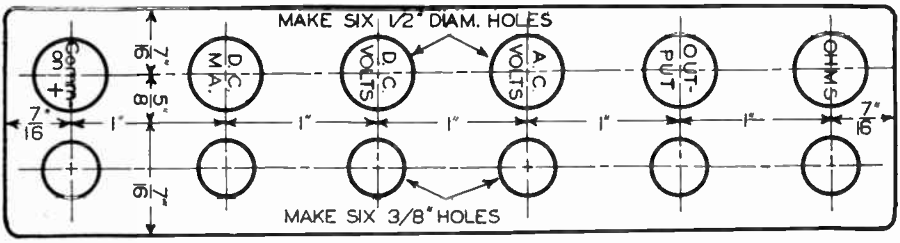

FIG. 4A

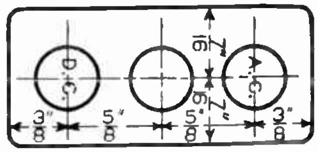

FIG.4B

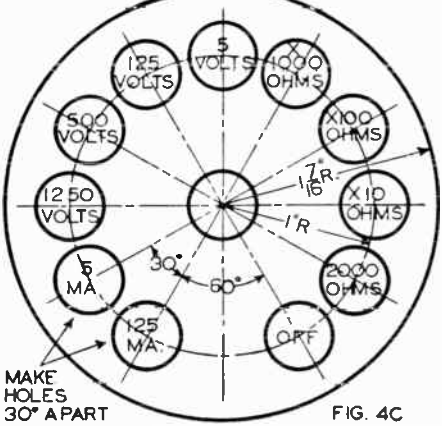

FIG. 4C

Fig. 4a. Layout for pup jack escutcheon plates.

Fig. 4b. Layout for rotary switch escutcheon plate.

Fig. 4c. Layout for toggle switch escutcheon plate.

Item #25: 6 Pup Jacks, #136 made by A.R.H. Co., Inc.‡
Item #26: 2 Test tip prods, #132.‡
Item #27: 2 Test clips, #130.‡
Item #28: 2 End tip prods, #134.‡
Item #29: 2 End tip prods, #135.‡
Item #30: 75 ft. #22 cotton insulated push back wire, tinned.
Item #31: 2 five-foot lengths of special test prod flexible stranded #18 cable or wire, 1 red and 1 black.
Item #32: 10—#6 round head, polished nickel wood screws ⅝" long.
Item #33: 4 Small ½" wide right angle brackets made from 1/16" stock.
Item #34: 1 Piece bakelite 8" x 3½" x 1/16" thick, black.
Item #35: 1 Panel, bakelite, 10-13/16" x 7-1/16" x 3/16" thick, black.
Item #36: 1 Sheet flat aluminum 6" x 6" x 1/32" thick.
Item #37: 4 Small rubber feet. (Can be obtained from your local hardware store.)
Item #38: 1 Cabinet or box 10-¾" x 7" x 5½" (See drawings for exact details).
Item #39: 2 Arrow head knobs for ¼" shafts.
Item #40: 6—⅜"-6/32 (nickeled) flat head brass machine screws.
Item #41: 4—¼"-6/32 round head brass machine screws.
Item #42: 50—#6 lock washers for above machine screws.
Item #43: 50—6/32 nuts for 6/32 machine screws.
Item #44: 4—⅝"-6/32 round head brass (nickeled) machine screws.
Item #45: 1 Piece white pine, 4" x ¾" x ½".
Item #46: 1 Piece white pine, 3" x ¾" x ½".
Item #47: 1 Piece white pine 3¾" x ¾" x ½".
Item #48: 6—#6 wood screws ¾" long, round nickel head.
Item #49: 2—#8 wood screws, 7/16" long, round nickel head.

‡ Jacks and tips similar to the ones made by the American Radio Hardware Company, Inc., 135 Grand St., New York City, may be used.

Item #50: 4 Dozen tinned #6 or #8 soldering lugs.
Item #51: 3 Dozen 4 penny finishing nails.

Plan the Layout Before You Build

I usually find it best to lay out all of the parts for the unit in front of me. By doing this I can locate each piece almost instantly as it is needed, and can better judge the space required.

Lay out in front of you every piece of equipment in the multimeter kit, either on your work-bench or on a small table placed nearby. The panels, pup jacks, screws and lugs, etc., should also be on hand.

Laying Out the Panel

Order your panels cut to exactly the correct size, so that you will only have to smooth down the edges with a file. Attempting to cut large pieces of bakelite with a hacksaw wastes time and results in a crude job.

Locate item #35, the front panel, and lay out carefully each of the holes indicated in Fig. 2. A 6-inch steel square or a steel ruler is used for measurements, and the marks made with a steel scriber or a large sewing needle.

The ten holes marked *b* have centers ¼" in from the edges of the panel. Holes *d*, for the pup jacks, are marked next. Locate the center of the meter hole *a*, of the four meter hold-down screw holes *c*, and of the other holes.

After marking the center of each hole by scratching or scribing intersecting lines

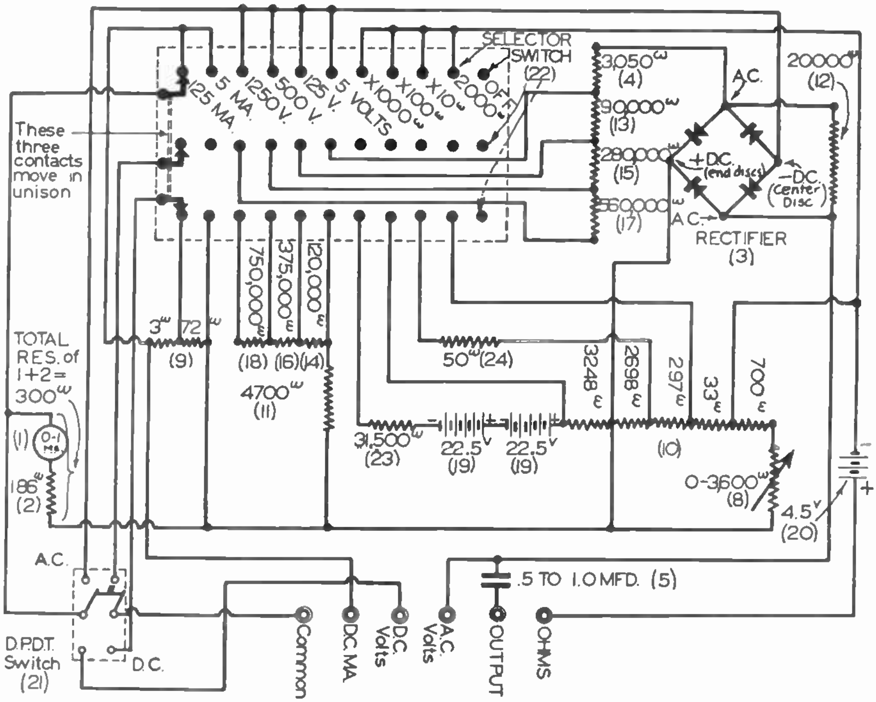

FIG. 8. *Follow this Circuit Diagram Closely when Wiring Your Multimeter.*

pointer should indicate approximately 100,000 ohms. Remove the 100,000 ohm test resistor and short the free test prods, to see if the meter returns to zero again.

Next test the 5 volt D.C. tap. Set the rotary switch at 5 volts and place the test leads in the pup jacks marked *common plus* and *D.C. volts*. The A.C.-D.C. switch is, of course, in the *D.C.* position. Connect the free ends of the test prods across the terminals of a new 1.5 volt dry cell battery. The meter should indicate a little more than 1.5 volts, if this section of your multimeter is connected properly.

The 125 volt D.C. range may be checked by using first a 45 volt B or C battery. If this range is found correct, then test with whatever higher voltages are available. The 500 volt and 1,250 volt ranges should be checked in the same manner with a 45 volt battery before higher voltages are tried. This procedure will prevent overloading of the meter if a mistake in connecting some part has been made.

With the rotary switch setting in the 5 ma. position and the A.C.-D.C. switch still in the *D.C.* position, use the following procedure to check the current-measuring section of the multimeter. A separate 4.5 volt battery, a 1,000 ohm, 2 watt resistor and a 4,500 ohm, 2 watt resistor will be necessary. Connect one of the resistors, in series with the battery, to the free ends of the test prods, and plug the other ends of the test prods into the pup jacks labeled *common plus* and *D.C. MA.* With a 1,000 ohm resistor in this test circuit the meter should indicate a current of approximately 4.5 ma. When the 4,500 ohm resistor is used in the same test circuit, a current of approximately 1 ma. should be indicated by the meter.

The last D.C. test will be the 125 ma. D.C. range. In this case we will use the 4.5 volt battery and a 200 ohm resistor. If everything is in proper working order approximately 22.5 ma. will be indicated by the meter.

Having checked the D.C. scales or ranges of the multimeter we may proceed to check the A.C. sections. Throw the A.C.-D.C. switch to the *A.C.* side and plug the test prods into the pup jacks marked *common plus* and *A.C.* volts. To test the 5 volt A.C. range, place the test prongs across a 2.5 volt filament transformer winding. If the pointer is at or near the mid-scale point, change the selector switch to the *125 volt point*. The pointer of the meter should in this case move almost down to zero. Now apply the free ends of the test prods to a 110 volt A.C. source. The meter should indicate a voltage of between 105 and 120 volts, depending upon the exact line voltage in your community.

The next range can be tested on the same supply voltage. Change the selector switch to 500 volts, the toggle switch still being on the A.C. side. If the 110 volt line reading is correct now to within 5%, place the free ends of the test prods across half the secondary winding of a power transformer supplying a type 80 rectifier tube. The same test voltage can be obtained with one test prod resting on the chassis and the other on one plate of the 80 rectifier tube. A reading of between 200 and 450 volts should be obtained.

The last test on the wiring of your ohmmeter will be on the 1,250 volt A.C. range. Place the selector switch at this setting, then check this range against the 500 volt range by using half the transformer voltage as before. If the readings check within about 5%, turn off the A.C. power and wedge the test prods against the plate terminals of the 80 rectifier tube. When good contacts are secured, stand clear and turn on the power. The reading of the meter should have doubled. Turn off the power before removing the prongs, for *the voltage of any power pack can give a serious shock.*

With this multimeter you can check in a few moments the resistance of any resistor or device, up to the 2 megohm limit of the unit. Voltages and currents can be checked just as easily once you are familiar with the use of this multimeter and can interpret the meter scale readings.

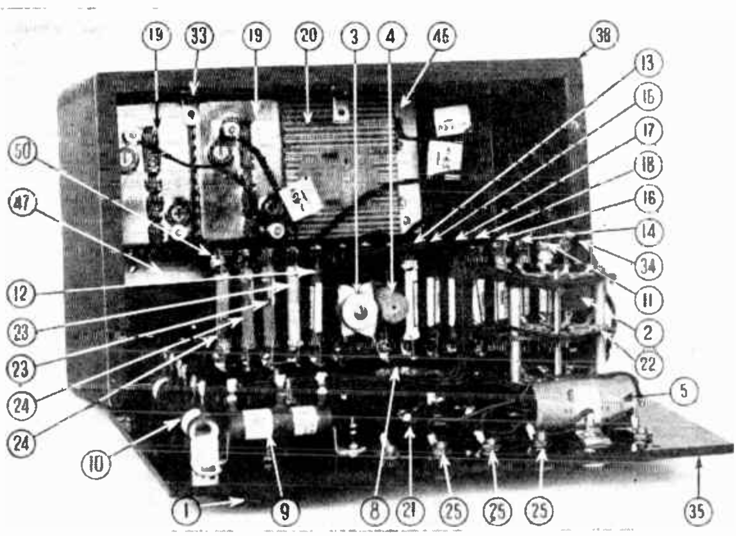

FIG. 6. *Cable-type Wiring Gives a Professional Touch to the Sub-panel Assembly.*

finished with two coats of black enamel. Allow the first coat of enamel to dry thoroughly, sand it down lightly with fine sandpaper, then apply the second coat.

Place the two 22½ volt batteries (item #19) upright in one corner of the cabinet, with item #20 lying flat alongside as shown in Fig. 6, and fasten the three batteries rigidly in place with the pieces of white pine listed as items #45, #46 and #47, and two of the right angle brackets, #33. Place the four rubber feet (item #37) about ½" in from the corners on the bottom to complete the cabinet.

Assembly

The panels and cabinet being completed, you are ready to begin the wiring. The photograph in Fig. 6 gives the position of each part and shows how the batteries are placed in the box. Arranging the parts exactly as shown makes the wiring as simple as possible. A very neat appearance is secured by running the wires in cable-like fashion, tying them together when the job is finished, but the unit will work just as well if wires are run directly to the different parts.

Follow the circuit diagram in Fig. 8 closely while making connections. Do not connect the battery wires yet. Note that the resistors are mounted on the subpanel and held in position by the lugs. When soldering to the connecting wires of the rectifier unit, use as little heat as possible to prevent damage to the sensitive discs.

Testing Your Multimeter

Like all pieces of delicate apparatus, this multimeter must be tested before being used for radio work. To test the ohmmeter section, plug your test prods into the *common plus* and the *ohm* pup jacks. Set the rotary or selector switch, item #22, on the 2,000 ohm tap and place a 2,000 ohm, 2 watt resistor between the free ends of the test prod cords. Now attach the leads going to #20, the 4.5 volt battery.

Place the toggle switch in the D.C. operating position, and rotate the zero adjusting rheostat, item #8, until the meter reads 2,000 ohms on the top scale. The pointer should return to zero when the two test prods are touched together. A slight adjustment of the zero rheostat may be necessary to make the meter read exactly 0 ohms.

The other three resistance scales are checked by testing the highest scale. In this case connect a 100,000 ohm, 2 watt resistor between the free ends of the test prods, turn the rotary switch to the position "X 1,000," and attach the battery leads to the two 22.5 volt batteries connected in series. The

OHMS

OUT-PUT

A.C. VOLTS

D.C. VOLTS

D.C. MA.

COMMON +

A.C.

D.C.

OFF

2000 OHMS

X 10 OHMS

FIG. 7. *Cut Out These Titles and Paste Them on White Paper for the Front Panel.*

X 100 OHMS

X 1000 OHMS

5 VOLTS

125 VOLTS

500 VOLTS

1250 VOLTS

5 MA.

12 MA.

on the panel, place the panel on a smooth, hard surface and center punch each intersection to insure that the twist drill will start at the proper spot.

When drilling through bakelite I usually clamp the panel to a flat ¾" board which is in turn clamped to the work-bench. The twist drill may now be used in a vertical position. Drill all holes first with a #30 drill, ⅛" in diameter. Drilling a small hole first prevents the drill from creeping out of the center punch mark or breaking away the bakelite at the back of the panel.

With the panel still clamped to the board, drill the holes again to the sizes indicated below:

Holes	*Diameter*	*For Item*
a	2-11/16"	#1—Meter
b	Use #18 Drill	#32—Panel holddown screws.
c	Use #18 Drill	Meter mounting screws
d	1/4"	#25—Pup jacks.
e	3/8"	#8—Zero-adjust. potentiometer.
f	7/16"	#21—D.P.D.T. switch
g	7/16"	#22—Rotary switch.
h	Use #18 Drill	Resistor and sub-panel brackets.

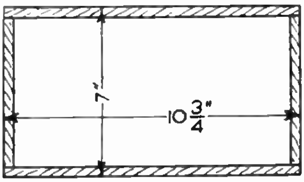

Fig. 5. *Multimeter Cabinet Construction.*

The large meter hole may be made with a fly cutter or by drilling a series of ⅛" diameter holes close together along the circumference. Since the meter flanges cover any irregularities which might show from the front, this latter method is perfectly satisfactory.

Having drilled all holes, clear away the burred edges with the small blade of a knife.

Holes *h* are counter-bored to take the heads of the nickel plated 6/32 brass machine screws, shown as item #40. A large twist drill may be used as a counter-bore.

The panel is now ready to be sanded down, to remove the scribe marks. With a short back and forth stroke go over the entire panel with #00 sandpaper, working only in the lengthwise direction. Wipe off the bakelite dust and apply a little oil with a cloth. This will give the dull black finish so popular on commercial equipment.

Laying Out the Subpanel

Item #34, the bakelite subpanel, is next laid out in the manner shown in Fig. *3*. Make hole *z* 3/16" in diameter (this is used for mounting item #3). All other holes are drilled with a #18 drill.

Laying Out the Escutcheons

The escutcheons shown in Fig. *4* are cut out with tin snips from 1/32" aluminum (item #36). Cut a little outside of the lines and finish with a file. Scratch or scribe intersecting lines as before to mark the center of each hole, then punch each with the aluminum placed on a flat piece of iron. Drill all holes first with a ⅛" diameter drill, using turpentine as a lubricant.

The holes may now be enlarged with a ½" tapered reamer, by placing the unfinished escutcheon in your bench vise, reinforcing the aluminum with a piece of strap iron having a ½" diameter hole centered with the hole you are working on. Apply turpentine liberally to the reamer while turning it slowly through the aluminum. Trim away the burred edges with a knife blade dipped in turpentine.

Sand one side of each escutcheon with #00 sandpaper to remove scratches. Next cut out a piece of stiff white paper and one piece of clear celluloid or heavy cellophane to sizes a little smaller than each of the escutcheons. Cut holes for the pup jacks and shafts of the switches.

Now trace on each paper the positions of the "windows" in the aluminum plates. Cut out the bits of lettering set up in Fig. 7, and paste these on your sheets of paper in the positions indicated in Fig. *4*. In this way you secure perfect professional lettering for your panel. The celluloid will protect the lettering from dust and dirt. The panel parts will hold the paper, celluloid, and aluminum plates in position.

Making the Box or Cabinet

The cabinet is built from ½" clear white pine boards cut to give the outside dimensions specified in Fig. *5*, assembled with finishing nails, and

Radio Servicing Jobs and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

How to Build an Effective All-Wave Signal Generator

NEXT to the multimeter, the most useful instrument for radio service work is an all-wave signal generator or test oscillator. A signal generator is almost a necessity when doing work on superheterodyne receivers; with it all-wave superheterodyne receivers can be accurately aligned for maximum sensitivity and selectivity, and I.F. amplifiers can be set to the frequency specified by the manufacturer.

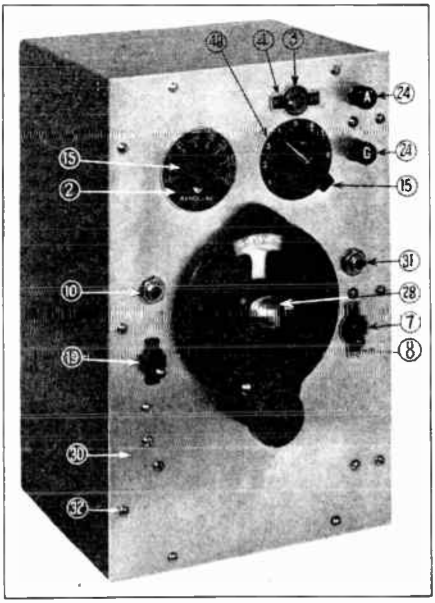

FIG. 1. *The completed signal generator, designed and built in the N. R. I. Laboratory, fits into 7" x 10¾" x 5½" cabinet.*

This job sheet covers the construction and calibration of a signal generator; the use of each control or outlet of the unit is discussed briefly at the end. In other job sheets and in the regular lesson books you will find detailed instructions for using signal generators in radio service work.

Factory-made signal generators will usually be more reliable, more accurate and more impressive in appearance than a kit-assembled unit; I recommend the purchase of a commercial unit, just as I did in the case of the multimeter. However, if you have enough time available to assemble and calibrate your own unit, and feel that the few dollars saved will be important, or you want the experience of making radio equipment, follow closely the instructions given here.

The most difficult part to construct, when building an all-wave signal generator of any kind, is the coil assembly. I suggest, therefore, that you purchase this part. In order to follow through a typical assembly, I have selected the R.C.A. test oscillator kit #9559.*

The frequency range of the signal generator extends from 90 kc. to 25,000 kc. A selector switch allows you to set the generator to any one of the eight overlapping bands listed here:

Band #1 —	90 to	200 kc.	
Band #2 —	200 to	400 kc.	
Band #3 —	400 to	800 kc.	
Band #4 —	800 to	1,500 kc.	
Band #5 —	1,500 to	3,100 kc.	
Band #6 —	3,100 to	6,800 kc.	
Band #7 —	6,800 to	14,000 kc.	
Band #8 —	14,000 to	25,000 kc.	

These bands cover all radio frequency and intermediate frequency line-up points of all types of receivers. This frequency range is covered entirely by the fundamental frequency of the oscillator, no harmonics being used. A separate modulator tube putting out about a 500-cycle note is provided to modulate the radio frequency output, a panel switch being included to start and stop modulation.

Parts Included with R.C.A. #9559 Unit

Item #1—Shielded coil assembly.
Item #2—Range switch escutcheon.
Item #3—High-low output switch.
Item #4—High-low output switch escutcheon.
Item #5—220,000 ohm resistor.
Item #6—2,200 ohm resistor.
Item #7—Modulation switch.
Item #8—Modulation switch escutcheon.
Item #9—Dial scale (not used).
Item #10—Sweep condenser jack (open circuit type).
Item #11—Instruction book and drilling template (not used).

---

* This kit can be obtained from radio parts supply houses. It is sometimes called the "oscillator modernization kit," necessary to convert the R.C.A. TMV-97-B unit for use with the cathode ray oscillograph and frequency wobbulator (frequency modulator).

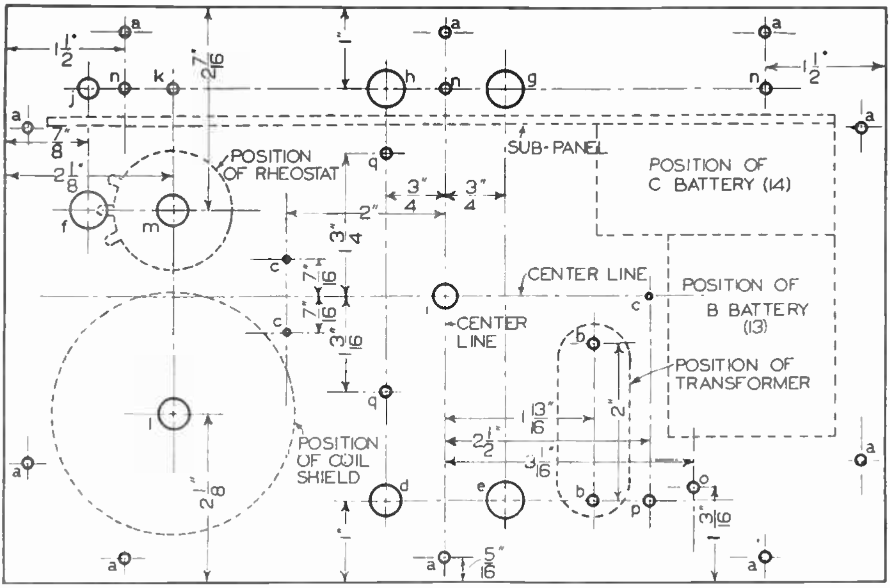

FIG. 2. *Layout for 10-13/16" x 7-1/16" aluminum front panel (front view). Refer to dotted lines when mounting parts on the panel. Locate holes "a" 5/16" from outside edges and 1½" from nearest corner.*

The following are additional parts required, obtainable from mail order supply houses, except those furnished in N. R. I. units.

Item #12—Two 4-prong wafer sockets.
Item #13—One 22.5 volt small B battery, Burgess #4156 or its equivalent.
Item #14—One 4.5 volt C battery, Burgess #2370 or its equivalent.
Item #15—Two short arrow-pointer type knobs.
Item #16—One *N.R.I.** A.F. transformer, listed as item #24 in your home experimental outfit.
Item #17—50 feet #22 solid insulated hook-up wire.
Item #18—One *N.R.I.* 10,000 ohm potentiometer, listed as *N.R.I.* item #13.
Item #19—OFF-ON toggle switch (S.P.S.T.).
Item #20—.05 mfd. paper non-inductive condenser listed as item #28 in your *N.R.I.* shipment.
Item #21—One 250 mmfd. fixed mica condenser.
Item #22—Two type 30 tubes, listed as *N.R.I.* item #10.
Item #23—One 100 mmfd. mica fixed condenser.
Item #24—Two binding posts with insulated washers.
Item #25—.000350 mfd. variable condenser, listed as item #23 or #33 for *N.R.I.* units—*1 rotor plate is removed.*
Item #26—One 250,000 ohm, 2 watt resistor, listed as item #45 for *N.R.I.* units.
Item #27—One 50,000 ohm, 2 watt resistor, listed as item #47 for *N.R.I.* units.
Item #28—One 4-inch vernier tuning dial reading from 0 to 100 in a counter-clockwise direction.
Item #29—Six dozen soldering lugs.
Item #30—One panel, aluminum, 7-1/16" x 10-13/16" x 3/32", cut to exact size.
Item #31—Yaxley jack #702, closed circuit type.
Item #32—Ten #6 nickel-plated round head wood screws, ⅝" long (to fasten panel to cabinet).
Item #33—One subpanel, bakelite, 9⅝" x 4⅞" x ⅛", cut to exact size.
Item #34—One aluminum or brass strap ⅝" wide, 10" long, 1/16" thick (to hold batteries in position).
Item #35—One 50,000 ohm, 2 watt resistor.
Item #36—One 50,000 ohm, 2 watt resistor.
Item #37—One .05 mfd., 200 volt paper condenser.
Item #38—Four angle brackets ⅜" wide, 1/16" thick brass stock, with holes ⅜" from bend; use 3 to mount subpanel, one to hold the C battery in position.
Item #39—Two angle brackets ⅜" wide, 1/16" thick brass stock, with holes 11/16" from bend; used in mounting tuning condenser.
Item #40—Two 6-32 round head brass machine screws ⅝" long.
Item #41—4 dozen #6 lock washers.
Item #42—½" clear white pine lumber for cabinet; 1 piece 7" x 10¾", 2 pieces 5" x 10¾", 2 pieces 5" x 6⅛".
Item #43—One piece ordinary copper screen, 20" x 24", for cabinet lining.
Item #44—4 dozen ⅜" flat head carpet tacks.
Item #45—4 dozen 1¾" long (4-penny) finishing nails.
Item #46—3 dozen ⅜" long 6-32 round head nickel-plated brass bolts.
Item #47—3 dozen ¼" 6-32 hex nuts for above screws.
Item #48—Escutcheon for attenuator control.

*All N.R.I. items refer to parts furnished with your Home Experimental Outfits.

Laying Off the Panel and Subpanel. Lay out the holes for both the panel and subpanel with a square and steel scriber, following carefully the dimensions given in Figs. *2* and *4*. Make your lines very lightly and use a center punch to spot the holes. Apply turpentine liberally when drilling or working the aluminum panel, to improve the cutting qualities of the tools you use.

*DRILLING DATA—ALUMINUM PANEL**

Holes	*Diameter*	*For Item:*
a	**Use #18 drill**	**#32—Panel hold-down screws.**
b	**Use #18 drill**	**#46—Transformer mounting bolts.**

Holes	Diameter	For Item:
c	Use #32 drill	Bolts for mounting dial (#28).
d	3/8"	#10—Open circuit jack.
e	7/16"	#19—OFF-ON toggle switch.
f	7/16"	#3—High-low R.F. output toggle switch.
g	7/16"	#7—Modulation OFF-ON toggle switch.
h	7/16"	#31—A.F. output closed circuit jack.
i	5/16"	#25—Variable condenser shaft.
j	1/4"	#24—Antenna binding post.
k	Use #18 drill	#24—Ground binding post.
l	3/8"	#1—Coil assembly switch.
m	1/2"	#18—Volume control potentiometer.*
n	Use #18 drill	#46—Bolts for subpanel bracket (#38).
o	Use #18 drill	#46—Bolt for battery clamp (#34).
p	Use #18 drill	#46—Grounding lug (Not absolutely necessary).
q	Use #18 drill	#46—Condenser mounting brackets (#39).

DRILLING DATA—BAKELITE SUBPANEL

Holes	Diameter	For Item:
a	Use #18 drill	#46—Subpanel bracket bolts.
b	3/16"	Wire to antenna post.
c	Use #18 drill	#46—Resistor mounting bolts.
d	Use #18 drill	#46—Socket mounting bolts.
e	Use #18 drill	#46—Grid condenser mounting bolts.
f	1-1/4"	#12—Wafer type tube sockets.
g	Use #18 drill	#46—Bolt for battery hold-down bracket (#38).
h	Use #18 drill	#46—Bolts holding "A" battery lead lugs.
i	1/4"	Wiring passing through subpanel.
j	Use #18 drill	#46—Bolt for battery clamp (#34).

Mounting the Parts. There is nothing particularly difficult about the assembly of this unit. The photographs shown in Figs. *1, 6* and *7* should be studied and all items placed as shown. Follow the shortest routes when wiring the circuit, but keep the wiring as simple and neat as possible. Use only rosin core solder. All connections are given in the circuit diagram in Fig. *5*.

To secure a maximum tuning condenser capacity of 290 mmfd., break off one rotor plate from your 350 mmfd. condenser by bending it carefully back and forth, finally pulling it out with pliers.

The tuning condenser is supported on the panel by the two large angle brackets, item #39; all other parts are mounted directly on the panel or subpanel. Resistors and condensers are supported by soldering lugs bolted to the subpanel.

A vernier dial is necessary to give accuracy with this signal generator. Adjust the dial to give a zero reading when the plates are completely meshed together, note the position of the set screw on the condenser shaft, and file the shaft flat at that point. Always turn the dial slowly when approaching the 0 and 100 marks, for there are stops on the condenser and the jar of banging against these might shift the position of the dial on the shaft.

Making the Cabinet. Assemble the cabinet for your signal generator with 4-penny finishing nails. The parts list gives the dimensions of the pieces required.

* When mounting this item be sure to use a fibre grommet to insulate the shaft from the panel.

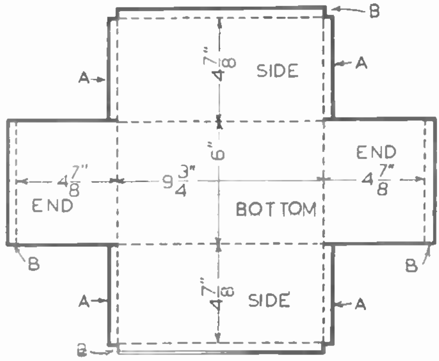

FIG. 3. *Layout of copper shielding screen. Cut on heavy lines. Flaps A and B are 3/8" wide. Bend flaps A up on dotted lines; bend sides and ends up, then place in cabinet and bend flaps B down over the top edges of the S.G. cabinet.*

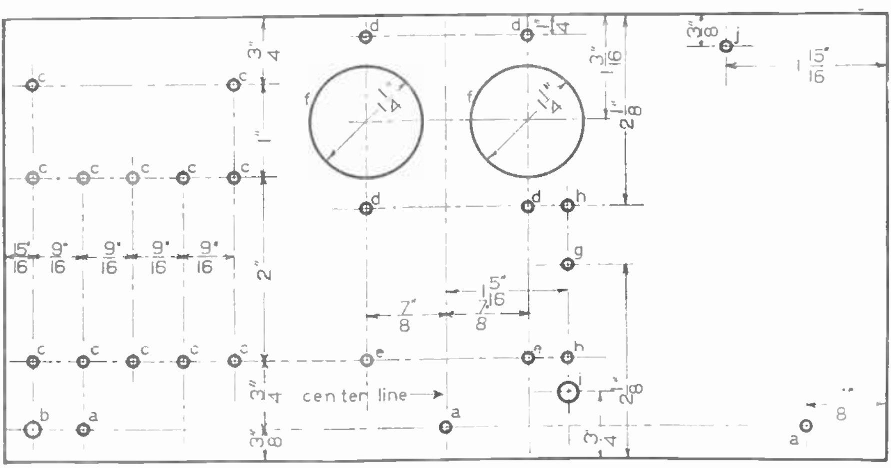

FIG. 4. *Layout for 9 5/8" x 4 7/8" subpanel (bottom view). See tables for hole diameters.*

So, A.W.R. to 1460 kc. station, which gives four points in range #2, at 365, 292, 243 and 208 kc. Other local stations give only two or three points.

We have now completed the calibration of the S.G. below 1,500 kc., by using as standards broadcast stations whose frequencies are known. To calibrate points above this frequency, you will have to construct a small unmodulated oscillator, tuning from 500 to 1,000 kc. You will need the following parts:

SW—OFF-ON switch, toggle or knife type.
C1—Variable condenser, 350 mmfd.
C2—Fixed condenser, .00025 mfd.
C3—Fixed condenser, .001 mfd.
R1—50,000 ohm, 2 watt resistor.
L1—120 turns #28 D.C.C. wire wound on a 1.5 inch diameter form; 70 turns for section a and 50 turns for section b.
One—45-volt "B" battery.
One—1.5-volt "A" battery; use a #6 dry cell.
One—4-prong tube socket.
One—Type 30 tube.

The complete oscillator unit should be mounted on a ½" board about 6" wide and 8" long, connecting the parts as indicated in the wiring diagram in Fig. 8. This unit is connected to the ground post on the receiver by a 3-foot long wire.

If you use the parts specified above, the test oscillator will produce frequencies between 500 and 1,500 kc. With the rotor plates almost completely meshed with the stator plates, 500 kc. will be obtained; with plates half in 1,000 kc. is produced, and with plates nearly all out 1,500 kc. is obtained.

We will use this test oscillator to produce precise 500 and 1,000 kc. signals, to be used in calibrating all the S.G. bands above 1,500 kc. by means of harmonics. First we will use the harmonics of a precise 500 kc. signal. Connect the S.G. to the input of the A.W.R., which is tuned to 1,000 kc. The test oscillator will transfer its signals to the A.W.R. through the 3-foot ground lead. Set the S.G. to band #3 (already calibrated) and for 500 kc. exactly. Tune the test oscillator to about 500 kc., plates nearly entirely meshed, and adjust this test oscillator carefully to as near zero beat as you can. Under no condition touch this adjustment while you are relying on the accuracy of its 500 kc. adjustment. Harmonics of this test frequency will be picked up on the A.W.R. These harmonic frequencies are: 1st—500 kc.; 2nd—1,000 kc.; 3rd—1,500 kc.; etc.

Knowing that the new oscillator is set at 500 kc. you can then change the selector switch on the

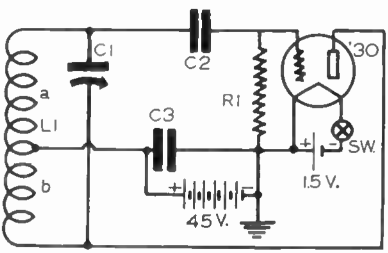

Fig. 8. *Circuit for test oscillator.*

S.G. to the 1,500 and 3,100 kc. band. To secure a calibration at 1,500 kc., set the A.W.R. at 1,500 kc., then slowly increase the frequency of the S.G., starting at the low frequency end, until you hear a strong audio beat note with the third harmonic of the 500 kc. oscillator. Be sure and reduce the volume on both the S.G. and A.W.R. to eliminate confusion with the image frequencies of the receiver. We have now spotted the 1,500 kc. setting. The next points will be on the fourth, fifth and sixth harmonics of the 500 kc. oscillator. It is advisable that you check each new point against the rough calibrations made with modulation, as the image frequency response is rather serious here if an I.F. frequency of 465 kc. is used in the superheterodyne receiver.

The range between 3,100 and 25,000 kc. should be calibrated by using a 1,000 kc. test oscillator frequency. Tune the receiver to 1,000 kc., with reduced sensitivity. Set the unmodulated S.G. at 1,000 kc., then tune the unmodulated test oscillator until you secure zero beat note; the oscillator will now be set at 1,000 kc.; check by tuning the A.W.R. to 2,000 and 3,000 kc., and listening for similar beats.

Knowing that the 1,000 kc. oscillator is functioning properly on exactly 1,000 kc., we may work with its harmonics in locating all frequency settings above 3,000 kc.

Errors in calibration are easily detected, for

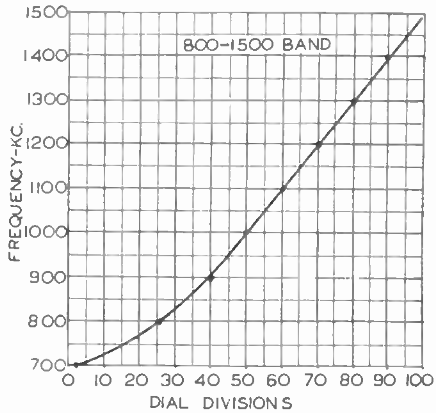

Fig. 9. *Sample S.G. calibration chart.*

they will show as irregularities in the curves plotted on the graph paper. The entire beat method of calibration is reviewed in the following table:

Range	*Method*
#1—90-200 kc.	**Beat harmonics of S.G. against station of known frequency near middle of broadcast band (1,000 kc.).**
#2—200-400 kc.	**Beat harmonics of S.G. against station at high frequency end of broadcast band (1,500 kc.).**
#3—400-800 kc.	**For 400 to 550 kc., beat 2nd harmonics of S.G. against stations between 800 and 1,100 kc. For 550 to 800 kc., beat fundamentals against broadcast stations.**
#4—800-1,500 kc.	**Beat fundamentals of S.G. against broadcast stations.**
#5—1,500-3,100 kc.	**Beat fundamentals against 3rd, 4th, 5th and 6th harmonics of an accurate 500 kc. oscillator.**
#6—3,100-6,800 kc.	**Beat fundamentals of S.G. against harmonics of accurate 1,000 kc. oscillator.**
#7—6,800-14,000 kc.	**Beat fundamentals of S.G. against harmonics of 1,000 kc. oscillator.**
#8—14,000-25,000 kc.	**Beat fundamentals of S.G. against harmonics of 1,000 kc. oscillator.**

Purpose of Each Control. Each of the controls or outlets mounted on the front of the S.G. panel has a definite purpose. The selector switch (which is part of the coil assembly) determines the frequency range of the S.G., while the vernier tuning dial (#28) permits tuning to the particular frequency desired in any one range. The OFF-ON toggle switch (#19) is in the battery circuit, and controls the entire S.G.

The sweep condenser jack (#10) located above the OFF-ON switch, is used for sweeping (varying) the radio frequency delivered by the S.G. over the frequency band desired. This jack is provided for cathode ray oscillograph work.

The modulator toggle switch (#7) starts and stops the audio frequency modulation of the S.G. The A.F. output can be used for checking the audio frequency characteristics of radio receivers, by plugging into the closed circuit jack (#31) just above the modulation switch.

The high-low toggle switch (#3) and the potentiometer just below it control the output voltage of the S.G. The potentiometer gives a fine control of this R.F. voltage over each range.

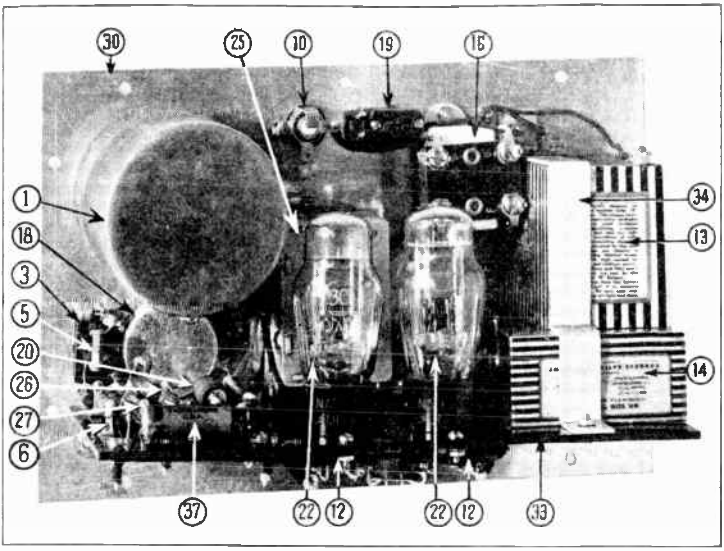

FIG. 6. *Item numbers marked on this photograph assist you in arranging the parts.*

set as low as possible. This will not only eliminate confusion with image frequency response but will increase the selectivity of the receiver should it have AVC.

Beat Method of Calibration

You can accurately check any frequency of a signal generator provided that you can "beat" this frequency against a signal of high precision. Fortunately such precision signals are readily available. All 540 to 1500 kc. broadcasting stations must, according to rulings of the Federal Communications Commission, stay within 50 cycles of their assigned frequency, a precision far greater than you can hope to attain with any service signal generator. With these standard broadcast band frequencies to check against, you can calibrate some ranges of the S.G. directly or by harmonies. Other ranges are calibrated just as accurately by means of a simple unmodulated oscillator.

In the beat note method of calibrating the signal generator, the method which I am about to describe, we make use of beat notes between the known frequency of a broadcast transmitter and either the fundamental or some harmonic of the S.G. frequency. This method is simple and accurate, but requires time and patience. Its principle is simple; when the S.G. is tuned to zero beat with the transmitter, the transmitter frequency is an exact multiple (or a whole number times) the S.G. frequency. This holds true regardless of the setting of the A.W.R., as long as this receiver is tuned to bring in the desired station with sufficient volume for calibrating purposes. The procedure is as follows:

1. Prepare rough calibration curves for each S.G. range by the A.W.R. method described.

2. Connect calibrating apparatus. Use regular antenna on A.W.R., making a ground connection to both A.W.R. and S.G. Connect a three-foot length of wire to the S.G. antenna post if a stronger signal is needed. The other end is free. Do not use modulation on S.G.

3. Tune the S.G. to the low frequency end (condenser plates meshed) of band being calibrated, either band No. 1, 2 or 3.

4. Tune the A.W.R. to a local or nearby station broadcasting on a frequency which will be a harmonic of at least four frequencies within the S.G. range being calibrated.

5. Increase the S.G. frequency until a beat note is heard: tune the S.G. for zero beat (between the whistles).

6. Refer to your rough S.G. calibration graph to determine the approximate S.G. frequency setting; divide the broadcast station frequency by some whole number which gives a quotient closest to this approximate frequency. This quotient is then the exact frequency of the S.G. at that setting. Record the point on a calibration graph (chart).

7. Increase the S.G. frequency until another beat note is heard. Determine this frequency by the same method used above,* log the point and repeat for all other S.G. frequencies in that range which produce harmonics at the broadcast station frequency.

8. Change the S.G. range, and select another broadcast station whose frequency, when divided by whole numbers, gives at least four fundamental frequencies in the range being calibrated. Log the points on a new graph.

9. For ranges #3 and #4, tune to stations whose frequencies you know, beating the fundamental of the S.G. against each until four or five points are secured in each range.

Example; Calibrating range #2—200 to 400 kc.
Location—Washington, D. C.
Local Stations: WJSV—1460 kc.; WOL - 1310 kc.; WRC—950 kc.; WMAL—630 kc.

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* Or divide by a number one less than the harmonic number used in the previous calculation.

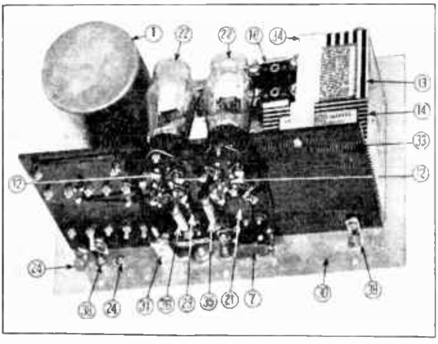


FIG. 7. *Photograph of bottom of subpanel.*

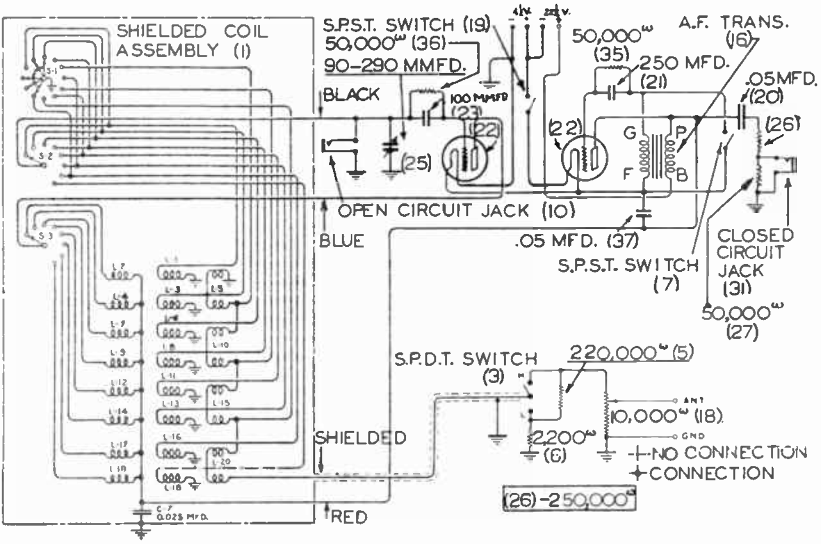


FIG. 5. *Circuit diagram for signal generator. Note colors of RCA coil assembly leads.*

Finish the cabinet exactly the same as the multimeter cabinet, sanding, applying two coats of black enamel, and allowing to dry.

When the enamel is dry, cut out the copper screening to the dimensions given in Fig. *8*. Bend the screen, place in the box, and fasten with the carpet tacks listed as item #44. Solder the screen together in spots about ¾ inch apart along the corners, using rosin core solder (not acid), and a *hot* iron. This insures a completely shielded signal generator.

Calibration of Signal Generator

After completing the assembly of your signal generator (S.G.), calibration is the next step. Unless properly calibrated, the S.G. will be of little value in service work.

There are many ways of calibrating an S.G. if you have laboratory equipment on hand. The methods I shall describe require a minimum of auxiliary equipment.

You may, if you wish, use the calibrations on an all-wave receiver (A.W.R.) as your only guide, this being our first method. In this case the station selector indicator is calibrated in kilocycles. If a superheterodyne receiver is used, choose a set having one stage of preselection. Don't use a skip-band type receiver; it is generally unsatisfactory for calibrating purposes.

The A.W.R. Method. To calibrate ranges 4, 5, 6, 7, 8 and part of 3 by this method, connect the S.G., operating with modulation, to the input of the receiver. To do this, disconnect the A.W.R. antenna, then connect together the Ant. and Gnd. terminals of the A.W.R. and S.G. Set the S.G. dial to at least five evenly distributed points in the above S.G. ranges and tune the A.W.R. in each case until the modulated S.G. note is heard loudest in the receiver. Do not overload the receiver. Record the frequency indicated by the A.W.R. for each S.G. setting.

If your receiver is of the American all-wave type, the lowest frequency on the tuning dial being 540 kc., you will not be able to calibrate the low frequency ranges of the S.G. by this simple direct method. You can, however, make use of harmonics of the S.G. to calibrate the remaining ranges (#1, #2 and #3 up to 540 kc.).

For range #1, set the A.W.R. at 1,000 kc. Set the S.G., operating with modulation as before, to zero dial position (lowest frequency, with condenser plates totally meshed). Now rotate the S.G. dial slowly towards the 100 point, until you hear the first modulated signal in the A.W.R. Tune the S.G. carefully to secure maximum volume of tone. You are now picking up with the A.W.R. a harmonic of the S.G. output. You know this harmonic is at 1,000 kc. (from the A.W.R. dial), and know that the fundamental S.G. signal is about 100 kc., this being about the lowest frequency which the S.G. can produce.

It is important that we determine what harmonic is being heard, for then we can easily determine the fundamental frequency. We know that 1,000 kc. can be a 11th, 10th or 9th harmonic of a basic S.G. frequency. To determine which it is, tune the A.W.R. over the entire dial and record the frequency difference between the modulated S.G. signals heard. The average frequency difference between harmonics will be approximately the fundamental S.G. frequency. Divide 1,000 kc. by 12, 11, 10, 9, etc., until you come closest to this average value. The quotient will be the *fundamental* S.G. frequency, and the number will indicate the harmonic.

Now turn the A.W.R. again to 1,000 kc. and increase the S.G. frequency slowly until another modulated signal is heard. The S.G. frequency will then be 1,000 kc. divided by a number one less than the harmonic in the previous setting. For example, if the first note you heard was a tenth harmonic (indicating an S.G. setting of 100 kc.) the new S.G. setting will be 1,000 ÷ 9 or 111 kc. Repeat for three more points on range #1, dividing 1,000 in each case by a number one less than the previous number.

For band #2 follow exactly the same procedure, but set the A.W.R. each time at 1,400 kc. instead of 1,000 kc. Whenever you are in doubt as to the number of the harmonic being heard, determine the average frequency difference between modulated signals heard as the A.W.R. is tuned across the band, and check this value against your computed fundamental frequency.

You now have enough data to plot a calibration curve for each range of the S.G. Secure at least eight sheets of ordinary graph paper. Lay off the S.G. dial divisions along the bottom of each sheet, and the frequency range along the left side, as in the sample chart in Fig. *9*. Choose a value in kilocycles for each large square vertically which makes the smallest units represent a convenient even number of kc. Plot the data you have on the eight charts, then draw a smooth curve through as many of the points as possible on each chart. Now you can determine the S.G. frequency for any setting of its dial simply by referring to the calibration chart for the range used.

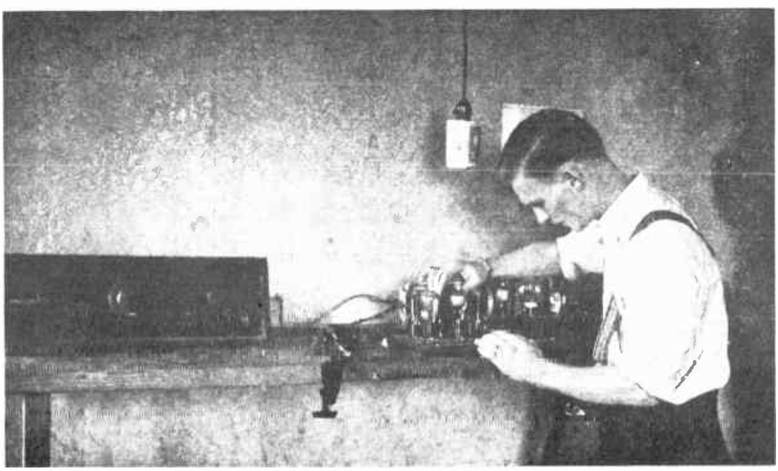
Somewhat greater accuracy can be obtained when using the above calibrating method if the volume controls on both the A.W.R. and the S.G. are

Radio Servicing Jobs and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

Tips for Getting Started in Spare Time Radio Servicing

You are now ready to seriously consider radio servicing. So far in your regular course you have studied enough about radio circuits and radio receivers to understand what I am going to say about repairing a receiver that either does not work, or operates unsatisfactorily. Bear in mind that there are thousands of different receivers, made by hundreds of different manufacturers, embodying the ideas of hundreds of different radio engineers. It would be an impossible task to tell you at one time how each and every defect or trouble can up, broad tuning, etc., and have located the fault and applied a satisfactory remedy, you have made important progress on the road to successful radio servicing. The *symptom* (what you heard or observed); the *cause* (which you will reason out from your knowledge of radio and from the acquired experience); and the *remedy* or change that you made will become fixed in your mind. The next time a similar trouble is encountered you will tackle the job with confidence, and more than likely you will finish it in less time



Student working on an old receiver

be remedied, although elsewhere in this course you received the reference textbook, "Radio Receiver Troubles. Their Cause and Remedy," in which an index directed you to a paragraph indicating what was probably causing the difficulty that you found with a radio receiver and how it could be remedied.

Yet, this is not the way—you will eventually service a radio receiver. Radio servicing is an art which you must develop by experience; all the book study in the world will only do so much and no more for you. Once you have heard hums, rattles, noise, squeals, distortion, poor pick- than the previous similar job and no doubt in a more thorough manner.

But, I venture you are saying to yourself, how am I to get this all-important experience? Let me make a few suggestions. Have you, or has a close friend of yours, an old receiver, one that is not in use? There are thousands upon thousands of old receivers that can be obtained for the asking. Even if you cannot locate an old receiver among your friends, buy one from a radio dealer who has dozens of receivers taken in on trade. You should be able to procure an old set with tubes and loudspeaker for less than ten dollars.

At first get a tuned radio frequency A.C. socket power operated receiver,* and preferably one that plays.

I assume that you have a bench in the attic, basement, garage or in one corner of your bedroom where you can work. This is the place to take the receiver. Connect it to the aerial, ground and power supply outlet; study its operating abilities. Examine each and every part. Trace the circuits; you do not need a service diagram, although one will help. Try to draw the circuit diagram from your study of the chassis. If you want to learn more about some part, unsolder the connections, unbolt the mechanical support and examine the part. Be sure to study how it was originally fastened and connected into the chassis, as you will have to put it back correctly. In fact, you should draw a picture sketch of the part and the connections. Imagine, for example, that a coil has to be taken out for repairs. You take it out and then next day repair it. If you make a picture sketch you will know exactly how to reconnect it.

What has all this got to do with radio servicing? It has a lot to do with correct servicing. You will develop the "knack" of taking things out and putting them back; recognizing parts that you formerly only saw as illustrations or pictures; and what is more important you will develop that feeling best expressed by saying: "Who's afraid of a radio receiver?" Your fingers and your mind will start to work together.

Fully familiar with the receiver, you may proceed to clean and overhaul it. In a future job I will tell you how to align or pep it up. When you get it working in a first class manner, you must say to yourself: "What will happen if I open this grid circuit, or short this bias resistor, or take out this filter condenser, or connect a resistor across the secondary of the audio transformer, or change the type of detection, or change from a resistance coupled to transformer coupled type of audio amplifier, or adapt it to this kind of power." Hundreds of other ideas will probably "pop up" in your mind. Try out your ideas and see what happens. Of course, do not attempt things that are foolish, like shorting the input filter condenser, or raising the filament voltage unduly, or any other change that your study indicates would damage the set or the tubes.

N. R. I. experts are always ready to help you

By knowing what you have done and observing what happens you are adding enormously to your experience. To be sure, just the reverse of what you will be expected to do on a service job, but just the same, valuable experience to "tuck away" in your mind.

When you get this far, ask someone, a brother or a friend to do something to the receiver. For example, cut a wire, or short some part and then try to locate the fault, in the manner considered in a later job sheet. When you get to know the receiver "inside out," put it into first class condition, sell it or give it to a friend.

Get another old receiver, and for that matter ask a radio dealer for an old re-

* If you live in a D.C. district, experiment in some relative's home where A.C. power is available. On a farm, it is wiser to procure a battery receiver and batteries.

ceiver that does not work. If you explain you will try to fix it and return it to him, or else pay for it if it is damaged, he very likely will oblige you. Locate and correct the trouble; clean, overhaul and pep up the receiver. Return it and get another, and graduate to superheterodyne receivers. Incidentally, if you return the receivers in an *A1* condition, the dealer may eventually consider you for a service job.

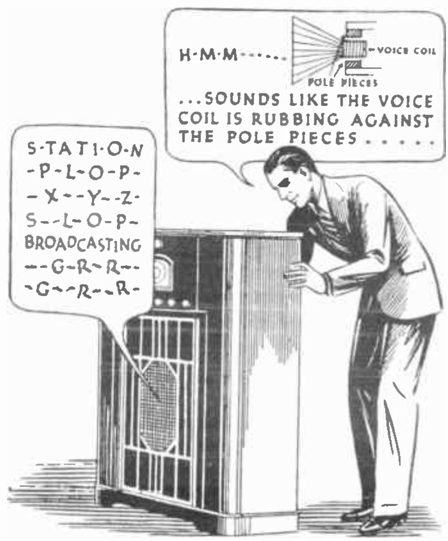
Perhaps you have enough confidence to start in at once to service a radio set. Many of my students who have faithfully studied my course, the study lessons, and performed the practical Home Experiments, have developed by this time the necessary confidence to repair a defective receiver. They usually start on their own or their relatives' and friends' receivers. When they get "stuck" they go to an expert radio serviceman and pay for the work done, on the condition that they can watch.* The Institute will gladly help if you will write in, but before you do, be sure you have done everything you possibly can yourself. Our radio experts can only suggest what you can do, and will probably tell you facts that will be presented in the next few Radio Servicing Job Sheets.

Radio Receiver Troubles You Should Recognize

If you are going to repair a radio receiver, it is highly important that you know what troubles you will encounter. You start with confidence, if you recognize the customer's complaint. Perhaps some of the troubles will be imaginary, but you must be able to recognize that difficulty which is uppermost in the mind of the set owner. The family doctor is a master in recognizing human ills, and he can pry out of you the exact symptoms. You have an easier job, because the trouble is squarely in front of you, although at times you will have to question your customer, by identifying the "off color" performance and by turning to the customer, ask: "Is that what seems to bother you."

In this job sheet I am not going to consider what causes the trouble, or where and how to locate the cause; but rather present conditions which you may encounter and how they may be recognized. Then, too, I must limit myself to the important radio receiver trouble symptoms.

Of Prime Importance.—The following may seem almost self evident, yet I want you never to forget it on a service job. Be sure to settle in your mind: "Does the receiver play; or is the set dead (no stations are heard)?" I will explain in a later job sheet the importance of this primary break-down in receiver trouble analysis. Briefly when a set is dead, you have nothing initially to go by; you must search out the reason for this inactivity. On the other hand, if a set plays but "off color" (not as it should), then perhaps what you hear and what you see may suggest the probable cause of the trouble and its origin. And at this point you will appreciate more than ever the knowledge you have acquired of the fundamental principles of radio and radio circuits. The better you master the basic principles of radio receiver operation, the quicker you will locate the source of the trouble; the quicker you will become an expert Radio-Trician.



Every disturbance or interference has its meaning

To see an expert radio man work on a defective receiver makes anyone marvel at his uncanny speed for locating the defect. He listens, looks, stops to reason and in a flash he mutters to himself: "Of course, the grid of this or that circuit is open," or whatever happens to be at fault. In that brief minute, he has connected a radio receiver circuit with a defect that will produce what was observed; he has verified his reasoning with past experience.

Now let me present to you the more common "ills" of a radio receiver under the condition that it plays, yet unsatisfactorily.

Noise is a common complaint, and by this I mean noise in the ordinary sense of

* In fact, if you live in a town or city where there is a wholesale parts jobber, he will probably have a wholesale service bench where the work that baffles you can be taken. If you buy your parts from him, I am quite sure he will let you watch his expert.

the word. It may sound like what you get when you rub two pieces of sandpaper, and the noise may be continuous or broken up in time. You may hear sudden blasts like the noise you get by slapping against each other two wooden boards. Then there is the noise that sounds like rushing water, or the grinding of gears, or thunder (which incidentally may be produced by lightning which precedes a storm). Every noise has its meaning, and with experience, what you hear will be a direct indication of the cause.

Hum.—Place your finger on your tongue so it cannot move. Pronounce a long *A*. That is what hum sounds like and believe me when it comes out of a loudspeaker mixed with a program you are ready to throw the set out of the window. Getting rid of hum is a common job for a serviceman.

Squeals.—Perhaps if I call it a sharp, shrill whistle or howl you will understand what I mean. There is nothing that gets a customer provoked more than squeals, even though in the early days of radio a squeal was the delight of every radio amateur. Today the listening public has tabooed the whistle as ancient history. Even though the set designer has taken the squeal out, let something go wrong in a set and back it comes.

"Distorts" is a word that the set owner rarely uses. What they are more likely to say is "sounds like Tin Pan Alley," or "boy, that announcer talks with a hot potato in his mouth," or "the tenor sings between his teeth;" while others will say that the radio sounds muffled, harsh, raspy, unintelligible or simply terrible. With no training at all in music or voice culture you will recognize distortion because what you hear does not sound anything like what you are accustomed to hear.

Cuts-Off.—Just as the customer gets upset when his receiver squeals or howls, you will get thoroughly provoked, perhaps even "cuss," when you get a set that "plays, cuts-off, plays, cuts-off" time and time again. Anything may be at fault and locating the source of trouble is a real test of your ability. I will have more to say about this problem in a later job and in the main course. You will be a wonder if you can fix every one of these jobs in a "jiffy."

No Volume.—There are many combinations of this fault. The output does not get louder when you turn the volume control on full, or it is loud at one and weak at another spot on the control, or the volume control has no effect whatsoever. The action of the volume control is an important clue in what may be at fault.

No Sensitivity, or better expressed, only a few stations and only the locals are strong. You will recognize this trouble with a little experience, and you need a little to recognize it. You expect a ten tube set to be more sensitive than a four tube midget, a superheterodyne to be more sensitive than a tuned radio frequency set (tube for tube).

No Selectivity is a very annoying trouble, for the customer cannot get a distant station without interference from another yet undesired station. A certain amount of station interference cannot be helped, particularly at the higher broadcast range of frequencies. But how much can only be determined by gradual contact with all kinds of receivers.

Other complaints are bound to come to your attention, which must be considered as special problems. Thus you will hear a "putt-putt-putt" sound indicating motor-boating or audio stage oscillation; or the local station riding in on a distant station, identified as cross-modulation; smoke or an offensive odor emanating from the chassis, of course, telling us that some part has broken down; or a scratchy distorted sound at all points of the volume control, indicating a rubbing voice coil form; and many other special cases.

Extra Money Jobs
and how to do them

How To Erect an All-Wave Noise-Reducing Antenna

Not so many years ago, a short wave receiver in the home indicated that the owner was a radio enthusiast, a DX fan, an amateur; individuals mostly interested in getting radio reception from transmitting stations located a long distance from the receiver. Today the all-wave receiver is to be found in the home of the average radio listener, enabling short and broadcast wave band radio program reception at any time. Furthermore, all-wave receivers have come to stay.

Here is a curious fact, one of the many that you will encounter which will lead you to extra money-making jobs. A customer decides on an all-wave receiver, goes to a radio dealer, picks out a set and has it installed in his home. The curious part of this entire transaction is that in most cases the set is connected to his existing regular antenna system. Of course, the customer gets foreign, aircraft, police, amateur and other short wave stations and says, "that's fine." But he will get them stronger, clearer and with less noise if he has an all-wave noise-reducing antenna erected. Indeed he needs one! In other words if the dealer did not install one, you should convince the customer that he needs one and then install it for him.

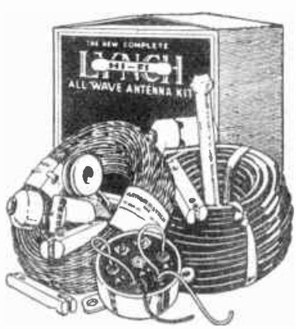


FIG. 1

Yes, every all-wave receiver needs an all-wave antenna but how can you tell your prospective customer or the public this? You cannot very well knock at each and every door, make an inquiry and then recommend one. However, when you erect an all-wave antenna, and you will when you start to sell receivers and do radio jobs, let the neighbors know about it.

You have seen small signs in front of homes testifying that an oil burner or an electric refrigerator is being installed or an indoor painting job is being done. Why not adopt the same scheme? Have a sign painted by a good sign painter. Do not make the sign too small. I would say that is should be at least two feet wide by four feet long. You can use a sheet of pressed celotex, beaver board or ply wood purchased from and cut to size by your local lumber yard. Have the painter put an attractive lettering arrangement on it looking something like this:

> AN ALL-WAVE NOISE REDUCING ANTENNA
>
> is being erected by
>
> *John K. Student, 1720 Main Street*
>
> Your All-Wave receiver needs one!

Hang it on the front porch, or screw it to a pointed stake which is driven into the front lawn. Of course, get permission from the householder to use it and have it out when you first get the job. Then leave it out a day or two after you make the installation. Tell your customer you will get it when you make your final inspection in a day or two.

Now let's get on to the problem of selecting and erecting a noise-reducing antenna. There are all kinds and designs of all-wave antennas—some which you may prefer to others. The one I am selecting and going to explain to you is made by the Lynch Manufacturing Company and can be purchased from most parts distributors and radio mail order houses. Their product is typical of the types in use. When you size up the outdoor space available for the straight-away you must decide whether you have room for a 120 foot or a 45 foot length straight-away aerial wire. This determines whether you should use the kind of all-wave antenna that requires a long straight-away or a short one. For this job let us consider the long one.

Figure *1* shows the kit of parts that you can buy to erect this complete "HI-FI" all-wave antenna. The kit contains 125 feet of aerial wire; 35 feet of special (double wire) lead-in, called transmission cable; three aerial insulators; two nail-it-knobs; one porcelain tube; one stand-off insulator; and one HI-FI receiver coupling transformer. The purpose of each item will be apparent when we describe where and how they are to be used.

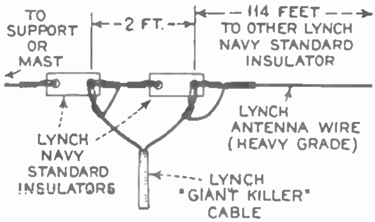


Fig. 2

Always follow the instructions sent with a kit, for manufacturers make improvements or suggestions that are important if you want the best results. The instructions with this kit indicate that the straight-away antenna must be cut to be exactly 114 feet long. Furthermore, the transmission line or cable is connected to one end of the antenna straight-away. This will mean that this support should preferably be directly above the lead-in window.

The transmission cable is expensive and should therefore be kept as short as possible. This is why one support should be above the lead-in window. However, lengths up to 500 feet may be used if necessary with very little electrical loss. If a long length of cable is necessary to meet a particular installation, it is suggested that you purchase a cable of suitable length to meet the requirements. This will eliminate the necessity of splicing two lengths together. Of course, you can join two lengths together, provided you employ a regulation Duplex Western Union soldered joint.

Figure *2* shows the proper connections of the transmission line end to the antenna straight-away. Notice how the two insulators, the transmission cable and the antenna wire are connected together. First connect the two insulators with aerial wire spacing them approximately two feet apart. Attach the 114 feet length of antenna wire to the free eye of one insulator. Be sure the wire is coiled until you are ready to string it, for easy handling. The other insulator will be connected to a support.

Now remove with a knife about 3½ feet of the outside insulation on the cable, exposing two insulated wires. One wire is connected to the aerial wire, the other wire to the short 2 foot length as shown. The ends are stripped of their insulation for about 1½ feet, looped through the opening in the insulator and twisted to themselves. Each connection must now be made electrically perfect. Considering the antenna connection, the remaining free piece of transmission wire or cable is twisted around the aerial wire. Solder this joint. The other cable lead is joined to the short 2 foot aerial length in the same way.

The antenna is then ready to be pulled up into position between the two supports spaced 120 or more feet apart. When the antenna straight-away is in place it should be above surrounding objects and of course as high as possible. This is to keep it as far as possible away from all man-made static.

The transmission cable is anchored to the wall of the building using either stand-off screw eye type or the split knob (nail-it-knob) type of insulators. These insulators are placed at various points to keep the transmission cable away from the building. Generally a stand-off insulator is best at the edge of the roof. A porcelain tube insulator is used through the window casing as shown in Fig. *3* and through which the transmission cable passes to the receiver coupler.

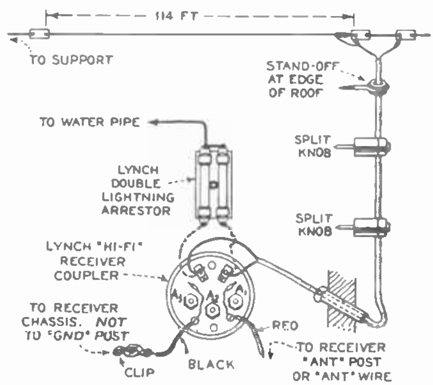


Fig. 3

Observe that the receiver coupler has two legs which permit you to screw the device to the inside of the radio cabinet. Be sure you place it close to the ANT post of the receiver, with the terminals A_1, A_2 and A_3 facing the ANT post. Now strip about 4 inches of outside insulation off the transmission cable wires and clean about an inch of insulation from each cable lead; then connect the wires to the Fahnstock clips of the coupler.

Notice that a lightning arrester may be connected to the two Fahnstock clips as shown in Fig. *3*. The length of the leads between the coupler terminals and the arrester should be equal in length and as short as possible. This will insure a balanced connection and little loss or noise pick-up.

The other terminals of the receiver coupler are carefully marked A_1, A_2 and A_3, which are of the "pup" jack type. Note that there is a black lead coming from a hole marked *G* and a red lead from a hole marked *A*. The black lead is connected to the chassis of the receiver (not the GND post) using a clip if you wish. The red lead is connected to the ANT post of the receiver. It is important to keep the leads from the receiver coupler to the chassis and ground post as short as possible. The wire supplied with the coupler is of the correct length and should not be lengthened. These instructions must be followed carefully—if you want to retain the noise reducing properties of this arrangement.

Connect the regular ground to the GND post of the receiver. Having connected the red and black wires of the receiver coupler to the antenna post and chassis of the receiver, your next step is to connect the two leads from the *A* and *G* holes to two of the tip jacks. With the receiver turned on, a trial should be made using the black and red wires connected to A_3 and A_2, A_2 and A_1 or A_3 and A_1. One of the combinations will prove to be best. However, in the majority of instances, best results will be had from inserting the tip of the black wire in A_3 and the tip of the red wire in either A_1 or A_2 and then leaving them there.

Before leaving the set with the customer listen in with him for a few minutes for distant broadcast and short wave programs. Usually a tremendous improvement is noticeable. Signals unheard before become audible.

How To Erect an All-Wave Noise-Reducing Antenna in a Limited Space

Thanks to the ingenuity of radio engineers, we now have all-wave antennas that can be used in a limited space, provided, of course, that you can erect two supports for the straight-away at least 45 feet apart. A Lynch all-wave antenna coupling system is shown in Fig. *4*. Only the basic parts, including the special double cone shaped antenna transformer, 50 feet of transmission cable and a receiver coupling transformer are shown. You are required to supply the antenna wire, nail-it-knobs, stand-off insulators, antenna insulators and insulated staples, etc.

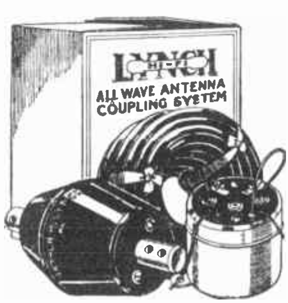


FIG. 4

Figure *5* gives you a general idea how the all-wave antenna system is connected. It is called by Radio-Tricians "a doublet antenna." The straight-away consisting of the antenna coupler, the two 20.5 foot lengths of aerial wire, and the end insulators, placed far above surrounding objects and roofs. It is the ideal system to string between two peaks of the ordinary sloping roof house, the end supports being iron pipe masts 4 to 6 feet in height, as shown in Fig. *6*. Whenever possible try to have the straight-away so positioned

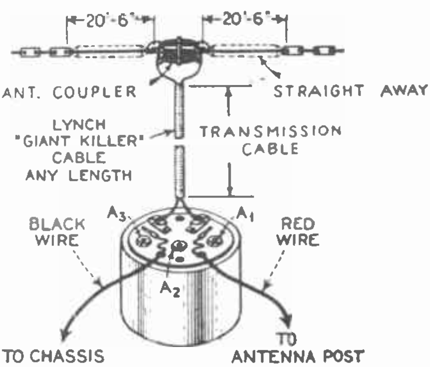


FIG. 5

that the antenna coupler is above the lead-in window. This, as stated previously, reduces the length of the transmission cable. Of course, the transmission cable can be any length you wish, even 500 feet, if expense is no objection.

One or more insulators may be used at the ends of the 20.5 foot length of antenna wire. The idea is to prevent the extension from absorbing the radio signals, especially on very short waves.

Each length of the antenna may be made of a 21 foot length of heavy aerial wire. Insert one wire through one insulator eye for about 4 inches from the end and close the loop by twisting the free wire around itself. The other end is passed through an end eyelet of the insulator which passes through the antenna coupler as shown in Fig. 7. About 8 inches of wire is required. Make a snug loop hook curling the free wire over the main wire and attach the free end to A_1 or A_2 of the antenna coupler depending on what side you are working on. The other straight-away wire is prepared in the same manner.

angle for a distance of at least 25 feet. This is to enable each portion of the doublet antenna to work properly. The antenna circuit will then be balanced. Using stand-off and nail-it-knob insulators, fasten the cable to the side of the house. Pass the cable through a porcelain insulator where it goes into the house, and

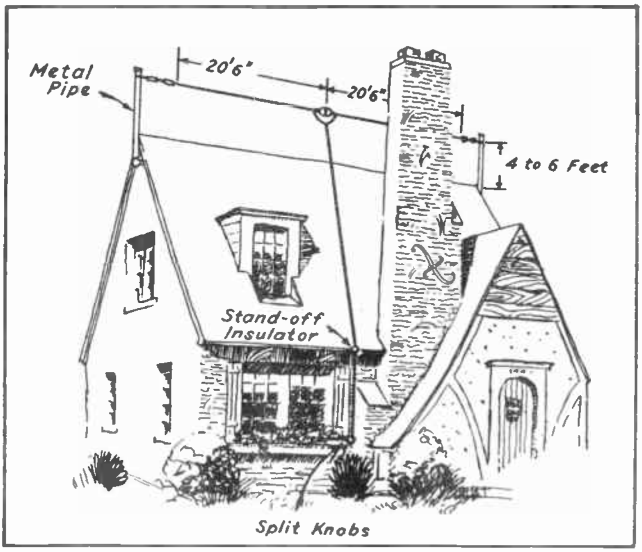


FIG. 6

A foot of the external insulation is removed from one end of the cable and about 5 inches of the insulation of each wire removed from the ends. The bare leads are slipped through the second hole in the insulator of the coupler, wrapped around itself and to terminals L_1 or L_2.

Now you may proceed to string up this doublet antenna. Do not let the transmission cable become twisted or broken in any way. Assuming that you are erecting the antenna to the roof shown in Fig. 6, I would attach a long strong string or rope to each end of the doublet. Then I would place the coupler at the edge of the roof directly under its final position. Of course, the coupler should be propped up to prevent it from falling. Holding the string or rope of one end of the doublet, I would go up to the proper mast, pull the wire up and anchor it to the mast, but I would not pull the coupler off its resting place. Now I would repeat the process for the other wire, this time pulling the aerial up in place. Returning to the other mast, I would pull the doublet firmly in place.

The transmission line should leave the doublet antenna at approximately a right

tack it indoors to the woodwork by insulated staples.

Attach the receiver coupler near the antenna and ground posts of the receiver and connect the cable to coupler and the coupler to the receiver as explained in the previous job. The ground wire from the water pipe may be connected to the GND post of the receiver.

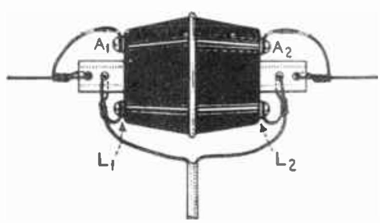


FIG. 7

Determine which of the A_1, A_2, A_3 combinations gives the best average signal.

Should you run across a receiver with *two* ANT and *no* GND posts, connect as follows. From the two Fahnestock clips continue a short piece of cable to the two *ANT* posts. Connect jack A_3 to the ground.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ◆ WASHINGTON, D. C. ◆ PRACTICAL JOB SHEET

How to Install Electric Time Switches for Controlling Radios

Every one is familiar with the ordinary electric clock, but few know that it is now possible to purchase, at very reasonable prices, combination clocks and electric time switches which will turn a radio or electrical appliance on or off at any predetermined time. Since the installation of one of these timers is simple and requires only a few minutes, an alert radio man can make a nice profit on each unit sold.

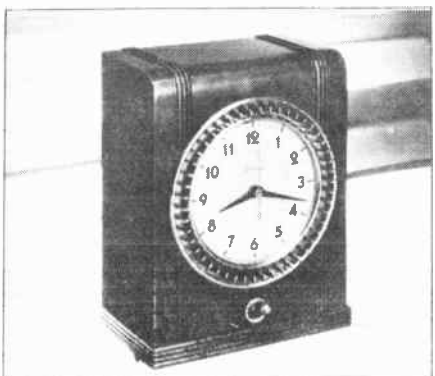


FIG. 1. Telechron Model 8B53 "Organizer" household time clock, made by Warren Telechron Co., Ashland, Mass., for controlling radio receivers and low-power electrical appliances.

Two distinct types of time switches for home use are now on the market; one type has a twelve hour dial like an ordinary electric clock, while the other, more like a commercial time switch, has a twenty-four hour dial.

An example of the first type, the *Telechron* unit, appears in Fig.*1*; the unit sells for less than ten dollars. There are forty-eight keys arranged around the face of the clock dial, one corresponding to each fifteen-minute period of time. Pulling out a key causes the switch in the clock to close for that fifteen-minute period of time to which the key corresponds; for example, with the 12:00-12:15 key pulled out, and a radio connected to the unit, the radio would be turned on automatically at 12 o'clock and turned off at 12:15. If more than one successive key is pulled out, the radio will operate for the corresponding number of fifteen-minute periods. If a listener desires to hear certain programs which are scattered through a half-day period, he need only look up the times of these programs in the daily newspaper and pull out the corresponding keys; the clock will do the rest, turning the radio on at the beginning and off at the end of each desired program.

To install the Telechron time switch, you need only plug the power cord of the clock into a wall outlet and plug the radio set power cord into an outlet provided at the back of the time switch. The manual toggle switch just below the clock dial shorts the contacts of the time switch, allowing the radio set to be operated independently of the electric clock without changing any connections.

Remember, a time switch like this does not *tune* the radio; it simply controls the power to the receiver. The automatic turning on of the set usually attracts the attention of the listener, however, and he can easily retune if an undesired station is heard. This clock will repeat its switching operations twice a day, so it is customary to turn off the toggle switch after the last desired program in a twelve-hour period has been heard. Many people use an automatic time switch like this as an alarm

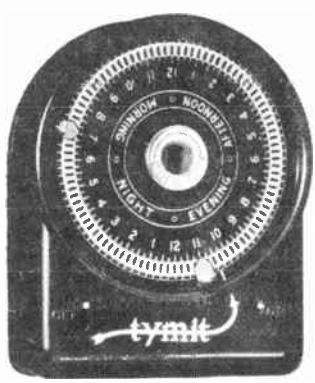


FIG. 2. Model No. 6 "Tymit" electric clock-operated time switch with 24-hour dial, made by the Tork Clock Co., Mount Vernon, N. Y.

clock, setting it to turn on the radio at the desired time in the morning; the essential requirement is that the time at which the clock is set and the time at which the switch is to operate be not more than eleven hours and forty-five minutes apart. The contacts on this unit are designed to handle safely the power drawn by any radio receiver.

One example of the twenty-four hour type of switch, known commercially as "Tymit," is illustrated in Fig. *2*; the power cord of the unit is plugged into any 110 volt A. C. wall outlet and the device to be controlled, such as a radio set, is plugged into a receptacle at the left side of the switch unit. The circuit diagram of this unit, shown in Fig. *3*, is representative of

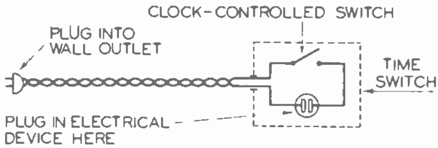


FIG. 3. Circuit diagram of a typical household electric time switch.

that for all simple electric time switches. While this unit can be used as a timepiece if desired, its chief utility lies in its automatic switching.

There are two manual switches, with interlocked action, on the face of the unit; one turns on the automatic switch feature and the other disconnects it. A synchronous motor-driven electric clock inside the unit rotates the entire dial face, on which are divisions for every fifteen minutes of the day, as well as notations for morning, afternoon, evening and night. There are two movable pointers, one being set to the time at which the switch is to turn on the radio, and the other being set to the time at which the radio must be turned off in a twenty-four hour period. To start the clock (it does not have a self-starting movement like the Telechron unit) it is only necessary to lift and release a lever on one side of the unit.

The unit contains a single pole switch with pure silver contacts arranged to give a quick make and break, and capable of handling currents up to 6 amperes (600 watts at 110 volts). The price of this unit is less than ten dollars, but this price, like any price quoted in this job sheet, is of course subject to change; a model giving two off-and-on operations a day is available for one dollar extra. For handling more than 600 watts of power, it is necessary to use a commercial clock timer, having essentially the same clock movement but using mercury tube switches in place of contacts.

Many other uses for electric time switches almost suggest themselves. A unit can be used to turn on certain lights in the home at night when the family is away, to ward off burglars; some use a time switch to turn an oil burner off at bedtime and on again early in the morning, to turn poultry house lights on for predetermined periods of time in the evening or before sunrise, to defrost the refrigerator regularly each day, or to control the operation of electrical appliances such as small heaters, fans, bells, small electric advertising signs of all kinds, etc.

When ordering an electric time switch it is wise to specify the use to which it will be put. Standard electric clock switches are made for 110 volts, 60 cycle operation; models having eight or ten-day hand wound clock movements are also available, but usually at higher prices than the more widely used A. C. models. Hand wound time switches designed especially for controlling poultry house lights can be obtained from mail order houses like Sears, Roebuck & Company or Montgomery Ward, and sell for about twenty dollars.

When and How to Install Antennas and Antenna Eliminators

Sooner or later you are going to hear about the supposedly marvelous reception you can get on a modern radio receiver with a wire thrown about the window frame, a "gadget" plugged into a power outlet, or any of the other queer-shaped gadgets which I call "make-shift" antennas.

Yes, there is a need for such devices, but if you will take my advice you will only consider them when an outdoor antenna cannot be installed. Here is the reason why: Manmade static, the radio bugaboo, is the radio signal killer and is quite prominent in most localities. If it were not for this noise, radio reception would be more reliable and enjoyable. When you have a good antenna, you pick up enough of the radio signal to make the undesirable noises less prominent. With a make-shift antenna you can generally receive local stations satisfactorily (and at night those within an area of less than one hundred miles), but in most locations the programs from distant stations will be mixed with noise sounding like rain on a tin roof.

When are make-shift antennas useful? When the straight-away part of the antenna breaks away from its support on a stormy day and the roof is so covered with snow or ice that you don't dare go up to make repairs, you are justified in using a "gadget" antenna, provided the set owner will be satisfied with temporarily less reliable reception. If you rent a receiver for a short time and the customer does not care to pay for the erection of a good aerial, then a make-shift antenna will have to be satisfactory.

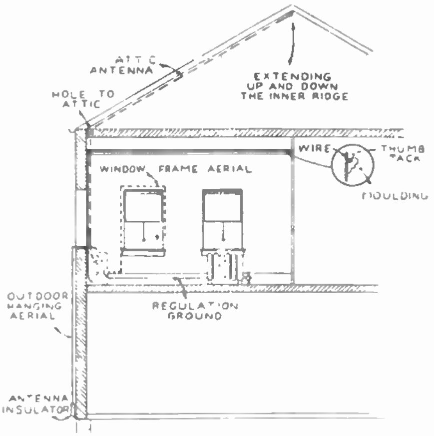


FIG. 4. When a standard outdoor antenna is not practical, consider one of the three make-shift antennas illustrated here.

If the house owner won't allow an outdoor aerial to be erected (fortunately these individuals are becoming scarce nowadays), then an indoor antenna is about all that can be used. But tell your customer what to expect. When you start to sell radios, try not to demonstrate on a make-shift antenna. In a noisy location the chances are that you will lose the sale, through no fault of yourself or the set. Give your set a chance to perform!

Now that you know there is a place for make-shift antennas, I will tell you more about their construction and placement. There are, generally speaking, two classes of make-shift antennas. One class consists of the indoor antenna, which is usually a wire laid in and around the moulding of a room, a wire running around a window frame, or one that is strung up in the attic. In either case a regular ground connection is needed. Indoor aerials are usually much shorter than outdoor aerials. They work very much like the outdoor aerials, but of course the signal picked up is much weaker, due to the short length and to the shielding effect of the house and its contents. Indoor antennas are particularly unreliable in steel buildings or in houses with metal roofs or metal lath construction.

The other class of make-shift antennas consists of aerial eliminators and devices which you plug into a power outlet, or those that can be connected to a radiator, gas pipe, telephone box or just a ground terminal. These aerial eliminators do not always work as efficiently and satisfactorily as a good indoor aerial. However, in some locations an aerial eliminator will work very well. It is extremely difficult to say when or where the aerial eliminator will work the best. There is no set rule that can be applied and a trial seems to be the only reliable method of finding out. The aerial eliminator combinations are generally noisy because the power line or whatever you employ as the pick-up is right in the region where the noise originates.

Let me tell you about the installation of some of these make-shift antennas. The indoor aerial consists of about thirty to fifty feet of insulated copper wire of approximately No. 20 or No. 18 gauge, run around and set into the picture mouiding of the room where the set is used. To make the presence of the wire less noticeable, select a covering color to match the wall. Fasten the wire to the wall with insulating staples, or with thumb tacks having colored heads.

Figure 4 illustrates how an indoor aerial can be run up a corner of the room to the picture moulding, then pushed down into the moulding so it will be out of sight; use tacks at frequent intervals to keep it down. The aerial should only extend around two walls of the room. If you prefer, you may

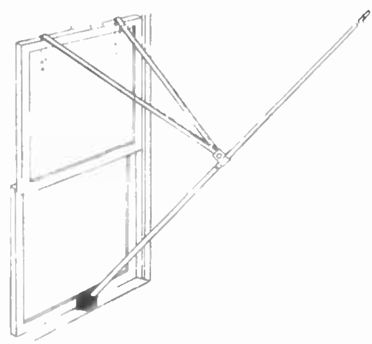


FIG. 5. A fishpole type antenna for temporary use, such as while demonstrating a radio receiver in a home, is illustrated here.

tack the aerial wire to the baseboard instead of running it up to the moulding.

Figure 4 also shows an aerial run around three sides of a window frame; this procedure is suggested for rooms where there is no picture moulding. Several thumb tacks are used on the sides and top of the window frame to hold the insulated copper wire in position.

For rental radios it is more convenient to use the outdoor hanging antenna shown in Fig. 4; this antenna is also recommended when the regular outside antenna has broken down. A light weight, such as an insulator, is tied to the lower end of the outside wire, this weight being kept at least one foot above the ground. You can tie the lower insulator to a nail driven in the wall. This will eliminate swaying in the wind. Be sure the aerial does not cross telephone or power wires.

For the unfortunate radio set owner whose landlord objects to outdoor antennas, the attic antenna shown in Fig. *4* should be recommended. Your greatest problem will be in leading the wire into the attic. As a last resort, a small hole can be drilled through the ceiling.

The fishpole window aerial shown in Fig. *5* is another favorite. This is primarily a device for home demonstrations, being neat, easily erected and more successful

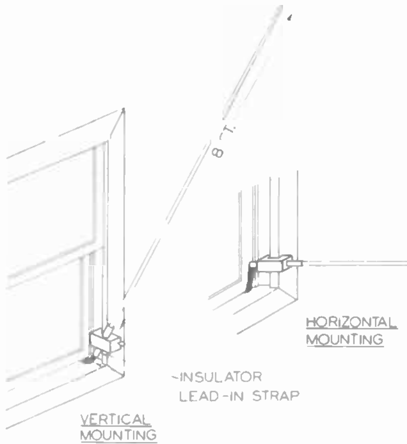


FIG. 6. Tobe window pole antenna, made by the Tobe Deutschmann Corp. for use in apartment buildings; it is especially useful to radio dealers who need a temporary antenna for a demonstration or for use with a rental receiver. The clamp attaches to the window frame, and permits mounting the 8-foot antenna rod in either a horizontal or a nearly vertical position.

than most of the other make-shifts. Another fishpole antenna, better suited for permanent installations in apartment buildings, is shown in Fig. *6*.

Now let me tell you about the so-called aerial eliminators, which are not really aerial eliminators since they make use of the power line to pick up radio waves. The outlet to which the radio power plug is connected has two leads, one of which is usually grounded; the other lead will pick up radio signals. If the outside wiring is exposed (as on poles) excellent pick-up is generally obtained, although plenty of noise may ride in.

The simplest way of using this picked-up radio energy is to connect the receiver antenna post to the ungrounded power line lead through a condenser of small capacity. The connections are shown in Fig. *7*; you will need a .001 mfd., 600-volt condenser, an ordinary two-prong electrical plug, and enough flexible insulated wire to run from the wall socket to the antenna post. Be sure to connect the ground post on the receiver to a good ground. Reverse the plug in the wall socket a few times, selecting the position which gives the best pick-up.

Most of these so-called aerial eliminators are much like that which I just described, but are placed in metal or non-metal housings to improve their appearance and sales appeal. A typical commercial device and its internal electrical connections are shown in Fig. *8*. The device is merely plugged into a wall outlet and the power plug from the receiver inserted in the device. A long, flexible lead or a binding post to which a lead can be connected, serves as a connection to the

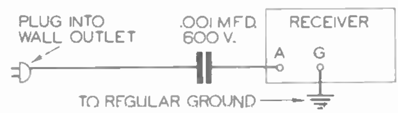


FIG. 7. A condenser connected like this, between the receiver antenna post and one side of the power line, often gives satisfactory signal pick-up.

receiver antenna post. The device must be reversed in the wall socket as before, to find the best position. The R. F. choke coil *L* is used in the better aerial eliminators, for it serves to prevent radio signals from entering the power system of the receiver and forces the signal through

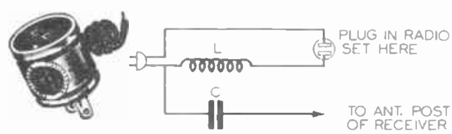


FIG. 8. A typical commercial "antenna eliminator" (left) and its circuit diagram (right).

condenser *C* to the receiver antenna post.

Very often the aerial can be eliminated by simply connecting the ground lead to the antenna post, leaving the receiver ground post without any connection to it.

Reversing the power plug will often improve signal pick-up, but if satisfactory signals are not obtained, this scheme must be abandoned. Oftentimes sufficient pick-up for local reception can be obtained by connecting the antenna post of the receiver to the wall plate of an electrical outlet.

Again let me stress the fact that the effectiveness of any of these aerial eliminators can only be determined by actual experimentation. The design of the different sets and the nature of the power line as it enters the house or the receiver determines whether or not sufficient energy can be picked up from the power line and ground terminal leads.

As a final word of caution, never use a make-shift antenna when an outside aerial can be installed.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE • WASHINGTON, D. C. • PRACTICAL JOB SHEET

How to String Antennas to Various Types of Support

Radio servicing is fascinating because every job is different. "What's next" is on the tongue of the service man. Antennas are no exception, for every installation has its special problems. The differences in antenna jobs are due to the construction of the home or the apartment, and the location of surrounding buildings or trees.

You may have to string the straight-away from a chimney to a garage, a chimney to a tree, a gable of the house to the gable of a nearby house. You may have to string the straight-away between two poles erected on the house; you may have to string the straight-away across an alley. Size up each and every situation and decide on the best means of supporting the straight-away. You will find it, in most cases, quite easy.

Here are a few facts that you should bear in mind. The straight-away should be about sixty feet long; twenty feet longer or ten feet shorter will hardly make any difference in radio reception. The straight-away should be as far above the roof and surrounding objects as you possibly can put it. As a general rule, one support should be directly above the window to which the antenna lead-in is to go. The other support should be selected so the aerial wire will lead away from the most favored station, but it is hardly worth while going to a lot of trouble to do this. Keep the aerial straight-away as far from any outside power wires as you can and if this is not possible, run it at right angles to the power wire. Never set up the aerial so that if it were to fall accidentally, it would lie across a power wire.

You'll get the knack of doing this work after you have erected two or three antenna systems. Most radio men who master the practical radio theory that you get in your lessons, learn to do the right things, for it becomes a second nature. But now let me give you a few practical examples on stringing antennas.

1. Imagine, if you will, a tall tree seventy-five to one hundred feet away from the house. To give you a better view of the situation, look at Fig. *1*. Notice that the chimney has several small smokestacks. I would loop a No. 14 galvanized iron wire around one of the stacks. Allow a five or six foot extension, to which is attached the insulator of the prepared straight-away and lead-in wire. You already know how to prepare the straight-away and lead-in wire and how to lead the lead-in wire to the receiving set.

Now let us consider the anchoring of the far end of the straight-away to a tree. The insert in Fig. *1* shows you how to do this. While on the ground, prepare the section shown in the insert. You will need an insulator, an antenna coil spring which can be purchased from any radio supply house, some galvanized wire and a rope. Pull the aerial wire through the insulator and loop the wire firmly in place,

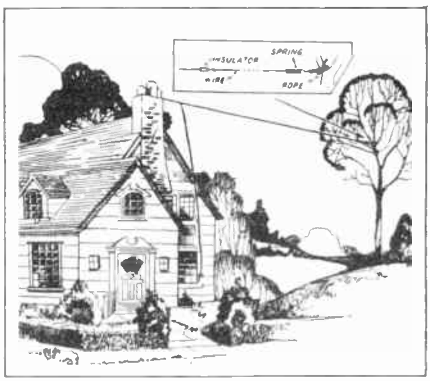


FIG. 1

but be sure that the straight-away length including the insulator is such that when drawn into place they will be outside of the branches and leaves of the tree.

Also while on the ground, decide on a sturdy branch which you will use to support the antenna. Select one that is about the same level above the ground as the support on the roof of the house. This will put the straight-away in a level plane. Now, enough rope with the galvanized wire should be used to allow you to reach the base of the tree trunk. If the rope is not long enough, a piece can be temporarily added so that you can take it to the branch selected and anchor the far end of the antenna with the galvanized wire to the branch as shown. Do not pull the antenna too tight. Let the spring have some play when the tree sways.

2. Suppose you were called upon to erect an antenna where there are no nearby trees, house nor garage. A solution is shown in Fig. 2. This installation will not be difficult once you get the supports in place.

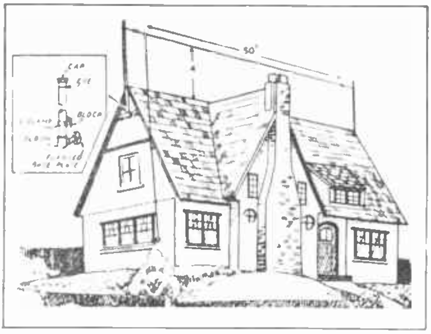


Fig. 2

You can buy iron pipe supports of the proper size and length from a supply house, or you can get them from a plumber who will cut them the right length for you. You need 6 feet of 1½" galvanized iron pipe; a screw eye bolt; a right angle elbow; a flanged base; a pipe cap; and a small piece of pipe threaded at both ends to connect the elbow and the flanged plate. This pipe is erected as shown, the pipe sticking up above the roof about 4 feet. In this installation two such assemblies are needed.

You will need an extension ladder, large wood screws, prepared blocks of wood, screw driver, hammer and nails to complete the erection. All this will be obvious when you get on the job.

The vertical pole (iron pipe) should not rest against the overhanging shingles but against a wood block nailed near the top of the house.

When the poles have been erected, prepare the straight-away and lead-in wire in the usual way. Fasten the lead-in end to the pole above the window to which the lead-in is to go. Attach a rope or strong string to the other end of the straight-away and fling the straight-away across the roof. Holding the string, go up to the other support and after fastening an antenna insulator to the second pole, draw the straight-away into place and fasten the aerial wire to the insulator in the approved manner.

Now you may proceed to the lead-in wire and the rest of the installation.

3. You may have to erect and string an antenna system atop an apartment or tenement house. Assume that no vertical projections are available but are needed, if the radio owner wishes to have the best possible results. The answer to this problem is clearly seen in Fig. 3. Note that each pole is guyed with three galvanized iron wires broken with strain insulators. In this installation two 10 foot poles are required; 2 x 3 inch wood poles free of knots may be used, although 1½ inch galvanized pipe is recommended. In many towns and cities the use of iron pipe is compulsory. They are not a fire hazard. If pipe is used, you will need two flanged base plates, two pipe caps and two 10 foot pipes, the upper end of each pipe drilled with four holes to take four screw eye bolts, one for the straight-away and three for the guy wires.

Either type pole requires a small baseboard about one foot on each side and about 1 inch thick. In the case of a wooden pole, a spike driven through the baseboard into the pole is used in keeping the base of the pole on the base plate. With the iron pipe screw the flange on the pipe to the board. The wood base should not be nailed down to the roof. The down pressure created by the pipe and guy wires is sufficient to prevent the pole from slipping away. The guy wires are anchored as shown. You won't have any difficulty in finding anchoring points if you are working on a frame house. In the case of a brick house, 3 inch expanding bolts (lag bolts) may be used. Simply drill a hole into the mortar between two bricks using a star drill. Place the lead wedges provided with the lag bolts into position and then screw the lag bolts in tight. Leaving about one inch of the 3 inch lag bolt projecting, tie the guy wire around the head. These lag bolts can be obtained from your local hardware store.

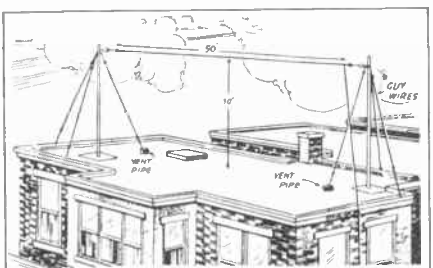


Fig. 3

In stringing the elevated straight-away, you may use a pulley and cord at each pole or anchor the prepared straight-away directly to the tops. Use whichever method is more convenient. Some servicemen lead the down lead-in wire through a stand-off insulator screwed to the edge of the roof as shown in Fig. 3; some allow the wire to press against the edge but protect the wire with a porcelain tube. The rest of the installation should be quite simple to you by now.

4. Most servicemen do not want to go to the trouble of erecting poles. In fact, many customers will not tolerate the expense. In those cases you will have to look around for other supports. Figure 4 is an example where advantage is taken of the surroundings, in this case a clothes

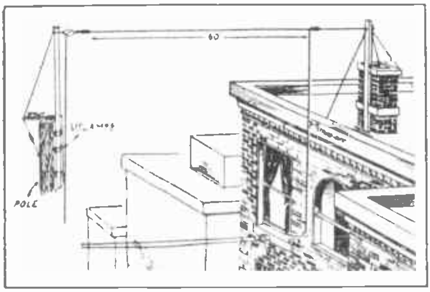


FIG. 4

pole and the chimney. If I were on this job, I would put an 8 foot extension on the clothes pole, assuming that it was safe to climb to the top. I would have two or three U shaped brackets made by a blacksmith or machine shop. The U brackets should be just large enough to allow a 2 x 3 inch pole to slip through them. I would loosely screw or bolt these brackets near the top of the clothes pole. Then I would slip the 8 foot pole through the U brackets and screw on the pulley with its rope, the guy wire screw, eye bolt and then attach the guy wire. I would then push the pole up in place, tighten the U bolts, then nail the bottom part of the pole to the clothes pole. Now I would nail a strut to the top of the clothes pole and place the guy wire in place as shown.

Although a wood pole is shown for the roof end of the straight-away, a galvanized 1½ inch pipe anchored to the chimney would be much better. It can be held in position with a guy wire arrangement or fastened to the chimney with lag bolts fitted with U clamps. These lag bolts are inserted as previously explained.

Prepare the straight-away and lead-in wire in the home in the usual manner. A little thought should be given to the position of the lead-in wire connection to the straight-away. Select a position which will allow the wire to drop vertically down along the side of the house.

In stringing the straight-away, start at the chimney, leaving the coiled lead-in wire on the roof. Attach a strong piece of string to the free end of the straight-away and drop it to the ground. With the string and free end of the straight-away, climb to the top of the clothes pole, attach an insulator to the pulley rope and attach the aerial wire. After pulling the straight-away into place, fasten the pulley rope to a nail and proceed with the lead-in wire and the remaining portion of the installation.

How and When to Install a Good Outdoor Ground

A good ground is an indispensable part of an antenna system. This you know. But what are you to do, when what you would consider to be a good ground is 40 to 100 feet or more away. A general rule to follow is that the ground lead should be as short and direct as possible. In a number of cases an outdoor ground would be far more satisfactory than any indoor ground that you could use. Here are a few examples to help you realize what the problems may be like.

Suppose you had to install a radio in one of those apartments or flats, as they are called in some localities of this country, where the living room is at the front of the house and the kitchen or bathroom is at the other end, or about 50 to 60 feet away. If the lead-in window is about 30 feet above the ground level, an outdoor ground should be erected.

The farmhouse is another example where an outdoor ground should be used. About the only ground available in the house is the kitchen water pump which may be some distance from where the radio is to be placed. I would even consider the pump less satisfactory than an outdoor ground directly under the lead-in window. The house on the outskirts of a town, the summer cabin, a camp house, recreation rooms and halls offer similar problems, which you will, with a little experience, recognize at first sight.

FIG. 5.—*Ground Rod and Clamp*

In fact, an outdoor ground is so reliable, so simple to install, that you may prefer to use it in many cases where you doubt the value of a radiator or a gas pipe as a ground terminal.

What is an outside ground? Nothing more or less than a six foot galvanized pipe or heavy iron rod driven into the earth so that about four inches of it sticks out, to which part the ground clamp is attached. The ground stake is usually placed about 12 inches away from the wall of the building.

Figure 5 shows a ground rod that can be purchased from any electrical supply or radio mail order house. The rod is about six feet long, galvanized, with a sharp point at one end.

A 6 foot long, 1 inch diameter, galvanized water pipe may be used as a substitute, which you can obtain from your local plumber. He should prepare the pipe as shown in Fig. *6*. Ask him to put on a metal pipe cap. To do this he will have to thread the end of the pipe. The other end of the pipe should then be hammered flat to form a wedged point to allow this end to be easily driven into the ground.

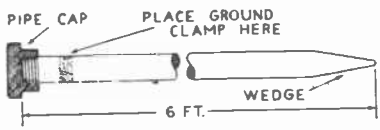


FIG. 6

With either type of ground stake, a ground clamp *must* be employed. The clamp is identical to those employed in making ground connections with the radiator or water pipe. Before applying the clamp, file the surface clean at the point of contact. After the connection to the ground wire is made, cover the entire clamp with paint. This will prevent corrosion.

It is important to place the ground rod or pipe directly below the lead-in window or at a position near this window. This will make the ground lead as short as possible. Place the point of the ground stake about a foot away from the building directly in front of the ground terminal of the lightning arrester and drive it in with the blunt end of an axe or sledge-hammer. You will need to stand on a four foot step ladder, chair or box at first in order to get the proper vantage or swing. Short swings at the start will drive the stake in straight. Figure 7 shows you how the finished job should look.

The use of a galvanized iron pipe or rod is not the only means of getting a good outside ground. Here are a couple of different outdoor grounds.

An old automobile or steam heating radiator makes an excellent ground. The radiator is buried about five feet below the surface of the earth and six or more feet away from the building. A No. 10 copper rubber covered wire is soldered to the grid of the automobile radiator or to the pipe of the home radiator. To do this you need a blow torch. Extreme care must be exercised so the wire does not become broken. The original earth is then used in covering the radiator. After you have filled in about a foot or two, stamp the ground down with a heavy wood block nailed to a broom handle. It is well to stamp the earth down again after you have filled in the next foot.

Neither a ground rod nor a buried radiator will suffice in a dry or rocky place as we meet in some sections of the country. The best arrangement in such a case is to place a 50 foot length of No. 10 B & S bare copper wire in a narrow ditch approximately 18 inches deep. One end of the 50 foot length of the ground wire is connected to the ground terminal of the lightning arrester. The other end is extended out along the bottom of the ditch. After you have completed the ditch, then the 50 foot length of wire may be laid in and the original earth used to cover the wire.

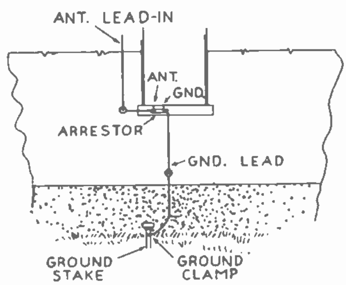


FIG. 7

The ditch should be dug directly under and in the same direction as the antenna, if it is at all possible.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

Service Hints for Universal Receivers

MANY thousands of midget universal A.C.-D.C. receivers have been and are still being sold to the public. In most cases no service information whatsoever can be secured. Fortunately, however, these receivers all have more or less the same T.R.F. circuit with four or five tubes, and minor variations in the circuits are quite easy to recognize. This job sheet gives you the basic circuits and the common variations, then shows how you can service these universal T.R.F. receivers without the aid of circuit diagrams.

Signal Circuits. As a general rule, the signal circuits in a universal T.R.F. receiver are extremely simple; the typical circuit has one R.F. amplifier stage, a detector stage, and an audio output stage, as shown in Fig. *1*. The R.F. amplifier tube is usually a super-control pentode such as the 78, 6D6 or 6K7, having a 6.3 volt filament. There are two tuned circuits, controlled by a two-gang variable condenser; one couples the antenna to the input of the R.F. stage, and the other couples the R.F. stage to the detector. The volume control circuit simultaneously varies the antenna input voltage and the gain of the R.F. tube. A regular R.F. pentode tube such as the 6C6, 77, or 6J7 is used in the high-gain detector circuit. The detector feeds through resistance-capacitance coupling into a high-gain power audio amplifier tube, which may be a 38 or 43 pentode or a 25L6 beam amplifier tube. An electrodynamic loudspeaker coupled to the audio output by an impedance-matching transformer is most common, but you will also encounter magnetic loudspeakers which are connected directly into the plate circuit of the power tube.

Universal receivers usually have an antenna consisting of about twenty feet of flexible insulated wire which comes wound on a fiber card and connected to the receiver input circuit through a small tubular or mica condenser; this wire should be unwound and dropped out of a window, tacked around a window or wall, or placed under a rug. Satisfactory reception can often be obtained simply by connecting this aerial wire to a radiator or other ground.

Two distinct types of grounding systems are employed in universal receivers. In the type represented by Fig. *1*, the chassis is not an electrical part of the circuit; the ground symbols in the diagram simply indicate a connection to a common wire which serves as the return path for signal currents. In the second type of grounding system, the chassis is the common return path for signal currents. One side of the power line is directly connected to the chassis, so for one position of the power cord plug, the chassis

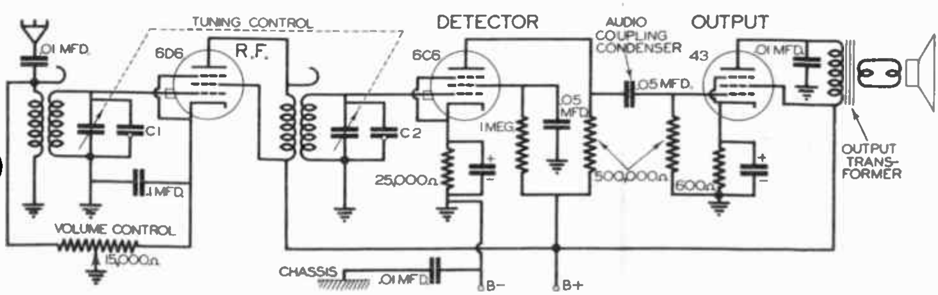


FIG. 1. Signal circuits of a typical universal T.R.F. receiver. Alignment simply involves tuning in in station, then adjusting trimmer condensers *C1* and *C2* (mounted on the gang tuning condenser) for maximum output volume.

will be "hot" (connected to the ungrounded side of the line). Under this condition a shock may be felt if some part of the body is grounded when the chassis is touched. Never connect the chassis to an external ground, for this may short-circuit the power line.

Power Supply Circuits. In a universal receiver, the power pack must rectify the A.C. line voltage and deliver the maximum possible rectified voltage to the tubes. Furthermore, since the tube filaments in these receivers are always connected in series, and since the sum of the required filament voltages for the tubes is considerably less than the A.C. line voltage, the power pack must limit filament current to the correct value. Rectifier tubes having 25-volt filaments, such as the 25Z5 and 25Z6, are quite popular, as also is the 12Z3 tube which employs a 12-volt filament. Sometimes a "dummy" tube is used to reduce filament current and give the added sales appeal of an extra tube, even though this is not good engineering practice. Dummy tubes are easily identified by their socket connections; only the filament terminals will be connected into the receiver circuit.

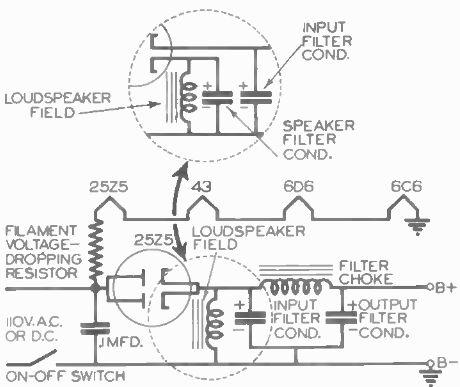


FIG. 2. One type of power supply circuit commonly found in universal receivers. Alternative loudspeaker field coil connections are shown inside the dotted circles.

A typical power supply circuit for a universal receiver is shown in Fig. 2. A 25Z5 tube is connected as a half-wave rectifier; the unfiltered output is fed directly to the loudspeaker field coil, while the output of the filter system is fed to the tube electrode circuits. The 25Z5 and 43 tubes each have 25-volt filaments, while the other two tubes have 6.3-volt filaments, making the total filament voltage requirement about 63 volts. The filament voltage-dropping resistor must therefore drop 115—63, or 52 volts, in order to keep the current at the correct value of .3 ampere. Knowing the voltage across the resistor and the current through it, Ohm's Law gives the correct resistor value as 52 ÷ .3, or 173 ohms; increases of up to 10% in this resistance value are permissible when an exact-size resistor is not available. This resistor may be a wire-wound resistor mounted on the chassis, a ballast tube (a resistor in a glass or metal envelope), or a line cord resistor having resistance wire imbedded in asbestos and placed in the receiver power cord along with the usual two copper wires. Ballast tubes are favored by most manufacturers, for they give the impression that the set contains an additional tube.

A resistor is sometimes used in place of the filter choke in Fig. 2, but when this is done the plate D.C. voltage for the power tube is obtained ahead of the filter system by a direct connection to the cathode of the rectifier tube. The field coil of the dynamic loudspeaker is occasionally used as a filter choke, in which case its D.C. resistance is made sufficiently low to prevent excessive drop in the rectified voltage. Sometimes the two diode sections of the 25Z5 tube are used separately, one section for the tube circuits and the other to supply field coil excitation; in this case an extra filter condenser is connected directly across the loudspeaker field coil, as indicated in the dotted circle in Fig. 2. There will usually be a condenser (about .1 mfd.) across the power line to keep out line noise.

A type 37 triode tube with gride and plate connected together is sometimes used in the power pack as a half-wave rectifier; with this arrangement or with a single 12Z3 rectifier tube there will usually be a magnetic loudspeaker, for these tubes cannot supply sufficient current for field excitation of a dynamic loudspeaker without failing prematurely.

When a filter choke is used, the drop across this choke is often made to serve as the C bias for the power tube. The choke would in this case be located between the negative lead of the output filter condenser and the on-off switch, with the grid circuit of the power tube connected to the switch terminal.

The screen grid and plate of the R.F. tube usually get the same D.C. voltage, but sometimes a resistor is inserted in the screen grid lead to lower the D.C. screen grid voltage.

The screen grid voltage on the detector tube must be lower than the D.C. plate voltage; this lower voltage is secured either with a series resistor as indicated in Fig. *1* or by connecting the detector screen grid to the positive end of the cathode resistor for the audio output tube in the manner indicated in Fig. *3* (this point is sufficiently positive with respect to the detector cathode to meet detector circuit requirements).

If a magnetic loudspeaker (or a dynamic loudspeaker having the field coil connection shown in the dotted circle in Fig. 2) is used with the detector arrangement in Fig. *3*, there will be no continuity between the detector screen grid terminal and the cathode of the rectifier tube. All other plates and screen grids will trace to the cathode of the rectifier tube, however, and the control grid, cathode, and suppressor grid terimnals will trace to the power switch, which is the B— terminal. Remember these facts when checking continuity of electrode circuits in universal receivers.

Pilot lamps used in universal receivers are generally connected in series with the tube filaments; the lamps are not designed to handle the usual filament current, and hence are shunted by a resistor in the manner indicated in Fig. *4A*. When a ballast tube is used, a tap is provided at the proper point on its resistor for a pilot lamp connection, as indicated in Fig. *4B*. When a pilot lamp burns out, replace it with a lamp having the same voltage rating and the same color of glass bead around the filament supports. When a ballast tube burns out, replace it with one having the same code number.

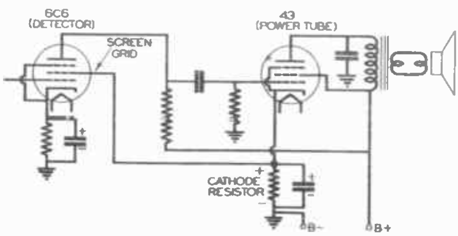


FIG. 3. Detector and output stage of a universal receiver, showing a simple but entirely satisfactory method for getting a low positive screen grid voltage for the detector tube.

Replacing Filter Condensers. Electrolytic filter condensers are more likely to become defective than any other part in a midget universal receiver. All electrolytic filter condensers are usually grouped in a single block. When one condenser in a block becomes defective, it is advisable to replace the entire block, as the other sections will very likely fail in the near future. Whenever an exact replacement filter block can be obtained, it should be used. Ordinarily there will be no identifying numbers on the condenser filter block; in this case the following procedure will enable you to order a suitable replacement.

Make a sketch of the old condenser block, showing all of its leads. Trace each of these leads in the receiver and determine the type of power pack circuit used. Now draw in the internal connections for the condenser block (this will be easy once you become familiar with the power supply circuits used in these sets), and indicate on your diagram the polarity of each lead and the condenser section to which it belongs. Now you can

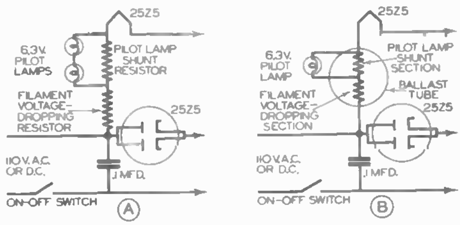


FIG. 4. Pilot lamp connections for power supply circuits employing a filament voltage-dropping resistor (*A*) and a ballast lamp (*B*).

place on your condenser block sketch the approximate capacity values for each section. Use the following general rules as your guide: *Input Filter Condenser*—any value between 10 mfd. and 20 mfd., rated at 200 volts D.C. working voltage or higher; *Output Filter Condenser*—any value between 8 mfd. and 16 mfd., rated at 200 volts D.C. working voltage or higher; *Loudspeaker Field Coil Filter Condenser*—between 4 mfd. and 8 mfd., rated at 200 volts D.C. working voltage or higher; *Cathode Resistor By-Pass Condensers*—about 5 mfd., rated at 25 volts D.C. working voltage or higher.

Your condenser block sketch now gives you the necessary data for ordering a replacement unit. First try to secure a single condenser block to replace the defective unit; if this cannot be secured, order a block to replace some sections and use individual midget electrolytics for the remaining sections, or build up the complete assembly with individual units. Before ordering, make sure the replacement units will fit in the available space. Three examples of condenser block sketches are shown in Fig. *5*. That at *A* is for the power pack circuit in Fig. *2*, while the diagram at *B* is for the circuit in Fig. 2 when the loudspeaker connections are as indicated in the upper dotted circle. When the choke coil is in the negative power supply lead and provides C bias for the output tube, the condenser block diagram may take the form shown at *C* in Fig. *5*.

Performance of Universal Receivers. As you become familiar with midget universal receivers, you will learn for yourself that there is a definite limit to what can be expected from these sets. They give reliable reception only on local stations; they have little selectivity and consequently should not be used on long antennas; they will overload and distort if the volume control is advanced too far when tuned to a local station; fidelity of reproduction, especially as regards bass notes, is poor. This lack of fidelity is inherent in these sets because low-power output tubes are used, because the loudspeaker is small, and because the baffle is small. Be on the lookout for complaints which indicate that the customer is expecting more from a universal set than it can possibly give.

Because of the limitations in size and circuit design of universal receivers, circuit defects tend to be concentrated in a few critical parts. Short-cut methods for locating these common defects will now be considered; conventional servicing techniques as presented elsewhere in the Course can be applied whenever these short-cuts fail to locate the trouble.

Service Hints for Dead Receivers. A break in the filament circuit is a common cause of a dead universal receiver, for a defect in one part or lead in this circuit will block filament current to all tubes. Check all tubes with a tube tester, then check continuity in the filament circuit with an ohmmeter.

A defective (open, leaky or shorted) electrolytic filter condenser is another common cause of a dead universal receiver. A shorted filter condenser can damage the rectifier tube, so check this tube after replacing a filter condenser. A measurement of the rectified output voltage of the rectifier tube will often give a clue to the trouble. With the set plugged into an A.C. outlet, the D.C. voltage as measured between the rectifier tube cathode (B+) and the tuning condenser frame (B—) should be between 90 and 120 volts; if lower, a filter condenser is very likely defective. When making a circuit disturbance test to isolate the defective stage in a universal receiver, remember that you cannot pull tubes; remove and replace each control grid cap or short the grid momentarily to the cathode to produce the disturbance.

Distortion. Excessive distortion may be due to an off-center cone or an open field coil in a dynamic loudspeaker, to improper centering of the armature in a magnetic loudspeaker, to a leaky audio coupling condenser, or to a defective audio output tube. Always try a new output tube when you are unable to find any other cause of distortion, even if the present tube tests okay in a tube tester.

Low Volume. Open filter condensers, defective volume controls, and inadequate antennas are common causes of low volume in a universal set. The antenna wire should be completely unrolled.

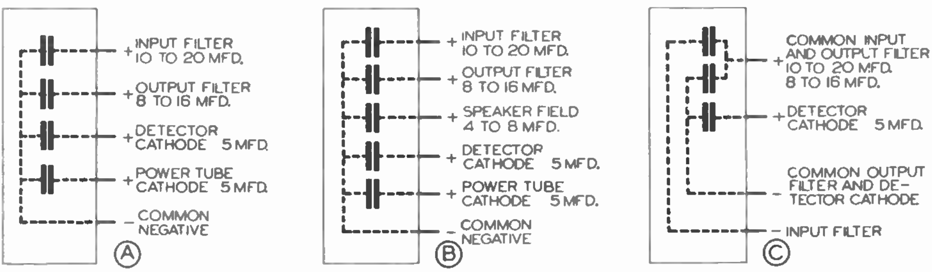


FIG. 5. Typical condenser block diagrams for universal receivers.

Oscillation. A certain amount of oscillation at high volume level is normal and unavoidable in some universal receivers, so if a reduction in volume will stop the oscillation and allow the signals to come through clearly, nothing should be done. If the oscillation cannot be controlled or if the volume must be reduced too much in order to eliminate it, look for a defect. The most common defects are an uncoiled antenna, a misplaced control grid lead, an open by-pass condenser or an open output filter condenser. If a check of all these fails to locate the trouble, try connecting the antenna wire to a radiator or other ground, or try detuning the trimmer condensers which are mounted on the gang tuning condenser.

Intermittent Reception. Experience has shown that the most common cause of intermittent trouble is a defective audio output tube or a defective audio coupling condenser, so check these parts first. Also check for intermittent breaks in the antenna cord.

Where To Place The Receiver In The Home

THREE important factors must be kept in mind when selecting a location for a radio receiver in a home: 1, the receiver should be as close as possible to the antenna lead-in, ground and power connections; 2, the receiver should be so placed that the sound from the loudspeaker will travel a maximum distance before being deflected or absorbed by a wall; 3, the location should meet any particular preference of the housewife and other occupants of the house (some will insist that the radio harmonize with the interior decorating scheme of a room, while others will want the radio in the most convenient location).

Connection Problems. If a new antenna and ground system is to be erected at the time that a radio is installed, there will be a great many possible suitable locations for the receiver. If the antenna is already installed, however, the choice will naturally be limited to locations in the vicinity of the antenna lead-in window. Any extensions of receiver connections should be kept at a minimum length, for wires running around the baseboard never improve the appearance of a room. Sometimes you can secure permission from the housewife to bring the antenna lead-in wire through a basement window and run it up through a ¼" hole which has been drilled through the floor directly back of the selected receiver location. Make this hole as inconspicuous as possible, and be sure before drilling it that you will not run into a cross beam under the floor.

Acoustical Problems. Here you must take into consideration the various points in the home at which people will want to listen to the radio programs. Oftentimes a single receiver will have to serve two or more rooms; in this case, you should recommend a location which will permit sound waves to travel through the two rooms without having to bend around corners or be reflected by the walls. Be sure that there are no large pieces of overstuffed furniture closer than ten feet to the receiver in the direct path of sound waves to a listening location, for such furniture tends to absorb the high frequency notes, making programs sound unnatural.

A radio receiver having an open back should never be placed right up against a wall, for this gives it a boomy tone. If the customer will not allow you to place the receiver at an angle to the wall or diagonally across a corner, you should at least suggest

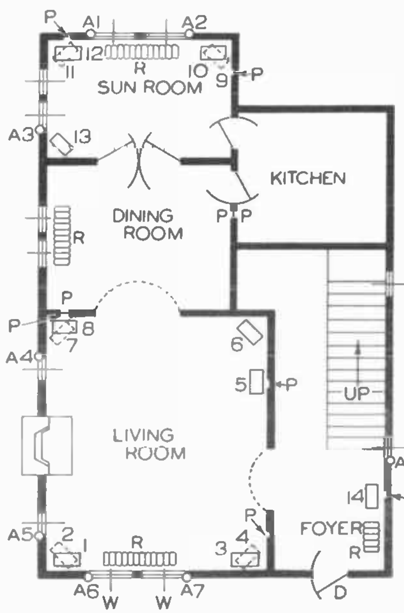


FIG. 1. First-floor plan of a typical two-story home, showing a number of possible receiver locations. Windows are indicated as W; D—doors; R—radiators; P—power outlets; *A1*, *A2*, etc.—possible antenna lead-in locations.

a three- to four-inch separation between the back of the receiver and the wall. Only where receivers have closed backs or special acoustical chambers having trade-names such as the cathedral acoustical chamber, the acoustical labyrinth, magic voice, bass reflex, or peridynamic cabinet can the receiver be set right up against a wall.

Interior Decorating Problems. It is generally best to respect the wishes of the housewife when considering the general effect of a radio receiver upon the decorative scheme of a room. If the receiver is old or does not harmonize with the type of furniture in the room, she may want it to be as inconspicuous as possible; on the other hand, if she has a new receiver and is proud of it, she may want to place it in an unusually prominent location regardless of the rules of interior decorating. It requires tact and a willingness to understand the problems and desires of a customer in order to arrive at a compromise location which will prove satisfactory. Never insist outright upon a particular location; your duty is to make recommendations, allowing the customer to make the final choice.

Analysis of a Typical Home. An analysis of each possible receiver location in a two-story home having a first floor arrangement like that shown in Fig. *1* will serve to illustrate the receiver placement rules just discussed. Only console receivers and the larger table model sets need be considered, for there is little which can be done to change the tone characteristics of midget or cigar box sets. First of all, study the floor plan carefully and get a clear picture of how each room would ordinarily be used. You can safely assume that the dining room will be used only during meals. The living room will undoubtedly serve for guests and for parties, but at other times either the living room or sun room may serve for general living purposes. Remember that the housewife spends considerable time in the kitchen during the day, and may want to hear radio programs while working.

In the living room, receiver positions *1, 2, 3* and *4* are all good. Ground and power connections are right alongside the receiver in each case, and there are three possible antenna lead-in positions *(A5, A6* and *A7)* which can serve these locations. If the house has a front porch, *A5* will undoubtedly be the best entrance for the lead-in. From an acoustical standpoint, sound will be directed into the living room and through the dining room into the sun room from any of these locations. With locations *1* and *2* you must, of course, be sure that an overstuffed chair or sofa will not be placed on the receiver side of the fireplace; likewise, with locations *3* and *4* there should be no large chair in that corner of the room.

If the radio is to serve only the living room, locations *6, 7, 8* and *14* will be satisfactory. Location *5* is less desirable because sound can travel only a short distance from it over an unobstructed path. Positions *5* and *6* are quite a distance from antenna and ground connections and should be considered only when a transmission cable is used for the lead-in and is brought in through a basement window and then up through a hole in the floor. A ground connection would likewise have to be brought up through a hole in the floor. Positions *7* and *8* are not conveniently near a ground, but it would not be hard to make an outside ground connection through the nearby window or drill a small hole in the floor for a connection to a basement water pipe.

Location *14*, in the foyer, will be favored by some housekeepers. A low-boy console or a phono-radio combination console lo-

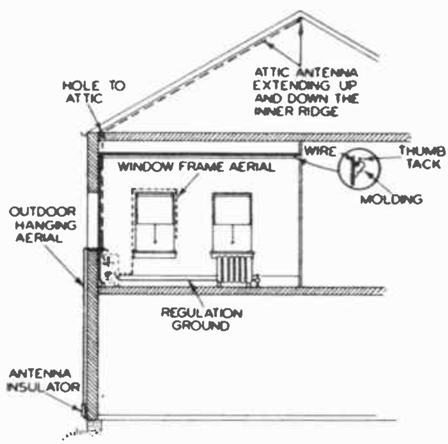


FIG. 2. When a standard outdoor antenna cannot be installed for any reason, consider one of the makeshift antennas illustrated here.

cated here, with a mirror hung on the wall above it and a calling card tray or a lamp on the top of the cabinet, is one solution to the problem of furnishing the foyer. Note that this position is near antenna, ground and power connections; furthermore, sound waves will travel through the arch into the living room over a reasonably long path. Bear in mind, however, that for any of the locations indicated in Fig. *1* the radio will be heard in any of the other rooms if the volume control is turned up sufficiently. When sound waves must pass around corners to reach other rooms, however, higher notes will be lost, making low or bass notes more prominent.

A radio is seldom located in the dining room. Although the dining room shown in Fig. *1* is centrally located, there is no possible location in it from which a receiver could radiate sound waves into both the living room and sun room directly.

Now let us consider the possible receiver locations in the sun room. Position *11* is perhaps the best, for it is near antenna, ground and power connections and will radiate sound over a long direct path into the kitchen and into the dining and living rooms when the respective doors are open. Positions *9* and *10* neglect the kitchen, but otherwise are equally desirable. Position *13* would generally be unsatisfactory because it serves only the sun room and because it would require an extension of power and ground connections in this particular house.

This same analysis can be applied in much the same manner to any house. Just keep in mind that receiver connections should be handy and that sound waves should travel over the longest possible direct path before hitting a wall; remember also that a receiver having an open back should be kept at least three or four inches away from a wall. The diagonal corner locations indicated in Fig. *1* are ideal from an acoustical standpoint, and should therefore be used when no objections are raised by the housewife from a decorating standpoint.

When and How to Install Indoor Antennas and Antenna Eliminators

When the radio set owner will not allow a good outdoor antenna to be erected, an indoor antenna of some sort must be used. Be sure to point out, when you are asked to hook up a makeshift antenna, that the supposedly marvelous reception which is claimed for many of the antenna eliminators now on the market will be accompanied by considerable noise in most cases; reception of distant stations, particularly in short-wave bands, will in most cases be poor. There are many instances, however, where an indoor antenna is the logical choice; in some apartment buildings outdoor antennas are actually prohibited, and oftentimes a temporary antenna will be desired.

Indoor Antennas. The true indoor antenna is usually a wire which is laid in the molding which runs around the room, a wire fastened around a window frame, a wire placed under a rug, or a wire strung up in the attic. The total length of the antenna will usually be much less than for an outdoor antenna, and consequently the signals picked up will be much weaker. Indoor antennas are seldom satisfactory in homes having metal roofs, metal laths, or steel frame-work, because of the shielding effects of the metal. Since indoor antennas are considerably lower than regulation outdoor antennas, they will pick up more interference noise. A conventional ground connection to a water pipe or external ground should be used with an indoor antenna.

Figure *2* shows a few of the different ways in which an indoor antenna can be installed. From the receiver location a wire can be run up along a window frame to the picture molding, then run along this molding across two walls of the room. Thumb tacks can be used to keep the wire down in the molding where it will be out of sight. Use either No. 18 or No. 20 stranded or solid insulated copper wire. An alternative procedure would be to run the aerial wire around the baseboard, fastening it in position with insulated staples. The insulated indoor aerial wire could also be run around three sides of a window frame,

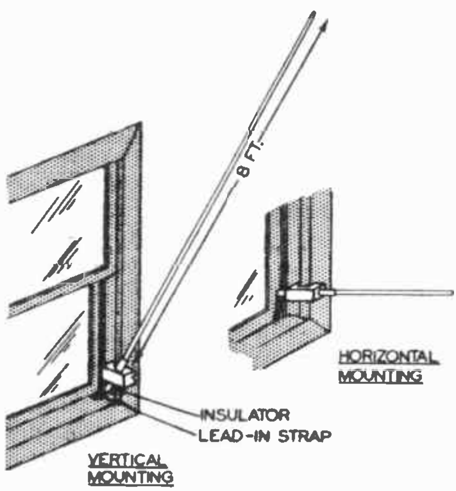


FIG. 3. Window fish-pole antenna which is available for temporary receiver installations and for apartment houses where excessive steel in the building prevents use of an indoor aerial.

being held in place either with thumb tacks or with insulated staples; this procedure is suggested for rooms which do not have a picture molding.

An antenna strung across the rafters in the attic is somewhat more difficult to install, but gives improved performance. Your greatest problem will be to get the wire up into the attic; as a last resort you can consider drilling a small hole up through the ceiling if you find it impossible to get the wire up inside the walls.

When radios are to be installed temporarily, a length of insulated wire tossed out of a convenient window can be considered.

FIG. 4. A condenser connected like this, between the antenna terminal of the receiver and one side of the power line, often gives satisfactory signal pick-up.

Tie a weight such as an insulator to the lower end of the wire to prevent excessive swaying in the wind; if possible, tie the lower end of the insulator to a nail driven in the wall. Keep the end of the wire at least one foot above the ground; for a one-story house this means that you can get only a few feet of wire outside, but considerably more wire can be used for second-floor locations.

A substitute for the outdoor hanging aerial is shown in Fig. *3;* this is simply a metal fish-pole antenna which can be clamped in a few minutes to the outside of a window casing. The rod can be adjusted either to a horizontal or to a nearly vertical position, as desired.

Aerial Eliminators. One side of the power line in the average home is usually grounded; the other side of the line, being ungrounded, will pick up radio signals. Aerial eliminators simply provide a connection to the power line which permits these radio signals to enter the receiver. If the outside wiring com-

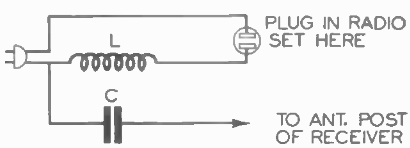


FIG. 5. Circuit diagram of a commercial antenna eliminator of the better type.

ing to a home is exposed (on poles), excellent signal pick-up will generally be obtained, although it may be accompanied by noise.

In Fig. *4* is shown the simplest way of utilizing this picked up radio energy; the antenna terminal of the receiver is connected to the ungrounded side of the power line through a low-capacity condenser. You can make this aerial eliminator yourself, with a .001 mfd. mica condenser, an ordinary two-prong electrical plug and enough flexible insulated wire to run from the wall outlet to the receiver. The ground terminal of the receiver should be connected to a good ground. When you have connected these parts together and have thoroughly insulated the condenser leads, try reversing the plug in the wall outlet a few times. Select that position which gives best signal pick-up; this is simpler than trying to determine which side of the power line is ungrounded.

Most of the so-called aerial eliminators now on the market are essentially like that which I have just described, except that the condenser and plug are combined in a metal or non-metal housing to improve the appearance and sales appeal. Sometimes an R.F. choke coil is also included in the unit

FIG. 6. Typical antenna eliminators. Installation instructions are printed directly on the units or provided with them by the manufacturer.

and connected as shown in Fig. *5;* when the antenna eliminator is plugged into a wall outlet and the receiver power cord plug is inserted in the eliminator outlet, this choke forces the radio signals to enter the receiver through condenser *C* rather than through the receiver power cord. Typical antenna eliminator units are shown in Fig. *6;* always reverse one of these units a few times to find the position which gives best signal pick-up.

Oftentimes satisfactory reception of local stations can be obtained by simply connecting a ground lead to the antenna terminal of a receiver, leaving the ground terminal disconnected. You can also try connecting the antenna terminal of the receiver to the metal plate of a wall outlet. Reversing the receiver power plug will often improve reception with one of these arrangements. Always try out several arrangements, for a connection which works fine for one receiver and one location may be worthless in another home.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

Recognizing Receiver Troubles

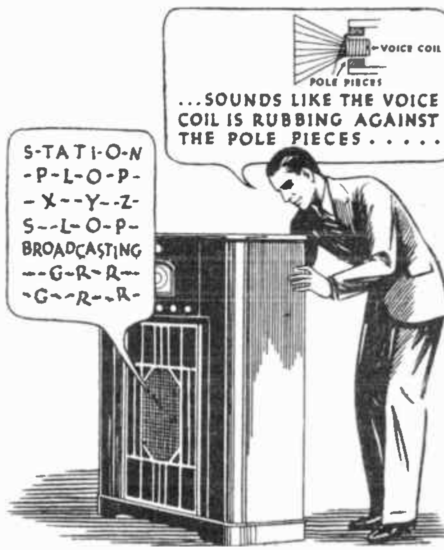
IN THE preceding job sheets you have studied the procedures used by the radio mechanic in installing and servicing radio receivers. At the same time, the lessons in your regular Course have given you a great deal of fundamental information on radio and electricity. You are now ready to begin studying the professional servicing technique as used by Radiotricians.

When an experienced Radiotrician is called in to repair a defective receiver, he will first try the receiver himself, listening to it carefully if the set is not completely dead, then make a brief inspection for surface defects while reasoning how the observed trouble could possibly occur. A few simple voltage or resistance tests based upon this reasoning are generally sufficient to locate the trouble. Repair of the defect and a general tuning of the receiver completes the job. Yes, the professional technique makes servicing as simple as this for the great majority of jobs which are encountered.

The first step in this professional technique is obviously the recognizing of the particular receiver trouble encountered, first by asking the customer to describe the trouble and then by actually trying the receiver and verifying the complaint. A dead receiver is easy to recognize, since no sound whatsoever comes from the loudspeaker. Receivers which play unsatisfactorily can have a great many troubles, but each provides certain clues which make identification quite easy. The first part of this job sheet will tell you how to recognize common troubles of improperly operating receivers, such as noise, hum, squeals, distortion, lack of volume, poor sensitivity, poor selectivity and intermittent reception.

Noise. Ordinary noise accompanying a radio program is a common receiver complaint. Sometimes this noise may sound like two pieces of sandpaper being rubbed together; it may be sudden, loud sounds like those obtained when two boards are brought together suddenly; it may be a sound like that of rushing water or the grinding of gears; it may be loud crashes produced by lightning discharges. Each noise has its meaning; with further study of the professional servicing technique and with actual experience, you will learn to associate the various noises with particular defects.

Hum. A regular throbbing sound which is heard with a program or is so loud that



Each unnatural sound has its meaning.

it actually drowns a program is readily identified as hum. Sometimes the hum will remain at the same volume regardless of how you adjust the receiver controls, while at other times it will increase or decrease in loudness as you tune in a station or adjust another control. The tone (frequency) of the hum, the loudness, and the manner in which the loudness varies when receiver controls are adjusted all are clues indicating the cause of the trouble.

Squeals. Sharp, shrill whistles, squeals or howling sounds which occur either continuously or only when a station is being tuned in are easily recognized. There are a number of possible receiver defects (all of which are taken up later in your Course) which can cause undesirable oscillations which are heard as squeals, but in each case the sound itself or some condition associated with it will give several clues to the defect.

Distortion. Whenever music or spoken words sound unnatural, distortion is present. Severe distortion makes reproduced sounds muffled, harsh, raspy, unintelligible or, in the words of a customer, "simply terrible." Mild distortion is more difficult to recognize, but when a customer describes how he turns off the receiver in disgust after listening to it for an hour or so, you can be pretty sure that distortion is the cause. The nature of the distortion, the particular conditions under which it occurs, and the effect of the receiver controls upon the amount of the distortion all will be clues to the cause of the trouble, once you have mastered the professional servicing technique and the radio theory and circuit data in your regular Course.

Lack of Volume. The customer complains that he cannot make the radio play loud enough, even when the volume control is at its maximum setting. This complaint is, of course, quite easy to recognize and verify. Furthermore, the conditions accompanying the lack of volume are important clues as to what may be at fault. The volume control may have no effect at all upon volume; only local stations may be heard; a great number of distant stations may be heard, but with insufficient volume; sounds may be loud at one setting of the volume control but weak at another setting. With experience and further training you will learn to associate each of these actions with a particular receiver trouble.

Poor Sensitivity. When the customer complains that only a few distant stations or none at all can be received, the Radiotrician knows that the complaint is really poor sensitivity. With a little more experience and study, you will be able to recognize under-normal receiver sensitivity; you will learn that a four-tube midget receiver is normally far less sensitive than a ten-tube set, and that, tube for tube, a superheterodyne is more sensitive than a tuned radio frequency receiver. You will also know where to look for trouble when you find that the receiver is sensitive in one region of a tuning range but lacks sensitivity at another part of the dial.

Poor Selectivity. This can be recognized by the fact that the customer will be unable to get certain stations without interference from undesired stations. For instance, the program of a powerful local station may always be heard along with that of a desired distant station. Oftentimes poor selectivity will be accompanied by poor sensitivity. Be on the lookout for combination troubles like this, for they are important clues in tracking down trouble. Poor selectivity in itself can occur in many different ways, each of which is a clue to the trouble once you have mastered receiver circuits.

Giving satisfactory radio service.

Intermittent Reception. When a customer complains that the receiver will play all right for a while, then suddenly stop playing or operate improperly, with the process of playing and not playing repeating itself either at regular or irregular intervals, you can identify the trouble as intermittent reception. It will invariably be due to a make-and-break contact in a connection, a part, or a tube. Intermittent reception is without doubt the most difficult problem encountered in radio receiver circuit servicing, for the actual defect generally lasts only for a few minutes. In later job sheets and in your regular Course, however, you will learn that there are definite clues and definite methods for handling this trouble successfully.

Miscellaneous Complaints. There are a number of other complaints which are bound to come to your attention eventually if you engage in radio servicing. For instance, you may hear a "putt-putt-putt" sound from the loudspeaker, indicating motorboating or audio stage oscillation; you may encounter the condition where a local station rides in on a distant station, giving what is known as cross-modulation; you may note smoke or a peculiar odor coming from the chassis, indicating that some part has broken down; you may note a scratchy distorted sound whenever the volume control is adjusted, indicating a defective volume control; you may note that spoken words are difficult to understand, indicating that the voice coil is rubbing against the pole pieces; there will be many other complaints like these, most of them being encountered only at infrequent intervals, but once you have mastered the professional servicing technique, each will suggest possible causes and methods for checking these causes.

Developing a Professional Servicing Technique

The ultimate goal in any servicing procedure is the location of the defective part, tube or connection. This goal can be reached either by the long and tedious "groping in the dark" process used by radio mechanics, but such a procedure is obviously inadequate for the Radiotrician who is planning a career in radio servicing. A professional servicing technique gives assurance right from the start of a job that the defect will be located by a logical procedure in which you will always know what to do next.

The professional servicing technique is essentially a reasoning process, in which test equipment is used chiefly to verify the results of your reasoning. With proper training and a certain amount of experience, this process of reasoning will become almost automatic and will take but a few minutes at the most for any job. It is obvious, then, that the professional servicing technique which you will now begin studying makes it possible to service radio receivers with an absolute minimum of time and effort.

Equipment Needed. The mere fact that a serviceman is equipped with every conceivable type of test instrument is no assurance that he will be able to service a radio receiver quickly, efficiently and to the satisfaction of the customer. The only test equipment which is essential for the professional servicing technique is a signal generator, a multimeter, and (in an actual servicing business) a tube tester. The purchase of any other piece of test equipment is not justified until such time as you are positive that it will meet a real servicing need. Remember that special test equipment is of little value unless you understand how to use it.

A Radiotrician At Work. Let us assume that you are a "full-fledged" Radiotrician in order to get a condensed but complete picture of how the professional servicing technique is followed on an actual job. With this complete procedure in mind, it will be considerably easier for you to master the individual steps in the technique as they are described in later job sheets.

The Phone Call. The telephone rings, and a lady asks if you can come right out to fix a radio set. You ask for her address; if it is fairly close to your place, simply ask when it will be most convenient for you to come out. If she lives more than about ten miles away, making it advisable to repair the set in her home if possible (to avoid an extra trip) ask her to describe the trouble and to give you the name of the receiver and its model number; she will usually be glad to look on the chassis or inside the cabinet for this data. Of course, if she is an old customer of yours and still has the same receiver, you will have its model number in your files. With this information you can take along the proper replacement tubes for her receiver, as well as its circuit diagram or service manual. You always bring along your tool box, a portable signal generator, a multimeter, a tube tester, and an assortment of common replacement parts.

Entering the House. Arriving at the customer's home, you carry in your tool box, multimeter and tube tester, but leave the other equipment in the car until needed. As you approach the house, you look over the antenna installation, particularly if the complaint was a dead or weak receiver, noisy reception or poor selectivity. An antenna system defect can cause these troubles, and oftentimes this initial inspection will reveal the defect.

Verifying the Complaint. Entering the house, you introduce yourself and proceed to verify the complaint by trying the receiver yourself. If the complaint is unsatisfactory operation, you try each receiver control and check the performance on several stations; if the receiver is completely dead, this condition will be obvious at the start.

Inspection for Surface Defects. Regardless of whether the receiver is dead or plays unsatisfactorily, your next step will be an initial inspection for surface defects. You see if the antenna and ground wires are properly connected to the receiver. You note whether the dial lamps are glowing. You note whether the tubes are all in place, and whether they all heat up. You see if the top cap connections for the tubes are in place, and make sure that none of them touch the tube shields. You observe whether there are any unusual odors coming from the chassis, indicating burned out parts. Experience enables you to do all this in just a few minutes. The results of the inspection for surface defects tell you immediately what the next step will be. Since the procedure will be different for a dead receiver than for an improperly operating receiver, we will consider each in turn.

The Dead Receiver. If the inspection for surface defects fails to reveal an above-the-chassis trouble which might cause a dead receiver, you will check the tubes next. One at a time, you take them out and check them with the tube tester, replacing any which are defective.

Assuming that you have definitely eliminated tubes and above-the-chassis defects from your list of suspects, the next step is the removal of the chassis from its cabinet. You place the chassis upside-down on a nearby chair or table, making sure that there is sufficient newspaper or cloth under it to prevent damage to the furniture, and inspect for surface defects such as loose or broken connections, broken resistors, charred parts, etc. You have learned that it is a waste of time to spend more than two minutes on this visual inspection, so if the trouble is not located in this time you proceed to check the D.C. output voltage of the power pack with the multimeter. This one measurement can tell whether the power pack is producing the proper voltage for the tubes.

Next comes the location of the defective stage; you will use either the circuit disturbance test or the dynamic stage-by-stage test, or both. With the defective stage located, a systematic continuity check of that stage quickly reveals the defective part or connection. You make the required repair or replacement, do whatever overhaul work is warranted, then return the chassis to its cabinet and make a final check of performance.

The Improperly Operating Receiver. Knowing that tubes are very common causes of improper operation, you make a careful check of each tube before doing anything else. The loudspeaker may also be at fault, so you give this a careful check-up next. If a rubbing sound is heard when you push the cone in gently and uniformly with your fingers you suspect that the voice coil is improperly centered; often you can feel that the voice coil is rubbing. If local and distant stations are heard, but weakly, and the loudspeaker is of the electrodynamic type, you make a voltage test to determine if the field coil is energized. In other words, you try to eliminate the loudspeaker as a possible source of trouble before removing the chassis from its cabinet.

After a two-minute inspection of parts underneath the chassis for surface defects, you reason from the observed effect to the possible causes (effect-to-cause reasoning) and check the most likely causes first. For example, in the case of oscillation you would look for open by-pass condensers; with hum you would look for an open or leaky filter condenser; with distortion you would look for a shorted or leaky by-pass or coupling condenser; in the case of weak reception of local stations, there might be an open coupling condenser.

In those few cases where effect-to-cause reasoning fails to locate the trouble, you resort to systematic procedures for checking all electrode voltages, checking continuity between all tube electrodes and the common voltage supply terminals to locate open circuits, checking for gassy tubes, and checking for leaky condensers. If this fails, a systematic stage-by-stage dynamic test is made; a signal is fed into the receiver and the output of each stage in turn is analyzed and checked. Once the defective section has been located, you check the parts in that section in a logical manner.

The Question of Home or Shop Repairs. There is a limit to the amount of work which can reasonably be done in the home of a customer. Furthermore, for the beginner it is highly advisable that most of his work be done at his own work-bench. Surface defects both above and below the chassis can be checked, tubes can be tested, and obvious minor defects can be repaired in the home, but whenever a problem becomes perplexing, it is best to inform the customer that it will be necessary to take the receiver to your shop for a careful analysis.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

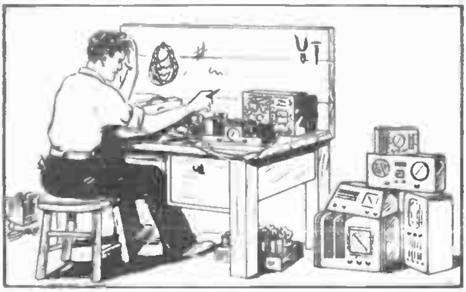
How Radio Men Service Receivers

FROM the very first days of radio, the methods used for servicing receivers have kept right in step with the progress of the radio broadcasting industry. The earlier receivers were so simple in design and construction that very little knowledge of radio theory was required by servicemen in those days.

When one of these early sets performed unsatisfactorily or became entirely "dead," the usual servicing procedure involved testing all the tubes, all the parts and all the connections one at a time until the defect was located. This *mechanical procedure* was not particularly difficult, but the time required to fix a particular set was largely determined by luck. If the defect was in one of the first parts tested, fine and dandy; if it turned out to be in the last part tested, the serviceman probably shrugged his shoulders and sent word home that he'd be late for dinner again.

As radio receivers became increasingly more complicated, servicing problems increased correspondingly, particularly in connection with the larger sets. Soon it was not at all unusual to find anywhere from ten to twenty tubes in a receiver, and the testing of each tube and part in one of these was pretty nearly an all-day job. Wiser servicemen began figuring out methods for determining which section or stage of the receiver was at fault, so they would only have to test the parts in that one section—and thus was born a new servicing technique.

Today the *professional servicing technique* has been developed to the point where the Radiotrician can diagnose the defective stage or section in a few minutes by observing the performance of the receiver, making a few simple tests, and combining these clues with his knowledge of radio theory—his knowledge of how that receiver will act when various parts of it become defective. A Radiotrician employing this technique will be able to service from three to five times as many receivers per day as can his untrained competitor who is using the "guess and try" or mechanical servicing procedure. As a result, the Radiotrician can devote more time to business problems, can enjoy shorter working hours, and can devote more time to his family, to rest and to recreation.



Here it is almost noon, and not a single set repaired. Seems like I've tested and wiggled every single part on this chassis—what'll I do next?

Servicing sure is fascinating when I can use my head as well as my hands. One more to fix, and I'll be ready for lunch and the ball game.

The professions of radio servicing and medicine have a great deal in common. Consider the doctor first; from many years of study he has come to know how each part of the human body functions when a person is well, and how each part produces its own set of observable symptoms during an illness. When the doctor visits a patient, he listens first to the description of the ailment, then looks for observable symptoms and makes simple tests; with this information and his

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previous training he can diagnose the trouble and prescribe the proper remedy.

A radio man can be just as professional in his methods. From the statements made by the set owner, from the symptoms which he observes himself when trying out the receiver, from a few simple tests and from his knowledge of radio receivers, he, too, can make a diagnosis and prescribe exactly the correct remedy for that particular ailing receiver. A man who knows radio as it is presented in the N. R. I. Course has confidence in his own ability; as a result, he is proud of his profession and is respected by all in his community.

A professional radio servicing technique cannot be acquired in a day, nor a week, nor a month, for it depends upon a mastery of the entire N. R. I. Course.

The mechanical servicing procedure, however, is quite easy for even beginners to master, and can be used successfully in servicing a great majority of even the more complicated present-day receivers; in fact, many radio servicemen still depend entirely upon this method, and manage to get along.

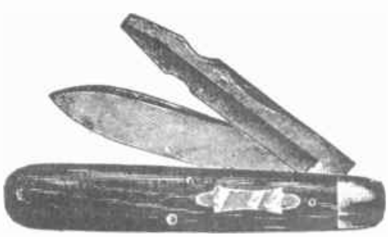
Knowing you are anxious to get started in radio as soon as possible, and realizing how welcome are those extra dollars which can be earned by spare time service work, I am going to start right in with the mechanical servicing technique in these Practical Job Sheets; later on, after you have progressed sufficiently with your regular lessons to be familiar with the important radio fundamentals, I will teach you the more difficult but speedier professional radio servicing technique.

Tools And Testing Equipment Used By Radiotricians

The actual repair or replacement of a defective part is just as important as the location of the defect. To do this mechanical or manual part of a radio servicing job, the Radiotrician needs tools—not elaborate, costly equipment, but ordinary tools of reasonably good quality. Many beginners in radio make the mistake of buying a huge assortment of tools right at the start, more than they ever will need; too many tools may be a hindrance to efficient work, just as too few tools may be a handicap.

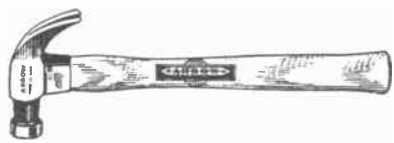
The essential tools required by a beginner in radio servicing are pictured and described in this job sheet. Many of these you may already have; the others you can purchase from practically any department store, mail order radio supply house or hardware store.

Pocket Knife. Almost any heavy pocket knife having one large, strong, steel blade will do for radio work, but the electrician's pocket knife pictured here is particularly



handy, since it has in addition a screw driver blade and wire stripper. A pocket knife is used for cutting off the insulation from a wire, and for scraping wires and joints clean before making a soldered joint.

Hammer. Service men prefer an ordinary claw hammer of medium weight. It is used chiefly when installing antenna systems, for pulling out as well as driving in nails. You will find many other uses for your hammer,



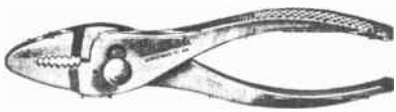
however; sometimes it will come in handy for spreading the end of a rivet on a chassis, or you may use it with a nail to form a starting hole for a wood screw.

Screw Drivers. Machine screws, wood screws and set-screws are so extensively used in radio that you will constantly be in need of good screw drivers. Two different sizes of screw drivers will generally meet all requirements.

For ordinary heavy work you should have a heavy-duty screw driver about eight inches long. The handle is gripped in the palm of the hand and is turned with a wrist motion. Never apply force to a screw driver until you are sure its blade is firmly seated in the groove or slot of the screw head. This screw driver will be particularly useful in removing the machine screws which often hold a chassis in its cabinet.

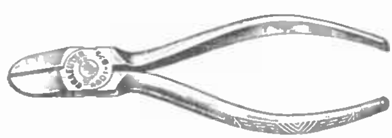
You will need a midget screw driver for loosening the set screws in control knobs and for loosening or tightening the various small screws which are found on radio parts. This small screw driver is held between the thumb and first two fingers and is rotated by rolling between these fingers.

Combination Pliers. These are perhaps the commonest and best known of all pliers; with them you can grip an object of almost any shape and hold it firmly while you twist or pull. The flat sections at the ends of the



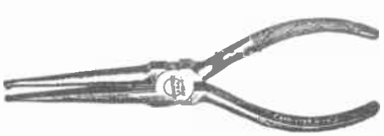
jaws are just about right for flat surfaces and for the heads of bolts, while the alligator-like inner teeth will hold round objects such as metal rods, bolts or tubing. The extending adjustment on the jaws allows you to use these pliers on objects up to an inch and a quarter thick.

Diagonal Cutting Pliers. A radio man cuts wires so often that the purchase of a special pair of pliers for this purpose is well justified. Diagonal cutting pliers like those shown are the best for this purpose; I recommend the six-inch size. Be sure they are of good quality, and use them only for cutting wires, leads and rivets. Do not use these pliers for cutting steel objects such as nails or bolts, for this would soon dull the cutting edges.



Radio men often use diagonal cutting pliers for stripping the insulation off a wire. This is done by holding the insulated wire in one hand and cutting through the insulation (but not through the wire) with the pliers held in the other hand; the pliers are then pulled toward the end of the wire, forcing off the insulation. Try this a few times and you will soon get the knack.

Long-Nosed Pliers. Nothing is better than a good pair of long-nosed pliers for



holding a wire deep down in a chassis, for gripping small parts, or for holding wire leads while soldering to them.

Alignment Tools. An important part of a serviceman's work is the alignment or tuning up of a receiver to make it selective enough to separate adjacent stations on the dial, to make it sensitive enough for reception of distant stations, to secure good tone quality, and to reject certain types of inter-

ference. In each receiver a number of adjusting screws or nuts (usually on trimmer condensers) are provided for alignment purposes. The tools used for these adjustments cannot be made of metal; special small screw drivers and wrenches (midget socket wrenches) made of fibre, bakelite or hard rubber are available. A simple set of alignment tools like those illustrated here will serve for practically all tune-up requirements.

File. One of the secrets of successful soldering is keeping the tip of your soldering iron bright and clean; this can best be done with an ordinary flat file.

An eight-inch flat mill file of good quality will serve nicely for keeping the tip of your soldering iron shiny, for cleaning water pipes before making ground connections and for trimming down metal parts.

Sandpaper. When preparing a wire for soldering, it can often be cleaned or the enamel removed more quickly with sandpaper than with a knife. You can get a small package of assorted grades of sandpaper in any hardware store for about a dime; this will last a long time in radio work.

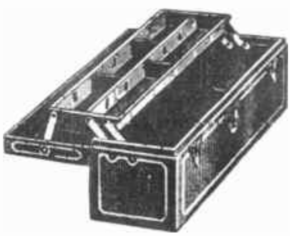
Hand Drill. A hand drill like that shown here, with a set of twist drills up to ¼" in diameter, will prove a valuable addition to

your radio tool collection. With this drill you can remove the hollow rivets which are used extensively for fastening radio parts to a steel chassis, and can make new holes in a chassis.

Soldering Iron. Every connection which you make in a radio receiver chassis and in the antenna and ground systems *must be* *soldered.* This involves flowing around the joint a lead-tin mixture called *solder,* which provides a good metallic path for electric

current between the parts being joined and increases the mechanical strength of the joint. An excellent soldering iron for radio work will be sent to you with the first Radio Kit in your Practical Demonstration Course, so there is no need for you to buy one.

Tool Box. If you value your tools, you will want to keep them in an orderly manner. I find that a tool box about fifteen inches long, six inches wide and six inches



deep, with a metal tray which can be lifted out by hand or which raises up automatically like that shown in the illustration, is just about right for the important radio tools and for small spare parts.

Test Equipment. Although the various pieces of test equipment required for radio servicing will be considered in detail later, when I take up that particular branch of servicing which involves their use, I do want to discuss briefly at this time the three instruments which are really essential for a small radio servicing business.

1. Multimeter. A radio receiver depends for its proper operation upon the flow of definite values of *current* through various parts of its circuit, and for each current there must be a driving force or *voltage.* Receiver defects are often accompanied by changes in these operating current and voltage values, so we can usually locate a defect by means of simple measurements.

Since both D. C. and A. C. voltages and currents are present in a receiver, we must have *voltmeters* for measuring D. C. and A. C. voltages, and *ammeters* for measuring direct currents of various values. Alternating currents in radio sets need seldom if ever be measured.

Radio parts each have a certain amount of *resistance* or opposition to current flow. We can often determine whether a part is defective simply by measuring its resistance with a simple instrument known as an *ohmmeter,* which measures the resistance of a part directly.

Obviously it would be quite expensive to buy all these meters separately and quite inconvenient to carry them all around. Meter manufacturers have solved this problem by designing a single instrument known as a *multimeter:* this is a compact unit containing a single meter and a switch which can be set to convert this meter into any one of the instruments mentioned above.

2. Signal Generator. It is perfectly possible to test the operation of a receiver by connecting it to a good antenna and tuning in various stations. Radiotricians seldom follow this procedure, however, because they are not always able to tune in stations having the frequency desired for a particular test and are not always able to secure the type of program which is suitable for test purposes. The Radiotrician uses an instrument which actually replaces the broadcast station insofar as the receiver is concerned. This instrument is known as a *signal generator,* because it produces a test signal corresponding to the signal picked up by an ordinary antenna. A signal generator can be adjusted to give any desired frequency at any desired signal strength.

3. Tube Tester. With a signal generator and a multimeter (often mounted in a single carrying case) we can tell whether any tube in a receiver is better or worse than a new tube by making a simple comparison test. Busy Radiotricians prefer to use a special instrument for tube testing purposes, however, since with it they can do far speedier work. The tube being tested is simply plugged into the proper socket on the tube tester, a few adjustments are made, a button is pushed, and a meter then tells whether the tube is good or bad.

You will not have to worry about getting a tube checker until you actually go into regular service work. With a signal generator and a multimeter you can learn how to service receivers and can secure all the experience needed to become a radio servicing expert.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

How To Install A Master All-Wave Antenna For As Many As 25 Receivers

IT is possible to arrange two or even three antennas on a single home or building so they are neat and more or less inconspicuous, but when more antennas than this are erected on any one building at different times by men who may vary greatly in ability, the roof top begins to resemble a jungle of wires. There is little wonder that many owners of apartment houses and flats specify on their leases that there will be "no outdoor radio wires."

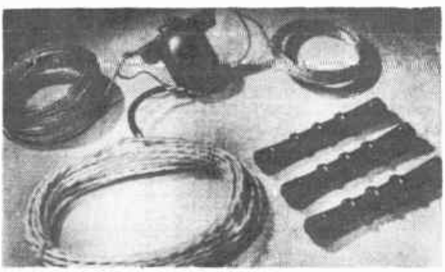


FIG. 1. Foundation unit of Taco type 320 master antenna system, which will serve up to 25 receivers. Note the sleeving or loom just below the antenna transformer;this can be slid along the transmission cable to the point where the cable first touches the building. Taco also makes a smaller master system for 6 to 8 receivers.

With more and more apartment tenants demanding suitable antenna facilities for all-wave receivers, owners of these apartments are ideal prospects for one or more master antenna systems, each of which is capable of serving at least 25 all-wave receivers. When you locate a large apartment which has no antennas at all or a jungle of wires on the roof, contact the owner and sell him on the idea of your installing the required number of master antenna systems. Point out that such an installation will in no way detract from the appearance of the building. With a good all-wave antenna outlet in each apartment, he will find it far easier to rent the apartments. Point out also that the master system will meet all fire regulations, whereas a jungle of wires may be a fire hazard.

Home owners are also prospects for master antenna systems. There is a rapidly growing tendency toward 2, 3 and even 4 separate radio sets in a home, but usually the smaller sets are served only by makeshift indoor antennas. A single neat master antenna system will permit satisfactory all-wave reception from any room in the house.

Practically every radio store can use a master all-wave antenna installation, to permit demonstrating a number of radios simultaneously under optimum conditions. As an independent Radiotrician, you can make good money installing these systems in hardware stores, furniture stores, drugstores and general stores which sell radio sets but have no servicemen on their payrolls. Hotels, houses, club houses and institutions of all kinds are potential customers for master all-wave antenna systems. You can get this business if you go after it, once you master the fundamental principles of installation as presented in this job sheet.

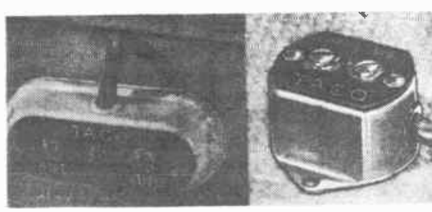


FIG. 2. These two types of matching couplers are available for use with the Taco master antenna system; choose according to appearance and finish, since both have the same performance.

Essentials of a Master Antenna System. First of all, an effective pick-up system must be used in order that sufficient signal will be fed into the transmission line. A two-in-one antenna is quite desirable, with one section for the broadcast band and the other for the short-wave band. An antenna-to-line coupling transformer is necessary to prevent interaction of the two antenna units and to give efficient transfer of the picked-up signals to the transmission line. Furthermore, each receiver should be connected to the transmission line through a matching transformer, to give most effective coupling.

Although practically any ordinary all-wave antenna will give fairly satisfactory results with 2 or even 3 receivers connected to its transmission line, much better results are obtained if an antenna system which is

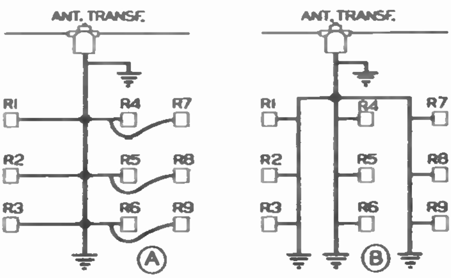


FIG. 3. Two methods for connecting receivers to a master all-wave antenna.

designed specifically for multiple receiver operation is employed. A number of manufacturers produce such systems, and there is no question but that each serves its purpose. Rather than give installation instructions general enough to apply to all systems, we have selected one, the Taco master antenna system, for purposes of illustration. This has been tested in the N. R. I. Laboratory and found to be entirely satisfactory. It is made by the Technical Appliance Corp., 17 East 16th Street, New York City, and can be secured directly from the manufacturer, from practically any radio jobber, or from a mail order radio supply house. Manufacturers of master antenna systems are prepared to give you engineering advice on problems encountered while installing their products.

General Data on Taco System. The foundation unit for the Taco master antenna system is shown in Fig. *1;* it consists of an antenna transformer connected between two pick-up wires, one 22 feet long and the other 80 feet long. The two-wire twisted transmission line supplied with this foundation unit is 30 feet long, but may be lengthened to as much as 250 feet by splicing on additional lengths of this same wire, which is sold separately. The pick-up wires should be located as high as possible above all objects on the roof; the minimum height from the standpoint of effectiveness is about 10 feet. Fire inspectors have the right to cut down any wires which might impede firemen in case of fire, so be sure that you keep all guy wires, lead-in wires, ground connections, and masts near the edges of the roof, with the horizontal pick-up wires at least 7 feet above the roof level.

Each Taco foundation unit will handle up to 25 receivers. For each receiver you will need a matching transformer; two styles, which differ only in shape and size, are shown in Fig. *2.* These may be connected to any point along the transmission line, and any amount of standard transmission cable may be used for the connection as long as the total length of cable between the aerial and the receiver matching transformer does not exceed 250 feet. In this system, one of the wires in the transmission line has red insulation, and the other has black insulation; always connect a red lead to a red lead, and a black lead to a black lead.

Two methods for connecting receivers to a master antenna system are shown in Fig. *3.* In the system at *A,* all receivers are connected to a single transmission line, while

FIG. 4. Essential transmission cable connections.

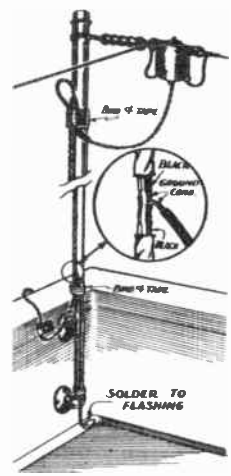


FIG. 5. Typical installation of supporting mast on an apartment.

at *B* there is a separate transmission line or "riser" for each vertical row of apartments. The procedure illustrated at *B* is to be preferred, for if a defect occurs in any one section, that section may easily be disconnected at the roof and tested. Risers may be connected by cutting away the outer insulation from the original transmission line at any convenient point near the antenna transformer, then making strong mechanical joints between wires of the same color. Solder the joints carefully, using rosin core solder, then protect each joint with electrician's friction tape.

Ground Connections. In the Taco system selected as an example for this job sheet, the black lead is the ground lead. This black lead for each riser should be grounded at each end (near the antenna transformer and at the lowest end of the riser), as indicated in Fig. *4*. No lightning arrester is needed in this installation, since one is built into the antenna transformer. Figure *4* also shows one method for bringing the transmission cable into a room; an upward-slanting hole is drilled through the window sash from the outside, and the cable is simply pushed through the

with a cap, to prevent water from getting inside. When severe man-made interference noises are present in the locality, use the best grade of marine tarred rope instead of wire to anchor the horizontal pick-up sections. This is especially important if the elevator superstructure is used as one support for the aerial. Place tarred loom over the transmission line at the point where it goes over or around the parapet (roof edge), and at all other points where the transmission cable goes over metal flashings, stone cornices or brick sills; one length of this loom comes with the foundation unit. Use nail-it knobs, one at the level of each floor, to hold the transmission line in place against the wall of the building.

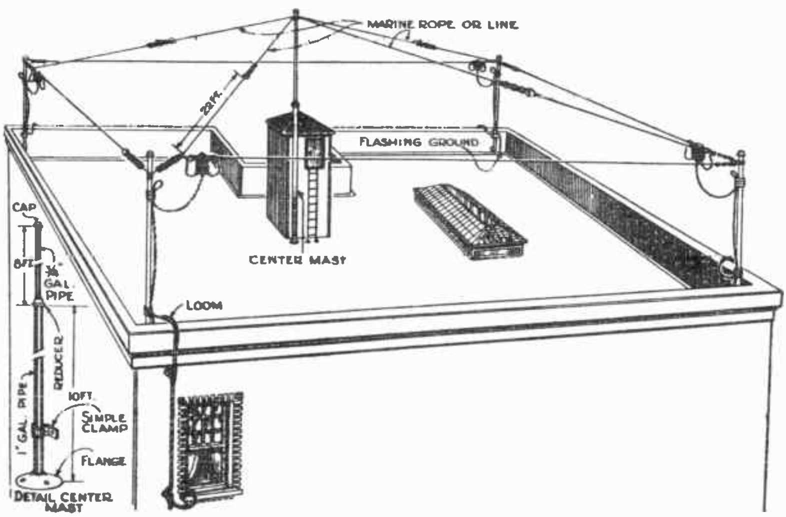


FIG. 6. Installation involving 4 master antenna systems on the roof of a large apartment building. Each system serves one vertical row of 20 apartments.

hole. The receiver transformer can be mounted on a wall, baseboard or window frame near the receiver location.

Erecting The Antenna. Detailed instructions for erecting the two horizontal pick-up sections cannot be given, since each installation will be different. Follow the general rules for antenna erection, keeping in mind that this installation must stay up for many years. If you use only the heaviest grade of galvanized iron pipe, at least 1½ inches in diameter, for the antenna supports, and they are not more than about ten feet high, no guy wires will be needed. Apply several coats of aluminum paint at all points where the galvanized coating is removed while cutting or threading the pipe. Cover the upper end of each pipe

The two horizontal pick-up sections of the Taco master antenna system have a combined length of 102 feet; about 3 feet additional is required for insulators and supporting wires or ropes. When there is not sufficient room atop the building for a straight stretch of 105 feet, the two sections of the antenna may be erected at right angles to each other or in the form of a V without incurring any serious loss in pick-up and with only a slight change in the directional characteristics.

Ordinary pipe fittings arranged as shown in Fig. *5* form a sturdy anchorage for a pipe mast. The two pipe flanges are bolted to the parapet with lag screws of the lead-expansion type after holes for these screws are drilled out with a star chisel or star drill. Nipples (short lengths of pipe, threaded at each end) are screwed into the flanges, after which an elbow is screwed onto the lower nipple, and a Tee joint is placed over the upper nipple. This Tee should be reamed out so that the pipe will just pass through. The pipe is threaded at each end, then pushed through the Tee joint and turned into the lower elbow. A cap is then placed over the top of the pipe to complete the mounting. You can have all the threading work done beforehand by a plumber if you do not possess the necessary tools. Note how the two sections of the antenna are at right angles to each other in Fig. 5, with the antenna transformer located close to the insulator; note also that the black

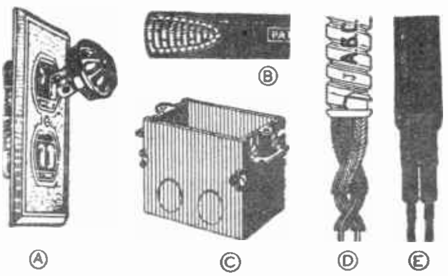


FIG. 7. Accessories sometimes required for a master antenna system when the transmission cable is brought down between the walls of the building. *A*—Combination polarized antenna-ground outlet and power outlet; *B*—loom for protecting transmission cable; *C*—conduit box for use with any wall outlet; *D*—armored BX cable with two No. 14 insulated wires, used between walls in place of regular transmission cable; *E*—lead-covered cable, used in place of regular transmission cable when extra protection is desired at some point on the roof.

lead of the transmission line is tapped slightly above the parapet and a connection made from it to the grounded metal flashing on the roof. The transmission line is fastened to the metal mast with friction tape at two points.

An interesting installation of four master antenna systems on the roof of a 20-story apartment building having 4 apartments on each floor is shown in Fig. 6. Note the central supporting mast and the umbrella-like arrangement of the 4 antenna systems, with each serving one vertical row of apartments. When planning an installation for any building, study the roof arrangement carefully in order to devise an installation which will be effective and which can be put up at a price acceptable to the owner of the building.

Inside Wiring. When a master all-wave antenna system is installed in a building during construction, all transmission lines may be brought down through the walls, giving complete concealment; this is a job which must be done with the cooperation of an electrician. Whenever the transmission cable is run through walls, it should be protected either with ordinary electrical conduit pipe or with flexible metallic conduit. To eliminate pulling the transmission cable through the conduit, you can purchase regular armored BX cable which has two twisted, insulated No. 14 wires inside, and use this in place of the transmission cable. Transmission lines can terminate in standard electrical cut-out boxes in each apartment; these boxes can also serve for 110-volt power outlets if a combination radio and power outlet like that shown at *A* in Fig. 7 is used. Note that a polarized plug is required for the radio aerial and ground connections. The receiver matching transformer can be placed in the cut-out box and connected to the terminals of the polarized outlet. Be sure that all outlet locations meet with the approval of the architect.

Transmission cable may be concealed inside the walls of homes already built, provided the owner is willing to go to the expense of having BX cable pulled through the wall. The connections are exactly the same as for outdoor installations. Inside wiring should always be done in cooperation with an experienced electrician. Materials sometimes needed for master antenna installations are shown in Fig. 7.

For big jobs, it is best to seek the advice and criticism of the manufacturer of the antenna system which you plan to use. His reputation as well as yours is at stake, and each good installation can mean additional business for both.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

How to Erect an Antenna and Ground System

ANY GOOD radio receiver has sufficient sensitivity to bring in stations with a surprisingly short antenna. A few feet of insulated wire thrown out of a window, a wire strung around a room, or even a metal rod projecting from a window will provide sufficient signal pick-up for distant stations when connected to any A.C. operated superheterodyne receiver having five or more tubes. This does not mean, however, that a short antenna is recommended; it is the duty of a Radiotrician to convince his customers that a good outdoor antenna is superior for all receivers.

Here is a simple way in which you can demonstrate this fact for yourself, using a sensitive modern receiver having a good outdoor antenna. Tune in a fairly distant station at normal volume, then disconnect this antenna and use about a 10-foot long length of wire as an antenna. Notice how the background hiss or noise has increased. A modern receiver has automatic volume control (abbreviated A.V.C.), which automatically makes the receiver more sensitive to compensate for the poorer antenna; as a result, noise which originates in the first sections of the receiver is amplified to the extent that it becomes annoying. The shorter and lower the antenna used, the more noticeable will be this noise. A long outdoor antenna gives a clear radio signal with a minimum of noise, making distant broadcast band reception more enjoyable.

Every serviceman should know how to install a good outdoor antenna system for a broadcast band receiver. The antenna described in this job sheet is recommended for homes in the suburban regions of a city and in rural districts; it is not recommended for industrial or business sections, where electric motors, neon signs and other electrical devices create man-made interference which ruins radio reception. For these locations you should install a special noise-reducing antenna like that described in a later job sheet.

An ordinary inverted L type antenna system for broadcast band reception contains five essential sections: 1, the aerial wire, supported in a horizontal position between insulators; 2, the lead-in wire, which connects the aerial to the receiver; 3, the ground lead; 4, the ground; 5, the lightning arrester. The sketch in Fig. *1* shows these five sections for a typical installation.

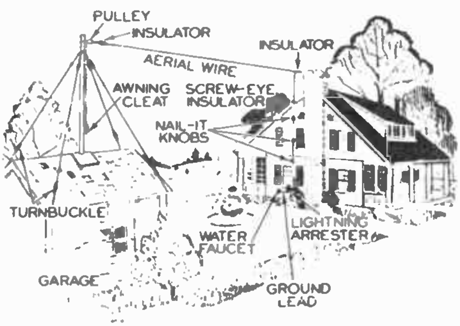


FIG. 1. Simple and effective inverted L type antenna and ground system for broadcast band reception.

General Suggestions. Each aerial installation presents a different problem, and careful study is required before the proper aerial location can be determined. Here are a few general hints for locating the aerial: The aerial wire should be as high above the ground as possible. Both the aerial and the lead-in should be kept away from trees, shrubbery, phone and power lines, and metal roofs. The lead-in wire should go directly to the window which is closest to the receiver. A chimney or any other convenient high point on a house can serve as one support, while a tree, a tall mast in the back yard, or a short mast on a garage roof can serve as the other support. An inverted L antenna picks up signals best from the direction in which the free end of the horizontal aerial wire is pointing, but the difference in pick-up for other directions is so

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little that a Radiotrician generally neglects directional characteristics. For best broadcast band reception, the horizontal aerial wire should be between 70 and 100 feet long, while the lead-in can be any convenient length.

A good ground is just as essential as a properly erected aerial wire. A coldwater pipe, either inside or outside the house, should be your first choice provided it is near the receiver location; second choice is

FIG. 2. A good ground rod like this can be made from galvanized pipe (any diameter) by flattening one end to the shape of a wedge.

a hot water or steam pipe. If none is available, a special outdoor ground should be used. This can be a galvanized iron pipe about 6 feet long and from ¾ in. to 2 in. in diameter, with one end hammered into the shape of a wedge as indicated in Fig. *2*, and a pipe cap fitted over the other end (this cap is not essential, however). The pipe is driven into the ground directly under the window, about a foot away from the foundation of the house. Ground rods are available at radio supply houses.

Parts commonly used in broadcast band antenna systems are shown in Fig. *3*; the exact quantities required will naturally vary with each installation. If a mast is required for a garage or house roof, you can either use a ready-to-install metal unit like those at *A*, *B*, and *C*, in Fig. *4*, or can construct a wood mast like that shown in Fig. *5*. Guy wires are essential with any mast, to offset the strain placed on it by the long aerial wire. When a mast is more than 6 feet high, it is advisable to attach the aerial wire to a length of clothesline and run it through a pulley at the top of the mast; this simplifies installing the antenna, and permits lowering the antenna for repairs without having to climb up the mast. When a chimney is to serve as one support, simply loop a length of galvanized guy wire around the chimney as indicated in Fig. *4D*, and attach an insulator to the free end of the wire. When one end of the antenna is to be attached to a tree which may sway considerably, the arrangement shown in Fig. *4E* is recommended.

A detailed description of the steps involved in erecting an antenna system like that shown in Fig. *1* will give you the essential information required for making any other installation of a similar nature.

Preparing the Aerial and Lead-In. Attach a glass or porcelain insulator to one end of

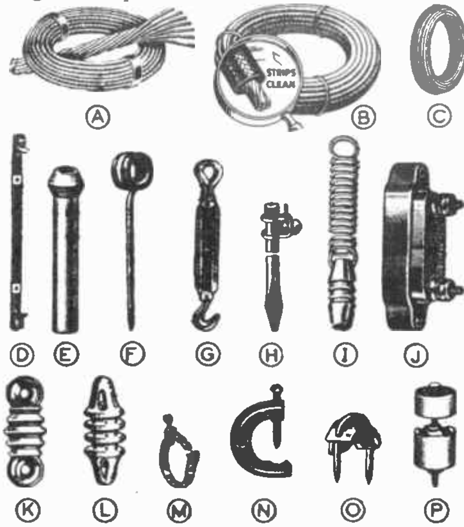

FIG. 3. Parts commonly used in antenna systems; they are obtainable from radio supply houses either separately or in antenna kits.

A—Antenna wire. From 50 to 100 feet of seven-strand bare or enameled copper wire is needed.

B—Lead-in and ground lead wire. Get at least 50 feet of No. 14 or No. 18 rubber-covered tinned copper wire, either solid or stranded.

C—Galvanized steel guy wire for use with masts. Order a 50-foot coil.

D—Window lead-in strip. Place across window sill, under window. If using an outdoor ground, two of these strips will be required (one for the ground lead, the other for the antenna lead-in).

E—Porcelain wall tube, 6 inches long. Used for bringing antenna lead-in and ground lead through a wall. Requires a 5-16" diameter hole.

F—Screw insulator. Porcelain ring mounted in 3" or 7" long screw eye. For holding a lead-in wire away from a wall.

G—Turnbuckle. For tightening guy wires. Sold by hardware stores.

H—Ground rod. Copper-plated steel rod 3-8" in diameter and 4 or 6 feet long, with screw clamp for ground lead.

I—Tension spring with insulator. Inserted in antenna wire to keep it tight and relieve strain when one end is anchored to a tree.

J—Lightning arrester. Install outside the house below window through which lead-in is run.

K—Glass insulator for antenna wire.

L—Porcelain insulator for antenna wire.

M—Ground clamp.

N—Ground clamp.

O—Insulated staples. For fastening lead-in and ground wires to wall inside house.

P—Nail-it knobs. Two piece, with nail through center. Leather washer under nail head prevents cracking porcelain. Used for fastening lead-in and ground wires to outside walls.

the aerial wire, leaving the wire coiled as indicated in Fig. *6*. Thread about 15 in. of lead-in wire through this same insulator and wrap the wire around itself a few times to make a strong mechanical joint. Now remove the insulation from the end of the lead-in wire, and clean the wire with your knife. Clean the antenna wire in the same way at the point where the lead-in is to be attached. Twist the lead-in wire around the antenna wire, tightening the joint with your combination pliers, then solder the joint. Leave both the lead-in and antenna wires coiled for the time being, to prevent them from becoming tangled.

Anchoring to the House. With a house of the type shown in Fig. *1*, you should be able to get up on the roof by climbing out through one of the dormer windows and using the dormer roof as a support while walking up the main roof to the chimney. Carry with you the prepared aerial and lead-

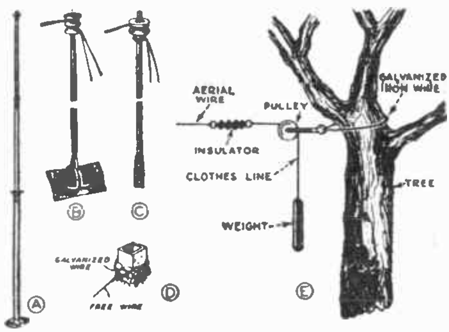

FIG. 4. Ideas for aerial supports. *A*—telescoping steel mast; base is adjustable to any slope of roof, and fastens to roof with wood screws; *B*—one-piece steel mast with adjustable base. Double insulator at top serves for aerial and guy wires; *C*—one-piece steel mast with flat base which can be screwed to side of house or bent at any required angle; *D*—method of anchoring aerial wire to chimney; a galvanized metal band (about 2" wide) around the chimney is preferred to wire by some Radiotricians; *E*—method of anchoring aerial wire to tree; the wire should be threaded through a section of an old bicycle tire where it goes around the tree. A large lag screw, of the type used for clothesline poles, is often used instead of a wire loop to fasten the pulley to the tree.

in wires, a pair of combination pliers and about 10 feet of galvanized steel guy wire. Loop this guy wire around the chimney in such a way that it will not slip up or down complete the loop by twisting, then attach the free end of the guy wire to the glass insulator at the lead-in end of the antenna wire. Partially unwind the aerial and lead-in wires, and allow them to drop to the ground.

Constructing the Mast. The mast and its base can be assembled in your work shop or on the ground, to reduce the amount of work you need do on the peak of a steep roof. You will need a 2-in x 2-in. mast of the desired height, a 12-in. length of 1-in. x 10-in. board and two 10-in. lengths of 2-in. x 4-in. wood. Nail the 2 x4 pieces to the board in the manner indicated in Fig. 5, then trim the lower end of the mast so it fits snugly in the corner provided for it. Fasten the mast to its base by driving one nail up through the 1-in. board into the end of the mast, and driving one or two more sidewise into the 2 x 4. Be careful not to split the mast. Now drill two small holes through

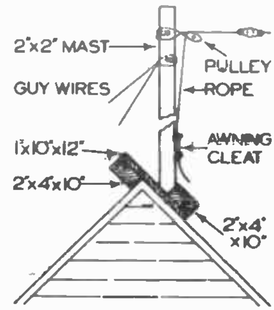

FIG. 5. Suggested construction for a wood mast which is to be at the peak of a roof.

the mast, one about 2 in. below the top and the other about 12 in. below the top. Thread a length of galvanized steel wire through the uppermost hole, wind it once or twice around the entire mast, then anchor it by twisting. Fasten a pulley to this guy wire about 6 in. away from the mast. Attach the guy wires next, threading them through the lower hole, winding them around the mast once and fastening them by twisting. Cut these a little longer than the estimated required length. Fasten an awning cleat near the base of the mast with wood screws (you can secure this cleat from a hardware store). Thread clothesline or sash cord through the pulley as indicated, tie an insulator to the upper end, and temporarily loop the lower end around the cleat. If necessary, nail a few wood laths between the base and the mast to serve as temporary braces during erection. Now you are ready to carry the mast up on the roof.

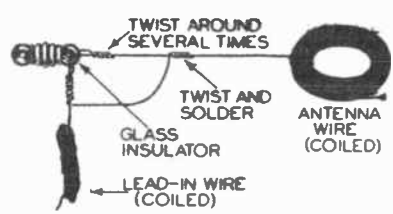

FIG. 6. Prepare antenna and lead-in wires like this in your shop before installing.

Erecting the Mast. Place a ladder at a convenient location against the garage, so you can carry the completed mast up to the roof. There is no need to nail the base of the mast to the roof, since the guy wires will provide sufficient downward pressure to hold the base in position. The guy wires can be fastened to large screw eyes which are inserted in the roof at the required locations. It is advisable to insert a turnbuckle in each guy wire to permit straightening the mast and tightening the wires after the installation is completed.

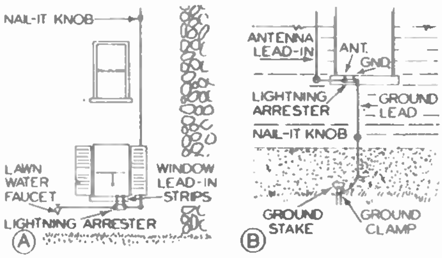

FIG. 7. Lead-in and ground connections.

Attaching the Antenna Wire to the Mast. Carefully unroll the entire coil of antenna wire, avoiding any kinks, and carry the free end up the ladder to the garage roof. Cut off surplus antenna wire so that the insulator at this end will be about one foot from the pulley when the antenna wire is tight; a little experimenting may be necessary, so do not cut the wire until you are sure it is the correct length. Loop the rope securely around the awning cleat when the antenna wire has been tightened; this completes the work at this end of the system.

Bringing Down the Lead-In. The lead-in must be brought down to the window nearest the receiver by the shortest possible route, and at the same time must be supported at sufficiently close intervals that no section of it can flap against the house during a strong wind. Use either screw insulators or nail-it knobs for this purpose. The lead-in wire is threaded through the porcelain rings of the screw insulators, and is placed between the two sections of a knob. The lowest lead-in support will be directly alongside the lightning arrester location.

Installing the Lightning Arrester. Mount the lightning arrester next, using wood screws. Run the lead-in wire to a lightning arrester terminal, and remove sufficient insulation from the wire at this point to permit looping it around the arrester terminal without cutting the wire. Tighten the terminal nut, then run the lead-in wire up to the window lead-in strip. Cut the wire to the correct length, remove the insulation at its end, and then insert the wire in the Fahenstock clip which is usually provided at each end of a window strip.

Ground Connections. In the installation chosen for our example, a water faucet was sufficiently close to the lightning arrester location to permit its use as a ground. Clean the water pipe with sandpaper or a knife, and then attach the ground clamp. One end of the left-over length of lead-in wire is now attached to the ground clamp; a screw is usually provided on the clamp for this purpose. Run the ground lead directly to the remaining lightning arrester terminal, using nail-it knobs if necessary. Loop the wire around the remaining lightning arrester terminal after removing the insulation, then run the wire up to the second window lead-in strip. Cut off surplus wire and connect to the strip as before. Details of this ground connection are shown in Fig. *7A*, while connections for a separate ground rod are shown in Fig. *7B*.

Connections Inside the House. Use flexible rubber-covered wire of the same color as the interior of the house (to make the wire as inconspicuous as possible) for connecting the two inside ends of the window lead-in strip to the antenna and ground terminals of the receiver. Generally it will be best to tack the wire around the base board with insulated staples, as in Fig. *8*. Keep the antenna and ground leads at least 3 in. apart. A neater installation can be secured by cutting off the Fahenstock clips from the lead-in strips and soldering the wires directly to the strips themselves, as indicated in Fig. *8B*.

Special Considerations. If an inside ground is used, only one window strip will be needed. The outside ground will still be connected to the ground post of the lightning arrester, however, for protective purposes. An outdoor lightning arrester is essential in any home installation, according to the requirements of the Board of Fire Underwriters. If a customer objects to the use of

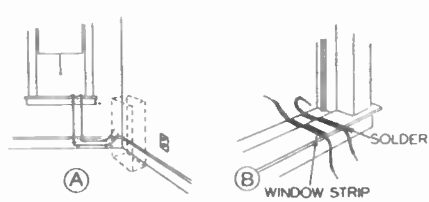

FIG. 8. Interior connections.

window strips, a porcelain tube may be inserted through the wood frame of the window after drilling a hole of the correct size, and the ground and lead-in wires threaded through this tube. Be sure to slope the tube downward from the inside wall so rain cannot enter through it.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

How To Erect An All-Wave, Noise-Reducing Antenna

REASONABLY good all-wave reception can be obtained with a conventional inverted L antenna system whose total length including the lead-in and ground wire is between 40 and 50 feet; the chief drawback to a simple antenna of this type, however, is its inability to reject noise signals which are created locally by electric motors, electric appliances, flashers, and other sources of man-made interference.

It is indeed fortunate that the magnetic and electric fields which are set up by interfering electric appliances stay pretty close to the ground, and affect vertical wires far more than horizontal wires. By placing the horizontal aerial wire up fairly high and by giving special treatment to the vertical lead-in and ground wires we can secure a noise-reducing antenna for all-wave reception.

Shielded cable (insulated wire covered with metal braiding) can be used for the lead-in; with the lower end of the shield grounded, interference signals travel down it to the earth without affecting the lead-in wire. Another common treatment involves using a lead-in made up of two wires twisted together; each picks up interference signals, and at the receiver these signals are made to cancel each other, leaving only the desired station signal. Special lead-in wires like these are often called *transmission cables*. Specially designed radio transformers are generally used to connect a transmission cable to the aerial wire and to the receiver; this procedure is essential for efficient transfer of radio signals over a wide range of frequencies in the short wave bands and in the broadcast band.

A complete all-wave, noise-reducing antenna system consists of the horizontal aerial wire, the aerial transformer, the transmission cable, the receiver transformer, and the usual ground system with a lightning arrester. All-wave antenna systems are designed to give nearly uniform performance over a wide range of frequencies, oftentimes from 500 kc. to 18,000 kc., but this can be secured only by a sacrifice in maximum pickup.

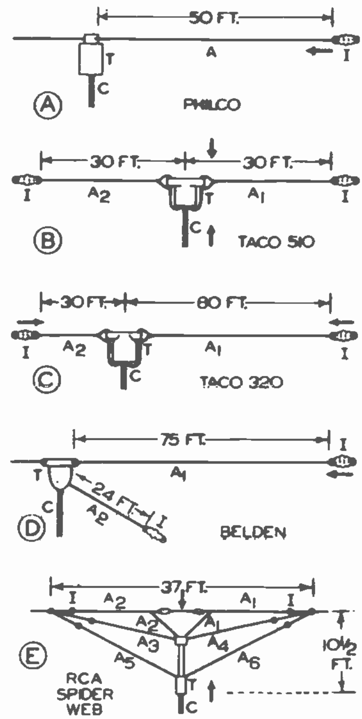

FIG. 1. The essential features of five basic types of all-wave, noise-reducing antennas are shown here in simplified form. In each case the exposed aerial wires which serve to pick up the radio signals are designated by the letter *A*; antenna transformers are designated as *T*; insulators are designated as *I*; transmission cables are designated as *C*. The heavy arrows indicate the directions from which radio signals are received best in each case.

This means that an all-wave system will *not* give better broadcast band reception than a simple 75 to 100-foot L-type antenna, nor will it give better short-wave reception

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than a 40 to 50-foot overall length L-type antenna.

The characteristics of all-wave antennas vary widely; one antenna may have better noise-reducing qualities with a sacrifice in signal pick-up, while another may have greater pickup ability in the broadcast band, with noise reduction in the short-wave band. For this reason it is impossible to make any specific recommendations. Radiotricians usually study and try out a few of the antenna units which are readily available in their locality, then standardize on one or perhaps two types which best meet their requirements.

Types of All-Wave Antennas. Thanks to manufacturers, the various types of all-wave antenna systems now on the market are quite easy to install. The aerial wire, aerial transformer and transmission cable are connected together at the factory; the aerial is

Philco all-wave, noise-reducing antenna kit.

cut to the correct length and all insulators are already attached to it. Your problem is to choose a system having the lead-in connection in the most favorable location (at the center, near one end or at the end of the horizontal aerial wire), and then provide the proper support for each end of the antenna, in a location which will permit dropping the lead-in or transmission cable down as nearly vertical as possible to a window close to the receiver location. Five basic types of all-wave, noise-reducing antenna systems which are available today in pre-assembled kits are shown in simplified form in Fig. *1;* let us consider the general characteristics of each.

Philco. This is essentially an inverted L-type antenna modified for all-wave reception. It is ideal for use in locations where a lead-in connection to one end of the aerial wire is most convenient. Only one antenna insulator (*I*) is furnished, for the antenna transformer (*T*) serves to insulate the other end. This antenna picks up signals quite well from all directions, and slightly favors signals coming from the direction of its free end, as indicated by the heavy arrow.

Taco No. 510. This system, shown in Fig. *1B,* is a typical doublet antenna, with

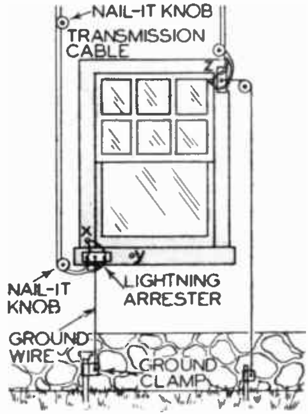


FIG. 2. This sketch illustrates various methods of bringing the transmission cable through the window or window frame into the house. Either screw insulators or nail-it knobs can be used to support the transmission cable along the sides of the house.

two equal horizontal sections, A_1 and A_2. This system is best for locations where the lead-in window is approximately midway between the two end supports; it receives best from its sides.

Taco No. 320. This system, shown in Fig. *1C*, is actually a combination of two different inverted L antennas. One section (A_2) has a short horizontal aerial for best reception of short wave stations, while the longer section (A_1) is for broadcast band reception. The aerial transformer (*T*) automatically routes the signal current from either antenna down the two-wire transmission cable without interaction between the two antennas. This system receives signals quite well from all directions, with a slight favoring of stations from the free ends.

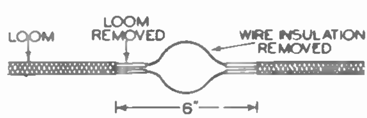


FIG. 3. Preparing transmission cable for connection to a lightning arrester.

Belden. In Fig. *1D* we simply have a variation of the system shown in Fig *1C;* instead of having the short and long horizontal sections in one straight line, they are arranged in approximately the same direction, at an angle of at least 30°. This permits anchoring the transformer end of the system to a support which is more or less directly above the lead-in window. Aerial section A_2 may be above, below, or to either side of aerial section A_1. Reception will be quite good in all directions, with stations in the directions of the free ends being favored slightly.

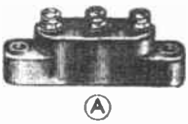


FIG. 4A. Typical 3-terminal lightning arrester.

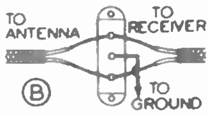


FIG. 4B. Connections for a 3-terminal lightning arrester.

RCA Spider-Web. This well-known all-wave system, shown in Fig. *1E,* is essentially a multiple doublet antenna, for it is made up of three balanced doublet antennas (like that in Fig. *1B*) in a single assembly. Its general appearance has given it the name "spider-web antenna," but you will find multiple doublet systems with other arrangements as well. A doublet antenna gives best reception of a station whose wave length is approximately twice the length of the horizontal doublet wire. If several doublets are properly connected to a common transmission cable, they will work more or less independently and thereby pick up a large number of stations effectively. The part labeled *T* in Fig. *1E* contains two coils which serve to lengthen section A_5 and A_6 for broadcast band reception. With this spider-web antenna the transmission cable must be a definite length; if the 45-foot cable which is provided is too long, coil up the surplus length and tuck it into the radio cabinet. If the cable is too short, add on as many extra 45-foot sections as are required, without cutting any of the sections. This antenna requires two high supports, at least 38 feet apart and at least 15 feet higher than the nearest object. This antenna system, like the balanced doublet shown in Fig. *1B*, receives best from its sides.

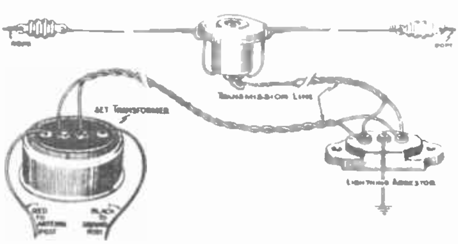
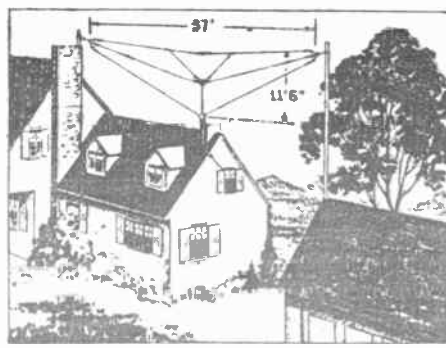


FIG. 5. Taco No. 510 all-wave, noise-reducing antenna system.

Installing the Transmission Cable. When installing an all-wave antenna system for a customer, it is always best to explain the possible ways in which you can bring in the transmission cable, and use that which is least objectionable to the customer. A few of these methods are illustrated in Fig. *2.* A hole just large enough for the cable may be drilled upward into the house through the window frame at point *x* or *y*, or a larger hole can be made at these points to permit use of a porcelain tube through which the cable can be run. Slanting the hole upward prevents water which collects on the cable from dripping through the hole into the house. If the upper window section is closed at all times, a small hole drilled through a corner of this window at point *z* will serve nicely.



Typical installation of an RCA Spider Web Antenna System.

Fig. *3* illustrates how a transmission cable is prepared for connection to a doublet type lightning arrester. A typical 3-terminal lightning arrester for doublet antennas is shown in Fig. *4A,* while the transmission cable connections to it are shown in Fig. *4B.* The center terminal should be connected to an outside ground rod or to a water faucet.

Inside the house, the transmission cable should be led down alongside the window sash to the base board, then run along the top of the base board to the receiver location. Use insulated staples for fastening the cable to the base board. At the receiver location, the cable is connected to the receiver transformer, which may either be bolted to the chassis or screwed to the inside of the radio cabinet. All connections for a typical complete system are shown in Fig. 5. The receiver transformer connections will differ with each system, but if the instructions supplied by the manufacturer of the unit are followed carefully, there should be no trouble.

Installing Filters for Line Noise Elimination

The first step in eliminating noise which interferes with radio reception is to determine whether the noise is originating inside or outside of the receiver. To do this, disconnect the aerial and ground leads to the receiver, then short together the aerial and ground terminals with a short piece of wire. If the noise about which the customer complains is still heard, it is either originating in the receiver or is coming in over the power line; if the noise is not heard, it was being picked up by the antenna system. Be sure to listen for the crashes, buzzes, or popping sounds about which the customer complains, rather than for normal atmospheric noises or the rushing sounds which are characteristic of a sensitive receiver.

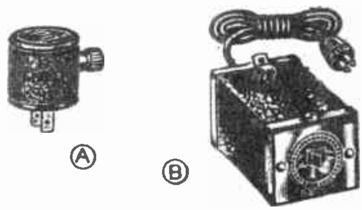


FIG. 6. Simple line noise filters.

If the noise is heard while the antenna and ground terminals are shorted, the next step is to determine whether it is coming in over the power line. This is done by inserting a line noise filter into the receiver power cord. Typical filters are shown in Fig. *6*; that at *A* contains two condensers with the common connection going to a terminal which should be connected to a good ground; that at *B* is more effective, and contains two coils in addition to the condensers. The coils serve to choke or keep out noise signals, while condensers sidetrack these signals to ground, thus preventing them from getting past the filter into the receiver. The receiver power cord is plugged into the outlet on the filter, while the filter unit itself or its power cord is plugged into the wall outlet. Be sure to connect the terminal on the line noise filter to the ground terminal of the receiver or to a separate ground, as indicated in Fig. *7A*.

If the noise is still heard while a line noise filter is installed and the antenna and ground terminals of the receiver are shorted, the trouble is unquestionably in the chassis. If jarring the chassis increases the noise, it will possibly be due to a loose part or connection. If the line noise filter reduces but does not entirely eliminate the noise, some of it may be entering the chassis through exposed parts; this is particularly true of the older receivers. Little can be done about this; a modern, completely shielded receiver is required.

Once you establish the fact that the noise is originating outside of the receiver, you should install a modern noise-reducing antenna. Keep the horizontal aerial wire as high as possible, and as far away as possible from power and telephone lines. If this is impractical, run the horizontal wire at right angles to these power lines. If some of the noise is coming in over the power line, you will also have to install a line noise filter. If the noise-reducing antenna and the filter give only partial reduction of the noise, your next step is to locate the offending electrical device and install a line noise filter on it. The method of doing this for the case of an electric washer is shown in Fig. *7B*; the ground terminal on the filter is here connected to the frame of the washer. Sometimes it will also be necessary to ground the frame of the washer or other offending appliance.

Oftentimes the customer will be able to give you clues as to the source of the noise. You may learn that it is heard only when an electric razor, electric refrigerator, electric fan, or electric sewing machine is in operation, and consequently you can concentrate your attention upon the particular device in question. Do not expect a simple line noise filter to be effective for all cases; in later job sheets and in your regular Course you will learn about other methods for eliminating man-made interference.

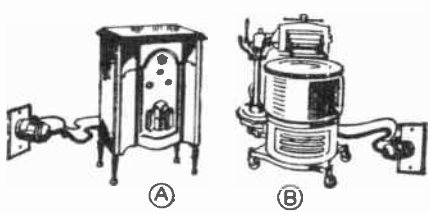


FIG. 7. Connections for line noise filters.

Power, Ground and Antenna Lead Extensions

THE installation of a radio receiver in a home ordinarily involves three separate connections: 1, to the antenna lead-in wire; 2, to the ground wire; 3, to a power source, usually a wall outlet. Whenever a radio receiver is moved to a different location in a home, it is usually necessary to extend these connections.

The two-wire power cord supplied with the average A.C. or universal A.C.-D.C. receiver is generally about six feet long; when this is not enough to reach from the selected receiver location to a wall outlet, there are two possible procedures: 1, the receiver power cord can be extended by splicing on an extra length of cord or by replacing the existing cord with a longer cord; 2, a permanent or semi-permanent power outlet may be installed within six feet of the receiver and connected to the house wiring system. These two procedures will now be described in detail.

Extending a Receiver Power Cord. If you decide to extend the existing power cord, determine how much additional power cord you will need, then buy the required amount, choosing a size and color which is a close match to that already used with the receiver. If you cannot match the existing cord or if the splice will be visible (not concealed by furniture), it will be far better to install an entirely new cord of the correct length, connecting it to the receiver chassis in exactly the same way as the old cord was connected. IMPORTANT: If working on a universal A.C.-D.C. receiver having a special cord which heats up considerably when the set is in operation, never attempt to extend or shorten the cord; use a semi-permanent power outlet extension if the cord will not reach to an existing outlet.

Assuming that you are extending an existing power cord, the next step is to remove the plug at the end of the old cord; usually this can be done simply by loosening the two terminal screws and pulling the wires out, but occasionally you will find it necessary to untie an anchoring knot in the wires before you can pull them out. Sometimes the plug will be molded on to the power cord; in this case, simply cut the cord as close as possible to the plug, and use a new plug for the extension.

To prepare the new length of cord for connection to this plug, cut away or push back the outer covering at one end for about three inches, as indicated at *A* in Fig. *1*. Now push these wires through the hole in the plug, and make the approved electrician's knot which serves to anchor the wires in the cap, by following the steps indicated at *B*, *C*, and *D* in Fig. *1;* this knot

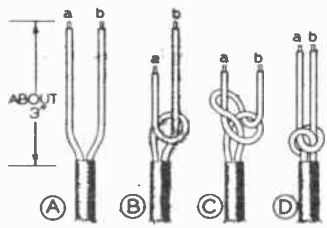


FIG. 1. Steps in tying the approved knot for a power plug cord connection.

takes up the strain which might otherwise be placed upon the actual terminal connections when the plug is pulled out by yanking on the cord. With a little practice you will be able to make this special knot in a few seconds.

As your next step, remove about one inch of insulation from each wire, then twist together the strands on each. Now pull on the cord while holding the plug, to bring the knot down into the plug, then bring one lead around the nearest prong, and loop its bare portion in a *clockwise* direction under the terminal screw for that prong. Tighten this screw, cut off any surplus wire which might project from it, then connect the other wire to the remaining terminal screw in the same manner.

Other possible methods of connecting to a wall plug are shown in Fig. *2;* the connection to *A* is the same as that just described except that a single simple knot is used in place of the approved knot. At *B* is shown the commonest method of connecting to a wall plug; the knot is omitted entirely, but each wire is still looped around a prong before being connected to a screw terminal.

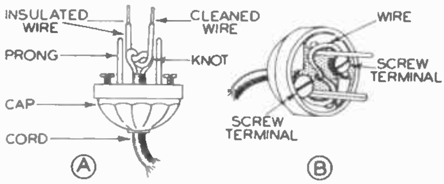


FIG. 2. Power cord plug connections.

Splicing together the old and new cords is the next step. The procedure is illustrated in Fig. *3;* prepare each wire as indicated at *A*, then clean the exposed wires and twist the strands of each wire together. Now place together the bare wires marked *a* (to form the letter "X"), and wind the ends in opposite directions as indicated at *B;* do the same for the bare wires marked *b*. This gives a staggered joint, reducing the possibility of a short circuit between the wires. Squeeze down any sharp projecting ends of the wires with pliers, then solder the joints. Wind each joint separately with ⅜-inch wide friction tape (you can secure tape in this width from radio supply houses, or you can split regular-width friction tape in half by ripping down the center). Now tape the two wires together, bringing the tape

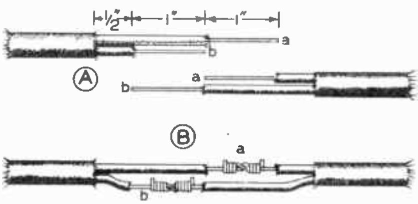


FIG. 3. Approved type of power cord splice.

over onto the outer covering for a short distance at each end of the splice. This completes the splice; arrange the cord in a neat manner from the receiver to the wall outlet. If the cord runs for any distance alongside a wall, fasten it to the baseboard with molding staples like those shown in Fig. *4A*. These are pushed behind the upper molding and serve to hold the cord just above it, as shown in Fig. *4B*.

Semi-Permanent Power Outlet Extensions. Although the installation of a new wall outlet by an electrician is the approved procedure for extending a power connection, the customer will not always approve of this because of the extra expense involved in drawing the necessary wires through the wall. The use of a semi-permanent power extension like that shown in Fig. *5A* is more likely to meet with the approval of the customer; this can be secured from any hardware or electrical store as a complete assembly and can be installed very easily inside the room. The extension usually consists of about ten feet of appliance cord, with a plug connected to one end and an outlet receptacle at the other end.

If you prefer, you can assemble your own semi-permanent power extension by using parts similar to those shown in Fig. *5*. Use either twisted or parallel lamp cord accord-

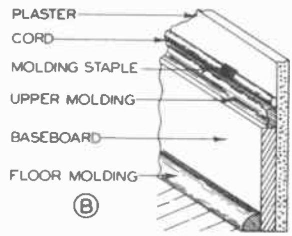


FIG. 4. Use molding staples to hold an extension cord neatly against the baseboard.

ing to the preferences of your customer, cut it to the required length, and connect to one end either a conventional plug like that shown at *D*, or the special plug shown at *E*, which also serves as an outlet for another plug. To the other end of the cord connect a double-outlet receptable like that at *F* or *G*.

When all connections have been made, mount the receptacle on the wall or baseboard at the chosen location. Units like that in Fig. *5F* are held in position by the single mounting screw through the center; with units like that at *G*, however, the removable fiber base is first mounted with two wood screws, and the outlet itself is then fastened to the base with a machine screw. Now fasten the cord neatly to the baseboard either with the molding staples shown in Fig. *4A* or with insulated staples like that in Fig. *5H*. The correct way to use insulated staples is illustrated in Fig. *6;* note that only the insulating paper is in contact with the cord. Place the staples about three feet apart, with two staples at each bend in the wire and two at each end.

Ground and Antenna Lead Extensions. When a radio set is moved to a different location in a home, it is almost always necessary to extend the antenna and ground leads. Start with the antenna lead; splice a length of insulated wire (any size; choose a color to match the wall finish if possible) to the existing lead-in wire or connect it directly to the antenna window strip. Now run this wire down to the top of the molding on the baseboard, and along this molding to the receiver location. Use insulated staples to hold the wire neatly in position against the molding. The ground wire is extended in exactly the same manner, but is run just above the floor molding so as to keep it at least six inches away from the antenna lead at all points. All this is illustrated in Fig. 7, which also shows a typical power extension.

If the existing lead-in is a transmission cable, use the same type of cable for the extension (it is a good idea to check the installation instructions for the antenna system before doing this, for with some systems a cable extension must be a definite length). A cable may be run alongside a ground lead if desired.

How Defects In An Antenna System Are Detected And Repaired

A check-up of the antenna installation in a home is an essential part of the initial inspection for surface defects. Before entering a home for a service job, the Radiotrician automatically looks for the antenna; if it is entirely visible from the front of the house, he checks for the following items: 1, that the horizontal aerial is up, is clear of all surrounding objects, and does not sag excessively; 2, that the lead-in wire is properly anchored to the house by insulators; 3, that there are no obvious breaks or defects in the system; 4, that the outside ground wire, if used, is properly connected. With experience, all this can be done almost at a glance. When the antenna is at the rear of a house, this check-up can generally be made by looking out of a window after the receiver itself has been inspected for surface defects. If an indoor antenna is being used, you have an excellent chance to sell the customer a modern outdoor antenna installation.

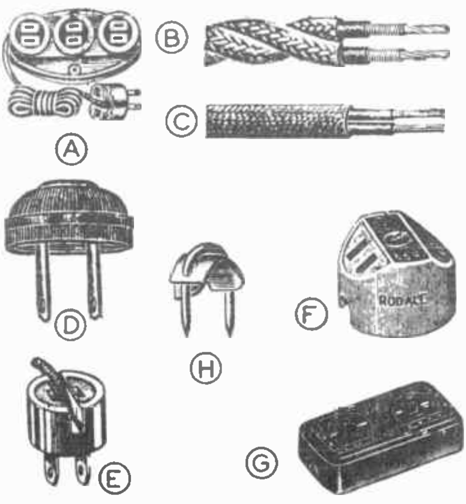


FIG. 5. **Parts used in making power extensions.**

Here are a few clues which indicate a defective antenna. If a strong hissing sound is heard along with a program when a receiver is tuned to a local station, you can be pretty sure that there is a poor antenna system. This sound will get stronger as you turn up the volume control. If the hissing noise increases only a little or not at all when the antenna is disconnected, the existing antenna system is practically useless. These tests apply to superheterodyne receivers which have six or more tubes; with smaller supers and with T.R.F. sets the noise may not be noticeable, but you can always judge antenna effectiveness by the number of distant stations which are re-

FIG. 6. **Method of using an insulated staple.**

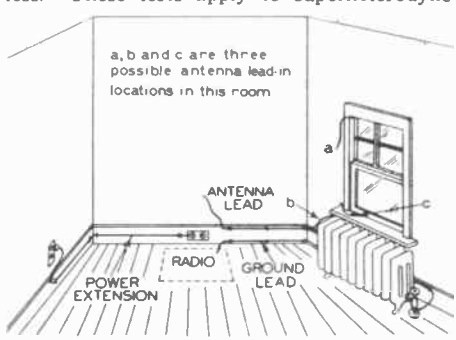


FIG. 7. **Example of receiver location which requires extension of power, antenna and ground leads.**

ceived (assuming that the receiver is in good condition).

If you suspect that a loose connection in the antenna system is the cause of loud crackling noises which are heard along with radio programs, tune the receiver off a station and turn up the volume, then proceed to shake or pull the ground and antenna leads inside the house. Give especial attention to the connections through the wall of the house, then shake the ground and lead-in wires at all accessible outside points. If the noise increases when a particular wire section is moved, you have localized the trouble. Poor joints should be resoldered; a break in a wire should be repaired by splicing; damaged insulation should be taped or the entire wire replaced.

Antennas which are more than three years old should be completely replaced, since the insulation will undoubtedly have deteriorated in this time. This is especially true for all-wave noise-reducing antennas, since sufficient improvement in the design of these has been made in the last three years to warrant the installation of a new and up-to-date system. Exposure to weather causes wires and joints to corrode, causes cables to become brittle, and makes insulation porous. If the customer will not approve of the installation of a new system, you should at least lower the horizontal aerial wire to inspect the soldered joints and resolder them if necessary, then wipe off soot and dirt from the insulators with a moist cloth. Make any other repairs which you consider necessary during this procedure.

Testing a Standard Antenna. If an inspection of a standard inverted L antenna system reveals no visible defects, and the check for noisy connections likewise does not show up trouble, disconnect the antenna lead-in and ground wires from the receiver and connect them to an ohmmeter. If the aerial and lead-in wires are properly insulated, you should secure an open circuit indication (no movement of the ohmmeter pointer). If this test gives a definite resistance reading or a zero resistance reading, check the lightning arrester first of all by disconnecting it and measuring its resistance with the ohmmeter. There should be no continuity between its two terminals; a definite resistance reading indicates a leaky or defective lightning arrester, which should be replaced immediately. In general, whenever a receiver performs better with a ten-foot length of wire tossed out of a window than with the existing antenna, there is undoubtedly a short-circuit path from some point on the aerial wire or lead-in to ground; look for it.

Testing Noise-Reducing Antennas. The most common source of trouble in noise-reducing antenna systems is the transmission cable. If this looks old, ragged and weatherbeaten, by all means replace with a new cable, using as nearly identical cable as you can secure. You will find three types of transmission cables in general use: 1, a single insulated flexible wire covered with a braided metal shield or loom; 2, two insulated wires twisted together, with a weatherproof braided cotton covering over both; 3, two twisted insulated wires surrounded by a braided metal shield and then by a weatherproof braided cotton covering. The metal shield should always be connected to ground at the receiver end. Transmission cables used in antenna systems for receivers usually have an A.C. rating of between 70 and 100 ohms; this rating has no relation to the D.C. resistance of the cable, which is approximately 13 ohms per 100 feet of two-wire cable. In other words, if you connect together the two leads at one end of a 100-foot cable and measure the resistance between the other ends with your ohmmeter, it should read about 13 ohms; for a 50-foot cable the reading will be about 6.5 ohms.

When trouble has been traced to a noise-reducing antenna system which is several years old, replacement is justified without further tests; when necessary, however, you can find the location of the defect with an ohmmeter. Test the lightning arrester first; disconnect it entirely, then measure the resistance between its center terminal and each of the outer terminals. There should be an open circuit in each case if the unit is good. To test the transmission cable, you will have to disconnect its wires at each end; this will mean cutting the cable a few inches below the aerial transformer if there are no terminals on the transformer, so it will be necessary to lower the entire antenna system in order to splice and solder the cable after tests are completed. If the cable is good, the resistance measured at one end between the two wires or between a wire and the shield should be more than 50,000 ohms; a lower resistance indicates leakage between conductors because of defective insulation, and the cable should be replaced. To check for an open circuit in the wires, connect them together temporarily at one end and measure the resistance between them at the other end. The ohmmeter should read the D.C. resistance of the cable; a very high-resistance reading indicates a break in one of the wires. With shielded cable this will be difficult to locate, so replace the cable.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

How Resistors, Coils and Condensers Are Tested in the Chassis

ALTHOUGH a surprisingly large number of receiver failures are due to tube troubles, power supply defects and surface defects, there naturally are a number of other receiver troubles. If you have checked the above items without locating the trouble, the logical thing to do next is to remove the chassis and loudspeaker from the cabinet.

Checking for Obvious or Surface Defects Below the Chassis. When a Radiotrician removes a chassis from its cabinet, he automatically looks over the parts and connections for obvious or surface defects in them. You can do this yourself now very easily, once you prop the chassis upside down on blocks so all parts will be accessible.

Go over the chassis wiring in a methodical manner, just as if you were overhauling the receiver. Pull each lead to each soldered joint with your long-nose pliers, and resolder every questionable joint. Look for damaged insulation on wires, especially at points where wires go through the chassis. Be sure that no wires or parts are touching the chassis at improper points. This inspection for surface defects underneath the chassis must be made with the power cord plug out of its wall outlet.

While making this inspection, "keep an eye open" for parts which are obviously defective, By this I mean any broken or charred resistors, condensers from which the wax has been melted by excessive heat, electrolytic condensers covered with a white substance which has oozed out of the paper or metal housing, and cardboard-covered electrolytic condensers with bulging sides. Wiggle the leads of each paper condenser to make sure they are not loose *inside* the condenser housing; do this also for other parts which may have loose internal connections. Make a second check of each suspected part by wiggling it with a wood stick while the receiver is operating; a crackling noise from the loudspeaker means that the part is defective due to a loose connection.

Each obviously defective part in the chassis or loudspeaker should be replaced and each defective connection repaired, and the performance of the receiver then checked. If performance is still unsatisfactory, or if no defects were located in this inspection, the hunt for the defective part must continue.

Making Continuity Tests. The design of the average A.C. radio receiver is such that there is a continuous metallic path from the chassis through radio parts and wires to each tube terminal. A check on this will often reveal an open circuit in some part or a break in a connection.

A condenser in the chassis of this receiver is being tested with the ohmmeter section of a multimeter.

An ohmmeter or the ohmmeter section of a multimeter is used for continuity testing between tube terminals and the chassis. One lead or test probe of the ohmmeter is connected to the chassis, and the other is touched in turn to each tube terminal; *be sure that the receiver power cord plug is out of its outlet* while this is being done. If the ohmmeter needle or pointer moves at all from its extreme left-hand position when this is done, you can assume that there is continuity between the points being tested.

An ohmmeter is simply a battery in series with a milliammeter and a current-limiting resistor; if the ohmmeter leads are connected to points between which there is a direct connection (or if the leads are connected together), the battery can send maximum current through the meter and make it register a full-scale deflection, with the pointer at the extreme right, pointing to zero ohms. A typical ohmmeter scale is shown in Fig. *1*. If there are resistors (or coils which have resistance) between the points to which the ohmmeter leads are touched, these will naturally offer opposition to the flow of battery current and will lessen the deflection of the meter. If there is no direct circuit between the ohmmeter terminals, no current can flow and the meter pointer will not move. Test only those tube socket terminals in which you can actually see prongs, for octal base tubes having 5, 6 or 7 prongs are always placed in standard 8-prong octal sockets.

When an open circuit is indicated by a test, you still have the problem of locating the exact position of the break. As you become more familiar with radio apparatus,

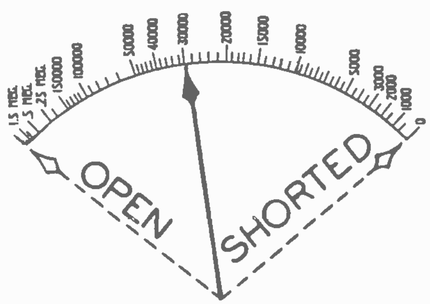


FIG. 1. Typical ohmmeter scale, with the pointer indicating a reading of 30,000 ohms. Normal or no-current position of pointer is at extreme left, as indicated by the dotted line. Maximum-current position of pointer is at extreme right, corresponding to zero resistance or a shorted part. Note that an ohmmeter scale has its lowest value at the *right*, whereas voltmeters and ammeters ordinarily have the lowest value at the left.

you will learn how to move the ohmmeter probe from the tube terminal toward the chassis, one step at a time, until you pass through the break. The continuity test which I have just described is very easy to make, and serves to locate open connections, open coils and open resistors; it will not locate open condensers or shorted parts, however.

Probable Causes of Common Defects. If continuity tests fail to reveal the defect, your next step in the mechanical servicing technique is a test of individual parts. This is a long, tedious job if every part in the receiver must be checked, but usually the observable symptoms will give you a general idea of where to look for the trouble.

Later in your Course you will receive a reference book "Radio Receiver Troubles; Their Cause and Remedy," in which many valuable clues for locating the more common defects are given, but for the present it will be sufficient to know the following facts about common receiver complaints:

Dead or weak receivers will often have a shorted condenser, an open connection, an open coil, or an open resistor.

Squeals are often caused by an open condenser.

Hum is often caused by a defective electrolytic condenser

Distortion is often caused by a shorted resistor or shorted condenser.

Motorboating, which results in a put-put sound coming from the loudspeaker, may be caused by a defective condenser.

Noise is invariably due to a bad connection at a joint or in a part, assuming that it is originating inside the receiver.

Testing Parts with an Ohmmeter. When one terminal of a resistor, coil or condenser on a chassis is *free* (so that there is no conductive path for direct current from that terminal to the other terminal except through the part itself), you can check the part very easily with an ohmmeter by connecting one ohmmeter probe to each terminal of the part.

The correct ohmic value of a resistor is usually printed directly on the resistor, or indicated by means of the standard color code which is given at the end of this job sheet. If the reading obtained with an ohmmeter connected across a resistor is approximately equal to the specified value, you know that the resistor is in good condition. (Variations of up to 10%, or 10 ohms in 100 ohms, are usually satisfactory for resistors; or example, a 100-ohm resistor may measure anywhere from 90 ohms to 110 ohms and still be good; a 200-ohm resistor may be 20 ohms more or less than this value; a 250,000-ohm resistor may be 25,000 ohms higher or lower than its rated value.) A zero-ohms reading would indicate a shorted resistor; on the other hand, if the ohmmeter pointer did not move at all when the ohmmeter was connected, you would know that the resistor was open (no connection between its terminals).

A coil having one free terminal can be tested in exactly the same way as a resistor. With coils the measured resistance will be low, and the lowest range on your ohmmeter should be used. A good coil will have a low but definite value of resistance; a zero-resistance reading indicates a shorted coil, while no ohmmeter pointer deflection indicates an open coil. When testing a transformer, test each coil separately, making sure that one terminal is free before connecting the ohmmeter. Ohmmeter indications for resistors and coils in various conditions are shown in Fig. 2.

Paper condensers having one free terminal can likewise be checked, using the highest range of the ohmmeter. If the ohmmeter pointer kicks slightly up-scale *and then returns to its original position*, the condenser is good. The amount of kick will be proportional to the size of the condenser, so with small paper condensers (below .05 mfd.) the kick may not be noticeable even when the condenser is good. A zero-resistance ohmmeter reading indicates a shorted condenser. No pointer movement at all (for large paper condensers) is an indication that the condenser is open. A definite ohmmeter reading of any value (such as 200 ohms or 75,000 ohms) is a sign of a defective (leaky) paper condenser. Typical ohmmeter readings for paper condensers are shown in Fig. 2.

Mica condensers are generally of such a small size that they cannot store sufficient electrons to kick over the ohmmeter pointer. Absence of ohmmeter pointer movement when testing a mica condenser can therefore mean either that the condenser is open or that it is good. A shorted mica condenser will give a zero-resistance ohmmeter reading, just as will any other shorted radio part.

When electrolytic condensers are tested with an ohmmeter, a reasonably high resistance reading (about 250,000 ohms or higher) indicates a good condenser. You will find, however, that electrolytic condensers will give two different resistance readings, depending upon how the ohmmeter is connected. Note the reading for one position of the ohmmeter probes on the condenser terminals, then reverse the positions of the probes and again read the ohmmeter. Use the *highest* reading as your guide in determining the condition of the condenser. Absence of a reading indicates an open connection in the electrolytic condenser, while a zero-ohms reading indicates a shorted condenser; in both cases the condenser is defective and should be replaced.

Testing Parts in the Chassis Which Do Not Have Free Terminals. You now know how to use an ohmmeter for testing parts which have one or both terminals free—but what about those parts which are connected across other parts and which therefore have no terminals free? Naturally we can unsolder one terminal or lead of the part which we wish to test, but this is a tedious job even for one who is an expert at soldering. Fortunately, however, there are a number of cases where we can secure useful information by checking a part directly with an ohmmeter while it is still connected across other parts.

When you wish to test a resistor which is shunted by a paper or mica condenser, simply connect your ohmmeter across the resistor terminals in the usual manner. If the ohmmeter reading corresponds to the ohmic value specified on the resistor or indicated by its color code markings, you know immediately that the resistor is good and

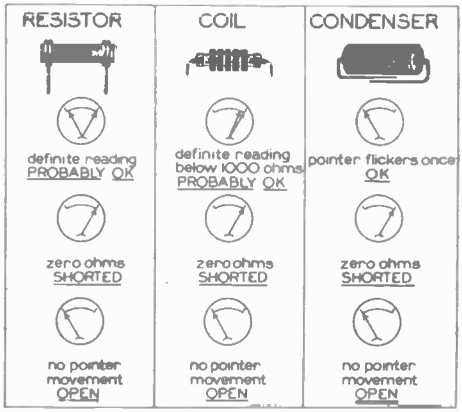


FIG. 2. When a resistor, coil or paper condenser is being tested with an ohmmeter, the position of the pointer on the ohmmeter scale tells a definite story about the condition of that part; typical readings and their meanings are indicated on this chart.

that the condenser is not shorted. If the reading differs greatly from the rated value, it is best to unsolder one lead of the resistor and repeat the test, rather than try to figure out how the condenser may be affecting the ohmmeter reading.

When a resistor is shunted by a coil and both parts are good, you should generally secure an ohmmeter reading corresponding to the resistance of the coil, and this will be a value lower than 1,000 ohms. A zero-resistance reading would indicate a short across either the coil or the resistor, making individual tests necessary.

When a paper or mica condenser which is known to be good is shunted by a coil or resistor, an ohmmeter connected across the condenser will read the true resistance of the coil or resistor. In the case of a coil the reading will be less than 1,000 ohms, while in the case of a resistor across the condenser, the reading may be anywhere from 100 to 1,000,000 ohms or even higher. Only when one of the parts is shorted will you obtain a zero-ohms reading.

A practical radio mechanic will usually make this short-circuit test on a suspected condenser regardless of how it is connected in the circuit, for an ohmmeter will always indicate a short. Upon finding no short, he will then turn on the receiver, tune in a local radio station, and place a good condenser of the correct size across the suspected condenser. If the trouble clears up, he knows that he has located an open condenser which requires replacement.

When a coil is shunted by a condenser, a zero-resistance reading would indicate a short in either the coil or the condenser.

Whenever there is some doubt as to the exact meaning of an ohmmeter reading when checking a part which is connected across other parts, *disconnect one lead of the part in question and make an individual test of it with your ohmmeter.* Wiggle or tap the part being tested while the ohmmeter is connected across it; this will often reveal a poor connection or what servicemen call an *intermittent open*, the clue being a flickering of the ohmmeter pointer.

Summary. At this time I want to give you a summary of the various steps already covered in the mechanical technique of servicing. This summary will help you to remember the various steps in their proper order, and will serve as a convenient reference list when you decide to practice the technique on actual radio receivers.

1. Turn on the radio receiver and tune in a local station.

2. Make a check to see if the receiver is supplied with power, either by observing the pilot lamps or in some other manner.

3. See if all of the tubes glow (in the case of glass tubes) or warm up.

4. Be sure that all top cap connections for tubes are in place and are not touching any metal parts such as tube shields.

5. Check to see that antenna and ground leads are properly connected to the receiver.

6. Test all tubes, replacing defective ones.

7. Remove the chassis and loudspeaker from the cabinet and set the chassis upside-down on your work-bench, then look for visible defects.

8. Check all connections in a logical manner by pulling on each lead with pliers, resoldering any which appear defective.

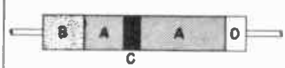
9. Check all tube electrode circuits for continuity with an ohmmeter.

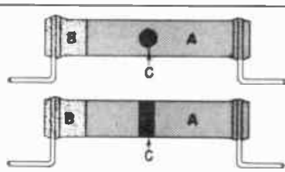
10. Check all suspected parts with an ohmmeter.

11. Make a general ohmmeter test of all parts in the chassis. BE SURE TO REMOVE THE RECEIVER POWER PLUG BEFORE MAKING ANY OHMMETER TESTS WHATSOEVER ON THE CHASSIS.

RMA COLOR CODE FOR RESISTORS

METHOD I
COLOR BANDS A,B,AND C GIVE VALUE.
GOLD OR SILVER BAND D, USUALLY OMITTED, INDICATES TOLERANCE.
BLACK BACKGROUND — UNINSULATED.
TAN BACKGROUND — INSULATED.





METHOD II
BODY COLOR (A), END COLOR (B), AND DOT OR BAND COLOR (C) GIVE VALUE.
GOLD OR SILVER BAND D, USUALLY OMITTED, INDICATES TOLERANCE.

Color	Figure
BLACK	0
BROWN	1
RED	2
ORANGE	3
YELLOW	4
GREEN	5
BLUE	6
VIOLET	7
GRAY	8
WHITE	9

COLOR A GIVES FIRST FIGURE OF RESISTOR VALUE.

COLOR B GIVES SECOND FIGURE OF RESISTOR VALUE.

COLOR C GIVES NUMBER OF CIPHERS FOLLOWING THE FIRST TWO FIGURES.

COLOR D: GOLD BAND INDICATES ± 5% TOLERANCE.
SILVER BAND INDICATES ± 10% TOLERANCE.
NO BAND INDICATES STANDARD ± 20% TOLERANCE.

EXAMPLES OF METHOD I

BAND A	BAND B	BAND C	BAND D	BACKGND.	RESISTOR
Violet (7)	Green (5)	Black ( )	Silver	Tan	75 ohms ± 10%, insulated
Orange (3)	Black (0)	Red (00)	None	Black	3,000 ohms ± 20%, uninsulated
Orange (3)	Black (0)	Yellow (0000)	Gold	Tan	300,000 ohms ± 5%, insulated
Red (2)	Green (5)	Green (00000)	None	Tan	2,500,000 ohms ± 20%, insulated

EXAMPLES OF METHOD II

BODY (A)	END (B)	DOT OR BAND (C)	RESISTOR
Violet (7)	Green (5)	Black ( )	75 ohms
Orange (3)	Black (0)	Red (00)	3,000 ohms
Orange (3)	Black (0)	Yellow (0000)	300,000 ohms
Red (2)	Green (5)	Green (00000)	2,500,000 ohms

FIG. 3. The two methods in common use for marking resistors according to the standard RMA color code are given here, with examples. When a color dot or band is missing, assume it to be the body or background color. The tolerance marking, when used, tells how much the resistor may vary from its rated value. Thus, a 100-ohm resistor with 10% tolerance may be as much as 10 ohms higher or lower than 100 ohms.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

How Defective Moving Radio Parts Are Repaired

EVERY radio receiver has a number of moving parts which are set in motion by knobs, buttons or levers on the front panel and which serve to control the performance of the receiver. *Variable resistors* are used to control loudness, tone and receiver sensitivity. A *variable condenser* is used to tune a receiver to a particular desired station; special *dial mechanisms* are often employed to simplify tuning. *Switches* are used to turn the receiver on or off, to change the tone characteristics, to change from one wave band to another and to tune in stations automatically. In this job sheet you will learn how each of these moving parts can be cleaned, adjusted, repaired when defective, and replaced.

Repairing Variable Resistors. As a general rule, variable resistors give more trouble than any other moving part in a radio receiver; fortunately, however, the trouble is quickly detected and can be remedied without any particular knowledge of the receiver.

Typical variable resistors are shown in Fig. *1*; they are all designed for single-hole mounting, and are held in position on the chassis by a single nut (visible in Fig. *1A*). Looseness of the entire control is a sign that this nut is loose; remove the chassis from its cabinet and tighten the nut with your combination pliers or a wrench. When only the knob on the resistor shaft is loose, look for a hole in this knob in which is a small set screw; tighten this screw with your smallest screw-driver. Sometimes these knobs are held in position by a small, flat spring inside the knob; if knobs of this type become loose, replace the spring with one taken from a new knob, or replace the entire knob.

When rotation of a variable resistor fails to give the correct change in loudness, sensitivity or tone, or when this causes noise, use the following simple ohmmeter test to determine whether the variable resistor is defective:

1. Remove the chassis from the cabinet and turn the chassis upside-down. Unsolder all connections to the variable resistor, labeling or arranging them so you can resolder the connections again without getting the wires mixed up.

2. Place your ohmmeter test probes on the outer two terminals of the group of three terminals. A definite resistance reading should be obtained, and this should check reasonably well with the rated value. (Variations of up to 20 ohms for each 100 ohms of resistor value are usually permissible.)

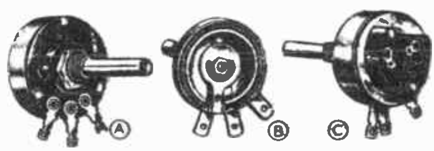


FIG. 1. Typical variable resistors which you may have to repair or replace. Note the group of three terminal lugs on each; the middle lug always connects to the moving contact arm. At *A* is a completely enclosed unit with a metal housing which may be removed for inspection by prying up a few metal tabs; at *B* is an open unit of the wire-wound type; at *C* is an enclosed unit with an ON-OFF power switch on its cover plate.

3. For a final test, transfer one probe to the center terminal. Rotate the control shaft; the ohmmeter pointer should move gradually up and down its scale, with no flickering, if the control is good. Flickering indicates an internal defect.

When a Radiotrician locates a variable resistor which obviously has some internal defect, he generally does not even try to repair it. Experience has shown that a repaired resistor cannot be depended upon to give smooth, reliable service for any period of time. Replacement variable resistor units are inexpensive and are readily obtainable for all common radio receivers; all you need to specify when ordering is the *make* and *model number* of the receiver and the purpose of the unit (whether it is a

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volume control, sensitivity control or tone control).

When removing a defective variable resistor, note whether its shaft is insulated from the chassis by fibre washers; if it is, be sure to use these same washers when installing the new unit. If the shaft of a variable resistor does not rotate freely, a few drops of plain machine oil or typewriter oil on the shaft bearings will loosen it. Variable resistors with bent or obviously damaged shafts should be replaced.

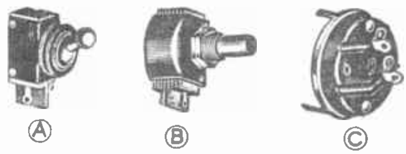


FIG. 2. Radiotricians generally replace rather than repair switches like these when defective. At *A* is the common toggle switch; a rotary snap switch is shown at *B*, while at *C* is a rotary snap switch arranged for mounting on the back of a variable resistor which is serving as a volume or tone control. The initial movement of the control knob closes the switch, turning on the power to the receiver.

Repairing ON-OFF Power Switches. Typical power switches used on radio receivers are shown in Fig. 2. A suspected power switch can be tested by pulling out the receiver power cord plug, then placing ohmmeter probes across the two terminals of the switch. The ohmmeter should indicate a zero-resistance reading for the *ON*-position of the switch and no continuity (no pointer movement) for the *OFF* position; any other readings indicate a switch which is defective and should be replaced. If a switch turns stiffly, apply a few drops of oil to its shaft.

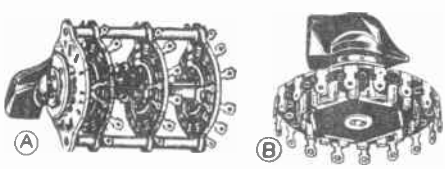


FIG. 3. Typical band-changing switches used in radio receivers. At *A* is a triple-deck switch, and at *B* is a single-deck switch.

Repairing Band-Changing Switches. In all-wave receivers you will find multi-contact switches like those shown at *A* and *B* in Fig. 3, connected to coils and tuning condenser sections in such a way that a different range of frequencies can be tuned in for each setting of the switch. The contacts are of the type shown in Fig. 4A, in which a projecting tab on a metal ring moves between the two prongs of a spring brass clip, or are of the type shown in Fig. 4B, where the moving spring brass contact arm sweeps over a fixed contact button. Band-changing switches are ordinarily well constructed and give little trouble. When defects do occur, they are generally in the soldered connections to the terminal lugs of the switch.

If a crackling noise is heard in the loudspeaker when the switch knob is wiggled, there may not be sufficient pressure between the moving and fixed contacts; with a switch construction like that in Fig. 4B, a repair is made by forcing the spring arm upward with a screw-driver or wedge, then pressing down on the end of the arm as indicated. The spring brass clips in Fig. 4A can be tightened in much the same way.

Usually the metal contacts of these switches are silver-plated and require no lubricant. Occasionally they may be covered

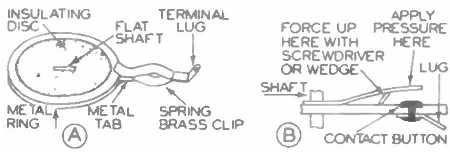


FIG. 4. Two common types of contacts used on rotary multi-contact band-changing switches. In an actual unit there will be a large number of spring brass clips (*A*) or contact buttons (*B*) arranged around the rotating part of the switch.

with vaseline; if this appears dirty, clean all contacts with benzine and then apply fresh vaseline.

Repairing Push-Button Tuning Switches. Switch assemblies are widely used in receivers employing automatic push-button tuning systems. An examination of the unit will generally reveal the cause of any particular trouble which may develop. These switches have a number of moving contacts; if they seem corroded, carefully clean and apply vaseline.

Repairing Variable Tuning Condensers. The main tuning condenser in a radio receiver ordinarily consists of two or more sections which are ganged together (mounted on a common shaft) to permit tuning of several circuits simultaneously, thus giving single-dial control of tuning. A fork-shaped spring clip like that shown in Fig. 5 is generally used for each section of the condenser gang; the ends of the clip press against a metal partition or end plate, while the center portion presses tightly against the sides of a groove in the rotor shaft, insuring a good electrical connection. A stud on the clip fits into a hole in the end plate, thereby keeping the clip in position. Be sure there is a good contact; clean the spring clip with sandpaper if necessary and increase the bend in the fork to secure a better contact.

Make sure that the tuning condenser turns freely; apply a few drops of light oil to the bearings. Rotor plates should be midway between the stator plates. If all rotor plates are off-center, it is possible to recenter them either by loosening the set screws on the rotor or by loosening the stator supporting screws; an inspection of the unit will reveal how to do this.

Tuning Dial Mechanism. Tuning dials serve a double purpose in radio receivers, in that they reduce the speed of condenser rotation to permit more accurate tuning, and also give a distinctive and attractive appearance to the receiver.

The direct mechanical drive, where the tuning knob is on the tuning condenser shaft, is so simple that it rarely gives any trouble and need not be considered at this time. Other dial mechanisms may be divided into three groups: *1*, the cord or belt drive mechanism shown in Figs. *6A* and *6B*; *2*, the single-gear or friction drive mechanism shown in Fig. *6C*; *3*, the multiple-gear system represented by Fig. *6D*.

The cord drive mechanism shown in Fig. *6A*, also known as a drum dial mechanism, employs two small pulleys on the shaft of the station-tuning knob. A cord is tied to a hole in the edge of one pulley, looped a number of times around the pulley,

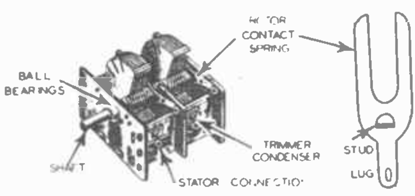


FIG. 5. Typical two-section variable tuning condenser, with detailed sketch of a rotor contact spring. The outer rotor plates are slotted and bent for alignment purposes; do not touch these bent plates until you know more about them.

then looped over the large drum wheel on the tuning condenser shaft, brought down to the small pulley at the rear of the tuning knob shaft, wound around this pulley a number of times again and finally anchored to a hole in this pulley. The result is that rotating of the station tuning knob unwinds the cord from one small pulley onto the other small pulley; since this cord grips the large wheel and is also tied to the large wheel at one point, the tuning condenser shaft rotates. A large printed celluloid scale is attached to the circumference of the large pulley, and passes in front of an escutcheon plate having a pointer which indicates the position of the rotor plates and this indicates which station is tuned in. A pilot light is generally mounted in back of the escutcheon to illuminate the dial scale.

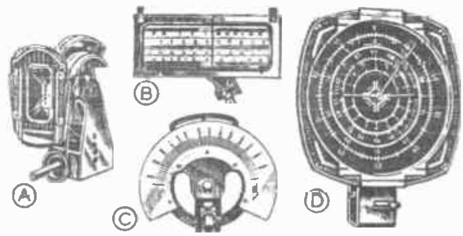


FIG. 6. Common types of tuning dial mechanisms.

The slide rule dial shown in Fig. *6B* is a popular variation of the cord drive dial. The cord is run over extra pulleys and a sliding vertical pointer is attached to the cord in such a way that it moves across the dial scale when the tuning knob is rotated.

The friction drive mechanism shown in Fig. *6C* is widely used. A large metal disc with a printed scale attached is mounted on the tuning condenser shaft. More than half of the inner section of the metal disc is cut away, to provide a circular inside edge which can be gripped by a small metal wheel on the tuning knob shaft. Sometimes gear teeth are formed on the inside of this circular disc, and a small gear is used on the tuning knob shaft; sometimes the inner circular edge is bent over to form a drum surface which is in contact with a soft rubber wheel on the tuning knob shaft.

In the gear train or aeroplane dial type of mechanism shown in Fig. *6D*, a small gear on the tuning knob shaft drives a larger gear on an auxiliary shaft; another small gear on this same auxiliary shaft in turn drives another large gear wheel which may be on a second auxiliary shaft or may be on the tuning condenser shaft. Enough gears are used to get the desired reduction in speed. In some units, pulling or pushing on the tuning knob removes one or more sets of gears from the train, changing the speed reduction ratio.

In each of these systems, there are bearings which may require oil; if a bearing appears dry, apply a few drops of sewing machine oil. If a bearing appears gummy, clean with kerosene and apply fresh oil. Vaseline applied to the gear teeth will often make the mechanism operate more smoothly and prevent binding.

Friction drive mechanisms employing rubber wheels will slip when the rubber hardens; the rubber wheel should be replaced. When an endless belt is loose, it should be replaced. Broken dial cords require restringing, a procedure which will be given special attention in the following section.

Restringing Dial Cords

Dial mechanisms using cord generally have a spring on the large pulley to take up slack automatically. If the cord has stretched beyond the slack-taking capabilities of the spring, pull up the slack at the spring, tie a knot, and loop the knot over the spring. If the cord appears old and frayed, replace with a new cord, which can be obtained from any radio supply house for a few cents. Whenever the ends of the dial cord must be tied together, use a square knot like that in Fig. *7*.

Dial cable mechanisms vary greatly in construction, and consequently I cannot give you specific instructions for restringing all types of mechanisms. In general, however, a careful study of the dial mechanism will show you how the cable should be strung. To familiarize you with the restringing process, I will go through it for two typical units.

The dial cord mechanism of one RCA receiver, shown in Fig. *8*, is typical of the simpler cable drives, and is found on dials of the type shown in Fig. *6A*. Restringing is done in this manner:

1. Remove all old cord. Set the tuning condenser at its minimum-capacity position, in which the rotor plates will be completely unmeshed. Attach one end of the new cord to that small drum *which winds up the cord* as the tuning knob is turned *clockwise*. Loop the cord once or twice around this drum. Do not worry too much about having the correct small drum, for an error will be obvious when you finish

FIG. 7. Use a square knot for splices.

FIG. 8. RCA drum dial mechanism.

restringing, and can then be corrected in a few minutes.

2. Bring the cord over the small auxiliary pulley which is nearest the first small drum, run the cord once around the large dial pulley, then loop it through the hole in this pulley and hook it over the slack-eliminating spring.

3. Pass the cord over the remaining small auxiliary pulley and wind it about six times around the remaining small drum in the opposite direction to that used for the other small drum. Anchor the cord to the hole provided in the small drum, but do not cut off surplus cord yet.

4. Try out the entire tuning mechanism; at each extremity of the tuning dial

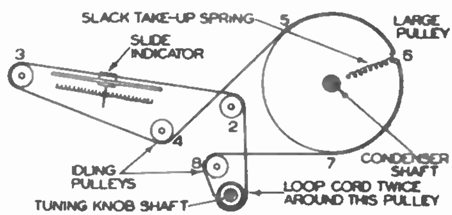


FIG. 9. Philco slide rule dial mechanism.

there should be at least one turn of cord around each of the small drums; loop extra turns around the last small drum if necessary. Cutting off surplus cord completes the dial restringing procedure.

The Philco dial mechanism shown in Fig. *9* is typical of those using a slide rule type dial. Remove the old cord, then tie one end of the new cord to the slack-eliminating spring (at point *6*). Loop the cord over the top of the large pulley (point *5*), and then over idling pulleys *4* and *3*. Run the cord through the slots at the back of the slide indicator, loop it over idling pulley *2*, wind it twice around station tuning knob pulley *1*, loop it over idling pulley *8*, then bring it around the bottom of the large pulley to point *6*. Adjust the cord length so that the end of the spring is just a little below the surface of the large pulley, then tie the cord to the spring. Now tune in a station whose frequency you know, and slide the indicator along the cord until the pointer is at the frequency of that station.

Extra Money Jobs and how to do them

How to Operate Battery Receivers from a 32 Volt Farm Supply

There are thousands of battery receivers in farm and rural homes which are not operated from the existing 32 volt D.C. power supply system. No wide-awake radio serviceman has attempted to make the necessary adaptions. The set owner will quickly appreciate the value of having a receiver which requires no battery replacement or charging, if you convince him that a battery eliminator system will be more economical.

FIG. 1

Assuming that the battery receiver is worth adapting to the 32 volt D.C. line, you must realize that there are two steps that you may take. You may replace: *1*, the filament supply only; or *2*, both the B batteries and the filament supply. Personally I would continue using C batteries, as they will last 1 to 2 years and a replacement is inexpensive. Nevertheless, they can be eliminated if part of the voltage produced by the B eliminator for the plate supply is used for the C bias voltage.

Eliminating the A Battery. You can procure from most mail order supply houses a 32 volt A eliminator as shown in Fig. *1*, which is easily installed in place of the A battery. First let me say that there are two styles: one for 2 volt battery receivers; and one for battery receivers using 01A, 12A and 71A tubes and referred to as the 6 volt battery receivers. Be sure you order the correct type. The eliminator has two terminals to which the A battery leads from the receiver are connected. But before you plug or screw the power cable from the eliminator into the 32 volt power outlet be sure the eliminator power switch and its regulator are set to the *off* position. Once the power connection has been made, turn the power toggle-switch to the *on* position, turn the control knob slowly and watch the needle on the scale of the eliminator meter. For a 6 volt receiver the adjustment is made until the meter reads 6 volts; for a 2 volt battery receiver adjust the rheostat (for that is what the control is) until either 2 or 2.5 volts are indicated. A voltage of 2.5 should be used only when the battery receiver was designed for air cell batteries or two dry cells in series.

If you wish, you may assemble a voltage reducing system as shown in Fig. 2. You will need a cord with plug, P_c; a toggle-switch S_w; an inexpensive 0-10 D. C. voltmeter, V_m; and for a 6 volt receiver R should be a 20 ohm, 50 watt resistor, R_h should be a 6 ohm, 2 ampere resistor; and for a 2 volt receiver R

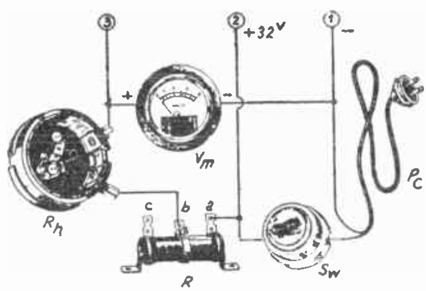


FIG. 2

should be a 100 ohm, 25 watt resistor, R_h should be a 25 ohm, ½ ampere resistor. Observe that R is a movable tap or semi-fixed resistor, while R_h is a power rheostat.

Assemble the power rheostat, voltmeter, semi-fixed resistor and switch on a baseboard, making the indicated connections to the cord and binding posts. Connect the A minus cable lead of the receiver to terminal *1*; A plus cable lead to terminal *3*. The other B and C cable leads are connected as indicated in the receiver instructions or tabs on the leads.

Before placing the plug P_c into the power supply, move contact *b* of the semi-fixed resistor R all the way to position *c*. Set the arm of rheostat R_h to the mid position. Plug P_c into the power outlet and turn the switch S_w *on*. If the meter reads down scale, reverse the power plug. Move contact *b* of resistor *R* slowly toward *a* until the voltmeter reads 6, 2 or 2.5 volts, as the case may be. Contact *b* of *R* should be securely locked and further adjustment for fluctuation of voltage should be made with the power rheostat.

The B Eliminator. This device should be purchased. Either of the 32 to 180 volt vibrator or dynamotor units may be used. Buy a type which has the 22½, 45, 67½. 90, 135 and 180 volt taps. These devices are also simple to install. Connect the receiver cable leads to the proper voltage taps of the eliminator (the cable leads are usually marked); plug the B eliminator power cord plug into the 32 volt power outlet, set the A eliminator and B eliminator power switch to the *on* position and the receiver will operate. You are still using the C batteries.

For the sake of the customer's convenience it is wise to connect both eliminators so one switch turns both units on. The receiver power switch is always left on. You will find on the commercial A eliminator two terminals that connect to the B eliminator. When this connection is made the A eliminator power switch controls both units. The A unit you build is wired for this convenience. The power plug should be removed from the B eliminator and the leads connected to terminals *1* and *2* as indicated in Fig. *2*. The B eliminator switch is left *on* continuously and switch S_w controls both the B and A eliminators.

C Battery Elimination. If the B eliminator has a 22½ volt tap you may eliminate the need for C batteries. This is done by disregarding the existing markings on the output of the eliminator and connecting the —B lead from the receiver to the +22½ volt tap. The other positive voltages will then be 22½ volts less than they were normally and the tap marked —B will be 22½ volts negative with respect to the new —B. The original —B terminal becomes the —22½ C tap. If you wish to obtain smaller C voltages, shunt the new —B and the old —B taps with a 10,000 ohm potentiometer. Any C voltage between 0 and 22.5 volts may be obtained by connecting to the movable contact and by varying its position. This C— lead on the potentiometer should be bypassed to the tap marked —B on the eliminator with a .5 microfarad condenser.

Several precautions are necessary when a receiver is connected to a 32 volt line. First: do not connect the ground terminal of the receiver directly to a water pipe or other ground. The ground terminal should be left disconnected or connected to ground through a 1 microfarad condenser. Second: be sure the aerial is not grounded. Third: be sure all tubes are inserted in their sockets before turning on the current. Fourth: never remove one or more tubes while the current is on; otherwise the remaining tubes will probably burn out.

Incidentally, if an A.C. receiver is to be operated from a 32 volt D.C. system take my advice and buy a D.C. to 110 volt, 60 cycle A.C. power converter. You will be surprised at the low cost of a vibrator type converter and your customer will be surprised at the excellent results he will obtain.

How to Rewire an A. C. Receiver for D. C. Operation

Some cities such as Washington, New York, Philadelphia, Chicago, etc., have comparatively large areas which are served with D.C. current. Frequently people move from an A.C. to a D.C. district.* These people do not wish to throw away their A.C. set and invest in a new one as in most cases they were well satisfied with its performance.

Now every radio expert, worthy of that name, should know that for a given receiver design and equal number of tubes an A.C. set will perform better than its D.C. counterpart; because in a D.C. receiver it is not possible to obtain more than 100 volts for the high potential electrodes. Even a universal receiver works more efficiently on A.C. than on D.C. It is therefore plain if an A.C. set is not to lose its excellent qualities of sensitivity and power output, when used in a D.C. district, that some method of supplying 110 volts, 60 c.p.s., A.C. from the D.C. source should be considered.

This may be done by either installing an inverter or a small rotary converter. The first will cost the customer about $25, the second device about $50. These costs are reasonable if the receiver is a good one. On the other hand you should consider whether an additional expenditure for a modern radio receiver would be more advisable. These facts should be carefully presented to the customer.

Most potential customers have heard of or have seen advertisements to the effect that their A.C. set can be rewired for D.C. at a very modest price. I am going to tell you how it is done. But be sure to inform your customer that only

* If the customer moves from a D.C. to A.C. district, do not attempt to rewire the receiver. Advocate a good A.C. receiver. Inexpensive A.C. receivers are readily obtained if cost is an important item.

local stations can be brought in with any degree of satisfaction. After all many radio listeners in large cities are merely interested in local chain broadcasts.

Radio receivers may be classified into: *1*, the receiver with specialized circuits like the high fidelity, all-wave, A.V.C., noise squelched receivers; or *2*, the simple broadcast receivers; *a*, the set using heater type tubes except in the power output stage; and *b*, the set using filament type tubes throughout except the detector.

Most reputable service men absolutely refuse to rewire receivers with specialized circuits. The customer has purchased such a set for its high fidelity or all-wave feature, and rewiring will destroy these features. When you get such a job insist on installing an inverter or rotary converter.

The only condition justifying rewiring an A.C. receiver to D.C. operation is where merely local reception of a fair quality is desired and no great expense is allowable. For this reason the broadcast receivers with heater type tubes throughout, except the output tubes should only be considered. The older broadcast receivers with 26 and 12A tubes in the R.F. and A.F. stages may be rewired at low costs but I, for one, would certainly recommend a new, properly designed, inexpensive universal receiver or chassis.

For the moment let me tell you how to handle an ordinary broadcast receiver with heater type voltage amplifier tubes. As I have no idea what kind of a receiver you may plan to rewire, I must of necessity present this job in a general way. A mere beginner should not attempt this job until he has had some service experience, can thoroughly read a circuit diagram and can trace circuits in a radio chassis. You are the only one capable to knowing when a rewiring job is within your ability. After you have rewired two or three receivers the procedure will be as easy as "rolling off a log."

It is vitally important that filament and plate voltage supplies and the loudspeaker field are properly adapted to the new D.C. source of power. It is seldom necessary to consider the control grid or screen voltages, as they are automatically produced, if the plate and cathode connections are correctly adapted. Nevertheless, the circuit diagram should be checked for any discrepancy with this fact.

Figure *3* shows the power supply circuits of a typical set such as you may be called upon to rewire. Only those circuits which will be involved in the change-over are shown. I will use it for purposes of discussion. The original complete schematic showed that all tubes receive their C bias and screen voltage in series with the +B supply, and may be forgotten. I have reproduced the output circuit because a change in the C bias voltage and connection will be required. Now let us turn to the changes required. I certainly recommend that, at the start, you draw a circuit diagram of the circuits changed.

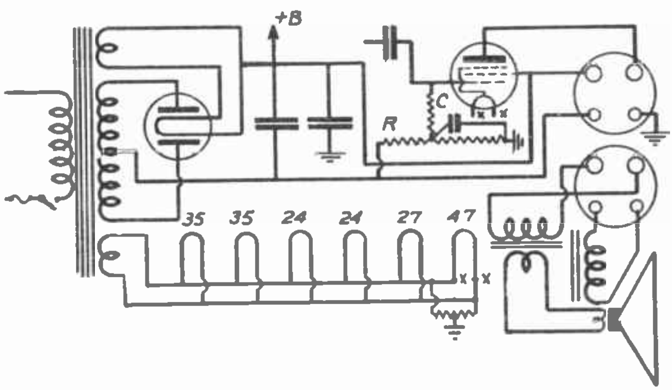


FIG. 3

The Least Expensive Change-over. The filaments must be wired in series to supply them economically with power. A glance at a tube chart shows that all of the tubes (35, 24, 27, 47) require the same filament voltage and current. The voltage to be applied to the series filament circuit is the sum of the required voltages (in this case $2.5 \times 6 = 15$) while the current drawn will be that of a single tube, 1.75 amperes. The voltage supply source is 110 volts so the limiting resistor must drop 110-15 or 95 volts and must carry 1.75 amperes. Its resistance is therefore 95 volts $\div$ 1.75 amperes, about 54 ohms; while the wattage dissipation will be 95 volts $\times$ 1.75 amperes about 166 watts. A 54 ohm resistor with sufficient wattage rating is not readily obtained. Most mail order houses carry in stock special resistors for this sort of job. One is a 20 ohm rated at 60 watts; the other is a 60 ohm resistor rated at 200 watts. Three of the 20 ohm resistors in series will give us a 60 ohm, 180 watt voltage reducer.

The use of a slightly higher resistance will result in about 2.25 volts being applied to the filaments instead of 2.5; and this is quite all right.

The power transformer, the 80 tube and electrolytic filter condensers must be removed.*

The new filter system will consist of a 10 henry low resistance choke capable of passing 60 ma.: and two 2 mfd., 250 volt paper condensers. The choke should have a D. C. resistance as far below 200 ohms as you can get it.

A 50,000 ohm 2 watt resistor *R*, and a

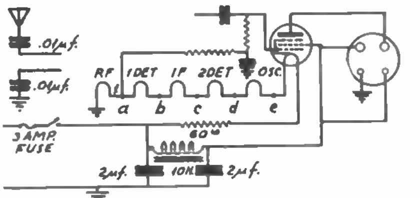


FIG. 4

.25 mfd. condenser *C*, will be required to feed the 47 output tube with a C bias voltage, as shown in Fig. 4. In this receiver the parts are already in the chassis. This bias may easily be obtained by connecting the grid return (point *1* in Fig. *4*) to a point in the filament circuit sufficiently negative with respect to the 47 filament to give the right C bias. The exact bias and connection is determined by experiment.

Figure *4* shows schematically the required changes. Note that .01 mfd., 600 volt condensers have been placed in both the aerial and ground leads. This is necessary to prevent a short in the line because one side, possibly the + side is grounded. If you could be sure that the antenna would never become grounded, the antenna condenser could be omitted. Be on the safe side and use it.

Now while this arrangement will work you may be disappointed with the results. First adjust the grid return connection of the output tube (point *1* in Fig. *4*) to give the least distortion. Positions *a*, *b*, *c*, *d*, and *e* should be tried. Pep up the set by realigning it. The procedure for aligning tuned R.F. and superheterodyne receivers is given elsewhere in the course. Some expert radio men like to adjust the screen and grid bias voltages to the other tubes. Decreasing the automatic bias resistor's ohmic value will lower the C bias voltage; changing one of the resistors in the screen voltage divider will permit an adjustment at this point of the circuit. Personally I would avoid these changes, as the job must be done at the least cost.

Changing the Power Tube. It will also be possible to obtain a material increase in power output by using a 48 type tube in place of the 47. The 48 requires a filament voltage of 30 volts and a filament current of .4 ampere and was designed especially for low plate and screen voltages. Figure *5* shows the required filament circuit, consisting of five 2.5 volt tubes producing a 12.5 volt drop and one 30 volt tube, making a total drop of 42.5 volts.

Since this is a series circuit the current flowing into it should be equal to the highest required by any of the tubes—in this case 1.75 amperes. The 48 filament cannot carry more than .4 ampere so we must place a resistor across this filament to carry the extra current. The extra current is 1.75 — .4 or 1.35 amperes. As the drop across the resistor is 30 volts and the current through it is 1.35 amperes; by Ohm's Law we find its value. This is 30 + 1.35, which equals 22 ohms. We may safely use a 20 ohm, 60 watt resistor.

Now let us turn to the line resistor. As the tubes drop 42.5 volts, and the

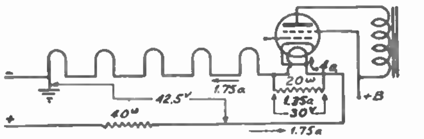


FIG. 5

power line supplies 110 volts, this resistor must pass 1.75 amperes and drop 110 — 42.5 or 67.5 volts. By Ohm's Law, its value is 67.5 ÷ 1.75 equals 38 ohms; its power loss is 67.5 × 1.75 equals 118 watts. Hence a 40 ohm, 120 watt resistor may be used.

Study the last procedure until you understand it thoroughly. This method is to be employed when two groups of tubes having unequal filament voltages and currents are to be wired in series.

The 48 is best biased by connecting its cathode to its positive filament and making its grid return as in the case of the 47. A six prong socket must be installed for the 48.

When Filament Type Amplifier Tubes Are Found. When filament type tubes are found in R.F. and A.F. amplifier stages of the receiver you rewire, the filaments are again connected in series; but the bias of each tube is obtained by connecting its grid return to its —F terminal or to the —F terminal of the tube ahead of it in the series filament connection. Each grid return should have a .1 mfd. condenser between itself and the low R.F. end of the input, the rotor of the variable condenser or to its —F filament terminal. Various C bias connections should be tried and in the audio circuits a larger condenser may be used. Never use any part that gives no apparent improvement, as costs must be kept down.

*If the electrolytics were left in and the line plug inserted so as to apply improper polarity to the condensers they would be ruined.

Extra Money Jobs and how to do them

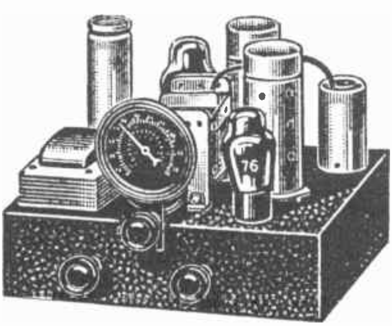
NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

How To Add an All-Wave Converter Adapter to a Radio

The ability to receive messages from foreign stations, the desire to listen in on amateur, police and aircraft conversations, the feeling of having the world of radio at your finger tips has gripped the nation. All-wave receivers and special noise reducing antennas are the radio enthusiast's favorite purchase when a new radio installation is considered.

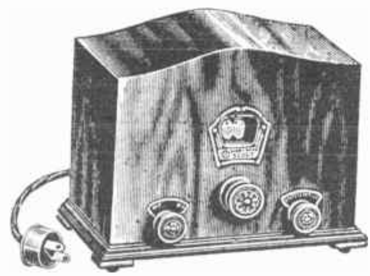
But how about the hundreds of radio set owners in your immediate locality that have good receivers, whose frequency range is limited to the 500 to 1500 kilocycle broadcast band. You cannot always interest them in a new all-wave receiver; yet you can sell many of these set owners on attaching an all-wave converter to their present sets.

These converters are rather inexpensive, in comparison with the cost of an all-wave receiver. Many all-wave converters are housed in attractive cabinets or can be installed in suitable cases. With some broadcast cabinet type receivers, there is enough room in the speaker compartment to install the converter chassis, the controls being brought through the side of the console. Indeed, it is possible to make a real professional and workmanlike installation.



Courtesy of Wholesale Radio Co., N. Y.
FIG. 1A

Radio mail order supply concerns offer a variety of converters; typical ones are shown in Figs. *1A* and *1B*. When the customer desires the best, a complete converter, the one shown in Fig. *1A* as an example should be considered. It has its own power pack. A cord is supplied to plug into the 110 volt A.C. power outlet. The antenna is disconnected from the receiver and connected to the ANT post of the converter; the two output terminals of the converter are connected to the ANT



Courtesy of Radolek Co., Chicago, Ill.
FIG. 1B

and GND receiver posts; and the receiver is tuned to some frequency value, usually 1,000 kc. Simple, to say the least.

This converter has an OFF-ON switch; a band selector, and there are 5 positions, 4 to cover 12 to 200 meters (1.5 to 23 megacycles or 1,500 to 23,000 kcs.) and one position to turn back to the original receiver; and finally there is the station selector and its tuning dial. Ordinary, doublet, or all-wave noise reducing antennas may be used with this converter. You will of course recommend the all-wave noise-reducing type.

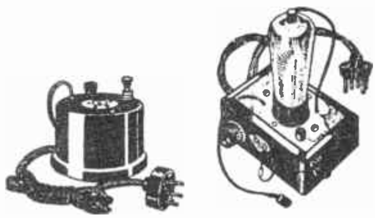
If the customer desires a finished, factory-made appearance, use the space available in the speaker compartment or shelf. I suggest that you permit the customer to try the adapter before you build it into the cabinet. Then if he is not satisfied with it all you have to do is to disconnect the converter. If the customer likes it, you can, if you wish, have a cabinet repair man do the necessary wood work. After the converter has been installed in the cabinet make a permanent parallel connection to the power cord of the receiver.

A less expensive converter is shown in Fig. *1B*. It is connected identically as the previous explained converter, has a power switch, and a tuning adjustment. It covers the 20 to 200 meter range, although better operation from 20 to 60 meters is obtained by using a second coil which is put into the cabinet after the one in it is taken out. The cabinet is small and neat and therefore can be set on top of the radio set cabinet. It is so designed so it may be operated from either A.C. or D.C. power line supplies.

An all-wave converter may be connected to either a tuned radio frequency (T.R.F.) or a superheterodyne receiver. The more sensitive the receiver the better all-wave reception you may expect.

How To Install a Police Call Adapter

There are quite a number of people (including policemen off duty) who own radio receivers and who find it a pleasure to listen in on local police calls. The words "calling all cars—calling all cars" is more than music to their ears. There is romance in following the activities of the local police.



A B

Fig. 2

Of course, you should try to convince them that they really need an all-wave converter. It will better serve their purpose. But when expense is a primary consideration, a simple *police call adapter* can be installed. They sell for far less than a converter, but unlike the converter which really changes a receiver to a super or a double heterodyne, the police call adapter uses only the audio system of the receiver. Only local reception can be reliable.

Figures *2A* and *2B* are typical police call adapters. Connecting one to a receiver is simple. Locate the detector tube; remove it and place the tube in the socket of the adapter. Plug the adapter plug into the empty socket of the receiver. Attach the top (grid) cap connection to the tube in the adapter if the detector tube is of the screen grid type, and connect a lead from the aerial to the ANT post of the adapter. Turn the adapter switch to the ON position and tune in the local police call. Remember that police test calls are transmitted every fifteen minutes and alarm calls transmitted whenever necessary. You must at first tune carefully and slowly. You must be patient or you might tune past the desired station.

Once the adjustment has been made, show the customer how to switch from regular reception to police call pick-up. Sometimes a change-over switch is located on the adapter. Show by switching from left to right that either police calls or the regular programs are obtained.

Adapters are made in a variety of ways. Always study the instructions given with each of the police call adapters before you install it. These simple adapters will only tune in local police stations, that is, stations located about 15 miles away as they are not very sensitive or selective. Follow the instructions carefully and you will get results.

How To Assemble a Simple, Effective Public Address System

Adapting a Microphone and a Phono Pick-up to a Radio Receiver. There is real money to be made in loudspeaking systems, commonly referred to as P. A. (public address) systems. Hundreds of service men are making money in this field. Large public address systems are costly and their installation should be considered only if you are going to give this field your major attention. Of course, you will thoroughly study this branch of radio, if you chose as your specialty the Servicing and Merchandising Course.

Yet every service man should give some real thought to getting in on the smaller P.A. installations. There is extra money in it for you, and by starting in a small way you will be prepared for the bigger things. A very simple installation can be made with a little investment—you know it takes money to make money.

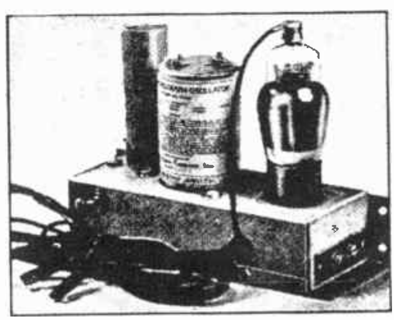


Fig. 3

In this practical job sheet I am going to consider the simple plan of changing a radio receiver to a P.A. system, which you must realize is used to amplify voice or music of a performer, or the reproduction of recorded programs.

The special equipment that I am going to describe is extremely simple to install in a radio receiver. In fact, I feel that it will be best to tell you how to attach it and then where and to whom you can sell the assembled unit.

The device I have in mind is shown in Fig. 3. It is an R.F. oscillator, a miniature transmitter, having a tuning range of 1,400 kc. to 1,700 kc., just below the normal broadcast band. This unit is manufactured by the RCA Manufacturing Company, Inc., of Camden, New Jersey, and is called the phonograph oscillator. It is also known by the stock number 9554. You can get it from the nearest RCA distributor. The factory will tell you where the nearest distributor is located, if you want this information.

unit to the receiver are quite short, it is advisable to mount the oscillator right in the cabinet, or console, above the chassis. All wires are colored, enabling you to easily determine their connection in the circuit. The blue lead is connected to the antenna. Two twisted wires go to the phonograph pick-up or to the microphone transformer circuit from the S.P.D.T switch.

To place this unit into operation, turn on the receiver and make sure the switch on the oscillator is turned on too. Tune the receiver to the oscillator frequency and talk into the microphone. Adjust the volume controls on both the set and the oscillator unit for best quality. Usually the volume control on the oscillator is advanced further than the receiver. Don't place the mike too close to the radio set or you will hear a singing noise. Keeping the volume controls turned down will eliminate feed-back and singing.

If you want to use the phonograph attachment, set the volume control of the

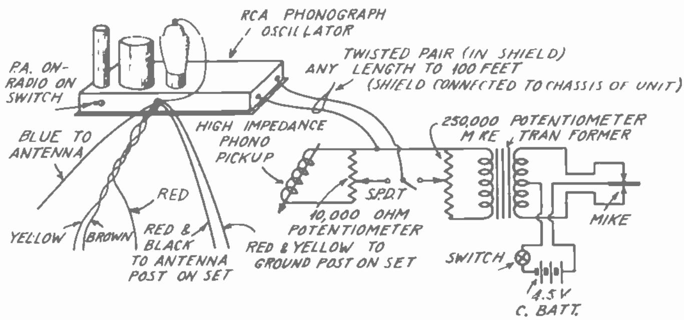


Fig. 4.—*The yellow and brown leads are connected to the heater prongs of any tube except the rectifier by means of tube prong clips; the red lead is connected to either one of the filament prongs of the rectifier tube.*

This device is connected to the "ANT" and "GND" posts of a good receiver, and either a phonograph pick-up (with a turntable), or a good microphone is attached to the oscillator. An "off and on" switch is provided which automatically shuts off the miniature transmitter, and if the receiver is connected to an antenna system this operation also reconnects the receiver to the antenna. There are leads with special contacts which connect to the radio receiver for the purpose of obtaining filament and plate power for the oscillator unit. The unit is sold without the tube shown, because you must select the proper type. If the receiver to which you connect the unit employs 2.5 volt filament tubes, use a type 2A7; if the receiver is equipped with 6.3 volt tubes, use the type 6A7 tube.

Having selected the correct tube for the oscillator adapter, next connect the adapter. Detailed instructions are given in Fig. 4 for connecting either the phonograph unit or the microphone system. As the leads provided with the oscillator

microphone to zero, flip the S.P.D.T switch shown in Fig. 4 and advance the volume control on the phonograph pick-up to the desired volume. Once the volume control position of the receiver has been selected for good mike and phono pick-up reproduction all volume control adjustments should be made at the pick-up units. Always turn these controls down to no output before making a change.

Merchandising P.A Systems.—Now let me tell you how to make extra money with this radio modulator. Of course, you really need one of these attachments to give the shrewd buyer a convincing demonstration. If you find it too costly to buy one when you are ready to start this work, obtain literature on the device and describe its use to prospective customers. When you have sold some one on an installation, have him advance at least the wholesale cost. After one or two installations made in this manner you will have enough cash to buy one to have on hand.

First, I want to say that this attachment will sound only as good as the receiver sounds when tuned to a local station. It cannot improve on the quality built into the receiver to which you attach it. I might add, though, the adjustment of the tone control on the set will affect the sound amplified. You will probably have to demonstrate it at your shop or home, so I suggest you have a radio receiver with fair fidelity.

Radio Plus P.A.—Think this over! A good radio is to be found in the vestry of a church, in fraternal clubs, at schools, stores, and many other places of business. There are many occasions where groups of fifty or more people are to be addressed. Sell the managers of these places on the idea of using an oscillator adapter on their radio receivers, to amplify the speaker's voice. Sell them the idea of a phonograph attachment to help entertain the listeners when the radio is not desired. The only precaution necessary, as I said before, is that you place the radio set to one side, preferably the microphone farther back than the receiver. This eliminates the singing noise you may get. Place the radio set facing the group listening.

This oscillator adapter plus a receiver makes an excellent store sales device. Connect it in the same way. Of course, you don't have to have an aerial connection if there is no need for radio reception. The radio can either be placed in the doorway to attract passing prospects for the store, or an extension loudspeaker, in fact, two may be employed, placed in the transom to the front door.

Radio, Phonograph and P.A.—Consider now the peculiar needs of a dancing school, or a gym class, or a vocal training school where a phonograph recording is used as the lead or for class guidance. Surely these places have a good radio to entertain their guests and pupils.

Why not sell them on the idea of adding a phonograph oscillator and an electric phonograph attachment? See Fig. 5 for special connection which permits the speaker and the reproduced music to be heard simultaneously or by themselves. The radio may be used whenever desired. When a class is in progress, the recorded music comes through while the instructor makes remarks, guides the students by talking into the microphone.

It is a wonderful way of giving popular illustrated lectures on music. Suggest it to a few music teachers. The set-up permits the lecturer to make the voice loud or soft by adjusting the volume control connected to the secondary of the microphone transformer.

There are other places where a combination microphone, phonograph pick-up and radio will aid business, and any live storekeeper will spend money when it helps sales. Consider the possibilities of such installations in roadside refreshment stands. Here, for example, one or more extension loudspeakers would be of great advantage. Selling stands at fairs, or at outings where electric power to operate the radio set is available, are other places where these conveniences would be appreciated. Radio, recorded music, sales talk, available by the throw of a switch!

Rental of Phonograph Oscillator.—Some service men would rather rent out a P.A. system than sell it outright. More money is to be made as you sell your service as well as rent your equipment. Customers will pay well for this service. They do not have to worry about or work with the equipment. They prefer a radio man on the job. They rely on you to keep it going and working as it should, and in turn you can charge a reasonable rate for the use of the equipment and the service work required. You should work out definite rates and adhere to them. Make a few rental installations and people will call on you to provide this sort of service. But do not wait until they come to you; go out after rental jobs; especially among people and concerns where a temporary need for a P.A. system exists.

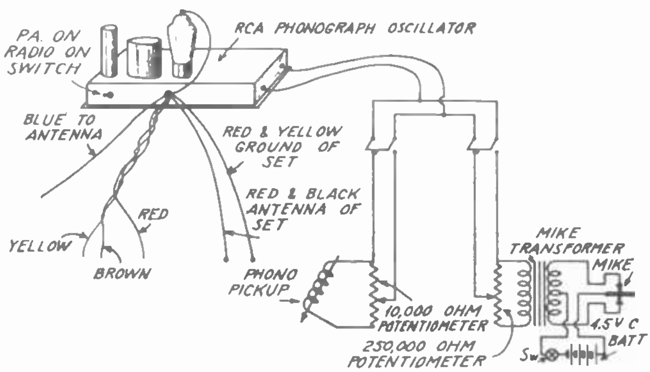


Fig. 5

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

Making Extra Money Revamping Receivers

Although most of the work that you as a Radio-Trician will be called on to do, will be to place a receiver in good working order, or to get the set to work like it did when it was new; you will also come across jobs where the receiver will not work on the power supply available, or uses too much battery power, or the power supply used requires too much attention. Then, too, you may find it advisable to make a simple circuit change or attach an inexpensive device, or make other changes which will improve or simplify the operation of the receiver. I like to call the latter jobs "receiver revamping."

checks the connections and mathematics of the circuits, the sample receiver is put together. Then it takes several weeks for an expert to "iron out the bugs" (troubles) he is bound to run into. Does an expert receiver repair man have as much skill as an expert radio designing engineer? Will he have all the laboratory testing devices to check each and every change? Think it over, and I feel you will be convinced that every urge to "modernize" a radio receiver should be preceded with plenty of thought.

So my advice is to "stick to your knitting," briefly, radio receiver repairs and installations; and to tackle revamping jobs

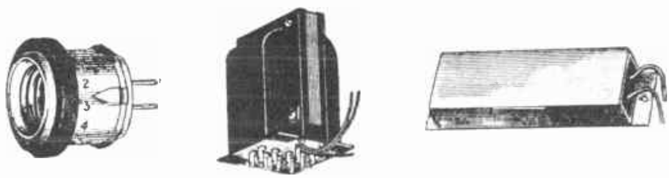


FIG. 1

An adjustable voltage regulator (to the left) designed to protect tubes and power pack against breakdown due to surges in line voltage. In the center is a universal replacement transformer extensively used. May be purchased for 25 C.P.S. operation on order. Made in a number of case styles to match the original transformer The two leads are the primary wires. To the right is shown a typical cardboard case dry electrolytic condenser, a condenser type preferred by many servicemen. The latter two units may be used in adapting a 60 C.P.S. receiver to a 25 C.P.S. line.

The beginner just "loves" to revamp a receiver, and so do many servicemen, perhaps because they do not know what they will be confronted with. They will try to rewire a receiver, change over to the latest tubes, use a different type of control, make changes in the power supply system, believing that they are modernizing the receiver. Of course, there is nothing wrong in this sort of work, but take it from me, you will involve yourself in more trouble than you expect, with the result that there is little if any profit from such jobs. There is a very good reason why the average serviceman should avoid complicated revamping jobs.

After a radio engineer lays out on paper the design of a new radio receiver and

only when they are brought to you, or where it is the only way of solving your service or installation job. A few examples will show what I mean.

Suppose you are called on to install a 110 volt, 60 c.p.s. (cycle per second) receiver on a 220 volt, 60 c.p.s. line. A new receiver would be foolish when the addition of an inexpensive voltage step-down transformer would do the "trick."

Suppose you were called on to service a battery-operated radio receiver on a farm where a 32 volt D.C. power plant was recently installed. To be sure, adapting the receiver to the new power plant would eventually save the customer money and make the receiver always play at its best. But if it were my job, I would figure out whether a new modern 32 volt receiver, even if it costs a little more, would not be a wiser suggestion. I would be tactful. If the customer had just bought the farm power equipment, I would not rush the idea. Not everyone can afford to have large expenditures come at the same time. Approach them something like this: "Mr. Brown, now that you have a very nice power plant, you should be thinking about making it run your radio set. A few additions to your present radio, which will not be very expensive, will eliminate all the trouble and expense you have had, or, for a little more, I can get you a modern radio set. Think it over, and if you are tired of the nuisance and expense of using batteries, let me know and I'll make the change for you." You have started the prospect thinking. If you don't hear from him in about a month, call on him again and the chances are you will sell him on either idea.

Your regular course has so far and will in future lessons present technical facts that can be used in revamping jobs. In this and the following Extra Money Job Sheets I am going to suggest jobs that you will in time find simple to do. I must be quite general in my presentation of these jobs, as I have no idea what sort of a receiver you will encounter. But do not let that worry you, for with the practical radio training you are getting from your course; and, with the experience you are getting from your NRI practical experimental units, also the experience you are acquiring on the side; and the general information I am going to give you, you will quickly understand how a radio job should be started and finished.

In this extra money job sheet, I will consider the following jobs, and in this order: *1*, how to adapt a 25 or 40 c.p.s. set to 60 c.p.s.; *2*, what to do when a 60 c.p.s. set is to be installed on a 25 or 40 c.p.s. line; *3*, working a 110 volt receiver on 220 volt lines (A.C. and D.C.); and *4*, how A.C. receivers may be operated from any D.C. voltage.

Thirty-two volt farm lighting plant adaptions and other interesting jobs will be considered in future job sheets.

1. In your service area there may not be any 25 or 40 cycle per second lines but, as often happens, someone may move into your community from a location where they were supplied with 25 or 40 c.p.s. power. Naturally they will bring their radio equipment with them and will want to use it on their new source of power. If they are wise, they will call in a reliable Radio-Trician, and I am assuming you are that man.

However, some servicemen on making such an installation will just hook up the antenna and ground, plug the set into the line and let it go at that. They may not know it but they may have by this one act involved their customer in possible future trouble and expense. Why? Because the greater efficiency of the 25 or 40 c.p.s. power transformer on the 60 c.p.s. line is going to result in slightly higher secondary voltages. In a short time the customer is going to need new tubes and he will keep on needing them entirely too often until you or some other radio man who knows what it is all about, makes the necessary line voltage adjustment.

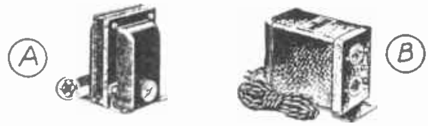


FIG. 2

The first step to take is to connect a low-range A.C. voltmeter across the filament of any of the receiver tubes. If it measures slightly below normal when the line voltage is measured as normal, no addition or change is needed. If the filament voltage is above normal, set the receiver line voltage regulator to the next highest position. For example, if the line is set originally to 110 volts, reset it to 120 volts. If a receiver adjustment does not exist, use a line ballast as explained in a previous job, or use the regulator shown in Fig. 1. The latter is very easy to install. Plug the regulator into the wall socket; insert a screw plug into the regulator; connect the receiver power cord to the screw plug; and set the regulator to a position which reduces the filament voltage to an acceptable value.

Let me "drive home" this important fact. Before you install a receiver, read the name plate. It gives the model number, line voltage, frequency and power rating. Obviously after reading this information you will not make a mistake.

2. Sets designed for 60 cycle per second operation should not be used on 25 or 40 c.p.s. lines without changing the power transformer for one designed for the frequency of the line on which the set is to be used.

When a 60 c.p.s. power transformer is used on a 25 or 40 c.p.s. power line an excessive amount of useless power will be drawn which only overheats the transformer. In time, the insulation will get so hot that it will char (turn to carbon) and the transformer will break down.

Therefore the only step you can take on such a job is to install a new power transformer designed for the frequency of the line and capable of taking care of the tubes used in the set. You can order a replacement power transformer for any well-known make of receiver *designed for 25 c.p.s.* lines. The same transformer will operate on 40 c.p.s. lines by following the precautions previously given. These transformers cost about 60% more than 60 c.p.s. transformers and in many cases must be made to order. Very often you may have to send the 60 c.p.s. transformer as a guide. Be sure to ask for a connection guide.

After wiring up the new transformer, try the set. Should the hum be abnormal remove any condensers shunting (connected across) the filter chokes and increase the capacity of the filter condensers, until the hum is brought down to normal, by connecting an extra 8 mfd. dry electrolytic condenser across each of the filter condensers used in the set.

3. To operate a 110 volt A.C. powered receiver on a 220 volt A.C. line of the same frequency it is only necessary to obtain a step-down power transformer as shown in Fig. 2A. The primary (the plug of the step-down transformer) is connected to the wall socket and the plug on the receiver power cord is inserted in the outlet on the step-down transformer. The set need not be changed in any way.

Incidentally, a step-up transformer may be purchased to operate a 110 volt A.C. receiver on power lines where the voltage is 90 to 100 volts. This condition usually exists in homes that are on the end of a power line. A typical transformer is shown in Fig. 2B. Two outlets are provided, one for 110 and the other for 115 volts. Personally I would use a ballast in series with the primary of the receiver transformer as described in a previous job.

Always buy a power transformer which has a *watt rating* equal to or greater than the value indicated on the name plate of the receiver.

In the case of a 110 volt D.C. set to be used on a 220 volt D.C. line, a resistor in series with the line and set will be required. The set manufacturer is the logical one from which to purchase the resistor, but you can determine the correct value yourself if you will do a little calculating.

Refer to the name plate of the receiver. Jot down on paper the watts rating. Let us say that it is 75 watts. Divide 12,100 by the power rating and the value you get is the ohms the series resistor should have. In our example 12,100 divided by 75 equals about 161 ohms. Procure from a radio parts supply house, a wire wound variable resistor of the next highest resistance and power rating. In this example, you will probably buy a 200 ohm, 100 watt resistor. Connect it as shown in Fig. 3, and vary the tap, which should be originally set at a to point b, and when V_m reaches 110 volts clamp the variable contact.

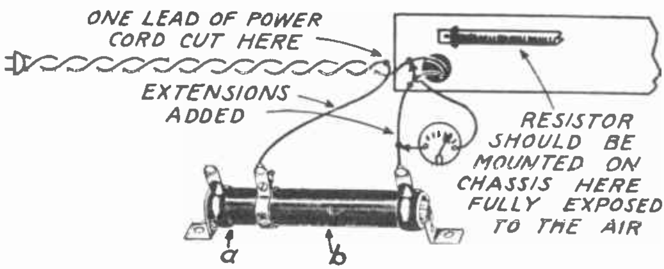


Fig. 3

4. Now I will consider the case where a customer has a 110 volt, 60 c.p.s. power receiver and has either a 32 volt D.C. or a 110 volt D.C. power supply. The chances are that he just moved in or someone gave him a receiver. If the receiver is a good one, and by that I mean is of recent construction, in good working order, and would probably cost over $50 to replace, it is worth a little expense to retain its good qualities. Recommend a D.C. to A.C. power converter. There are two kinds available: the vibrator converter, often called an inverter, as shown in Fig. 4A; and the rotary converter, as shown in Fig. 4B. The inverter usually costs about one-half the price of the rotary converter and can be used on practically 95% of the receivers. They will operate receivers up to 100 watts. However, the vibrator may have to be replaced once a year, an inexpensive procedure. The rotary converter may be obtained for high powered receivers and amplifiers. In either case be sure the wattage rating of the converter exceeds the rating of the receiver, and its input is of the correct voltage.

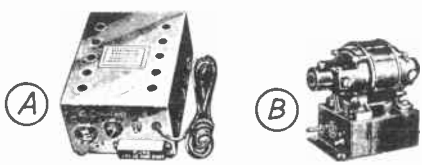


Fig. 4

You can make the conversion in five minutes after you reach the customer's home. Insert the plug on the power cord of the converter into the D.C. socket outlet, and connect the receiver power plug into the receptacle provided in the converter. Turn both the receiver and converter power switch to the *on* position and the receiver will operate. Ask your customer to use the converter off-on switch, or at least be sure it is always turned off when the receiver is not used. In some inverters a line voltage regulator is used. Study the installation instructions.

On the other hand, if the customer objects to the cost of a reliable power converter, the only other step is to rewire the supply circuit of the receiver, which will without any doubt destroy many desirable features of the receiver. But this is a subject that I will consider for another practical radio job.

How to Convert Old Battery Receivers to 2-Volt Tube Operation

Ever since the 2-volt tubes were developed, farm, rural and camp receivers using these tubes are selling rapidly. The old battery receiver was all right for the city home until the all-electric receiver was introduced, because the storage battery could be charged at home or a battery eliminator could be used; but out in the country where no electric socket power is available, charging and constant replacement of batteries is a nuisance that discouraged set buyers. No wonder the 2-volt sets which permitted a set of batteries to last a year, popularized farm and rural radios.

FIG. 5

You, too, can cash in on these tubes, and there are several things you can do. If you run across an installation where an old receiver is in use, and there is no electric power, you may suggest a revamping job. Or if you find a prospect for an inexpensive radio receiver, why not pick up from some radio dealer an old battery set and revamp it for these tubes? Incidentally, I know of several servicemen, who in their spare time revamp old battery sets, which they can purchase at "give away" prices, for the latest 2-volt tubes and rent them out to persons who go to a camp or some other vacation resort where electric power is not available. The first rental more than pays for the job of revamping the set and the future rentals are pretty near all "velvet."

Take my advice and make as few changes as possible. Do not try to rebuild these receivers so they will be up "to par" with the modern 2 volt tube battery set. If you try you will get into complicated circuit problems, involve more expense than you realize and probably lose any profit you might make. The sets that are worth changing over have the 01A, 12A and 71A tubes. You replace an 01A with a 30, 12A or 71A with a 31. The task is rather simple if you follow my instructions.

First hook the set up using the old tubes and necessary batteries; if necessary make repairs so it plays satisfactorily. This will save lots of time because if the set is defective when it is rewired you will not know whether the fault is the rewiring or the old parts.

When the set works normally remove the old tubes and filament resistors or rheostats. If the set is equipped with provisions for a C battery you should use one with the voltage recommended for the tubes and plate voltages you intend to employ. But in general no change in the B or C voltages will be necessary. For the A supply you can use one cell of a 6 volt storage battery, or an air cell A battery, as shown in Fig. 5. You can buy them from a mail order radio supply house.

When you use a single storage cell no filament resistor is required; with an air cell battery a fixed resistor in series with either A battery lead is required. The voltage of the air cell when new is about 2.5 volts. Therefore, .5 volt must be disposed of. You can figure the value of the required resistor by dividing .5 volt by the total filament current to be drawn from the battery. Add up the current drawn by each tube; a 30 tube draws .06 ampere, a 31 tube draws .12 ampere.

If the set used the filament rheostat as the volume control, a new control, consisting of an 0-5000 ohm rheostat connected across the primary of the next to last R.F. transformer would be required. This will probably be the most difficult part of the job for you if you have had no previous experience.

If the set is a neutrodyne, reneutralize it, if it should oscillate. If grid suppressors are employed and oscillations occur, reduce the plate voltage on the R.F. stages; or increase the value of the grid suppressor resistors. These changes are the only ones required and if you have a diagram of the set the adaption will take only a little time. After you revamp a couple of receivers, other similar jobs will be easy.

How to Operate 2 Volt Tube Receivers from Dry Cells

"But do I have to wait several weeks before you can get a new air cell battery"—or, "must I have this messy storage battery"—or, "why can't I use batteries that I can get at the general store," are questions you may receive from an owner of a battery receiver, even if he happens to own a modern battery set. Frankly, if you service many 2 volt tube battery receivers designed for air cell batteries, it is up to you as a good business man to keep at least one in your stock as a reserve unit. They are an excellent source to the average receiver for about 400 hours.

As the battery delivers 3 volts and the receiver requires 2 volts, a resistor or voltage regulator must be introduced to drop 1 volt. If a resistor is used it should be variable, because the voltage of the cell will gradually drop from 3.5* to 2.0 volts, the original and dead battery voltages, respectively.

The Burgess Battery Company has brought out a unique voltage control to be used with their A pack, and you may

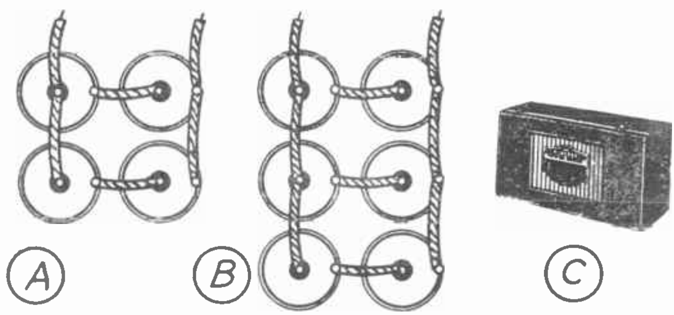


FIG. 1

of A power, and stand up for a reasonably long time. But I can hardly blame the customer in objecting to the use of a storage cell.

With a simple addition you can adapt the ordinary dry cells and get real good performance. These cells can be purchased in practically any hardware or general store, and I consider it worth your while to learn how they may be used. You should use at least four and preferably six No. 6 dry cells, connected in series-parallel as shown in Figs. *1A* and *1B*, and tie this group of cells together with a stout wrapping cord. You know that such an electrical connection should give you about 3 volts, and the four cell combination should last about 150 hours and the six cell combination about 225 hours; of course, on the average 2 volt tube receiver. Incidentally, a leading battery manufacturer produces an "A pack," shown in Fig. *1C*, which delivers 3 volts use it on your cell assembly. It is a special resistor providing four variable voltage steps, and is mounted on a stiff rectangular piece of cardboard. Figure *2* is the general appearance of this voltage regulator. The A+ nut of the post of the battery is removed, the regulator slipped on the screw (the center of the moving arm is hollow for this purpose), the nut of the battery is then turned on tight, the movable contact set to position *1*, and the A+ lead of the receiver connected to the spring binding post of the regulator (position *4*).

This regulator is designed so a new battery plus the resistance drop will feed not more than 2.2 volts to the receiver. The customer should be told that when reception gets weak, the contact should be

*Although each cell is rated at 1.5 volts, and two cells should give 3 volts of power, actually a new cell may start with as high a voltage as 1.75. Thus two new cells in series may supply 3.5 volts.

moved to position *2*, and later to positions *3* and *4*. Of course, you know this reduces the rheostat resistance. He should not make a rheostat change more than once a month. When the regulator is no longer necessary and the set plays weakly, a new set of dry cells or an A pack is required.

To my way of thinking, a regulator should be installed that will do its work automatically. The average broadcast listener should be asked only to turn the switch on, and tune the receiver. So I suggest you look to our old friend the ballast for a more fool-proof control. I have already told you how they work,

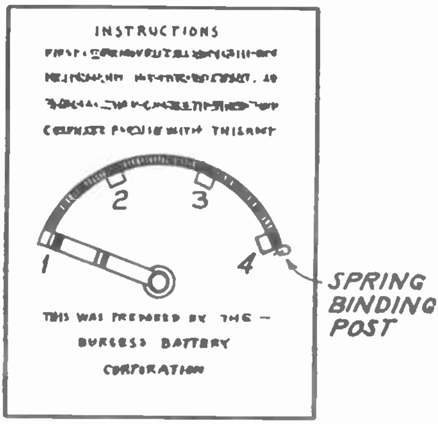


FIG. 2

so here I will merely tell you how they are connected. To my knowledge the only ones made are produced by the Amperite Corporation, 561 Broadway, New York City, and again I caution you to write to them for the latest information. Their latest instruction sheet says that they are made in current sizes from .06 to 0.7 ampere.* They are made in two styles: in a form that looks like a regular UX199 tube having a four prong base, the two large prongs (FF) being used only; and a style which has an automobile bulb base. In the first case a regular four prong socket is used and connections are made to the +F and —F terminals.

Instead of an automobile bulb socket, this company furnish a clamp which fastens to the A+ terminal of the battery,

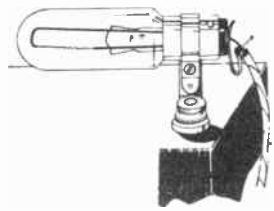


FIG. 3

holds the ballast, and the base of the ballast has a spring binding post for the A+ receiver lead. The latter set-up is shown in Fig. *3*.

Once the proper location and size of the ballast are determined, the actual connections are simple. The ballast is connected in series with either the A+ or A— *lead from the* A battery, although the A+ lead seems to be generally used. A schematic of the connection is shown in Fig. *4*. No ground connections must be made at the battery post in which the ballast is placed. If a ground is recommended at the A+ battery post, place the ballast in the A— lead. The ballast works splendidly, the A battery voltage may vary from 3.5 to 2.2 volts but the radio set will receive not more than 2.1

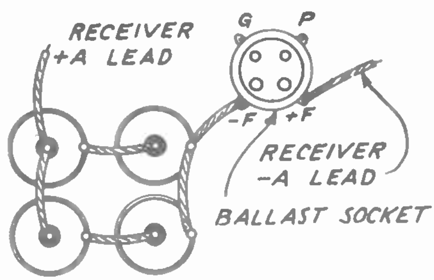


FIG. 4

nor less than 1.9 volts, during the life of the battery. And this is just what the "doctor asked for," as the so-called 2 volt tube works well on a voltage varying from 1.9 to 2.2 volts.

* The types are as follows: .060 use D6-1; 0.12 use 1-1; 0.18 use 1H-1; 0.25 use 2H-1; 0.3 use 2H-1; 0.36 use 3-1; 0.42 use 4-1; 0.5 use 5-1; 0.55 use 5H-1; 0.6 use 6-1; 0.66 use 6H-1; and for 0.7 ampere use the Amperite type 7-1.

How to Build and Use an A, B and C Battery Eliminator

Radio set owners will ask a serviceman to do a job which may often appear to be without any sound reason. You would think, for example, that the owner of a battery receiver would prefer a modern A.C. receiver and enjoy real crisp, "lifelike" reproductions. But the owner of a battery receiver may have an entirely different viewpoint. The receiver may have meant a large original outlay of money, and that may be one reason for holding on to it. However, it is more than likely that he likes the battery receiver because he prefers its tone. Now this seems to be an odd fact, when everyone knows that a modern receiver is a closer approach to high fidelity. The human ear is to blame, for in time it will train itself to accept and like the renditions from any reasonably good receiver, and there is no question that many of the older battery receivers were quite good.

These very same owners appreciate the convenience of having a receiver operated entirely from the A.C. power socket; but quite often they will ask you to revamp the set or adapt eliminators so this may be accomplished. As long as they have their original receiver, they are inclined to feel that the same sort of reception will be obtained. Now some radio servicemen will undertake the job of rewiring the receiver for A.C. operation. From personal experience let me stress the fact that you should maintain a policy of "hands off." The parts of a receiver must be laid out on the chassis quite differently for an A.C. set, so hum will not be produced. Getting the hum out of a rewired battery receiver is a "tough job."

How much more sensible it is to connect an A eliminator (a device which plugs into the A.C. power outlet and replaces the A batteries), and replace the B and C batteries with a B and C eliminator. Then if the customer finds that the addition does not suit him, all you have to do is to remove the eliminators and go back to the batteries. Of course, eliminators will make the receiver operate continuously as if it were on new batteries, and that alone is worth striving for; it will eliminate the nuisance of charging the A battery and replacing the B and C batteries, in fact will, in a couple of years, more than pay for the batteries that would be used. But with this increased "pep" and the tie-in with the power line, noises foreign to a battery receiver will be heard. This is the most difficult condition to explain to the customer. Add this to the hum problem and you will quickly realize why a rewiring job is inadvisable.

Unfortunately you cannot readily buy A, B and C eliminators; so I am going to tell you how to assemble two eliminator units, an A and a B-C eliminator.

The A Eliminator. First I will consider the A eliminator. The circuit diagram is given in Fig. *5,* and below this semipictorial diagram is a list of parts that you will need and which you can procure from most radio parts jobbers.

Assemble the parts on the baseboard and before you secure them to the base, figure out if you have arranged the parts so the connecting wires will be as short as possible. I cannot give you an exact layout as I have no idea what parts you will get; furthermore, it will be good experience to lay it out yourself.

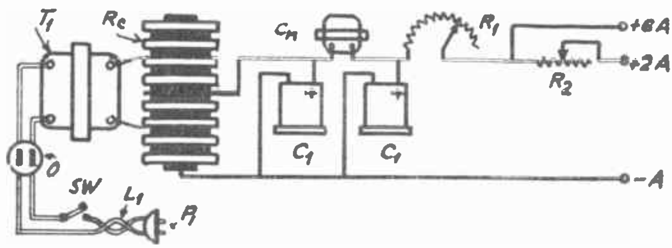


Fig. 5

T_1—*one* step-down transformer (110 volt primary—10 volt, 5 ampere secondary)
R_c—*one* full-wave dry disc copper oxide rectifier (2 ampere—6 volt type)
C_H—*one* 1.5 henry, 2 ampere, iron core choke
C_1—*two* 1,000 mfd., 12 volt, electrolytic condensers (Aerovox type A12)
R_1—*one* 10 ohm, 25 watt slide type power resistor
R_2—*one* 50 ohm, 25 watt slider type power resistor
S_w—*one* base mounted 110 volt toggle switch
P_1—*one* power plug
L_1—*ten* feet twin flexible cord
O—intermediate base mounting power outlet (for B-C eliminator)
Screws, binding posts, solder, connecting wire, etc.
One 8 x 12 inch baseboard, ¾ inch thick (ply wood preferable)

If the power transformer primary or secondary are not marked (quite often the primary has a flexible twin cord) you may determine which is the primary by using an ohmmeter. The primary of a step-down transformer has a larger resistance than the secondary. Connecting the full-wave cooper oxide rectifier is quite simple. The center lug (or terminal) and the terminal at the end connect to the input condenser, C_1. The other two terminals (the ones off the center) are connected to the secondary of the step-down transformer.

As the center terminal of this rectifier unit is the + (plus) A supply, the + terminals of the electrolytic condensers, the choke, the variable resistor and the fixed resistor must be to this lead connection, as shown. The plus lead of the condenser is usually a red covered wire, or the condenser container near the lead is marked +. Resistor R_2 is used, in order to adapt the eliminator to 2 volt battery tube receivers.

Before you accept the final construction, try the A eliminator on a battery receiver. If a receiver is not available use a dummy load (a fixed resistor). For the 2 or 6 volt terminals use a 3 or 4 ohm resistor, at least with a 10 watt rating. Be sure that R_1 and R_2 will control the output voltage within a reasonable value. If you test the eliminator on a radio receiver be sure that R_1 and R_2 are set to full value before a connection is made. The A eliminator is plugged into the wall socket, R_1 and R_2 set to maximum values the output connected in place of the A battery, switch S_w turned on, and with a low range D.C. voltmeter across the output, resistor R_1 is varied until 6 volts are obtained, or R_1 and R_2 are varied until 2 volts are obtained. The voltmeter is then removed.

The B-C Eliminator. This unit is extremely easy to make, and the parts are readily obtained. In fact, most of the units may be procured from an old A.C. receiver, and many servicemen in salvaging obsolete radio sets use the power pack parts for a B-C eliminator. However, any of the parts shown in Fig. *6* are obtainable from a radio parts jobber, and are laid out on the baseboard almost as shown in this sketch.

You may find the locating of the secondary windings a little puzzling, if they are not marked. As a rule the power transformer terminals will end in lugs. You can quickly locate the correct windings with an ohmmeter, if a chart of instructions is not supplied. First each winding should not show continuity with another winding. This isolates the windings. Next the windings will have various resistances, the high voltage secondary will have the most, the primary will have the next lowest value, and the filament supply secondary will have the lowest ohmic value. This test identifies the various windings. Finally you will want to know which of the three terminals is the center tap. Check for the maximum resistance for that winding, by placing the probe of the ohmmeter across two of the terminals; when you get maximum ohmic reading the remaining terminal is the center tap, tap *2* in Fig. *6*.

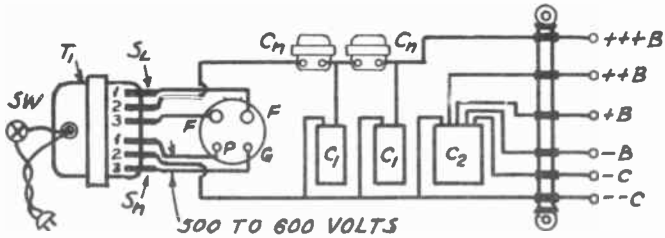


FIG. 6

T_1—*one* power transformer (110 volt primary), two secondaries. S_L (low voltage) 5 volts center tapped; S_h (high voltage) 250 to 300 volts end to center

S_w—*one* baseboard mounting toggle switch

S —*one* baseboard mounting 4 prong socket

C_h—*two* 30 henry, 100 milliampere, iron core filter chokes

C_1—*two* 8 microfarad dry electrolytic condensers each in a cardboard container—450 volts test

C_2—*one* 100 volt rated dry electrolytic condenser with 4-4 mfd. sections

V_d—one 13,000 ohm (50 to 75 watts) voltage divider, with two fixed end connectors and four movable contacts

One 80 type rectifier tube (not shown)

8 x 16 x ¾-inch baseboard, hook-up wire, twin lead power cord, power plug, screws and binding posts

To adjust this unit, first set the movable taps of the voltage divider equally apart. Connect the B-C eliminator to the receiver. At least two terminals, one of which is —B, should be used. Insert the 80 rectifier tube, turn on the switch and with a voltmeter across —B and some +B or —C, adjust the corresponding tap to the voltage you want. After each tap has been set, check the adjustments again. In moving one slide clamp you upset slightly the voltage value at the other terminals.

If the A and B-C units are to be used on the same receiver insert the plug of the B-C eliminator into *O*, the receptacle on the A eliminator, and use the off-on switch of the latter as a single control.

I would suggest that all A, B and C eliminator adjustments on a customer's receiver be done at your work bench.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

When and How To Install an Automatic Line Voltage Regulator

I am now talking about the power supply line voltage, the voltage you would measure if you were to insert the two probes of an A.C. voltmeter into the two slots of the power outlet receptacle. Does this power supply stay at one voltage, 105, 110, 115 or 120 volts, all morning, afternoon and night? For the best radio reception it should! In fact, the set designer assumes that it will, although they realize that a shift of a few volts (3 to 5) cannot be helped.

FIG. 1.—A typical Amperite Automatic Line Voltage Regulator. The special alloy wire is within the glass tube from which air is exhausted and an inert (inactive) gas is placed. Has a very good line voltage regulation.

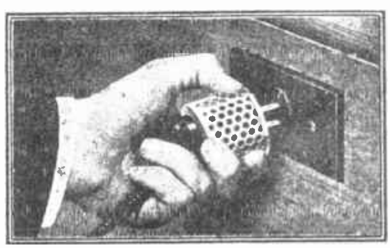
Although the average receiver is designed to work at 110 volts, many sets incorporate a line adjustment, often called a voltage compensator. This is nothing more than one or more taps on the primary of the power transformer so the set can be adjusted to operate from a line voltage of 100, 110 or 120 volts. Sets are usually shipped with one tap set at 110 volts. The usual way of making a change for a higher or lower line voltage is to place the "little" fuse in the two proper clips, which are marked either 100, 110 or 120 volts; or are marked "high" and "low," meaning of course, high or low line voltage. In other receivers a flexible wire with an end lug is clamped to the proper screw post—which may be marked in the same way.

Often, it is not enough to adjust the line voltage tap Let me make this clear Suppose, as is usually the case in rural and outlying districts of a city or town, the line voltage is about 118 volts in the morning, stays there until late in the afternoon, and when evening approaches drops to 100 volts. What happens? The receiver loses its "pep" and "life," that is, the volume decreases, the sensitivity is impaired and the fidelity though acceptable is not good. Should you set the line compensator at 110 volts as an average, as most radio servicemen do, then during the morning you make it possible for the weak tubes to burn out. If you set the compensator at 120 volts you protect the sets, but the results will be poor.

Here is a worth-while solution, which will bring in extra money and satisfy your customers. You can purchase from most mail order supply houses or local radio stores an automatic line voltage regulator, that will hold the voltage and the current at the *receiver input* at a constant value even though the power supply line voltage varies. The receiver line voltage compensator is set at 100 volts or at low, the automatic line voltage regulator is connected in series with the power cord, and the voltage to the receiver will stay constant at 100 volts to within a few volts, all day long. Of course, should the line voltage drop down to 90 volts as is often the case, you must handle the situation in another manner; this will be taken up in the next practical job.

First I want you to know when an automatic regulator is required; then I will describe how to install this device.

When you go into the radio service business, you will know from experience that the line voltage in a certain district is very irregular. As a matter of fact, on every



An I.C.A. Resistovolt.

Line voltage regulator. A wire like nickel is wound on a form inside the perforated tube. Its resistance goes up with the voltage causing the line current to go down. Air circulating through the perforations prevents overheating which would result in a burn out. Its regulation is not as good as the vacuum tube type.

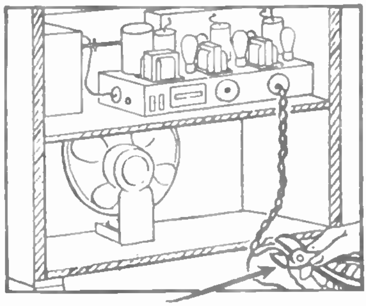
service call, you should measure the line voltage in order to check the compensator setting on the receiver. This is the experience I am talking about. Why not keep a record of the line voltage, date and hour? When you learn that it fluctuates (varies to a great degree) recommend an automatic line voltage regulator. Should your customer complain that there has been altogether too many tubes burning out and the receiver chassis has been checked as being normal, you can about make up your mind that it is due to line voltage variation. Recommend an automatic regulator, with the reservation "This will greatly reduce the number of burn outs." You cannot promise anything in radio 100 per cent. Tubes, especially, get weak and pass out of existence even if the line voltage has been constant.

How To Install a Regulator.—The automatic voltage regulator best known to most radio servicemen is the *Amperite* and is shown in Fig. *1*. This regulator takes care of fluctuating line voltages and employ a special resistance element whose resistance automatically goes up in value when the line voltage goes up, and goes down when the line voltage goes down. In this way the voltage and current input to the set is kept constant.

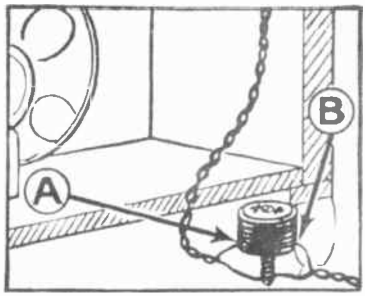
The Amperite line voltage regulator is easily installed. Figure *2* shows the necessary steps for its connection in the power line circuit. Each Amperite tube comes with complete instructions for the selection of the proper type of Amperite. But for initial ordering from a mail order house or direct from the Amperite Corporation, 561 Broadway, New York City, be guided by the following table:

Number of Tubes in Set	*Amperite Number*
4-5	5-A-5
6-7	7-A-5
8	8-A-5
9-10	9-A-5
11-12	11-A-5

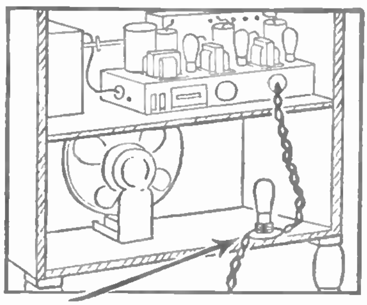
Hints on Sets Equipped with Line Controls.—A number of receivers are made with Amperite controls as standard equipment. A number have been made using *Clarostat* Ballasts. Both makes are interchangeable if you get the right type. If a regulator burns out, you have the same effect as if a fuse blew out. Check the regulator with an ohmmeter. If open, use a new one. Be sure to use the correct type. If in doubt write to the maker. The Clarostat Manufacturing Company is located at 285 North 6th Street, New York City.



To install the new AMPERITE line voltage control cut one lead of the power supply line or cable at any place between the set and the house socket plug.



Connect these two cut ends to the terminals of an AMPERITE adapter socket as shown by lines "A & B" or to any standard UX tube socket. If a tube socket is used, make connections to either two opposite terminals, leaving the remaining two terminals blank.



Mount the adapter or socket at any convenient place inside the cabinet. Insert the proper AMPERITE Line Voltage Control tube and the receiver is ready for operation. *When making the above connections, first disconnect the house line plug.*

Fig. 2

How To Compensate for Low Line Voltage

You cannot expect a radio set to work well if the line voltage varies from 110 to 90 volts. Not even a human being can work well if he is undernourished. No power supply company purposely furnishes low voltage when 110 volts is the rated value. If enough homes are troubled in this way, they will make suitable changes to correct the situation. But what can you do until they take the necessary steps? Boost the line voltage? This is done easily and with little expense if A.C. current is furnished.

Boost the line voltage with a toy transformer and protect the receiver from line voltage peaks by using a good line voltage regulator.

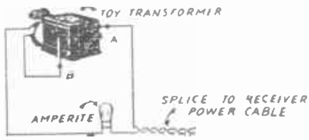


FIG. 3A

All you need is a small step-down transformer, such as a bell ringing transformer or a toy train transformer and a suitable Amperite line voltage regulator.

Figures *3A* and *3B* show the electrical connections made between the toy transformer and the receiver power cord. Take the plug cap off the receiver power cord. Connect one lead to the secondary of the toy transformer, the other lead is spliced to one lead in the cord which runs from the line to the toy transformer. The remaining power lead from the receiver is connected to an Amperite terminal and the other lead from the Amperite is spliced to the second lead of the line to the toy transformer.

Most toy transformers will deliver about 5 amperes without overheating. It will be safe to use it with any radio receiver as most radios draw from 1 to 2.5 amperes. With the Amperite out, test the voltage with an A.C. voltmeter after the booster transformer is connected. If it is lower than the line voltage reverse the secondary terminals *A* and *B*, shown in the diagram. Adjust the toy transformer so that the net voltage applied to the receiver is about 10 volts higher than normal and then insert the line voltage regulator. Always measure the voltage applied to the receiver and don't assume that it is correct until you do so.

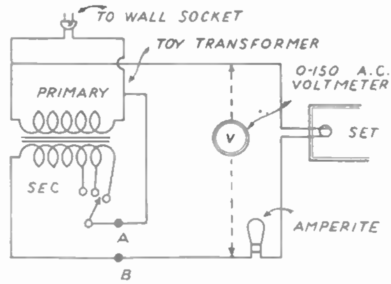


FIG. 3B

How To Detect and Remedy Vibrating and Microphonic Noises

"Do you hear that noise," a customer will often say to a radio serviceman. "See. I turn the power switch off and on and it stops for a little while." You hear a low whine that increases in loudness until it becomes unbearable. Or you hear an objectionable rattle.

Fortunately the first noise, called microphonics, is not heard as much nowadays. The chassis and speaker are so coordinated in a cabinet that there is less chance for this noise to start. Tubes and the parts are made much better and trouble due to microphonics is encountered less and less. Nevertheless you should be prepared to handle such cases when they arise.

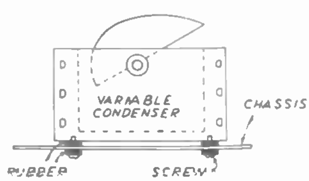


FIG. 4

These troubles may be due to: a microphonic tube, microphonic variable condenser, general feedback through the chassis, transformer hum or general vibration.

Microphonic Tubes. One of the most pronounced vibrating noises with a radio receiver is caused by defective, or what servicemen call "microphonic tubes." This is caused by the sound from the speaker striking the tube, causing a loose element within the tube to move producing a singing tone. This tone usually starts when a loud note is emitted from the speaker; although some noise may begin immediately after the set is turned on. Test each tube by snapping it with your fingers. Striking the defective tube starts the noise quickly. Usually a new tube inserted in place of the old tube will cure this trouble.

Microphonic Variable Condensers.—Surprising as it may seem, you will cometimes find that the plates in a variable tuning condenser vibrate, producing a singing tone. You can usually detect this cause quite easily by tuning the volume control down to a point where the singing is just inaudible. Then pluck the edges of the plates with the end of a neutralizing tool or some insulator much in the manner you would pluck a comb. If the noise is duplicated you have located the defect. If the gang condenser can be mounted on rubber absorbers, a great deal of this trouble may be eliminated. Of course, if these were originally used, the absorbers have hardened. Figure *4* shows you how the variable condensers are supported on rubber washers off the metal chassis. Be sure that the screw is not turned up too tight.

Replacement or slight readjustment of the rubber will reduce the mechanical transmission of sound energy from the chassis to the condenser. Often you will find the rubber badly deteriorated due to long wear and use. Always replace with rubber which has plenty of life.

Chassis Feedback.—Whenever you are working on a receiver which has a tendency to squeal or howl due to chassis sound feedback, be on the lookout for improper cushioning between the chassis and the cabinet. As you know the speaker is usually fastened directly to the cabinet thereby making it and the chassis vibrate very vigorously at times. This vibration may easily affect the tubes, condensers or the wiring. This is usually the trouble when it is impossible to trace the feedback directly to microphonic tubes or vibrating condensers.

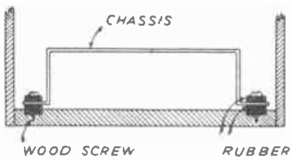


FIG. 5

Examine carefully the anchoring of the receiver chassis to the cabinet. Some servicemen are careless and do not loosen the bolts running through the rubber cushions when the set is installed. In other cases they neglect to put them back when servicing a receiver out of the chassis. Then, too, the rubber may harden or deteriorate so the springy action is lost. Figure *5* shows the general method of using rubber cushions. A rubber washer is held above and below the chassis edge. The lower washer fits into a cup shaped hole. Be sure the chassis floats on the live rubber. The chassis will move slightly but not enough to cause any of the controls to bind.

Rattles.—You will find sometimes many parts within the cabinet vibrating. This gives rise, not to howls, but rattles. One of these parts might be the glass window of an electric clock vibrating violently because it is placed directly in the center of the loud-speaker cone, receiving directly all of the sound energy. Usually this noise can be stopped by adjusting the clip holding the glass window in position. Perhaps a few small pieces of felt will remove the play.

Then, too, you will find that shielding used extensively in receivers over coils and tubes give rise to rattles because they are not held down or fitted very tight against their supports. If you cannot take up the looseness, you may find it necessary to bend the complete shielding to remove its natural frequency to an inaudible value. Loose plates on top of variable condensers cause rattling noises also. Look for them and tighten up the hold-down screws when you find them. Metal tube shielding cans touching the glass envelopes of the tube will also cause a rattling noise.

Room Rattles.—You will encounter jobs where the radio causes rattles to be heard some distance away in the room. These rattles are usually caused by metal objects vibrating. Most common of these is the metal covers for radiators. The tin in many cases actually vibrates and produces very undesirable sound effects. I find that these noises can be reduced to a minimum by gluing on small pieces of felt. Placing the felt at the points where the metal hits the radiator should stop the noise.

Window panes in french doors, ornaments around the room, in fact, any object with a large surface in the direct path of the sound from the speaker may create rattles. Suggest changing the position of the radio or the object which is rattling.

Transformer and Choke Core Become Loose.—Many power transformers develop humming noises which you could hardly believe would exist in a modern receiver. The loose laminations of their cores vibrate. This can be reduced in several ways. First attempt to tighten the bolts holding the core together. If the hum still persists, due to faulty construction of the core, you may resort to driving in several nails between the loose laminations. This trick may be used on filter chokes as well, if the hum is traced to them.

Sometimes brackets are used to hold the laminations in position and because they only clamp the laminations at a few points, the methods suggested may fail. Try wooden wedges. Do not make them with too large an angle or your wedge will fail to enter the small opening between the bracket and core.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

When and How To Install a Tone Control Combined with a Power Switch

Tone controls are quite common on modern receivers, particularly all-wave receivers. Surprising as it may seem, it is a device that usually destroys the fidelity of reproduction! Yet people like the effect it produces; the way some people like sour wine or ripe olives. The ordinary tone control is a simple radio circuit connected into the audio system of a set. It cuts off or removes the higher audio frequencies or tones. When the high tones are reduced in volume, the ears concentrate on the low notes and you get that deep bass effect that most people like. In the same way a lot of the hissing, scratching noise so prominent in the short wave ranges of all-wave receivers are made less noticeable. Now, you understand why all-wave sets incorporate tone controls.

There is one more reason why tone controls have a place in a receiver. When the volume is turned down, as most people do during meals, or when reading or playing cards, the best sound effects are obtained when the set is a little bassy; tone control in action.

So, when you come across a receiver without a tone control, sugest one. Explain what it will do! In fact, suggest that you install one temporarily and if they like it you will make it a permanent attachment.

Now what does it take to make a simple tone control? Nothing more than a variable condenser placed across the audio feed wires to side track some of the higher audio frequencies. It may be connected between: *1*, the grid and chassis; *2*, plate and chassis of any audio amplifier tube; and where two output tubes are used it may be connected; *3*, from the plate of one tube to the plate of the other tube. As you vary the capacity of the variable condenser usually in steps from 500 micro-microfarads to 6000 micro-microfarads the bassy tones become more audible. In fact, some tone controls have about seven small condensers in a circular case and as you turn the knob more or less capacity is placed into the circuit. The device has two lug terminals and looks so much like a variable resistor that you could not tell it from a resistor unless you tested it with an ohmmeter and find that the meter needle kicks over like it should when a reasonably large condenser is tested.

There is another and perhaps more common way of making a tone control; in fact, it duplicates the effect of a variable condenser. Usually a .006 mfd. (6000 micro-microfarad) fixed condenser is connected in series with a variable resistor. The more resistance in this simple circuit the less shunting effect the condenser has on the audio signal. Of course, you can visualize the condition where the resistance is very large. You almost have the condenser disconnected; therefore there is no shunting of the high audio frequencies.

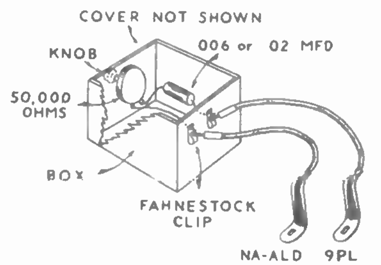


FIG. 1

Recall that I said that there were three ways to connect a tone control. Personally I would not use the grid to chassis connection, as the long leads from the grid may affect the action of the audio amplifier system. Use either the plate to chassis or plate to plate connection.

First let us consider the temporary connection of a tone control of the condenser-variable resistor type. You will need: 1, a .006 moulded fixed condenser; * *2*, a 50,000 ohm variable resistor; *3*, two Fahnstock clips; *4*, two prong contacts, each with a 5 foot lead terminating in phone tips; an Alden type 9PL Universal connector obtainable from most mail order houses, or direct from the Alden Products Company, Brockton, Mass., or some other similar simple tube prong connector will be just the thing to use.

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* If you find that a .006 mfd. condenser does not give enough bass tones, try a .02 mfd. condenser.

Assemble the tone control as shown in Fig. *1* and preferably in a small box, so when set on the cabinet it will not appear to be a make-shift attachment. I should mention that a similar portable device may be obtained from some parts distributors.

All you have to do is to slip one connector onto the plate of an audio tube; the other is connected to the chassis or GND set terminal. In the case of twin tube outputs, and where you prefer this connection, slip one prong adapter onto the plate of one output tube, the other prong adapter to the plate prong of the other tube.

How can you locate which prong of a tube is the plate? You will find this easy as you gain more knowledge and experience with radio receivers. For the present audio tubes, stick to the output or power amplifier stage. It is easier to identify these as they are usually much larger than the others and are generally in pairs. If you connect to an R.F. tube, you will know this fact at once, as the receiver will no longer tune in a station; or will be extremely weak.

Of course, it has taken some time to tell you how to build and connect the device. Actually when on the job, you will make the connection in a "jiffy." Place the control box on the cabinet or on the same shelf if it is a mantel job. Show the customer how to operate the tone control. Explain that different positions of the knob will give more or less bass effect. It is best to connect the variable resistor so that the *least resistance* is in series when the control is turned all the way to the left, giving in this position the most pronounced bass tone. When the control knob is turned away over to the right, the bassy tone disappears. This is the customary practice of tone control action.

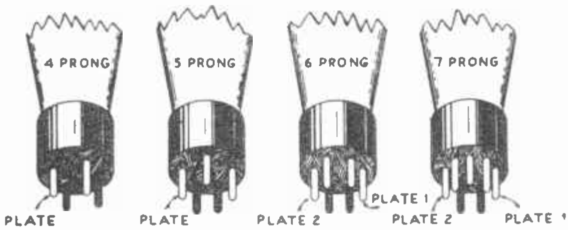


PLATE PRONGS FOR POWER OUTPUT TUBES

2A3, 10 12A, 20 31, 50 71A, 45	6A4, 33 38, 46 47, 49	Plate #1 only 2A5 Plate #2 only 41, 42 43, 48 89 Plates #1 and #2 19, 79	Plate #2 only 59 Plates #1 and #2 53

PLATE PRONGS FOR COMMON AUDIO AMPLIFIER TUBES

22, 30, 32, 01-A, 99,	24. 56 27, 76 36. 37,	Plate #2 only 55, 85 57, 6C6 75. 6D6, 77,	Plate #2 only 2B7 6B7 6F7

Fig. 2.—Schematic of 4, 5, 6, and 7 prong audio output and amplifier tubes, showing the plate prong or prongs in case of twin output tubes.

refer to Fig. *2*. The figures will tell you which prongs of 4, 5, 6 and 7 prong tubes are the plates; the table below each tube base, list the tubes which have the plate in this position. Merely slip the prong adapter onto this prong and put the tube back into the receiver socket.

Notice that some tubes have two plates. These are twin output tubes, two output tubes in one envelope. Connect an Alden 9PL to each plate. The tone control is completed.

Until you learn how to identify the

Now that you have explained to the customer how to operate the tone control, again explain that you have only made a temporary connection and if they decide that they want it you will make a better looking permanent connection, right on the receiver control panel.

Assume your customer decides to buy

the tone control. Remove the temporary tone control. Now make a permanent installation on to the control panel of the receiver. Procure a variable resistor which has a power switch attached. Replace the original receiver "off" and "on" switch mounted on the panel with this combination variable resistor power switch. A typical combination is shown in Fig. 3. Unsolder the power leads going to the old switch and connect them to the new one. Insert the new tone control unit in its place. Run one lead from the variable resistor lug to the plate of one tube. The .006 mfd. condenser is soldered to the other variable resistor lug. Of course, we complete the circuit by connecting the other condenser lead to the other plate or chassis as discussed previously. A plate to plate connection may be employed when push-pull amplification or when twin output tubes are used.

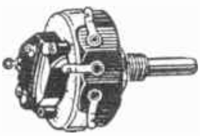


Fig. 3.—A variable resistor with slip-on power switch. Use the center lug of the resistor and either of the end lugs for a simple variable resistor. Use all 3 lugs when a potentiometer is required. The center lug is connected to the movable cantact.—The power switch has only 2 lug terminals.

The variable resistor should not short to the chassis when mounted. Be sure you get two insulating washers with it. After you mount the resistor check with your ohmmeter, between the chassis and the shaft. No reading should be obtained.

I would like to add that the leads should be short and direct. Keep them close to the chassis too. This will keep down feedback and stray coupling into other circuits.

It is possible to obtain tone controls of the variable capacity type with switches attached. You may prefer to use this style of tone control. The connecting procedure is the same except you omit the series condenser.

Always stick to the type of tone control that you prefer and the kind you find works best. This will save you trouble in repair and installation.

How To Install Extension Loudspeakers and Headphones

Dad or his son wants to stay up late at night listening to stations across the continent or in some foreign country. But he can't do it because the rest of the family or the neighbors object to the annoying sound. We don't blame them as there is nothing so unpleasant as a loud radio at one o'clock in the morning. An extension headphone connection will take care of this difficulty. Mother would use the set more often during the day, if she could only hear it while at work in the kitchen. She could, if an extension speaker were installed. Perhaps dad or the boy would like to have an extra speaker in the den or their bedrooms. Why shouldn't they? The cost for an extension is small compared to an extra radio set.

Of course, the question will arise whether it would be wiser to get a second radio set or make an extension. Here are a few "tips" to help make a decision. Should one member of the family prefer programs differing from the others, a midget or mantel receiver installed in their room, attached to a multiple receiver noise-reducing antenna should be recommended. For late listeners a second receiver is naturally unnecessary as the receiver in the living room will not be in use. Where good fidelity is desired by all, and expense is a consideration, it is best to have one high grade receiver and make extensions to the various positions desired.

First I will tell you how to install an extension loudspeaker. Then I will take up the headphone connection so the needs of the DX fans, the fellow that likes to "fish" for distant stations, will not annoy the other members of the family or the neighbors.

In the previous job you found out how to connect a tone control to the power stage of a radio set. You will remember connections were made to the two plates or one plate and ground. The extension speakers are connected to the same terminals or tube prongs but only to the output stage. The extension wire should be the ordinary No. 18 twisted twin lamp cord type. You can obtain many different kinds of this cord from your local hardware or electrical store. Don't forget a box of insulated staples. Select a cord that matches the color of the wood work or wall. Run the wires to the places where you expect to connect the extension speakers. Tack the wire to the picture molding or floor board in the out-of-the-way places. Leave an extra length of wire at the location of the extension speakers so that it will reach the speaker.

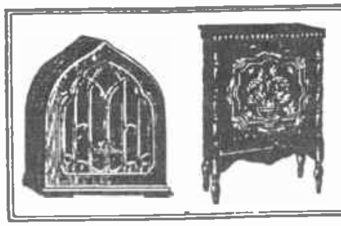


Fig. 4.—*One at left, mantel type; one at right, floor or console type speaker*

Extension loudspeakers are usually of the magnetic or permanent dynamic types for the simple reason that they are inexpensive and require no power to make them operate. Of course, externally excited dynamic speakers may be used, if the extension speaker is located near a power outlet. Such dynamic speakers have switches to turn on their power. Separate speakers may be obtained in attractive mantel or console cabinets. Your customer should be allowed to choose from pictures that you can clip from a mail order house catalog the type they would like. Figure *4* shows two typical extension speakers.

Regardless of the type of speakers selected, a switch, a volume control, a 4 mfd.

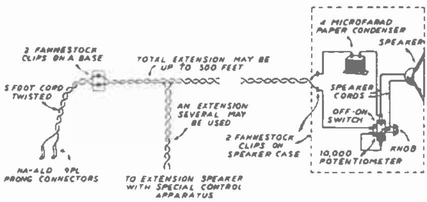


Fig. 5

paper condenser, 4 Fahnstock clips and 2 type 9PL Alden prong adapters are needed. The volume control is a 10,000 ohm wire wound potentiometer, a variable resistor having three lugs. The connections are shown in Fig. *5*. It is wise to obtain a combination potentiometer and off-on switch. Thus, turning the control to the extreme left will reduce the volume and eventually cut it off or out of the circuit. A 4 microfarad, 600 volt paper condenser is connected in series with each line as shown in Fig. *5* and used purely to prevent the D.C. current of the receiver from flowing through the extension speaker.

I would place the combination variable potentiometer and off-on switch and the paper condenser into the cabinet of the extension speaker. The internal connections should terminate at two Fahnstock clips. The extension wires are connected to these two binding posts. At the receiver end of the extension, I would terminate the extension at two Fahnstock clips mounted on a small 2" x 2" bakelite base about ⅛" thick.

Now the two leads from the Alden 9PL prong adapters are twisted together and connected to the Fahnstock clips. You need not worry about which lead connects to which post. As long as you keep the D.C. current out of the line, as we have done here, there is no polarity to worry about.

Phone Extension.—Now I will consider the headphone extension. If you have mastered the scheme of making a speaker extension you will have no difficulty. There are two things to do. One is make the phone adaption, the other is to disconnect the set speaker. If you don't do the latter you have not eliminated the troublesome noise that I said was so annoying when our DX fan did his station fishing.

The extension is really simple. You proceed just as you would for a speaker extension, except the leads from the Naald 9PL connectors terminate at 2 Fahnstock clips on a bakelite strip which I suggest you screw to the inside of the radio cabinet. These clips connect to a 4 mfd. paper condenser, a 10,000 ohm potentiometer as shown in part *A* of Fig. *6*. The phones which may be of the 1,000 to 5,000 ohm type (two in series) are connected to the potentiometer as shown. One phone lead connects to the center lug of the potentiometer, the other connects to either end lug. It really makes little difference.

Now, to include a switch to stop the set speaker when the phones are used. Disregard any of the connections to the speaker. As you know the set and the speaker has a 2, 4 or 5 wire cable connection. Focus your attention on the speaker transformer. You won't have any trouble finding it. Look for the voice coil, usually a thin round tube that is fastened to the speaker cone and moves in and out of the core of the speaker. There are two wires from the voice coil to the transformer. Disconnect one of these wires at the transformer; cut it if necessary; and connect a two wire extension. This extension connects to a two terminal toggle type power *off-on* switch as shown in Fig. *6B*. Mount the latter on the base with the Fahnstock clips.

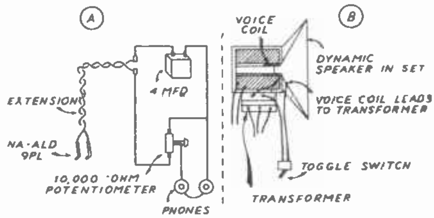


Fig. 6

To operate the phone extension, set the voice coil switch to the *off* position, tune in a local station, place the phones over your ears only after the potentiometer has been set to prevent it pounding sound into your ears. Explain all this to the customers. Tell them not to advance the control too far as the sound will be too intense. Advise them to use the volume control on the receiver.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

How a Good Speaker Baffle Will Improve Receiver Tone

There are hundreds of radio receiving sets in your neighborhood that bring in all the desired stations, but they are sadly lacking in tone or fidelity. I am referring now to mantel and box receivers. They do not convert the low audio signals to sound and they can't if the box or baffle around the speaker is small. One of my instructors brought to our laboratory a well-built box receiver and tuned in stations galore. On the locals we could see the speaker cone move one-fourth of an inch indicating that the low frequencies were working on the speaker, yet we didn't hear them. He put the set speaker into a 12" x 12" x 8" box and it sounded better, the lows were coming through. Then he put the speaker in an 18" x 18" x 9" box and the set sounded as different from the original as day is different from night.

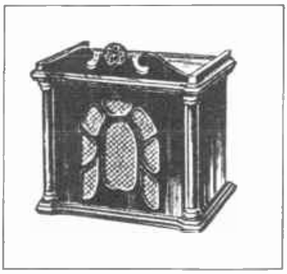


FIG. 1A

Here is an idea that can be turned into real money and be used to make a friend out of a customer. There are several other things you can do while making this change. You can place the entire machine in a console and approach the ideal of a big receiver; place the midget on an end table, the speaker in a box or cabinet at the best acoustical position and have a remote control receiver; or you can install the speaker in a small floor box cabinet and use the cabinet as a support for the receiver. Let me tell you more about the details.

To begin with, these changes are only to be considered for receivers that are sensitive and selective and have speakers that are more than 5 inches in diameter (at their rim). The speakers must not be of the magnetic type. Sets with five or more tubes or four tube sets using the "super" circuit should be a rough guide to follow. See that they bring in stations when connected to a good outdoor antenna system. Don't tamper with receivers that hum, because the hum will be more apparent with a good baffle. You will acquire this ability to judge a good small receiver in a short while after you start in the radio service business.

I like to insist on using the speaker supplied with the set, for then you don't have to worry about the speaker impedance or the field resistance. Their importance is taught in your regular radio course. All you need to do, is remove the speaker, without touching the grill and grill cloth, and add the necessary extension cable. The length of the new cable will depend on what your plans are. Use a four or five wire cable depending on the number of leads to the speaker. Cut the cable close to the receiver chassis, but before you do be sure that the cable uses different colored insulation. If not label the two cut ends 1, 2, 3, 4 and 5. The cable that you buy will have wires with various colored insulations. Be sure that the beginning and end of the new cable connect to same leads of the original. This procedure will prevent making a mistake in connecting.

FIG. 1B

Where you plan to run the extension

under a rug use flat or ribbon cable. Always make standard Western Union Duplex soldered connections.

Suitable Speaker Cabinet.—I pointed out that the larger the box or baffle the better the sound will be. You can procure from most radio mail order supply concerns, table or floor speaker cabinets. Both types are shown in Figs. *1A* and *1B*. The table model cabinet that you should select must be much larger than the original receiver box otherwise nothing will be gained. The table model shown is 12 inches wide, 12 inches high and 8 inches deep; the floor model is 18 inches wide, 30 inches high and 9 inches deep. I would say that actual box size of the floor model is about 18" x 18" x 9" and is quite suitable for the purpose mentioned.

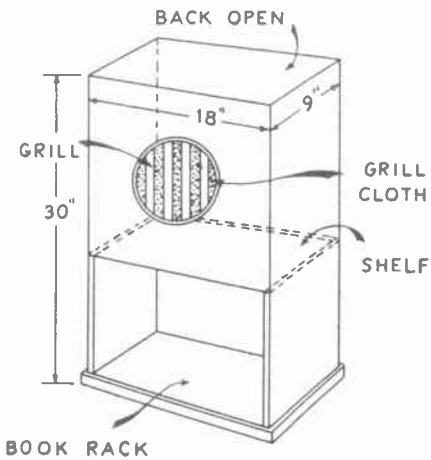


FIG. 2

If you are handy with carpenter's tools you can build a simple but attractive floor cabinet. Perhaps a local carpenter or cabinet maker will make cabinets as shown in Fig. *2*, on order. Note that the design is modernistic and if finished in jet black with silver stripes will harmonize with most radio cabinets. The entire cabinet can be made of white or gum wood. The front panel may be mahogany or walnut veneer wood if this is to be the finish of the rest of the cabinet. The cabinet shown has special utility. Not only will it house the speaker, but it may be used to support the receiver by placing the latter on the top. Space is provided below for books or magazines. Be sure that the shelf indicated is included, as the effect of the baffle is improved by its use. Grill cloth and a grill may be purchased from most supply houses.

Placing the Receiver in a Floor Cabinet.—You will find that many manufacturers place one of their compact chassis in either a table or floor cabinet. The reason for the floor model is, as you have already surmised, to improve the tone quality. There is a suggestion worth following. Why not suggest, where you find a good receiver in a small cabinet, that you install it in a good floor model?

If you live in a large town or city you may be able to pick up at reasonable prices, from radio dealers, cabinets that were salvaged from obsolete trade-in receivers. Or you can purchase radio console cabinets from many mail order concerns. Of course, if you have a simple floor cabinet made locally, like the one shown in Fig. *2*, provision can be made for installing both the speaker and the receiver chassis. All this will require a little ingenuity which I feel sure you can muster.

Whenever you use a larger cabinet be sure that it is placed in the home in a good acoustical position. When you transfer the chassis from one cabinet to the other be sure you make a paper template of the control knobs. This is to assure correct hole locations. If you remove only the speaker, it will be a good idea to back up the grill cloth with heavy cardboard.

A Remote Control Radio.—Don't overlook the remote control radio scheme, that I mentioned in the introduction of this job. Several manufacturers have similar models and they are liked by the public. The transformation of a small but good box receiver to a remote control system is simple.

Remove the speaker. Add a cable extension using flat cable if you intend to run it under a carpet. Use regular cable if you plan to tack the cable on the baseboard with insulated stables. Place the speaker preferably in a floor type cabinet. Back the grill of the original cabinet with cardboard. The position of the receiver on an end table near an easy chair and the selected position of the speaker cabinet will determine the length of the cable. Extend the ground, antenna and power leads as required; tack up the speaker cable and the job is finished.

How To Build Receivers into the Home

Built-in radio sets and speakers are gradually becoming important features in the modern home. There are many people who have just so much room in their homes, and to add a radio receiver might make the room crowded. Most home owners have set ideas as to the arrangement of the furniture in their home and there will be many who want permanent radio installations.

There are people who have fine old pieces of furniture such as tables, book cases, chests of drawers and china closets which will accommodate a receiving set and loudspeaker. While they might refrain from purchasing a receiver outright because of lack of space, they would be perfectly willing to have a permanent built-in radio installation.

This field is not limited to furniture, as there are installations where a receiver, speaker and phonograph motor with pick-up unit are built into the wall or under a staircase.

Where a Radio-Trician has a job to install radio apparatus in furniture he should first size up the dimensions of the furniture in question and decide upon what type of receiver can be accommodated, and he should then consult a good furniture repair man. Unless one has experience in wood working it is not advisable to cut the furniture, because it is very easy to ruin the finish or the supports of such furniture.

Where the receiver is to be built directly in the wall one should consult a carpenter and where clothes may rest against the receiver or speaker, to build a metal grilled box around the apparatus. Low amperage fuses should be connected in series with the supply line as a fire preventive.

Figure 3 shows an example of a receiver, speaker, and an electric turn table with a pick-up unit installed under a staircase. The speaker is mounted at the left, although any convenient position may be used; the receiver is at the right. Just under the receiver a drawer is provided that will accommodate a phonograph motor with pick-up unit. A space of at least one foot should be left back of the loudspeaker, if possible, for best tone quality.

You can lay out your plans for the receiver and its associated apparatus, obtain the approval of your customer, and take the plans to a mutually acceptable carpenter. Have him prepare the space for you in the wall. Such installations will

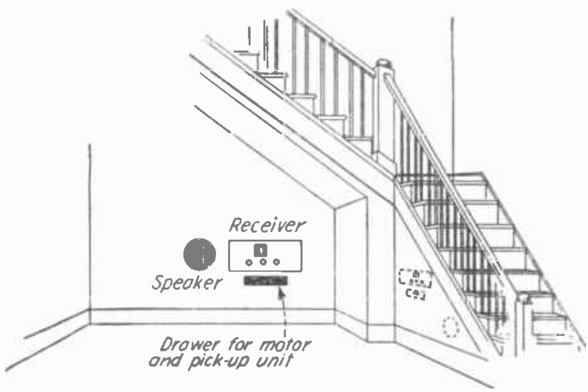


Fig 3

and have the holes cut to fit the receiver and its associated apparatus. Such installations should be absolutely fireproof. A complete metal cover should be built around the receiver. Be sure that ventilating holes are not omitted. It would be well, where the receiver is in a closet have to be neat, and one should take the advice of the carpenter in regard to the way the apparatus is fitted to the wall.

Don't overlook the possibility of making installations in secretaries, book cases, end tables, special period furniture or wall cases.

How To Build and Install a Remote Volume Shifter

Mrs. Brown is called to the telephone while the radio is on. If she turns off the radio set, she may forget later to turn it on. After all, we in the radio business want her to use the radio as much as possible so such a situation will hardly do. Perhaps she turns the radio off reluctantly, knowing that it has to be turned on later with the attending warming up and set regulation. A lot of people actually shift the station selector so the set will be on, only later to retune the receiver.

People have the habit at night to seat themselves in an easy chair after they have tuned in their favorite station. They often have to get up to alter the volume due to normal line voltage and receiver changes. Here is a condition where a remote volume control will be a welcomed addition. They often find that the voice announcements or talks are not as loud as the music, so they get up and adjust the receiver. Now they find that the music is too loud. So in disgust they turn the set off. Again there are certain short programs or parts of a long program that they are not interested in.

But they hesitate to turn the radio off knowing that the next part of the program is what they have been waiting for; as they sit in their chair they mutter to themselves, "If I could only cut the volume down without getting up." They can.

Maybe the family starts a discussion and they want the radio silenced, or the volume down. A remote volume shifter will do the trick in all these cases that I mentioned.

There are many ways of adding a remote volume control or volume shifter. One of my instructors doped out a novel scheme that we tried in our laboratory. Several were built and used by various members of the N.R.I. staff. I know you will like it and find its sale profitable.

Tack the cord to the woodwork and lead it to the easy chair or to the telephone table, depending on the service to which it is to be put. At this point connect the cord to an *off-on* toggle switch shunted by a 200 ohm variable resistor. The entire control is placed in a small box that is weighted down so it will stay where put. The connections are shown in Fig. 4. Observe that a potentiometer is used, and was selected so that the customer can never produce an open in the voice coil circuit. There is some chance of destroying the output tubes if an open is accidentally created. Never make this installation while the set is on. Be sure the extension circuit is complete before turning on the receiver.

As many parallel shorting switches may be included as you wish. Thus the cord may run past the telephone desk to the easy chair or the reverse, if you wish to control the receiver volume from both places.

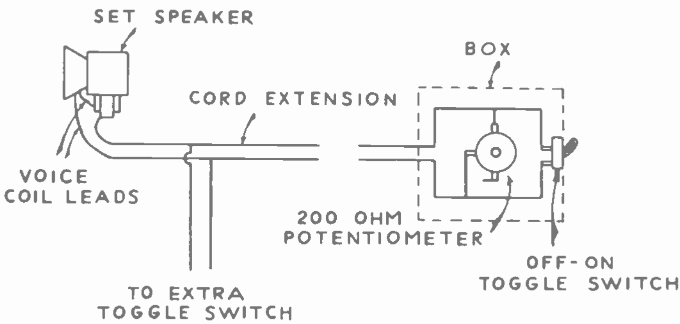


FIG. 4

Here it is and it is as effective as it is simple. Locate the voice coil leads of the receiver and disconnect one of the leads to the output transformer and preferably at the latter. Procure a two wire lead, an Underwriter's Approved twin lead cord is just the thing to use as the wires are large. Of course, the length of the cord is determined by the distance between the set and the point of control. Connect one lead to the open transformer terminal, the other is connected to the voice coil lead. Tape the cord to the transformer so any pull on the cord will not tear the voice coil lead from its anchor.

After the installation has been made, turn the set on and leave the toggle on the remote box at the *on* position. Have the customer adjust the volume control on the receiver to the desired level. Now throw the remote toggle switch to the *off* position and adjust the remote control to the desired low level. The customer may adjust the level as he likes or use the full volume of the receiver by merely switching the remote control. Try this scheme on your own radio. I know you will like it.

Extra Money Jobs and how to do them

How To Advertise Your Services

There is an old saying by a famous person that goes something like this: Make a better mouse trap than your neighbor, even though you live in a forest, all the world will beat a path to your door.

Sounds good and might have worked well some years ago but it won't work these days. There are hundreds of radio servicemen that are good radio-tricians and know radio. Yet they shut themselves up, as far as their fellow folk are concerned, in their home and wait for business to knock on their doors. I am afraid they wait, while their more progressive radio competitor "tells the world" what he has to sell. Such fellows eventually say that the world is against them, does not appreciate their good work, or the radio business has gone to the dogs. So you see, that this saying, like a lot of other old catch phrases, won't work these days, because they are not quite true.

Of course, you are going to be a "first class" radio-trician, thoroughly know radio and radio servicing inside out and outside in, if you study your N.R.I. Radio Course. But I also want you to "tell the world" what you can do—in plain words of the day—ADVERTISE. Nothing pretentious or elaborate. Simple, direct but persistent advertising. A little every day or every week will roll up into a mass of favorable attention. Then if you do the kind of work that I know you will be able to do if you study your textbooks and do your N.R.I. practical experimental units, your future in radio is on the road to success.

Advertising need not be expensive. To begin with, you should decide on a modest amount to spend each week, three to five dollars. Later you can budget 10 per cent of your total income per week for advertising. But once you start advertising, don't stop and don't start in too big a way, because it is hard to cut down. Build up gradually; don't build down. Don't expect results right off the bat; it takes time to build up good will in any business.

Although most people immediately think of an ad. as an advertisement in the local newspaper, there are many other more profitable ways of telling the world. Let me tell you some of the more common ones in this job sheet. You, too, will think of hundreds of other schemes that you can use. In fact, if you subscribe and read radio trade magazines like Radio Retailing and Radio Journal, you will get many other ideas and methods that have been tested by your fellow members in the radio field.

Telephone and Telephone Directory.—When a person needs a serviceman, he wants him, as a rule, as soon as possible. He will not take the trouble to come to your home, personally, if he can call someone else on the telephone. Do what every other successful business man does. Have a telephone installed in your home or shop, and have someone to write down the name, address and all details of the calls that come in. If you adopt a firm name like *Dick Brown's Radio Service,* you will accomplish two things. Your name will be listed in the regular phone list; and in the classified section your name will appear in the radio or radio service section.

KENNEDY'S J. P. RADIO SERVICE

PERSONAL
HIGH QUALITY SERVICE

Reasonable
Rates

418 W LaSalle.............3-2414

Courtesy Radio-Craft

FIG. 1

Many servicemen vouch for the statement that a special ad. like the one in Fig. *1* placed, for a few months, in the classified section of the phone directory pays. Such an ad. is inexpensive, only a few cents a day. Try it, for you, too, may find that it pays. In large towns and cities where there is a lot of radio service competition, a well planned ad. in the classified section is to be preferred. The advertising solicitor of the phone company will help you prepare one with good appeal. Have him show you samples of ads. used by radio servicemen in other cities and with him decide on one that will best suit your needs. He is anxious to help you have the best possible ad.

Make Each Service Call an Ad. for the Next One.—If you do a good job, make a pleasing appearance and are tactful in your dealings with your customers, they will remember you. But don't let them forget you and particularly your place of business. Prepare a little sticker (gummed label) about the size of your card, in fact, it may be a duplicate of it. Stick it to the back of the cabinet or to the chassis and on each tube you sell so that it will be a constant reminder, a permanent ad.

Tell the customer, "I believe you won't be troubled with ——— (whatever the complaint was), but should anything go wrong, be sure to call me. This sticker will tell you where you can get me."

Home and Car Signs.—Your place of business, even if it is in a spare room, basement or garage of the home, needs some outdoor sign to show that you are in the radio service business. Your local sign painter can make and suitably letter a sign that you can be proud of. Gold letters on a crystalline black background with molding around the edge is quite the thing. Don't get a sign that "shouts." Nail it to the front of the house below the first floor window, or to the railing of the front porch.

And make your sign work from dusk until midnight by having light reflected on it. Figure *2* tells the whole story.

If you use a car, as you will when your radio service business increases, have an attractive ad. painted on the spare tire cover. The rear of the car is the best place for a sign. People can see it longer than if the information you want to give is painted on the sides. Many servicemen even go to the trouble to paint their ad. on the back of the car, if it is of the closed car type. You should include your business name, your place of business, phone number and if these do not include the fact that you are in the radio service business, add *"Expert Radio Service Work," "Real Radio Service," "Honest Radio Service," "Practical Radio Service."* or any other words people are familiar with.

When you get to the stage where you prefer to use a light closed delivery truck, and you will need one if you sell radio receivers, be sure that attractive lettering with the same sort of information is painted on the truck by an expert painter.

While I am on the subject of cars and trucks, allow me to say that they should always be spotlessly clean, the paint job fresh and the whole surface wax polished. Everything connected with your business must be neat and clean, because it reflects the kind of work you do.

Placards.—One of my graduates lives in my neighborhood, and I know that he is on his toes. One day I walked into the neighborhood drug store and under the glass of the drug counter was his business card. Another day I happened to walk into the neighborhood hardware and electric store and a handsome 12-inch by 18-inch placard in a frame greeted my eyes as I approached the electrical accessory counter. It said "Calls for Dick Brown's Radio Service Taken Here. Prompt Service." Of course, Dick Brown is not his real name.

I made it my business to see him. He lived off the main street where few people passed his house. Yet he had a neat sign nailed to the front porch. His car, a used one, was parked in front of the house, but it was spick and span, with side hooks to take ladders with him when on an aerial job. A neat wooden sign was on the rear, mounted on brackets. Inside, his wife told me he was in the basement working. Needless to say that I found a happy man diligently at work and full of pep with a go-get-it attitude. Later, neighbors told me that he was honest, never made a promise that he could not keep, and was proud of his profession and his work.

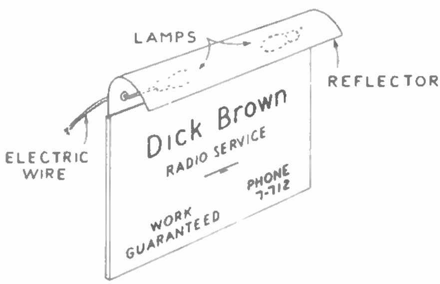


FIG. 2

I gave him a few tips, some that I have already told you. I asked him if he had done any auto radio work. "Some, but not enough to shout about," was the reply. I suggested that he tie up with Tompkins, who runs a garage and auto service department right on the main street. Two weeks later as I drove my car into this garage for its regular monthly tuning up, I saw a 3 foot by 4 foot sign over the engine tester; it read, "All Automobile Radio Installations and Service Done Here by Dick Brown. Prompt Service at Reasonable Rates."

A chat with the Mr. Tompkins informed me that about two weeks before, Dick called and made a commission proposition with him. Mr. Tompkins liked the idea of having the work done in the garage, as it brought new customers to the place and he could keep his eye on the work done on his customers' cars. He, too, felt that his customers' welfare was a matter of personal importance.

You have the same opportunities. Don't overlook the fact that the general store, the cigar and magazine store are also excellent places to arrange for a commission proposition.

Special Hints.—I am not going into the subject of newspaper advertising. That is a subject that will be considered, in some detail, later in your practical radio service Course. All I want to say now is that you go into it only when you are sure that you can stand the expense for four to six months without expecting any large, immediate returns.

You will be asked to take space on the programs so common with dance, church and community affairs. The general opinion is that they don't pay. The cost is high, the returns low. However, at times you can't afford to be "out." If the organizers of the event are good customers, they may feel offended if you refuse these direct requests. If you go into any program, try to furnish a radio for entertainment. Your ad. may say "Radio Entertainment Furnished by Dick Brown." In short, get something plus your space in the program.

In large towns and cities where there are apartment houses, many servicemen make a deal with the janitor, superintendent or house manager. For a small commission per call, or for free service on their radio, they will refer calls to you. You may not have had the experience, but most people in apartment houses rely on the management's recommendation on all types of service.

One graduate told me the following trick in conjunction with stickers. Here are the words he uses, "Madam, this sticker on the chassis is rather inconvenient to get at. Do you mind if I put one somewhere where it will be easier to see—oh, yes, do you mind if I put one on the calendar." He picks the one in the kitchen.

One last suggestion. No matter what form of advertising you employ, keep track of the results. You should know if a car sign is better than a store sign, a telephone directory ad. is better than a newspaper ad. Ask every new customer how they happened to call you. When you get back to your shop make a note of it. When business is a little dull, go over your records and decide where your money is buying the largest number of calls and push those mediums. Every successful business man does this in one form or other.

Remember you are a business man as well as a radio-trician. "Tell the world" you are in the radio business!

How To Install Simple Photoelectric Controls

Completely assembled photoelectric control equipment is now on the market at a price low enough to allow you a very good profit when making installations for stores, factories and homes in your locality.

change in the plate current of the amplifier tube which is large enough to operate a small relay. The contacts of the relay switch any desired apparatus "on" or "off."

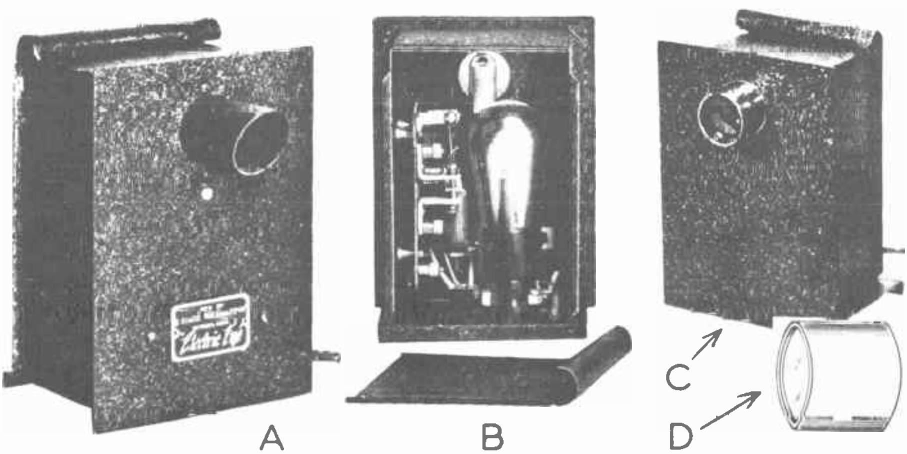


Fig. 3

A photoelectric cell, popularly known as an "electric eye," is the heart of any photoelectric apparatus. When the cell is connected into the grid circuit of an ordinary amplifier tube, the change in voltage resulting from a variation in the light falling on the cell causes a

Typical Photoelectric Equipment. In order to give you some idea of how photoelectric equipment is constructed, installed and adjusted, I am going to describe a typical assembly of apparatus, that which includes the Rhamstine Model A-C photoelectric relay and the Rhamstine light source.* This equipment operates from 110-volt A. C. power, and so can be plugged into any 110-volt A. C. light socket. It is designed specifically for indoor use, but can be made weather proof by building a simple wood or metal box, waterproofed with asphalt paint, around each unit; a hole for the light beam must be provided in each box.

Exterior and interior views of the Rhamstine photoelectric relay, which contains a caesium type photoelectric cell, a type 12A amplifier tube, a sensi-

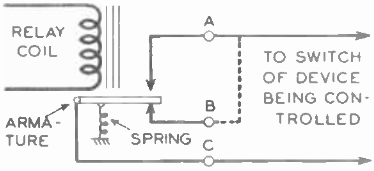


Fig. 4

tive relay and several *condensers* and resistors, are shown at *A* and *B* in Fig. *3*. Power is obtained from the A. C. line, a Cordohm being used to lower the voltage to the correct value for the filament of the amplifier tube.

At *C* in Fig. *3* is the Rhamstine light source, containing a bulb, reflector, lens, and step-down transformer. When the light source is properly focused on the electric eye, satisfactory operation can be obtained at distances up to 50 feet; about 25 feet is the maximum operating distance when the infrared filter shown at *D* in Fig. *3*, which cuts out visible light rays, is slipped over the light source lens to make the light beam invisible.

Instructions for adjusting the relay and light source of the Rhamstine apparatus are furnished by the manu-

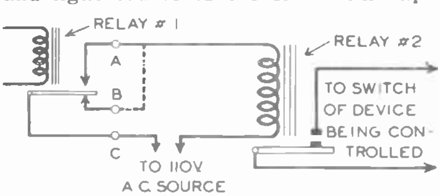


Fig. 5

facturer. The relay circuit is shown in Fig. *4*; connect the switch terminals of the device being controlled to terminals *A* and *B* if the controlled device is to be in operation when light is on the photoelectric cell. Make connections to relay terminals *B* and *C* when you want the device being controlled to operate when light is cut off from the photocell.

*Made and sold by J. Thomas Rhamstine, 301 Beaubien Street, Detroit, Michigan.

Relay ratings must be carefully considered in any photoelectric installation. The contacts of the sensitive relay in the Rhamstine unit will safely carry about one-half ampere, so the relay will control directly a 40- or 50-watt, 110-volt A. C. load. When heavier loads are to be controlled, use an extra relay connected as shown in Fig. *5*. Relay No. *1* is the sensitive relay in the Rhamstine apparatus; as you can see; it controls the current to the coil of relay No. *2*, the power relay. The proper size of this extra relay will depend upon the size of the load being controlled.

Simple Applications. The photoelectric apparatus which has just been described is ideal for announcing the arrival of a person at any certain point. If the light beam is directed across a doorway and an alarm bell or buzzer connected to the relay contacts, the alarm will sound whenever anyone passes through the beam.

Filling stations can use the photoelectric apparatus in the manner shown

Fig. 6

Fig. 7

in Fig. *6*, to announce the arrival of a car at the gas pump. The details of these installations will vary.

The Rhamstine apparatus or any other photoelectric apparatus can be used to count persons or objects intercepting a light beam. It is simply necessary to connect a magnetic counter and a source of power in series with the contacts of the relay.

The photocell housing can be mounted on a garage, as in Fig. *7*, so light from the spotlight of a car in the driveway can be directed on the cell. The relay can be connected to a solenoid and trip lever to release weights which pull the doors open, or to a power relay which will operate an electric door opener.

Photoelectric equipment is especially valuable for use in connection with window displays and signs. The apparatus can be arranged to set some part of the display in motion or turn on lights when a person approaches.

Lights directed on the radio service signs at your shop or home can very advantageously be photoelectrically controlled, so they flash on when someone approaches.

Radio Servicing Jobs and how to do them

NATIONAL RADIO INSTITUTE ■ WASHINGTON, D. C. ■ PRACTICAL JOB SHEET

What To Do When a Receiver Plays Intermittently

The phone rings at the Reliable Radio Service Shop.

"Good morning, this is Mr. John Q. Serviceman."

"Good morning, this is Mrs. Public. My radio set is not acting properly."

"What seems to be the trouble, Mrs. Public?"

"Why, when I turn it on it plays for an hour, then stops. If I adjust the set, it will play for a few minutes more, then stop again. It's a nuisance. I would like to have you look at it at once, because the family wants to listen to the symphonic hour tonight."

What would be your reaction as John Q. Serviceman, to this call for immediate service? Well, that depends upon how much or how little you know about intermittent receiver troubles. Let us see how an expert Radio-Trician would answer this phone call:

"Frankly, Mrs. Public, it would be unwise to promise to fix your receiver properly by tonight, for trouble of the type you are having often takes quite some time to locate. I'll do the best I can today, and will let you use one of my new receivers while your set is being repaired."

Well-informed Radio-Tricians know that intermittent reception is the most intangible trouble they may be called upon to remedy. The symptoms are: the set will be playing normally on a station and the signals will suddenly cut down to a lower level or fade out entirely. Jarring the set, snapping the switch on and off, or turning a light or appliance on the same line on or off may bring back the signals to normal strength. In the first case we administered a "mechanical jar" to the defective part, while in the second case we administered an "electrical jar."

If a mechanical jar momentarily clears up reception the trouble is probably of a mechanical nature and can be readily repaired. The electrical jar indicates a temporary open or short in some part, or a thermal contact which opens and closes with the application of heat.

Thermal Contact Troubles.—You are doubtless familiar with fading caused by defective heater type tubes. As the tube heats up the filament expands; in a defective tube this expansion loosens one of the welded filament wire joints. Current ceases to flow through the filament, electron emission falls off and the signal strength decreases. As the tube cools the filament contracts, the broken parts come together and the set will operate a little while longer. The trouble in this case is easily recognized by noting, if glass type tubes are used, whether any filaments are not glowing. Installing a new tube eliminates the trouble. With metal type tubes, some other identifying method is obviously necessary; the temperature of the outer shell will be quite high in a good metal tube.

But what if the tubes remain "lighted"—can a thermal contact in a tube be responsible for fading? Absolutely, for the plate, screen, control grid and any other elements used are welded to their supporting leads, and a thermal action can take place at any joint or weak spot. This leads us to the first rule in servicing an intermittent case in a customer's home. *Always try an entire set of new tubes.* If this stops the fading the old tubes may be replaced one at a time, operating the radio after each change of tubes, until the offender has been located by a process of elimination. This procedure is very necessary when metal tubes are employed, as it is impossible to see the condition of the filament.

All this sounds very simple, doesn't it? But when you consider that a set may play for hours without cutting out, you will see why immediate repairs cannot be promised when receiver trouble is intermittent. Such a receiver should be taken to your shop whenever possible, so it can be serviced while you are doing other jobs. Operate the set, after making each change in tubes or parts, until fading occurs or until you are certain the trouble is cleared up.

Installation Defects.—Another cause for fading, often overlooked by service men, is the antenna and ground installation. A poorly insulated aerial or a bad ground connection is often responsible. Disconnect the aerial lead-in and the ground wire from the set, and connect these leads to an ohmmeter. A reading on the meter, when the leads are shaken vigorously, indicates that the antenna is grounded.

Check the lightning arrester and all other antenna system connections.

When fading due to a break rather than a short in the aerial circuit is encountered, an increase in noise level (background noise) is to be expected (because of AVC). The effect is the same as if the antenna were removed and the set operated without it. A quick check on the efficiency of the aerial and the ground can be made by disconnecting both, then using a 50-foot length of insulated wire, run out through a window, for an aerial. No ground is to be used. If fading still is encountered on local stations the trouble is in the receiver.

Never neglect to shake the line cord and look for spliced joints made by the customer. Be sure to check every possible surface defect while the chassis is still in its cabinet before asking permission to remove the chassis to your shop. Frankly, when the customer objects to removal of his radio to your shop, in a case where lengthy tests and repairs are indicated by your preliminary examination, I would not waste any more time at his home in attempting to locate an elusive intermittent defect which may last only a few minutes.

Shop Bench Tests.—If these preliminary at-the-home tests fail, you will have to take the radio to your shop, set it up on one side of your work-bench, and make a thorough search for the defective part. Look over all wiring, pulling and shaking all accessible leads. Tap each part with a small hammer. Clean the friction contacts on the tuning condensers, and increase their tension. Check with an ohmmeter for intermittent resistances of different parts.

Condenser Troubles.—With the set in operation on your work-bench, check the various R.F. by-pass condensers and audio coupling condensers for intermittent opening by connecting other condensers of the same size, which are known to be in good condition, in parallel. If the signals clear up when this is done, the condenser under test should be replaced.

Intermittent breakdown of a condenser is somewhat harder to locate. A set analyzer or a voltmeter connected in any one of the voltage supply circuits will generally indicate a drop in voltage during the time the condenser in any part of the system breaks down (shorts). The suspected condenser may be checked by applying a slightly higher voltage across its terminals than is impressed across it in the set. If the condenser trouble was of an intermittent type, this higher voltage will probably break down the condenser permanently.

Resistor Troubles.—Resistors do not commonly cause intermittent reception. Sometimes they open up due to a thermal contact in the resistor element, or to a poor mechanical contact to the resistance wire in the case of wire wound units, and sometimes carbon resistors change in value. The effect, a change in voltage, will generally be indicated by meters, but the quickest and easiest way is to replace resistors one at a time with new units. In most cases the resistance values are not critical, so use sizes on hand which approximate those being replaced in the set. In the case of wire wound units reclamping the ends with pliers often effects a cure, as the resistance wire is not soldered to the pigtail.

Transformer Troubles.—R.F. transformers seldom cause trouble, but the coil forms sometimes expand, breaking the wire (which may have been stretched tight during manufacture) and forming a contact which the slightest jar will open. Here voltage measurements (grid and plate) together with an ohmmeter and visual inspection are usually sufficient to locate the trouble.

Audio transformers at times cause intermittent reception. A partial short between adjacent turns of a winding, a broken wire in the winding, a short between primary and secondary or between either winding and the core may cause the trouble. Ohmmeter and voltage tests should be made before and after the trouble makes its appearance.

Loudspeaker Troubles. — Intermittent loudspeaker operation may be due to open voice coils (phones in series with and then across the voice coil will show this up) and loudspeaker field defects. Windings on loudspeaker fields sometimes short; a change in voltage across the field or a change in pull on a steel screwdriver held near the pole of the loudspeaker field are the observable defects which indicate the trouble.

Power Supply Troubles.—Defects in the power supply are a possible source of intermittent troubles. Filter condensers which are leaky will cause trouble, as also will defective voltage dividers. Changes in operating voltages will be noted in each case. A.C. voltmeters may be left connected across the power transformer secondary windings to see if any voltage change shows up with the fading.

Isolation Tests.—The stage by stage elimination method must be employed when surface checks and effect-to-cause reasoning fail to locate the trouble. Remember that tests can be made only when the cut-off occurs. Since almost any shock or jar can clear up the intermittent trouble, you can readily see why I recommend bringing sets like this to the shop, where you can do other work while waiting for the trouble to reappear.

Connect a signal generator to the inputs of the different stages, starting with the second detector and working *back* to the first R.F. stage, leaving the signal generator on while you proceed with other work, until you locate the first stage where the intermittent defect is again noted. If this shows up when feeding into the second detector, the trouble may be in that stage or in the succeeding audio stages. The headphone test to be described later will isolate the bad stage under these conditions.

In AVC sets employing visual tuning you can make a quicker check which will partially isolate the trouble. When the signals fade out turn the dial past several strong stations.

If the meter or other visual device registers the station *normally*, the trouble is *past* the detector (second detector in superheterodynes). At one stroke we have eliminated the entire R.F., first detector, oscillator, second detector and AVC system. A pair of phones placed in the plate circuit of the first audio stage will cut off when the loudspeaker output cuts off, if the trouble is in that stage; test each succeeding A.F. stage until you locate the one where phone and speaker outputs fall down simultaneously.

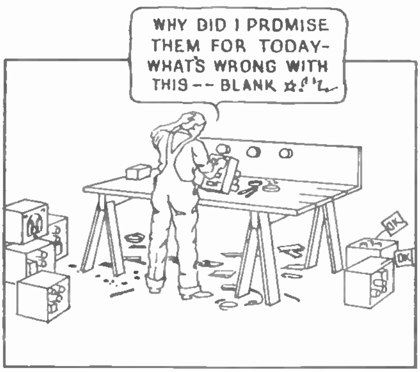
If the tuning indicator fails to respond to a local station, make a stage-by-stage check on stages up to the second detector, by connecting a milliammeter into the plate circuit of each stage. Start with the first AVC controlled R.F. stage and proceed until you reach a stage where a change is noted in the milliammeter when the loudspeaker output cuts off.

You have now isolated the trouble to one stage of the receiver; the next step is a check of the parts in that stage. For audio stage troubles, check the audio transformer first. Connect a pair of phones in series with the transformer primary; if no signals are heard the primary is open. Connect the phones in parallel with the primary; if no signals are heard the primary is shorted. If the primary tests okay but you hear the fading or cut-off when the phones are across the secondary, the secondary is shorted. Try a new audio transformer here.

AVC Troubles.—In AVC controlled sets the control grid returns (resistance-capacity filtered) should be watched closely. An open in the grid return condenser will often cause a drop in signal strength, as the condenser is a part of the tuning circuit. Resistors in the stages controlled by AVC should be checked by substituting new units. A gassy AVC tube may be satisfactory in some other stage where the control grid circuit resistance is low.

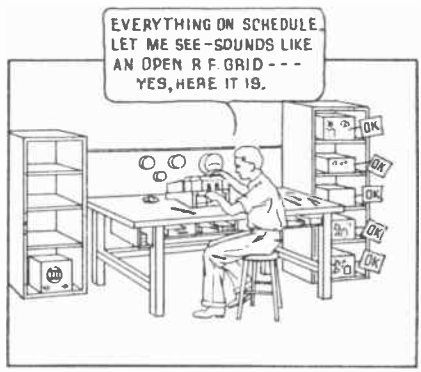
In all-wave receivers trouble may occur on only one band. If so, the defect is in the coil switching system (poor contact) or more likely in the preselector, oscillator coils or padding condensers.

Time of Cut-off Is Important Clue.—A study of intermittent action in receivers, over a period of years, has led to some very interesting facts. Most intermittent actions are thermo-electric in nature. A definite relationship generally exists between the *time required* for the thermo-electric *defect* to show up, and the *nature of the part affected.*



A HEADACHE
(The Hit-or-Miss Method)

and



A SUCCESS
(The Effect-to-Cause Technique)

Time	Probable Cause
0-3 minutes	—Tubes or poor connections in set.
3-5 minutes	—Resistors, especially cathode bias resistors which heat up after tubes are warm, and other parts which dissipate heat rapidly; loudspeaker fields are in this classification.
3-5 minutes (Universal AC-DC sets)	—Series filament resistors and heavy duty bias resistors which sag and touch the chassis.
Over 5 minutes	—Power transformers and large bias resistors.

The most common causes of intermittent action, condensers which either open or short, are not included in the time chart for the simple reason that they have no time constant. When the cut-off time is erratic, suspect a condenser first.

The following procedure should be adhered to on any intermittent job:

1. Eliminate the tubes as a suspect.
2. Eliminate the aerial and ground as a suspect.
3. Visually inspect the wiring and parts and apply the soldering iron freely to suspected connections.
4. Refer to all intermittent reception data you have in your files for the receiver under test or for similar circuits.
5. Apply the stage by stage elimination method.
6. Check condensers by shunting them or by substitution, preferably the latter.
7. Try voltage and resistance measurements before and after the trouble appears.
8. Make final check by playing the set for at least 3 or 4 hours (preferably all day) before reinstalling.

It may take you minutes or hours to correct an intermittent defect. Most of the time will be lost in waiting for the receiver to cut off. So, always do such jobs along with other bench repair work. Intermittent reception defects traced to internal defects are best located at the bench and to one side so as not to interfere with your regular work. Be sure that the chassis is open, and on end so that you see and can get at every part. Don't get discouraged; the best service technicians realize that a defect of this kind has no mercy on their patience.

Receiver Troubles That Cannot Be Remedied without Receiver Redesign

Do not invite trouble!

This seems to be an unnecessary statement, as no one looks for trouble—except some radio men. The service man with limited experience reacts peculiarly to troubles he finds in a receiver. He encounters a receiver with low sensitivity, never designed to have "lots of pick-up." Immediately he wants to change tubes, try better coils, add an extra R.F. stage, and try any of the other "stunts" to get more pick-up. This inexperienced service man reads about the unique features of AVC, noise suppression, diode type of detection and scores of additional unique radio refinements. "Fine," he says, "Mrs. Jones' set should have it."

Is he inviting trouble?—and how!

In this servicing job I want to stress the importance of "sticking to your knitting"—if your ambition is to be a "cracker jack" service man, be satisfied with restoring a receiver to its original operating ability. If the set lacks this or that basic receiver feature, and the customer recognizes that he needs it, then he should have a more modern receiver.

To be sure, this does not mean that you cannot or should not redesign a receiver—and all the above features call for redesign. If you want to play, do it on your own set. Do not do these things to a customer's radio if you can avoid it. Believe me, you will lose more time, more money and more goodwill than you expect.

A good service man knows when a slight circuit change, involving modest redesign, is worth while. A number of reasonable changes have been included in previous job sheets. As you gain experience and knowledge of radio circuits, others will suggest themselves. But if you remember to ask yourself: "Will this change pay—will the customer appreciate the change, considering the price I must charge?", you will not do unnecessary jobs.

Yes, this is a job bulletin on when not to do a job. Knowing when to refuse a servicing job is just as important as knowing how to repair a receiver or add some useful device.

RADIO-TRICIAN
REG. U.S. PAT. OFF.
Service Sheet
Compiled Solely for Students and Graduates
NATIONAL RADIO INSTITUTE, WASHINGTON, D.C.

MAJESTIC RECEIVERS
MODELS 90, 90-B, 91, 92, 93, 100, 100-B, 101, 102 AND 103

The receiver chassis of the above receivers are all practically identical, with the exception of models 90 and 100 which use separate power packs. The 100 series have, in addition, a radio-phonograph switch.

VOLTAGE TABLE

Tube Purpose	Type	Filament Voltage	Plate Voltage	Grid Bias Voltage	Cathode Volts	Normal Plate Milliamperes
1st R.F.	G-27	2.35	130	8	8	5.5
2nd R.F.	G-27	2.35	130	8	8	5.5
3rd R.F.	G-27	2.35	130	8	8	5.5
4th R.F.	G-27	2.35	130	9	9	5.0
Detector	G-27	2.35	230*	25**	25**	.8
Power	G-45	2.45	250	50	..	32
Power	G-45	2.45	250	50	..	32
Rectifying	G-80	...	...	..	..	..

Line Voltage 115 A.C. on 115 volt tap
*270 Volts in models 90 and 100.
**30 Volts in models 90 and 100.

ALIGNMENT

Remove chassis from the cabinet and connect for operation on a table or bench where the adjusting points will be accessible.

Supply a 1350 K.C. signal to the input of the receiver and tune it to the exact resonance point of this signal with both the main tuning control and the trimmer. Then turn the volume control to maximum volume position.

Insert a balancing tube (one having an open filament so that it will not heat) in the first R.F. tube socket and adjust the first R.F. neutralizing condenser for minimum output.

Proceed in the same manner to neutralize the remaining R.F. stages.

Supply a 950 K.C. signal to the input of the receiver and tune it to this signal.

Adjust all gang condenser aligning condensers for maximum output.

In all the above procedures be sure the shield cans are over the tubes and the volume control in maximum position when making any adjustments.

If available, employ an output meter to indicate exact resonance point when aligning the receiver. It should, however be disconnected when neutralizing the receiver.

COMMON TROUBLES

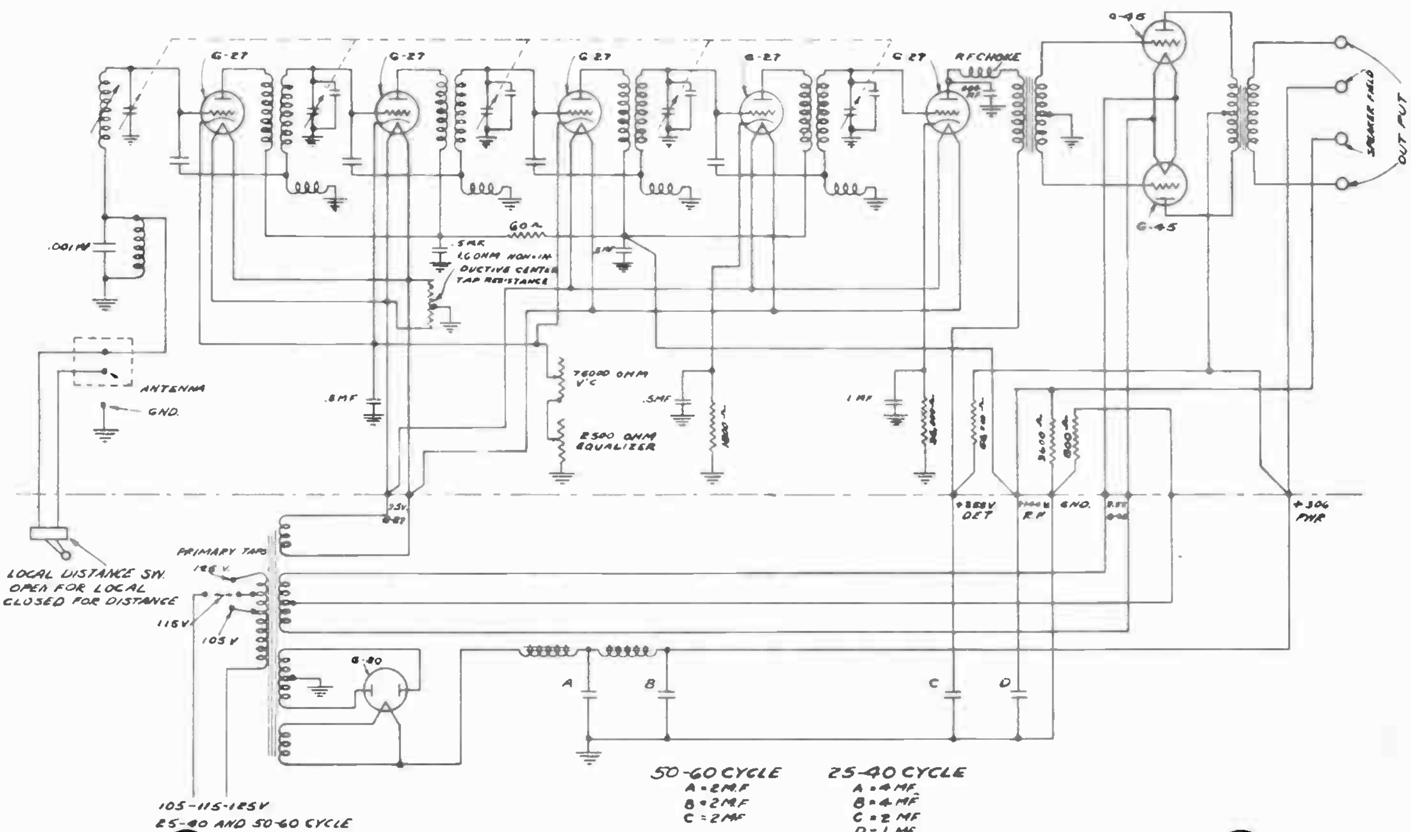
CUTTING IN AND OUT. Check by-pass condensers across cathode resistors to ground for opens. There are two in metal containers. Replace defectives with .5 or 1 mfd. condensers.

HUM that is apparent when tuned off of the station and becomes very loud at resonance may be caused by an open filter condenser; hum on resonance only may be caused by any condenser after the choke.

Ma-90-B

SCHEMATIC DIAGRAM FOR MODEL 90-B MAJESTIC CHASSIS

25-40 AND 50-60 CYCLE



CARRIER HUM OR RESONANCE HUM can often be eliminated by fastening the ground wire of the receiver to the A.C. floor outlet box. In more obstinate cases this can be eliminated by by-passing the 110 volt line to the ground post of the receiver through a .01 to .5 mfd. condenser. If this does not eliminate the trouble, try connecting a .001 to .1 mfd. mica condenser from each rectifier plate to the rectifier filament. It is sometimes necessary to try different values between the sizes indicated for best results.

SPEAKER RATTLE. Smear the overlap of the cone with collodion. Sometimes it is necessary to remove the wires which normally hold the overlap in place. Burping on dance volume. Usually due to poor matched 45's.

LOSS OF VOLUME AND EXTREME DISTORTION often indicate an open in the R.F. choke in the antenna stage. Indicated further by the absence of grid bias on the first R.F. tube with resulting high plate current.

INTERMITTENT RECEPTION. If complete set of new tubes does not cure this replace .5 mfd. condensers located on inside of chassis wall. These open intermittently.

FADING is often due to the volume compensator on the end of the tuning condenser shaft being defective. This can easily be checked by setting the volume control at maximum, connecting an ohmmeter between the cathode hole in any of the first three R.F. sockets and chassis. Erratic motion of the ohmmeter needle as the tuning knob is turned shows the volume compensator defective.

MOTOR-BOATING. Inspect flexible lead soldered to sliding arm attached to trimmer cup. After a time this wire wears, breaks.

NOISE, MOTOR-BOATING. Generally traceable to defective .5 mfd. R.F. by-pass condenser. The condenser may be open.

INTERMITTENT OPERATION. Intermittent operation in this model is often caused by a defective choke coil in the R.F. plate leads. Simply shorting across this choke cures the trouble and the performance of the set is not hindered by doing this.

DEAD - WEAK - LOW VOLTAGES - NO DET. PLATE V (MODEL 90 ONLY)

The by-pass condenser across the detector B supply lead frequently breaks down. On making a replacement, by inserting a 35,000 ohm resistor in place of the 2,000 ohm choke the chances of future trouble of this nature are lessened. In order to make the changes, disconnect the (generally green) wire which leads to the second and third lugs (from the top) on the condenser bank, leaving these lugs free. Now connect a 2 mfd. 600 V. replacement condenser between the first or top lug on the condenser bank and the wire which you disconnected. Connect the resistor between this wire and the fifth lug on the condenser bank.

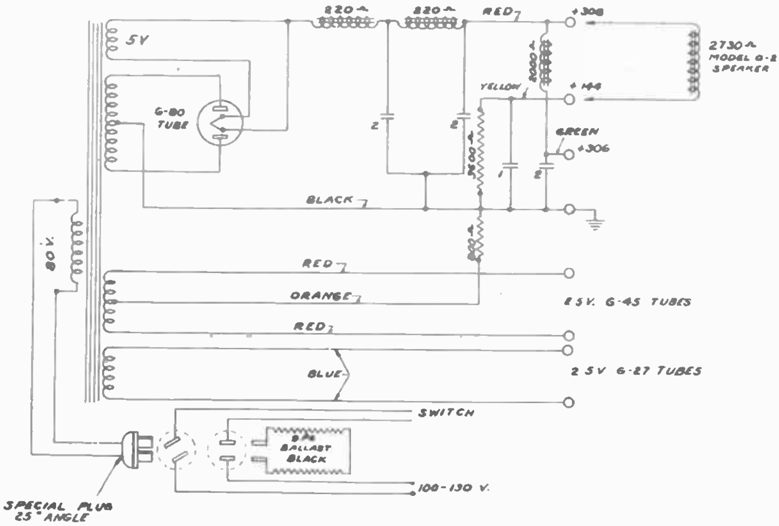
If only the condenser is to be replaced, cut the wire between the second and third lugs, leaving the third lug free. Connect the replacement condensers between the first and second lugs.

NOISY OPERATION - CUTTING OUT - LOW SENSITIVITY

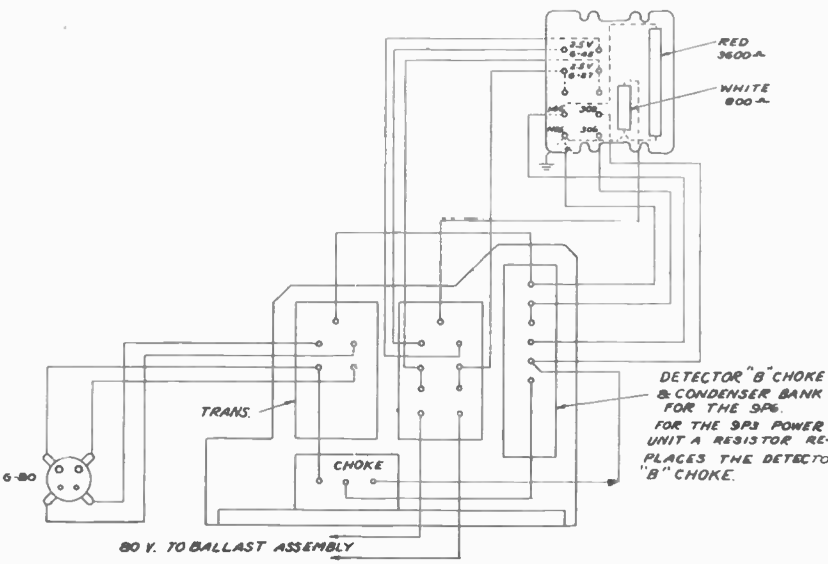
Sometimes caused by volume control - more frequently caused by dirt and fine metal peelings between the plates of the tuning condensers. Thoroughly clean between the plates with a pipe cleaner such as may be obtained from any tobacco shop.

In some cases the peelings have to be burned out by a high voltage. Unsolder <u>all</u> connections to the condenser gang. Apply a voltage of 100 to 500 volts between the stator and rotor connections of each condenser in turn, rotating the tuning control while the voltage is applied. After the peelings are burned out, resolder the leads to the gang.

SCHEMATIC DIAGRAM OF 9P6 POWER UNIT



WIRING DIAGRAM FOR MAJESTIC POWER UNIT-MODEL 9P6 & 9P3



Radio Servicing Jobs and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

How To Take the Squeal Out of a Neutrodyne Receiver

Thousands of "neutrodyne" receivers, popular in the early days of radio and famous for their ability to tune in stations without "squealing," are still in existence. When these receivers are thrown out of balance, however, they squeal ferociously, until they are rebalanced. It is important, therefore, that you know how to neutralize a squealing neutrodyne receiver.

The neutrodyne circuit employs triode tubes as R.F. amplifiers, using special coils and condensers to balance out or neutralize the R.F. voltage which, if allowed to feed back without being balanced out to preceding stages through the plate-to-grid path inside each R.F. tube, would cause regeneration or squealing. Placing new tubes in the receiver, changing the wiring, and general aging of the parts will often change the neutralizing adjustment, with the result that sharp hissing noises and squeals are heard as stations are tuned in.

Before attempting to make any neutralizing adjustments, be sure that you have a neutrodyne receiver. Identifying characteristics are triode R.F. tubes and one neutralizing condenser for each T.R.F. stage. These neutralizing condensers are mounted on the chassis or on a small insulating panel, connections being made to each stage by one of the methods shown in Fig. *1*. Do not confuse alignment trimmer condensers (which are mounted on variable condensers) with neutralizing condensrs.*

Midget book or trimmer type condensers are usually provided for neutralizing adjustments. The connection of the neutralizing condenser (C_N) in eight different typical neutralized R.F. stages is shown in Fig. *1*. Once the condenser for each stage is located, the adjustments are exactly the same regardless of the neutralizing circuit, the different stages being adjusted separately in any desired order.

Neutralizing Procedure.—1. Tune the receiver under test to a local broadcast station transmitting on a frequency near 1,400 kc., or tune the receiver to the output of a modulated signal generator set at 1,400 kc. Set the line voltage switch, if the receiver has one, at the correct voltage position.

2. Open the tube filament or heater circuit in the stage on which you are working, either by unsoldering a socket filament terminal lead, by slipping a soda straw or pill capsule over one tube filament prong, or by transferring the tube from its socket to a neutralizing adapter. The last method is quickest and most convenient in almost every case. The use of a dummy R.F. tube, having one filament prong cut off, is not recommended, for this tube may not have the same interelectrode characteristics as the tube to be used finally in that stage.

3. With no filament emission, plate current will not normally flow through a tube. If, after waiting about one minute for the tube to become cold, the signal to which the receiver is tuned can be heard in the loudspeaker, we know that this signal is passing from grid to plate inside the cold tube, and that this stage needs neutralizing to cancel the undesirable feed-back signal. If signals can flow through the tube in this direction, they can also flow the opposite way when the tube is operating, and produce annoying oscillations.

4. Adjust the neutralizing condenser for the stage being neutralized until the signal is at *minimum* volume, or cannot be heard. This completes the neutralizing adjustment for this stage.

5. Once a stage has been neutralized do not make any additional changes in that stage, and be sure not to change the tube used in that stage. Proceed to neutralize the other R.F. stages in the same manner, one by one.

Always neutralize a squealing receiver before aligning; a second neutralizing procedure may perhaps be necessary after the receiver is aligned. Of course, if the set is originally far out of alignment, it is wiser to align before neutralizing.

If you have a squealing receiver but cannot locate any neutralizing condensers, the set is not a neutrodyne. Many receivers which use triode R.F. tubes are

* On very old neutrodyne receivers the neutralizing condenser may be simply two metal rods mounted in a glass or fiber tube, the ends spread to give the desired minimum capacity. A metal sleeve fitting over the tube is moved to vary the capacity.

not neutrodynes; these usually have grid suppressors (resistors) connected between the control grid and tuning circuit to choke R.F. feed-back. When other means of eliminating squeals in a receiver of this type fail, try increasing the sizes of these grid resistors.

If the set squeals at some other frequency, say at 1,200 kc., after you have eliminated the squeal at 1,400 kc., repeat the neutralizing adjustment at this new frequency. If this produces oscillation again at 1,400 kc., it will be necessary to reduce regeneration in some other way, possibly by reducing the plate voltage. On receivers having line voltage switches, simply move the switch to a higher position. Before altering the supply system be sure that there are no defects in the receiver circuit which could result in regeneration.

How To Service a Receiver That Hums or Is Noisy

A loud hum or noise accompanying radio programs is a common radio receiver ailment. Just as soon as these interferences become annoying, the radio set owner will seek a service man and demand a cure.*

Suppose that some one calls you to his home to inspect a noisy radio—how would you approach the problem? Would you immediately remove the chassis from the receiver and test each part until you had located the trouble—or would you first use that most powerful of radio servicing tools, effect-to-cause reasoning? Of course you would choose the latter method, for it might take only a few minutes to repair a trouble located by using your head.

Effect-to-cause reasoning is a correct approach in eliminating noise and hum defects. Applying it to the present problem we will ask ourselves a few simple questions, the answers to which should reveal the cause of the trouble in the receiver.

Fixing the problem in your mind.—Hum is a regular audio signal and note of a frequency somewhere between 25 and 120 c.p.s. and usually is constant in value. A noise signal is a very irregular current, changing continually in strength. Electrically, noise may be a group of many frequencies without any regular relationship. *Hum* and *noise,* however, are produced by entirely different causes. We will consider hum first.

Hum—*Is the hum coming from the loudspeaker?* Push the cone of the loudspeaker gently to one side with a finger while you are listening to the hum. If the loudspeaker is reproducing the hum, the trouble is *electrical;* you will be able to feel the hum vibrations, and the volume of the hum should decrease when the cone is touched. If pressure on the loudspeaker cone has no effect on the hum, you know immediately that the trouble is *mechanical,* the sound being produced by vibrations of some other radio part than the loudspeaker.

Is the hum heard at all points on the dial? Tune the receiver to different stations, and note whether there is any change in the hum between stations or when different stations are being received.

Hum existing at all times, whether or not a station is being received, is *general hum.* If the hum is heard on several stations (particularly powerful stations), it is *tunable* or *resonant* hum, which you will usually trace to the R.F. system of the receiver. If normal reception of a local station is accompanied with hum, and a very short antenna (5 to 10 feet) continues to tune in hum, the trouble is in the station and will be eventually removed by the station engineers.

Is the hum accompanied by any obvious defects? An inspection of the chassis may reveal the defective part. For example, if the rectifier tube plate elements have a pink or blue glow between the elements,† a new tube is required; the old tube is gassy or defective and is also producing hum. If the plates get red hot be sure to check for a leaky filter condenser before inserting a new tube. Furthermore, look for loose connections, corroded connections and loose coil or tube shields. Is any insulation charred or damaged?

Does the set hum only when the tubes are heating up? If you encounter this condition, you may have a slow heater tube, probably in the audio system. Interchange similar tubes, or try new tubes. Many older types of receivers have hum adjusters. Where filament type audio amplifier tubes are present, the hum adjuster will usually be a potentiometer connected across the filament of a tube, the grid return usually being connected to the variable tap. Reset all adjusters for minimum hum.

Try reversing the power line plug; many receivers give better performance with the plug in a certain position. Try new tubes, as some circuits are prone to hum when the filament emission drops, or the tube becomes gassy or leaky.

If you are working on a neutrodyne receiver, touch the tuning condenser stators. If the hum (or oscillation) stops, the trouble is due to improper neutralization. This can be corrected by following the procedure given in the first part of this job sheet.

Is the hum still heard when the receiver aerial is disconnected? If the hum stops when the aerial is disconnected, the trouble is clearly outside the

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* A certain amount of hum and circuit noise is natural. The customer does not complain about this. It is the unusual hum or noise to which he objects.

† The mercury vapor rectifier tube, which gives off a blue glow continually, is an exception.

receiver.* Look for interference from nearby power lines or electrical apparatus.

Does the position of the receiver in the room affect the hum? Resonant effects in a room are often responsible for hum. Try placing a rug under the receiver, or moving the receiver away from the wall.

Finally, is there any other possible circuit defect that would cause a hum? You already have a reference text listing many possible sources of trouble. Be sure to master this effect-to-cause analysis before attempting a routine test.

After servicing a few radios for hum you won't even have to go beyond the procedure just outlined. All servicing is like this, a think-before-you-act game; your brains pay bigger dividends than your hands.

Short the input circuits one at a time, starting with the out, t stage and working back to the R.F. stages; this will isolate the trouble, for hum can only originate in the stage or stages following the short. For example, if hum is heard when the output stage grid circuit is shorted (for push-pull or push-push output stages, connect the two grids together), you know the trouble can only be in the output stage or the power supply. If no hum is heard, short the input of the preceding stages one stage at a time; the trouble will be in that stage where the hum is first heard, even if its input is shorted.

You will encounter some receivers where the above input-shorting procedure does not seem to show a sharp decrease in hum; reasoning tells you immediately that the hum voltage must be reaching

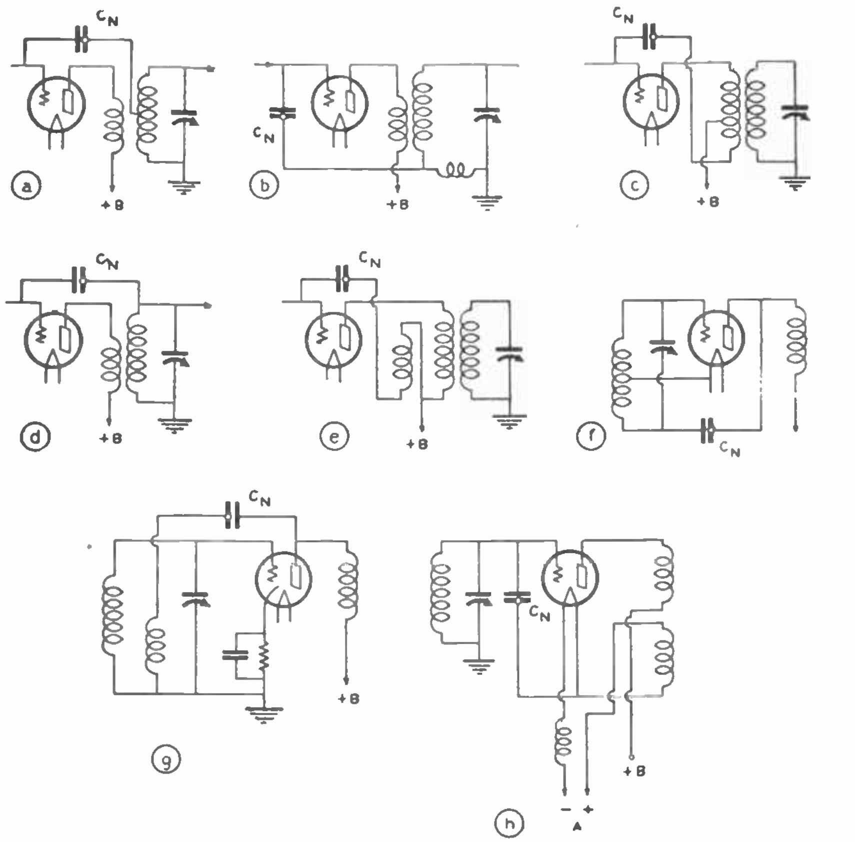


Fig. 1. Common methods of neutralizing feed back; all have the same adjustments.

Stage-by-stage hum test.—Assuming that effect-to-cause reasoning does not yield a solution, the next step is to isolate the stage in which the trouble originates. To do this you will have to remove the receiver from the cabinet, if you have not done so already to check some of the causes indicated by the process of reasoning.†

* This test does not apply to tunable hum, which is present only when a station is being received.

† Listen for hum before and after the receiver chassis is out of the cabinet—the loudspeaker baffle accentuates the hum. The repair must reduce the hum to a value considerably below that obtained when the baffle is not used. Incidentally, a "makeshift" hum repair, satisfactory where the customer does not demand good low note response, can be made in most cases by moving the loudspeaker an inch or two back from its baffle. I do not recommend this "stunt" unless all other methods fail.

all of the tubes. Wouldn't this fact lead you to suspect the common source of voltage, the filter system of the power pack?

Locating the defective part.—You have isolated the bad stage—now isolate the defective part. If you can secure a circuit diagram of the set, study it carefully, asking yourself: "What parts in this stage could cause the hum which I hear?"

Suppose the stage analysis indicates a common source of hum, a defect in the rectifier system. If you suspect the rectifier tube, try a new one.

To check the filter condensers for an open circuit, connect a good 8 mfd. condenser temporarily across each power pack filter condenser while listening to the hum. A reduction in the hum indicates an open in the condenser under test.

Leaky filter condensers can also cause hum. To check for this, turn off the radio, unsolder a filter condenser lead, and turn on the set again; a reduction in hum when a filter condenser section is taken out indicates that the section was shorted;

an increase in hum means that condenser is good, while no change indicates an open condenser. Other suspected condensers in the receiver can be tested in the same way. The remedy is obvious—replace all bad filter condensers with replacement units from your own stock, securing the correct sizes by referring to the circuit diagram for the receiver or by actual trial. Where power transformer windings are center-tapped, check voltages on each side of a center tap. Voltage differences of more than 10 per cent will bring unbalance and introduce hum. If a continuity test between transformer windings gives a resistance reading low enough to be readable, there is an electrical leak, due to poor insulation. The transformer must in most cases be replaced.

If you isolate the trouble to some stage other than the power pack, first test the tube in that stage by using a tube tester or by comparing its performance with that of a new tube.

An open grid return will cause hum. While referring to the circuit diagram check with an ohmmeter for open-circuits in resistors and in the secondary of the coupling transformer in the isolated stage.

tions and loose transformer coils vibrate badly at times; tighten the laminations and wedge the coil in position with an insulating wedge. Driving a nail between the laminations gives a speedy and satisfactory repair when the clamping bolts prove ineffective.

NOISE ELIMINATION.—A good receiver should have no noise † when antenna and ground are disconnected and these terminals on the radio set are shorted together. You already know how to trace and eliminate external noise picked up by the antenna; here we will discuss internal noise, heard in the loudspeaker when the above test is made.

Internal receiver noises are of two types: *1*, Sputtering, clicking or crashing noises due to a defective part or loose connection. *2*, Ringing noises, known as microphonic noises, caused by loose parts, poor tubes, or overloading of the receiver.

Loose connections can generally be located without tools. Listen for increases in noise while you tap each tube and part with a pencil; pull wires and leads; in other words, move each part or wire until you locate one which is loose. Carbon resistors change in value sometimes and become

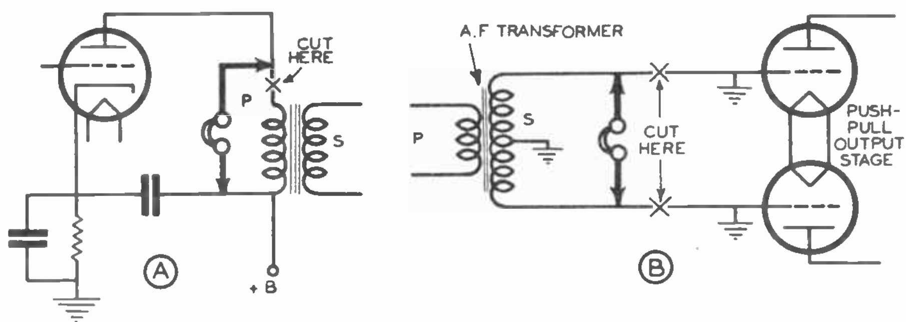


Fig. 2

If the hum is isolated in a detector circuit, remember that sensitive detector tubes sometimes pick up hum from the intense electrostatic field set up by the power transformer and rectifier tube. As a simple remedy, place a close-fitting metal shield around the detector tube.*

If hum seems to originate in the dynamic loudspeaker, remember that hum bucking coils may be in series with the loudspeaker voice coil. Try shorting or reversing the hum bucking coil connections; in other installations the coils may be accidentally shorted requiring repair.

A ground anywhere in the filament circuit of a receiver except at the filament transformer center tap will introduce a bad hum. A simple continuity test will locate the grounded point if the center tap grounds are temporarily removed.

If you start the stage-by-stage test with the knowledge that you have modulation hum, recall that the defect is originating in the R.F. stages. Neutralization of the receiver, improvement of the power pack filter circuit, improper voltages on the R.F. amplifiers, and in particular heater to cathode tube shorts should be considered.

Mechanical hum.—Now let us go back to the original test for type of hum. We find that mechanical hum exists. You should be able to locate the source of the hum by ear. Check the power transformer for loose laminations, then touch different parts of the cabinet or chassis until you locate the vibrations. Loose transformer lamina-

noisy; exchange suspected resistors for new units of the correct size and the same or larger wattage rating.

Take the chassis to a dark corner of the room and watch for sparks while you move the wiring. Use a hardwood stick or an insulated rod for testing connections, to prevent shocks and short circuits. Keep your soldering iron handy and hot, touching it to each lead which might possibly have a poorly soldered joint. It may be necessary to remove R.F. and I.F. transformer shields to check connections to each lug.

Noise heard only when some control is moved is an indication of a loose contact somewhere on the control. A potentiometer contact arm may be loose or may have lost its tension; a condenser rotor may be rubbing against a stator, dirt may have lodged between the condenser plates, or the rotors may be poorly grounded.

If a check for surface defects or effect-to-cause reasoning fails to reveal the defect, resort to a stage-by-stage elimination method. This is identical to that given for hum, except that noise is your guide. When the defective stage is isolated, check each part and connection with an ohmmeter. Transformers can be checked by breaking into the circuit with headphones (Figs. *2A and 2B*), listening while the set is *on*. If noise is heard in both the secondary and primary circuits, the trouble is not in the transformer; if noise is heard only in the secondary stage, the transformer is at fault.

* Tube shields can be obtained from any radio parts supply house.

† Except background circuit noise, which is always present in super-sensitive AVC receivers.

Extra Money Jobs and how to do them

How To Repair Defective Dials, Controls and Movable Parts

Of course, you know that any movable part eventually loses its smooth action. Wear and abuse lead to loose, stiff, squeaky, rough and jerky radio controls. There are many movable parts in a modern radio receiving set that will wear out or receive unreasonable treatment. Recall from your association with radio, such parts as: the volume control; a tone control which sometimes is a variable switch connected to several condensers, or a variable resistor connected to a single condenser; a multiple section multiple contact switch used in all-wave receivers; the off-on switch; and, the variable condensers and their controlling mechanism.

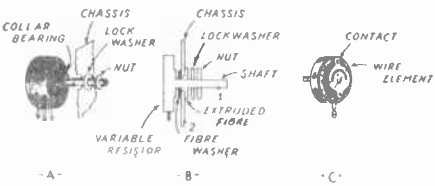


Fig. 1

A receiver is designed to have free and easy acting controls and as a radio serviceman you should be able to repair these units so they will remain that way.

Variable Resistors.—Figure *1A* illustrates the usual variable resistor employed as the volume or tone control. In most cases the device is held to the chassis frame by a nut pressing against a lock washer as shown in Fig. *1A*. In other cases, especially where the control arm within the unit is not insulated from the shaft and when an electrical path to the chassis is not wanted, two fiber washers, one with a collar, are placed on the shaft as shown in Fig. *1B*. Whenever you have to replace the latter type of control, be sure you connect an ohmmeter between the shaft (point 1) and the chassis (point 2) to prove there is no electrical connection. No ohmmeter deflection should be indicated. Of course, the terminals of the variable resistor should not be connected in its circuit when this test is made.

Volume controls must work smoothly and easily. Before using the new one be sure the shaft does not bind. Accept only good ones for replacement. In the case of repairs, drop a *little* 3 in 1, or similar machine oil, in the long collar bearing. If the shaft has frozen (usually due to corrosion) lubricate well with oil; remove the shaft (this will be obvious from inspection of the part); wrap around and insert very fine emery cloth into the bearings and clean off foreign material. Oil or preferably graphite grease is spread on the bearing. Only when a replacement control is impossible to obtain, the job is urgent, or the part costly does it pay to go to any extensive repairs.

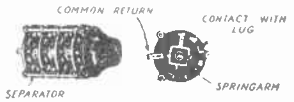
Should the stiff action be due to some moving part inside of the control, open the variable resistor case, usually the back can be pried off, and inspect: *A*, the variable contact to the wire or resistance element; *B*, the internal bearing contact. If lubrication is needed at the contact, use only pure petroleum jelly (vaseline). Graphite grease may only be used at a bearing contact where it will not spread and create a short. If the arm does not press its end contact to the wire element, see Fig. *1C*, remove the entire arm structure, if possible, and with your long nose plier shape the arm so the sliding contact makes a good (movable) connection. Use vaseline on the shaft bearing as a lubricant. Every manufacturer of variable resistors uses a slightly different mechanical system, but I am sure you won't have any difficulty in making a repair on any system.

A B

Fig. 2

Power Switches.—The switch that turns on the main power supply is usually of the rotary type as shown in Fig. *2A*, or the toggle type as shown in Fig. *2B*. Should these devices become mechanically stiff drop a little oil in the shaft bearing or the ball pivot. Don't try to repair them as they are inexpensive and easily obtained. As a matter of fact, they are usually made so that you have to destroy them to get inside. There are a number of large switches, occasionally used in receivers, where you can get at the "works." Vaseline applied to the moving parts or contacts, a little adjustment of the blade contacts, is about the only adjustments you can or should try to make.

Multiple Gang Selector Switches.—You will find switches like the one shown in Fig. *3A* in all-wave receivers. They are the switching contacts that connect the various coils in the R.F. system. The control knob, as you know, is referred to as the band or frequency selector. Actually these switches consist of several multiple contact switches, stacked one to the other, connected by a tongue and groove shaft and controlled by a single knob. Each deck, as a section is called, is electrically separated from the next one. Each deck has its own spring arm contact, electrically connected to a lug, (common return), by a friction contact. The end of the arm makes a self-cleaning or wiping contact with the studs each having its own lug connection as shown in Fig. *3B*.



A B

FIG. 3

When these devices become stiff, oil dropped onto the bearings will help free their action. A little vaseline can be placed on each moving or rubbing contact. Vaseline is used at these self-wiping contacts to prevent corrosion. Should any of the contacts corrode, sandpaper and apply a little vaseline.

You may find that the spring arm does not make a firm contact to the studs. A better connection can be obtained by inserting a wooden wedge under the arm, lifting the arm away from the deck, and pressing at the point above the wedge as shown in Fig. *3C*. When you remove the wedge a firmer contact is obtained. Don't try to bend the arm too much. You can usually tell these poor contacts by wiggling the selector knob and listening for the resulting noise. I would surely try to remedy a defect in a switch of this type while mounted in the chassis, before removing them for bench repairs. There are altogether too many lead connections, the position of which should not be changed, which must be unsoldered and resoldered, if the switch is taken out of the chassis.

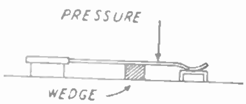


FIG. 3C

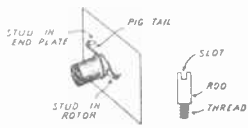
Variable Condensers.—A modern gang variable condenser is the result of years of experience in design, assembly and study of their use and abuse. Due credit should be given to the makers for the devices they now produce. Figure *4* is a typical 3 section gang of variable condensers. The two heavy end plates are the supports for the bearings and in this case are ball bearings. Like many other devices there are no adjustments when the frame or shaft are sprung. About all you can do is drop a little oil or insert a little graphite grease into the ball bearings. In

FIG. 4

some of the older types you can take the condensers apart, but I hardly recommend such a procedure for regular practice, as it takes real skill to assemble a variable condenser. It is far cheaper to buy a replacement.

Most trouble arises in the contact between the rotary shaft and the end plate of the condenser frame through which the connection to the rotor is made. In many condensers only the pressure between the shaft and the bearing is the connection, or as in the device shown in Fig. *4*, a spring contact is used. Be sure to use graphite lubricant at these contacts; be sure the spring makes a firm contact.

When this fails to remedy the trouble and you can usually tell by the noise you hear as the station selector is adjusted, consider a so-called "pig tail" connection. To do this you must remove the gang of condensers from the chassis. Make two studs as shown in Fig. *5A*. Brass machine screws with the heads cut off will do. Cut



B A

FIG. 5

slots in one end with a hack saw. Drill a hole in the shaft and one in the end plate so that a tap will thread the holes to take the studs. Screw in the studs. Solder one end of the pigtail (braided phosphorous bronze wire that you can get at most radio mail order houses). Now turn the shaft to maximum position allowing the pigtail to wind once around the shaft and then solder the end (cutting off surplus pigtail wire) to the stud in the end plate. The pigtail should unwind as the shaft is rotated. In fact, the original direction of winding the pigtail should take this into consideration. Pigtails should be used on all condensers where maximum efficiency is desired.

Modern Dials.—Every radio set maker has his own "pet" dial. In fact one of the distinguishing marks of a definite make is its dial, just like the automobile maker has his peculiar hood or wheel hub cap design. The dial is a mechanism which turns the ganged variable condensers and the scale indicator. They resolve themselves to just a few types. The ones that I will consider are the usual ones, but you must remember that they may vary in design.

In general, the dial mechanism has a large central collar into which the condenser shaft fits. It in turn is rotated by turning the selector knob. The indicator or scale rotates at the same time. The shaft of the condenser slips into this moving sleeve and is clamped to it by one or more set screws. The dial and condenser assembly is usually bolted to the chassis. Figure *6* shows a variety of dial mechanisms.

Figure *6a* portrays the usual drum dial, once extensively used in radio receivers. The main scale, marked off in kilocycles in manufactured receivers, is fastened to a rotating mechanism, which is turned by a dial cable, wound around it and over two wheels on a shaft placed below and at right angles. A knob is fitted to the shaft, the one on the front of the cabinet which we call the station selector. Turning the knob, turns the dial and the rotor plates of the condensers. An escutcheon plate is used with the dial and appears on the front of the cabinet. A hook bracket holds the pilot lamp behind the dial scale which is of the frosted celluloid type. In this dial the shaft supports should be lubricated with machine oil when stiffness or binding is detected. Enough trouble is experienced with the dial cables to warrant treating it in a separate job sheet, the next one.

Perhaps the simplest dial is the one shown in Fig. *6b*. The scale is riveted to a hollow hub which is slipped on to the condenser shaft and held by set screws. The shaft protrudes through the front panel and the escutcheon plate covers all but the illuminated part of the scale. Such dials are used in midget and cigar box radios or with secondary controls on the larger receivers. Watch for rubbing between the scale, escutcheon and the cabinet panel. This may cause binding. The remedy is to reset the position of the scale or the complete chassis within the cabinet.

Of course, you know the objection to the dial shown in Fig. *6b;* the selector knob does not have a "fine" or "vernier" control on the tuning condenser, as does the mechanism shown in Fig. *6a*. Naturally the dial shown in Fig. *6c* is more generally used. It is quite like the simple dial, except that the selector shaft is anchored to an upright having on it two round discs, grasping the inner edge of the dial cutaway at the lower semi-circle. Pressure is applied by a spring. The smaller the friction wheels, the finer the control. The usual reduction ratio is 6 to 1 which means that you have to turn the knob 3 times around to get a 180 degree movement on the dial. With these dials you must be sure the spring is free to act, particularly its alignment. If the mechanism squeaks apply a *little* oil to the friction drive. In some of the cheaper mechanisms a rubber wheel acts as the friction driver. When it gets hard—never apply a lubricant—replace the wheel.

A similar mechanism is shown in Fig. *6d*, but in this case a pinion and gear is used. Positive control is obtained, at the expense of some back lash (slight movements of the selector knob do not actuate the dial) and the characteristic gear unevenness. Be sure the teeth of the gears mesh and if stiff use a graphite or vaseline lubricant.

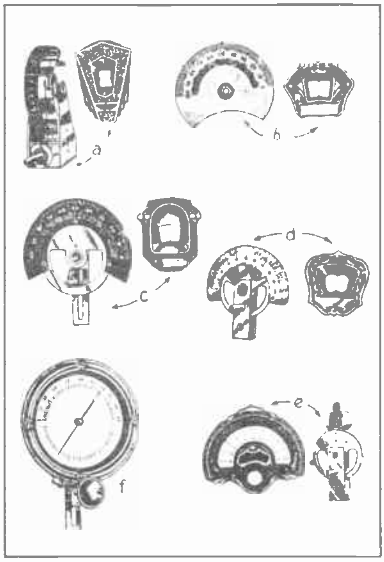


Fig. 6

Mechanism shown in Fig. *6e* differs from the others in that the scale remains fixed and the indicator is actuated by the selector knob. The mechanism may be of the friction or gear type.

The airplane dial, Fig. *6f*, so-called because its appearance is so much like the indicators used on the control panel of an airplane, is a favorite mechanism with all-wave receivers. Here, too, the scale is fixed and the indicator moves, usually by a train of gears, so designed as to eliminate back lash and gnashing gear teeth. Be sure they are lubricated with vaseline.

A trouble common to most dial mechanisms is where the dial and the condensers are not in line. This may be caused in shipping or by abuse. To remedy this, loosen the screws that hold the condenser to the chassis and the dial to the condenser shaft. Adjust their relative position so the shaft turns without binding the dial. Tighten all screws. You must note the position of the dial before you loosen screws; don't move the condenser while aligning the two devices and reset the dial in the noted position before tightening the screws.

Selector Knobs.—Knobs will break or even get lost. Most parts distributors handle a sufficient variety of knobs to make suitable replacements. Where the knob appears not to match with some other one on the panel, purchase two so they will match.

How To Restring Selector Dial Cables

Have you ever tried to tune a receiver where a turn of the station selector does not produce an immediate action on the tuning condensers? If you have, you know how objectionable it can be, especially on distant stations. Every effort is made by the set designer to use a dial mechanism which has no back-lash. Even well made cable driven drum dials develop this defect; in fact, the cable sometimes breaks, making station adjustment impossible. Let me first take up stiff and loose mechanisms.

FIG. 7

If the station selector acts stiff, lubricate the dial mechanisms and the bearings on the condenser. Should the control still bind, try aligning the condenser and dial mechanisms.

Loose action or back-lash effect is probably due to a stretched cable, poor spring, stiff mechanism or loose set screws. Remedies for this defect will be obvious, but I would like to say a few words about loose or stretched cables. When they are of the linen or fishing cord type I would wax the cable with beeswax; a wax with a little resin in it is best. You can get this at a tailor shop. Then where the cord hooks on to the spring, I would tie the two ends into a knot farther up and rehook the cord. This will take up the slack and cause the spring to be stiffer.

When the cord breaks and you have enough cord to make a square knot at the break, do so, following the illustration shown in Fig. 7. Should this be impractical, then you will have to buy a new cable.

You probably know that there are a large variety of cable drives, in fact, too many to consider, so I will have to take a typical case. It is always wise where possible to study the cable arrangement in a similar machine. Use it as a guide.

Figure *8* is a typical cable drive. It is quite similar to the one shown in Fig. *6a*. Observe that the selector shaft has two small drums on which the ends of the cords are wound and tied. Note that as the shaft is turned, the cord on one small drum winds on, as the other winds off. As the cable moves the grip it has on the drum dial causes the latter to turn and, of course, turn the variable condenser. If you bear in mind this general action your troubles in putting on a new cable will be greatly reduced.

Always take the radio chassis out of the cabinet, as this will simplify the work. If the cable has not come off entirely, study its assembly. Cables for the more popular receivers are available. Here are the usual steps that are taken.

1. Set the variable condenser at high frequency, condenser plates wide open, and hook the cable to the small drum that winds up as the selector shaft is turned in the clockwise direction (or the direction that sets the dial to lower frequencies). Loop the cord once around the small drum, so the cord will wind up when turned to lower frequency.

2. Now lead the cord once around the large dial drum stopping at the hole. Loop enough of it through the hole to hook onto the spring, when the latter is stretched. If you wish, insert a peg to hold the cord inside.

3. Continue to lead the cord to the other small drum, winding it several times around it, opposite to the direction taken on the other small drum. You can tell the correct direction if you imagine that the selector shaft is turned to a lower frequency and the cord on the drum unwinds. Anchor the cord to this small drum.

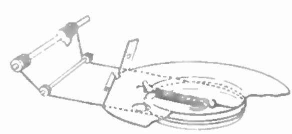


FIG. 8.—*Drive cord arrangement*

4. Attach the spring to the cord looped through the drum hole, freeing the cord wherever possible so the slack is taken up by the spring. Some dials have an adjustment to take up slack. Look for them.

You will now find out, if the mechanism does not act properly, where the mistake was made.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

How to Make and Erect a Tall Antenna Mast

Here is an installation you may be called upon to do. This job will probably arise in some rural homes, where no nearby house, tree, garage or barn is present to which you can attach the far end of the straight-away. Furthermore, the roof of the house may not be long enough to allow a reasonable length of antenna. A short aerial wire would hardly suffice, particularly if the customer must depend on stations 100 or more miles away.

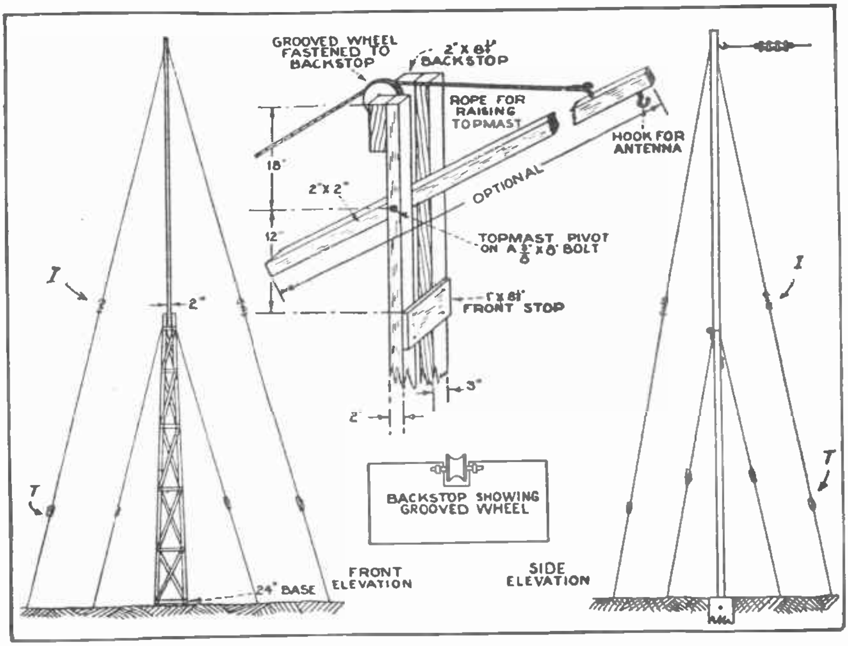


Fig. 1

Where the customer is especially anxious to get foreign stations on his all-wave receiver and an antenna directed in a definite direction is necessary, special means must be taken to provide a suitable remote support. Under these conditions a mast erected on the ground will solve the difficulty.

The mast shown in Fig. *1* has many unique features. The aerial wire is attached or replaced without lowering the bottom (main) portion of the mast. It is strong, inexpensive, and with a little patience can be built and erected by one man handy with a saw and hammer.

There are two sections: the lower section, a light but substantial latticed affair; and the upper section, a single pole, pivoted to the upper end of the lower section.

The lower mast is made from two lengths of 2" x 3" wood between 15 and 20 feet long. Lay these two pieces on the ground, spreading the bottom 24" and the other end slightly more than 2". Lattice first one side and then the other with 2" x 1" wood, nailed to the 3" face of the upright lengths. The latticing pieces should stop 36" from the top. Thirty inches from the top, screw on a piece of 1" x 8½" board. This is shown in the sketch as the front stop for the upper mast. The back stop is a 2" x 4" x 8¼" piece of wood, screwed or bolted on the other side at the extreme top, as shown in Fig. *1*. The upper edge of the backstop is cut to take a pulley wheel.

A suitable pulley wheel on a shaft is fastened to the back stop as shown in the center of the drawing. Be sure it is securely fastened to the back stop so that the wheel cannot slip off the shaft.

Pivot holes for the top mast are drilled 18" from the top as shown in the drawing. Four large sized eye screws are fastened to within 3 feet of the top of the lower mast and four guy wires each one about one-quarter of a length longer than the lower mast are firmly attached to the eyelets. These guy wires are fastened to stakes driven in the ground. For this purpose four 2" x 3" beams (or tent pegs) about 2 feet long are driven into the ground sloping away from the mast. They are placed about one-half the length of the lower mast from the base of the mast and in the four corners. An eyelet bolt is attached to each of those stakes.

The base of the lower mast is made by driving two 2" x 3" stakes 2½ feet long placed 30" apart, into the ground at the point where the mast is to be erected. (This position should be at least 75 to 100 feet from the house support.) One end of each stake should be pointed with a hatchet and driven at least 2 feet into the ground. Cut off the tops so that 3 inches remain above ground and drill holes through opposite faces large enough to hold a ⅜" diameter bolt. Similarly, the base of the lower mast is drilled at both ends with the same bit. The lower mast is then pivoted to the support with two bolts.

You are now ready to pull up the lower mast. Slip two of the guy wires through their corresponding anchor bolts and make a temporary lock. Of course, select the anchors in the direction opposite to the way you plan to swing the lower mast. Lift the lower mast and swing it into place.

If the two guy wires are made a little longer than necessary, the lower mast will droop slightly in the opposite direction from where it was lifted and will remain in place until you are able to attach the remaining two guy wires. Now adjust all four guy wires until the lower mast is vertical. If you included a turn buckle in each guy wire, you will be able to stretch the guy wires so they do not sag. Turnbuckles will allow you to adjust the uprightness of the mast.

Select a 2" x 2" mast about 10 to 15 feet long free of wood knots and flaws. Drill a bolt hole 18" from one end and screw in two screw eyes or eyelet bolts at the top as shown in the figure. If the cross pieces on the latticing of the lower mast have been extended, you will be able to climb to the pivot hole in the lower mast, taking with you the upper mast. In that position you can slip the pivot bolt through the upper end of the lower mast and the lower end of the upper mast. Attaching a strong rope to the correct hook, climb up again and set it into the grooved wheel. Prop the upper mast as far off the ground as you can. The higher you prop up this mast, the easier will it be to pull it into place. Hook on the aerial and attach two guy wires to the two eyelets screwed or bolted to the upper mast. Three anchor posts will be needed for the upper mast, one in a direction away from the antenna, and two diagonally but in the direction of the antenna. They should be located a distance from the base one-half the overall length of the entire mast. The guy wires will be 25 per cent longer than the entire mast.

The upper mast can be brought into position by merely pulling on the rope. When erect, the top mast will rest in place against the front and back stops and the rope will leave the pulley. The rope can then be secured as a guy and the side guys can then be placed in their proper position and drawn tight by means of turnbuckles. It would be wise to secure the lower end of the upper mast to the front stop by means of a wood screw or bolt.

All that is now necessary is to secure the other end of the antenna and connect the lead-in conductor.

More on How to Sell Your Services

About this time in your training, you are beginning to think about more ways of selling your services. Of course, you are the sole judge of how much you can actually do. If you are sincere with yourself, you will say "I am just about getting on my feet. I feel confident that in a little while I will be able to do some real radio work, stretch out in my activities." In fact, it is the near future I want you to think about now. There is nothing like looking ahead.

So far you have received a number of practical job sheets each with one or more Extra Money Making Jobs. With them you have learned how to improve your own radio and the radios of your immediate friends. In future job sheets there will be more jobs to master, all of which will give you a greater opportunity to make extra money. In turn this will lead to more jobs. Here is how it works—your friends will tell their friends what you did for them, some of them will find

RADIO SETS AND AERIALS INSTALLED
ADJUSTED, REPAIRED, TUBES TESTED

LEON WHITE

Member of National Radio Institute
Washington, D. C.

278 Berriman St. Brooklyn, N. Y.

FIG. 2A

radio jobs for you, and the "good word" will pass around that "if your set doesn't work call up Johnny Q. Radio Serviceman, he knows his business." As you study more of these practical job sheets and your regular textbooks, you will get a greater variety of jobs to work with. Gradually your contacts and jobs will increase and before you know it you should have as much work as you can take care of.

How can you further this condition? Help along this person to person form of advertising by using business cards. When you talk to someone about a new antenna system, about fixing their marred cabinet, or overhauling their receiver, or any of the many jobs you will learn to do, leave your business card. This will refresh their memory whenever they see it, tell them your name, address and phone number and what you can do.

your repair work in your basement or garage as so many independents do. Your local job printer can produce these cards at a very low cost to you. Do business with local people as they will send radio prospects to you.

Here is another question that is bound to "pop up" in your mind. "Where can I buy these radio accessories that you mention in the job sheets and the replacement parts for sets that I repair?" The answer is, at any radio parts jobber, radio mail order house, or distributor. You will find your local radio parts jobber, or

GUARANTEED RADIO SERVICE
MAIN 2843

WHITE'S RADIO SHOP

2614 Albertson St.

WEST VALE NEBRASKA

Member National Radio Institute

FIG. 2B

the distributor of the set you are working on listed in the telephone directory; while the leading mail order houses advertise in the radio magazines. But, there is a proper

JOHN Q. STUDENT
1705 MAIN ST.
TOWNVILLE, KANSAS

RADIO SERVICING

Blank Radio Wholesale Co.

170 Main Street

Syracuse, Missouri

FIG. 3

What you can do is purely a matter that you must decide. In a few more lessons you will be able to do a lot of jobs and I suggest that you prepare a business card with the future in mind. For example, Fig. *2A* shows a simple business card that you, as a beginner, can very well use. You will be able to do all the things mentioned shortly. Be sure to include your phone number if you have a telephone. Figure *2B* shows a variation of *2A*. The word *Shop* lends dignity even though you do

procedure to take and I am going to tell you how, as it is in line with your main task of getting into the radio business.

You will eventually need business stationery, a letter-head and a business envelope. They are really inexpensive, and are a great help. They command attention from your customers and the business concerns you will have to deal with, indicating to the latter that you are actually in the radio service business and that you are entitled to wholesale prices.

When you are ready to consider business stationery, I suggest that you plan for the future. You should have stationery that you can use when you go into a full time business. A typical envelope and letterhead are shown in Figs. *3* and *4*. Remember that here we have used imaginary names and addresses.

JOHN Q. STUDENT
RADIO SERVICE AND ACCESSORIES
PERSONAL GUARANTEED WORK
1705 MAIN ST. TOWNVILLE, KANSAS

PHONE
1721

February 7, 1935

Blank Radio Wholesale Co
170 Main Street,
Syracuse, Missouri

Gentlemen:

Please send me at once:

2 - # XQ 742 Antenna kits @ 73¢ . .	$1.46
1 - # XR 6 All-wave antenna kit . . .	3.95
1 - # XR 152 Side Cutters	.35
Check is enclosed.	$5.76

Very truly yours,
John Q. Student

FIG. 4

Your local printer will help you design suitable stationery and will be able to give you better service than an out-of-town printer. Also—remember that you should buy from your local business men whenever you possibly can, for they can, in turn, become *your* customers.

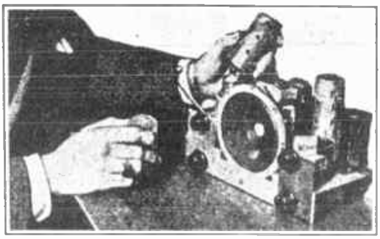
You might, after getting further along in your radio course, write to various radio mail order houses for their wholesale catalogs. Use your stationery, otherwise they may pay little attention to your request. You will find all kinds of service equipment and parts listed in these catalogs. You will find that all parts have a number and your net cost. Order what you need as shown in Fig. *4*. Only order those parts that are absolutely needed to finish the jobs you have orders for. Smart radio servicemen never tie up their money in parts they may never need. Remember that due to the physical differences of various receivers most of the parts used in them are not inter-changeable with parts for other sets, so buy what you need only when you need it.

Extra Money Jobs and how to do them

NATIONAL RADIO INSTITUTE ▪ WASHINGTON, D. C. ▪ PRACTICAL JOB SHEET

Replacing Burnt Out and Gassy Tubes

All of the tubes in a radio receiver must be in good condition to get good Radio reception. One bad tube may cause weak or distorted reception, or cause the receiver to stop working altogether.



Removing a tube shield for tube inspection

Try this on your own receiver. Remove any tube from its socket . . . the result, the music either stops or gets lower in volume. Well, that's what happens when a tube burns out. Among the very first things to question when a set stops playing, or something goes wrong with the quality of the reception, is the condition of the tubes. Has one or more of them burned out?

Now an expert Radio-Trician often replaces tubes without bothering to test them. He *knows* they are defective from observation. I want you to get this knack.

Recognizing Burnt Out Tubes. New tubes *may* burn out 10 minutes after they are installed in a receiver, but usually they burn out only after they have been in service a long period of time. They wear out just like tires or spark plugs on an automobile. Tubes gradually become weaker and weaker and then, when a sudden change in power supply occurs—the weak tube may burn out. This burning out usually comes just after the power is turned on. You see, the filaments draw a large heating current. This causes them to expand rapidly; then comes the break at the weakest point. This results in a burnt out tube.

The easiest way to make sure that the filament is working is to look at it. If it gives off some light, or if it has a dull reddish glow then the filament is in operation. If this light or glow cannot be seen, feel the tube. If it has been in operation ten minutes or so it should be giving out some heat, if the filament is working.

Now if the tube is in a shield, and you wish to test it, first feel the shield. If it is warm you know that the filament is hot, but if you can feel no heat, then it will be necessary for you to remove the shield and apply the two tests we have been discussing.

It must not be understood by this, however that a tube is always bad because it does not light nor heat. There may be some trouble in the tube socket or some other part of the receiver. For instance, if the socket is not making the proper connection to the prongs of the tube—then it stands to reason that no current can get into the tube, consequently no heat—no light. You will find plenty of the details of this situation in the lessons of your Course.

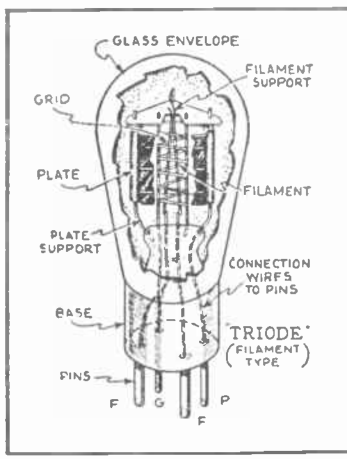


Fig. 1. An exploded view of a filament type tube

There are several ways to test the filament of a tube. Let's see what they are:

First, you can use a tube tester, but this is rarely necessary if there is another similar tube in the set.

Second, remove a similar tube (which is working O.K.) from its socket and try the doubtful one in its place. (Be sure the type numbers of the tubes are the same.) If the suspected tube works in the other socket then you know that the tube is O.K. and that there is trouble elsewhere.

Third, if you have a similar tube along with you, and you know your spare tube is a good one, try replacing it with the tube you think may be bad.

Shorted Tubes are often the cause for "no reception." As you will see from Figs. 1 and 2, there are other parts (known as elements) in the tube besides the filament. One part is called the plate, and there may be one or more grids. When any of these parts "short" (touch each other) the tube no longer works correctly.

All the tubes in the receiver may light and still you get no reception. There is the chance that the trouble is in some other part of the receiver, but the expert Radio man always suspects the tubes first.

A quick check on tubes for shorts is to snap your finger against the glass envelope bulb of each tube. The short will probably open temporarily from the jarring and a noise will be heard. Be sure to locate the tube which gives the loudest noise before you condemn other tubes, because the shock received by a good tube may be conveyed to the defective tube.

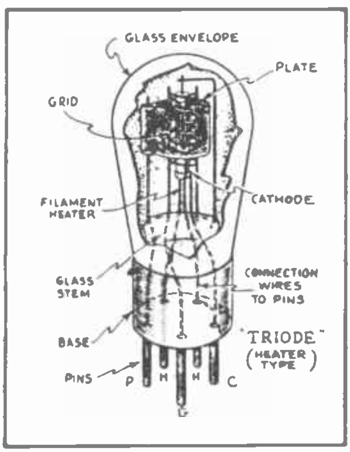


Fig. 2. An exploded view of a heater type tube

When a defective tube is located, try another one of the same number, or have it tested. A little later on I will tell you how to test a tube when you do not have a tube checker.

Gassy Tubes. Radio tubes sometimes become defective due to impurities in the metals used in the various parts of the tube or due to leakage of air through the glass envelope. Such tubes are called "gassy." While power or rectifier tubes, which you will be able to recognize from your study of the regular lessons are most apt to become gassy any tube in a Radio receiver may also get this way. Invariably the power and rectifier tubes turn blue or violet when they become gassy. This color glow should exist between the elements. However, it is quite possible that the inner surface of the glass envelope will have a purple glow. (Technically known as "fluorescence glow.") *This is not a defect.* You will note that it changes its brilliancy with the change of tones coming from the receiver.

If the blue glow is observed between the tube parts try a new tube in the socket. If the gas glow still continues, shut the radio off at once. The parts inside the Radio chassis are no doubt defective or short circuited and you may ruin the new tube. Always keep your hand on the off-on switch when trying a new tube, and be ready for quick action.

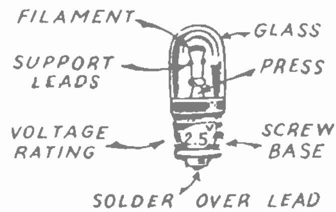


Fig. 3. Pilot Lamp

Should the gassy glow disappear when you have replaced the defective tube with a good one, you have in most cases made a satisfactory replacement.

You must also realize that there are gassy tubes that *do not glow.* You will soon learn from your lessons that there are rectifier, power, amplifier, oscillator and detector tubes in a modern radio receiver. The last three kinds generally do not glow when they become gassy. Gas in a tube may cause the receiver to start and stop playing (called intermittent reception) or continually increase or decrease the volume of the sound output. Such conditions in these tubes will only be discovered by use of a tube checker, that has a gas test indicator. You cannot recognize the cause for these defects unless you master radio thoroughly. Here is another reason why you must diligently study your lessons.

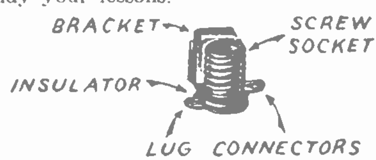


Fig. 4. Pilot Lamp Socket

Whenever a receiver is serviced, the tubes should be tested at the start or after any chassis defect has been corrected. The problem arises, what should you do if all the tubes light, none appear gassy and you feel that the tubes are defective.

If you don't have a tube checker, take the tubes out of the chassis, numbering the tube and its corresponding socket with a crayon. Have them tested by a friendly serviceman or a dealer. The dealer will, if you explain that you are taking up radio as a profession, test the tubes and may even give you a small discount, on any purchase of radio apparatus. Ask him to test the tubes for: *1*, open filament; *2*, shorted elements; *3*, gas; *4*, leakage; and *5*, for its merit or worthiness. All these tests are possible with a modern tube checker.

Tube Numbers. Watch the tube type numbers when you replace a tube. The numbers are printed on the tube base or on the glass of the tube. There are many different types of tubes which have different duties to perform in radio receivers. It is extremely difficult to memorize all of the different numbers. Do not attempt to, as there are entirely too many. But you should learn to recognize the important numbers or letters of any tube identification.

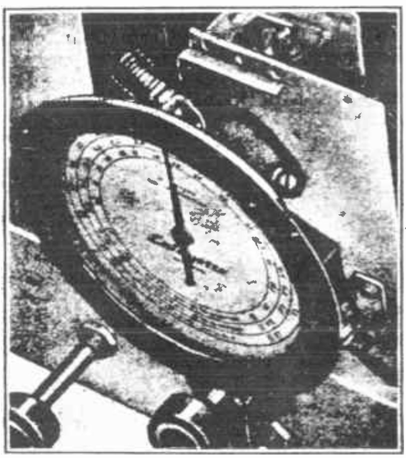


Fig. 5. Pilot Lamp and Airplane Dial

Parts of the tube identification like 71A, 45, 36, 56, 58 and so forth indicate the type of tube. Sometimes radio manufacturers identify their own product from other makes. They do this by placing a letter or a number ahead of the type number which I have just given. The number may be a 3, 4 or a 2 and even a 1, the letters may be NU, UX, UY, RCA, etc. A receiver having four 226, one 227, one 171A and a 380 type tubes may be replaced with four 26, one 27, one 71A, and one 80 type tubes of any other make regardless what numbers precede the identification.

There is another way of classifying radio tubes which is fast becoming standard. You will run across tubes having numbers like the 6A6, 6A7, 25Z3, or 2A3 type tubes. Notice in particular that there is a number, a letter, and then another number. This method of numbering is much better because it tells something about the electrical characteristics of the tube. The first number or figure in front of the letter indicates the approximate voltage applied to the filament of the tube. The letter indicates the use that the tube was designed for. The last number indicates the number of parts (elements) found in the tube. There is generally one more pin or prong than indicated by this number, because the filament uses two pins or prongs. The top cap is figured as a pin or prong. For example a 2A3 type tube is designed to operate with 2.5 volts, is used as an amplifier, has three elements. There are four pins to the tube base. This really is a simple method of presenting the general characteristics of a tube at a glance.

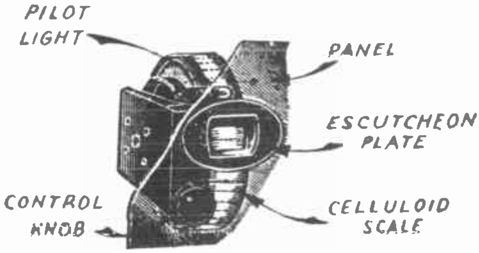


Fig. 6. Pilot Lamp and Drum Dial

Do not worry about the exact numbering or lettering of the tubes, just as long as you insert the proper type number in the socket of the receiver from which you removed a tube. I would check the pins and the caps on top of the tubes, as this will afford an extra check on getting the correct tube. Do not become confused when you find that the new tube has changed its outside shape. This is an improvement in the construction of the tube.

Cautions and Hints. Tubes are easily pushed into their sockets if you go about it correctly. First, they are designed to go into their sockets in one way only. All 4 prong tubes have a definite pin arrangement which differ from 5, 6, and 7 prong tubes which have their peculiar pin layout. This makes it impossible to insert a 4 prong tube in a 5 prong tube socket. And there is only one way it can go in its own socket.

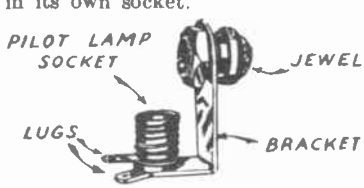


Fig. 7. Pilot Light bracket, Pilot Lamp illuminates the jewel when the current is turned on

I find it easier to insert the tube by resting the pins on the socket and merely rotating it slowly until it drops into position. You will feel a slight locking. All you need to do then is to push the tube into the socket. It should go in without excessive force.

Tubes that don't light or don't heat should be checked for burn out. Be sure that the set is not at fault.

Replace defective tubes only with tubes of the same type number.

Never have more than one tube of the receiver out at one time if the power is on.

Only those tubes that glow *between the parts* are gassy defective tubes.

Be sure that the tube shield goes back as it was originally and the top cap lead is in the original position.

Replacing Burnt Out Pilot Lamps

When the power switch of the receiver is turned on, the station selector dial becomes illuminated. The light comes from a small pilot lamp. It indicates that the set is on; illuminates the dial and allows tuning without a strain on the eyes. In some dial arrangements the numbers on the scale cannot be read unless the lamp lights. If the pilot lamp does not light, but by looking at the chassis you see that the tubes are heating up, all indications point to a burnt out pilot lamp.

Figure *3* shows a typical pilot lamp. It is just a small electric lamp. It has a metal screw base with a contact at the bottom for one terminal. The brass screw base forms the other terminal. They are connected to the small filament inside the glass bulb. The filament of a pilot lamp is supported between two wires coming up into the bulb of the lamp.

Figure *4* shows you the mechanical construction of the socket used to hold a pilot lamp in position and in making the electrical connections between it and the receiver. The screw socket is always the same as its size has been standardized. However, there are a number of methods of mounting the screw socket. Some of the brackets are permanent. Others are so constructed that the lamp and its socket may be lifted off its mounting. Two leads coming from the receiver are soldered to two lugs on the screw socket. The power is fed from the receiver to the leads, through the socket to the lamp base.

Before you reject a lamp because there is no light, see that the pilot lamp is screwed tight in its socket. They often become loose. If you consider a pilot light defective and install a new one which lights up, don't bother to test the old one. Throw it away. They are very inexpensive. Figures *5* and *6* will show you the approximate location of the pilot lamp in a radio receiver. You won't have any difficulty in locating it.

Not all pilot lamps are used to aid in tuning a radio receiver. Some are merely used to indicate when the receiver is turned "ON" and when it is "OFF." A red or amber jewel mounted on the front of cabinet as shown in Figure *7* is illuminated by the pilot lamp. It glows red or yellow when the receiver is "ON." This type pilot however is rarely used nowadays on receivers, but is used extensively in broadcasting stations, etc.

Getting at the lamp. Pilot lamps can usually be removed by reaching in from the rear of the radio cabinet. In some cases, however, it is necessary to remove the chassis from the cabinet to get at the pilot lamp. This is true on some midget radio sets. Be on the lookout for the lamp that is not on a bracket. It may be held in position merely by the stiffness of the connecting leads.

Lamp Sizes. Pilot lamps are constructed to operate at different voltages. The voltage ratings are marked on the brass screw base and can easily be found. The lamps are made for 1.5, 2.5, 5 and 6.3 volt operation. Should the marking on the defective pilot lamp fail to show, determine the correct size. There are several ways of doing this. The simplest scheme if you have a set tester or multimeter, which all service men eventually get, is to measure the voltage by connecting an A.C. voltmeter to the two lugs on the socket.

Suppose you have no tester and are willing to take out the chassis. You will observe that the two leads from the pilot lamp socket leads to some tube socket, or to two wires that connect to a group of sockets. If you know the type number of the tube that goes into one of these sockets and refer to a tube table you will find the filament voltage used. (Tube tables are given elsewhere in the Course.) The pilot lamp must have the same voltage rating.

A third scheme, especially when you carry an assortment of lamp sizes, as you eventually will, is to insert the highest voltage rating lamp in your assortment. If the light given off is entirely too dim, change it for one with a lower voltage rating. It will most likely be the 6.3 or the 2.5 volt type.