INSTRUCTIONS FOR PERFORMING RADIO EXPERIMENTS 1 TO 10

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NATIONAL RADIO INSTITUTE
ESTABLISHED 1914
WASHINGTON, D. C.

PIONEER HOME STUDY RADIO SCHOOL

NRI

A COURSE IN PRACTICAL DEMONSTRATIONS OF RADIO FUNDAMENTALS

A PLAN FOR STUDYING THE EXPERIMENTS

As you know, these Experimental Kits will come to you on a definite schedule. When you have completed a certain number of Lessons (and have submitted reports on any previous experiments), the next Kit will be sent to you.

This arrangement is such that you will study the necessary theory in your regular Lessons *before* you carry out any corresponding experiments. This permits you to adopt either of the following plans of study:

1. You may wish to complete one or two experiments in a Kit, then do a Lesson, and then return to the Kit for one or two more experiments. This plan permits the experiments in one Kit to be finished about the time the next Kit is due. Thus, the Lessons and experiments run along together, and provide you with a varied program of study.

2. You may prefer to break away from your Lessons and to complete all the experiments in a Kit at one time, before going back to your Lessons. This plan has the advantage that you do not waste any time getting out and putting away materials, but it can be followed only if you can leave your equipment set up long enough to finish.

Whichever plan you follow, you can begin NOW with the experiments in this Kit. Be sure to read the preliminary information on pages one through ten *before* you begin, however, so you will know just how the experiments are to be carried out. In a similar manner, begin on future Kits as soon as you receive them.

J. A. Dowie.

NATIONAL RADIO INSTITUTE

WASHINGTON, D. C.

1949 Edition

A LESSON TEXT OF THE N. R. I. COURSE
WHICH TRAINS YOU TO BECOME A
RADIOTRICIAN & TELETRICIAN
(REGISTERED U. S. PATENT OFFICE) (REGISTERED U. S. PATENT OFFICE)

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Instructions for Performing Radio Experiments 1 to 10

Bringing Lecture Room Demonstrations to Your Home

MASTERY of an important radio or electrical principle which you study in your NRI Course becomes much easier if you can actually demonstrate that principle for yourself. Seeing is believing; when you carry out an experiment, you impress indelibly upon your mind the principle involved.

The NRI Course of training in radio is a well-balanced combination of radio theory and practical instruction, *supplemented by the practical demonstrations* given in this and the following experimental Manuals. By doing these experiments yourself, you get actual experience in handling radio parts and making radio measurements, and you acquire the ability to understand explanations of more advanced circuit actions. This experience *is even more valuable to you* than demonstrations by an instructor in a lecture room.

These practical NRI radio experiments will develop confidence in your own ability, and will provide exactly what you need to develop yourself into a practical radio technician—a real *Radiotrician and Teletrician.* You will encounter and master technical problems, one by one. You will learn to connect radio parts together in a professional manner. You will see for yourself what happens when a particular part in a radio circuit is removed or made defective. You will learn how to detect and correct errors in connecting parts together, and how to adjust and align practical radio circuits.

Every single experiment is important, so do not pass over any one of them hurriedly even though you may already know what the results will be.

Importance of Mastering the Art of Soldering

If you examine the chassis of any modern radio receiver or public address amplifier, you will find that the parts are connected together by means of soldered connections. These are the most reliable connections it is possible to make in commercial production; a good soldered connection will not deteriorate appreciably during the entire life of a piece of radio equipment.

When repairing a defective receiver, you must first locate the defective part. But the ability to determine what is wrong with a radio device is of little value unless you also know how to remove the defective part and how to solder the connections for the new part. Furthermore, it will often be necessary to *unsolder* one or more connections in order to make tests which will reveal the defective part.

This first Manual in your Practical Demonstration Course is devoted entirely to soldering. You study the fundamentals of radio soldering, then learn how to make each of the common types of soldered connections used in radio work. The soldering iron, solder, hook-up wire, and radio parts included with this Radio Kit for these first ten experiments are all standard, just like those you would work with when servicing.

Contents of This Radio Kit

The parts included in your first Radio Kit are illustrated in Fig. *1*

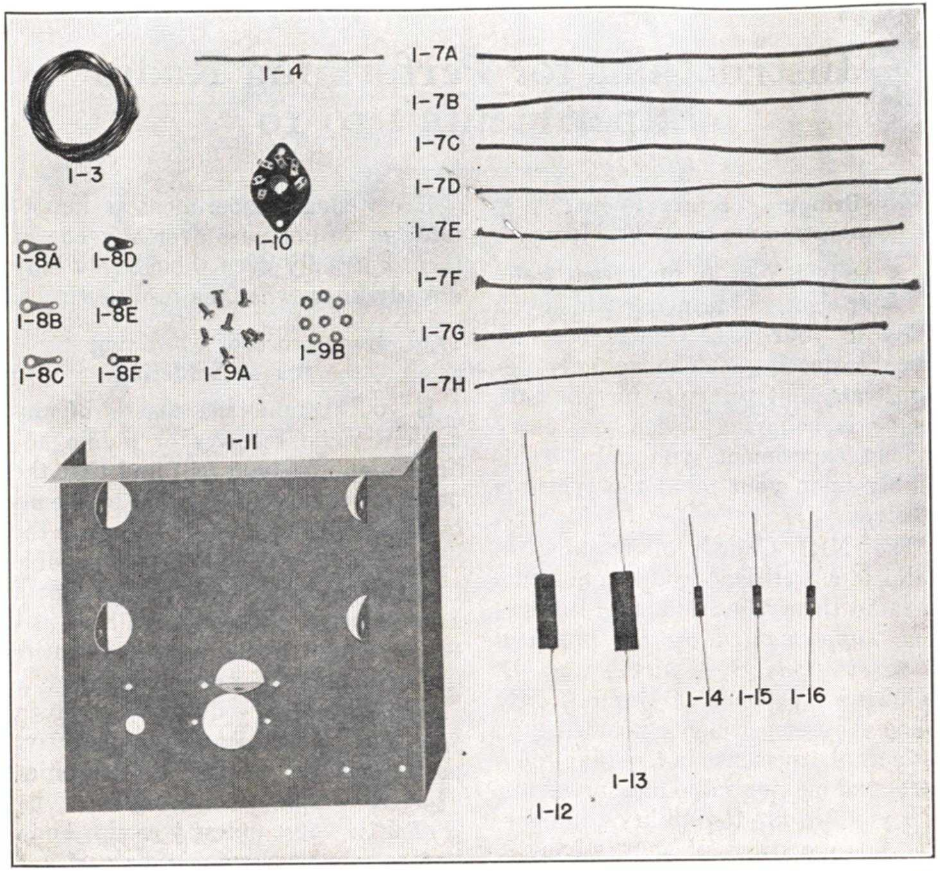


FIG. 1. The parts included in this Radio Kit are pictured above, and identified in the list below. The first numeral in a part number is that of the Kit in which the part is supplied; thus, parts supplied in the second Radio Kit will be numbered *2-1, 2-2,* etc., and parts supplied in the third Kit will be numbered *3-1, 3-2,* etc. With this system, you can tell at a glance the number of the Kit in which a particular part was supplied.

PART NO.	DESCRIPTION
1-1	One electric soldering iron (not shown above).*
1-3	One roll of rosin-core solder.
1-4	One 3-inch length of plain solder.
1-7A	One 8-inch length of No. 20 *solid* tinned push-back wire.
1-7B	One 8-inch length of No. 20 *solid* tinned push-back wire.
1-7C	One 8-inch length of No. 20 *solid* tinned push-back wire. (Parts *1-7A, 1-7B, and 1-7C* are identical, and are numbered differently merely for convenience.)
1-7D	One 8-inch length of No. 20 *stranded* tinned push-back wire.
1-7E	One 8-inch length of No. 18 solid *untinned* insulated wire.
1-7F	One 8-inch length of No. 20 stranded tinned wire with glazed insulation.
1-7G	One 8-inch length of No. 18 stranded untinned lamp cord.
1-7H	One 8-inch length of 7-strand No. 26 enameled aerial wire.
1-8A	One 13/16-inch tinned soldering lug.
1-8B	One 13/16-inch tinned soldering lug.
1-8C	One 13/16-inch tinned soldering lug. (Parts *1-8A, 1-8B, and 1-8C* are identical, and are numbered differently merely for convenience.)
1-8D	One 5/8-inch untinned soldering lug.
1-8E	One 1/2-inch untinned soldering lug.
1-8F	One 11/16-inch untinned soldering lug.
1-9A	Eight ¼-inch long, 6-32 cadmium-plated binder-head machine screws.
1-9B	Eight cadmium-plated hexagonal nuts for 6-32 screws.
1-10	One octal-type tube socket with six terminal lugs. (Slots 2, 3, 4, 5, 6, and 7 should have lugs, as shown in Figs. *39* and *40.* Some lugs may seem loose, but they will tighten automatically when a tube is plugged into the socket.)
1-11	One metal chassis bent to shape, with all holes already punched out for future use.
1-12	One .03-mfd., 400-volt tubular paper condenser.
1-13	One .05-mfd., 400-volt tubular paper condenser.
1-14	One .24-megohm, 1/2-watt resistor with 5% tolerance (color-coded red, yellow, yellow gold).
1-15	One .1-megohm, ½-watt resistor with 5% tolerance (color-coded brown, black, yellow, gold).
1-16	One 18,000-ohm, ½-watt resistor with 10% tolerance (color-coded brown, gray, orange, silver).
1-17	One metal-marking crayon (not shown above).

* If you have previously notified the Institute that you do not have 115-volt power available, Part *1-1* will be missing. In its place you will receive Part *1-1A,* a plain soldering iron of the same general construction as the one illustrated in Fig *6.*

and listed in the caption underneath. Check off on this list the parts which you received, to be sure you have all of them. Do not destroy any of these parts until you have completed your NRI Course, for many of the parts will be used over and over again in later experiments.

IMPORTANT: If any part in this Radio Kit is obviously defective or has been damaged during shipment, please return *the defective part* to the Institute *immediately* for replacement.

Tools Needed

For the experiments in your Practical Demonstration Course, you will need the tools which are shown in Fig. *2* and listed in the caption underneath. These tools are *not* supplied in this Radio Kit. You undoubtedly have at least some of them already since they are common home tools. Those which you do not have are readily obtainable at local hardware stores, dime stores, mail-order firms, or radio-supply firms. All of the tools will be needed for radio servicing work and for later experiments in your Practical Demonstration Course, so they are a really worthwhile investment.

Theory of Soldering

Any art or technique is easier to master if you first study the fundamental principles and theories which are involved. For this reason, we will consider now what solder actually is, why it adheres to certain metals under certain conditions, and why solder is so essential for permanent connections in radio circuits.

Molecular Attraction. When two ordinary solid objects are pressed together, nothing happens. Thus, we cannot make a block of solder stick to a block of copper merely by pressing the two blocks together.

It is possible to grind two metal surfaces so perfectly flat and smooth that they will adhere to each other when pressed together with a twisting force. The Johansson gage blocks used by machinists for precision measurements are an example of this phenomenon. When these blocks are pressed together hard enough to force air out from between the adjoining surfaces, the molecules of steel get close enough to attract each other with tremendous force. *Molecular attraction* thus explains why Johansson gage blocks stick together.

Why Solder Adheres. In soldering, it is unnecessary to have perfectly flat surfaces on the objects which are to be joined together. When both metal objects, even though irregular, are made perfectly clean (free of foreign materials such as chemical oxides, grease, and dirt) and are heated to the proper temperature, molten solder will adhere to the two cleaned surfaces and will bridge the gaps between them. Now, when the solder has cooled and hardened, its surface molecules will be just as close to the molecules in the adjoining cleaned but irregular surfaces as are the molecules in gage blocks. *Molecular attraction* thus makes solder adhere to certain metals.

Once a metallic surface has been *tinned* by making a layer of solder adhere to it, additional solder can very easily be *fused* to that already on the metal. (Two pieces of solder can be combined or fused simply by placing one in contact with the other and applying heat.)

What Solder Is. Solder is a *fusible metal or alloy of metals which is used to provide a good bond between two or more metal objects.* Solder used for radio work contains only

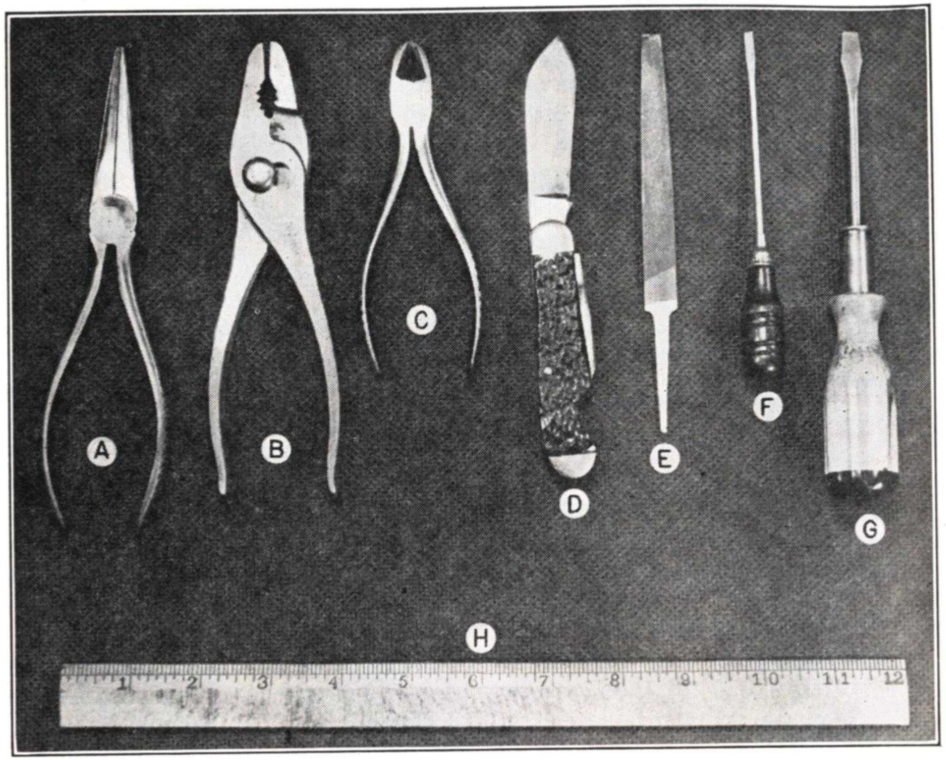


FIG. 2. The essential tools which you will need for the experiments in your Practical Demonstration Course are pictured here and identified below. Get the best diagonal cutting pliers and long-nose pliers you can afford, for you will use these tools continually throughout your Practical Demonstration Course and in actual radio work of all kinds.

A—One pair long-nose pliers (5 to 7 inches long). These may have wire-cutting jaws, but this feature is not essential.
B—One pair ordinary all-purpose pliers (6 to 7 inches long).
C—One pair diagonal cutting pliers (5 to 6 inches long).
D—One ordinary pocket knife (jack-knife).
E—One medium-size flat metal-cutting file (about 7 inches long).
F—One small screwdriver (about 5 inches long).
G—One medium-size screwdriver (about 7 inches long).
H—One 12-inch ruler of any type.

lead and tin. The ratio of lead to tin determines the hardness, strength, and melting point of the solder.

Radio solder will adhere to iron, steel, brass, copper, cadmium, and phosphor bronze when these metals are properly cleaned. Radio men have no need for soldering to aluminum, which requires a special aluminum solder.

Importance of Heating the Work. Solder will *not* adhere to a metal surface unless that metal surface is perfectly clean. Furthermore, *molten solder will not adhere to a cold surface.* To solder successfully, you must *heat the work to a temperature that will melt the solder into a smooth flowing liquid when it is applied directly to the work.* If you fail to melt the solder to a liquid, you will get a "cold" joint that will be no good at all.

It is also essential that you apply the heat for a sufficient length of time to burn *all* the rosin flux out of the joint. If you fail to do this, you will get what radio men call a "rosin joint" which introduces unnecessary resistance into the circuit.

Soldering Irons

All types of soldering irons have a pointed tip made of copper or some suitable alloy of copper, a handle (usually made of wood), and a hollow metal tube, or some other suitable means of joining the handle and tip. The pointed tip is heated and applied to the work. Heat is transferred from the tip to the work, which quickly becomes hot enough to melt the solder. Soldering irons differ principally in the methods used to heat the pointed tip—some having the tip heated continuously by an electric current, others requiring an open flame.

Electric Soldering Irons. Electrically heated soldering irons like those shown in Fig. *3* are used more than any other type by the radio industry. The various makes differ in size and shape, but their essential construction is the same. Some have the pointed rod completely surrounded by the heating element; others have the heating element fitted inside the soldering tip.

At the other end of the hollow metal tube is a wooden handle. The line cord passes through the wooden handle and the hollow metal tube, and connects to the terminals of the heating element. The heating element itself consists of nichrome resistance wire (like that used in electric stoves) wound into a coil and covered by a heat-resistant insulating material.

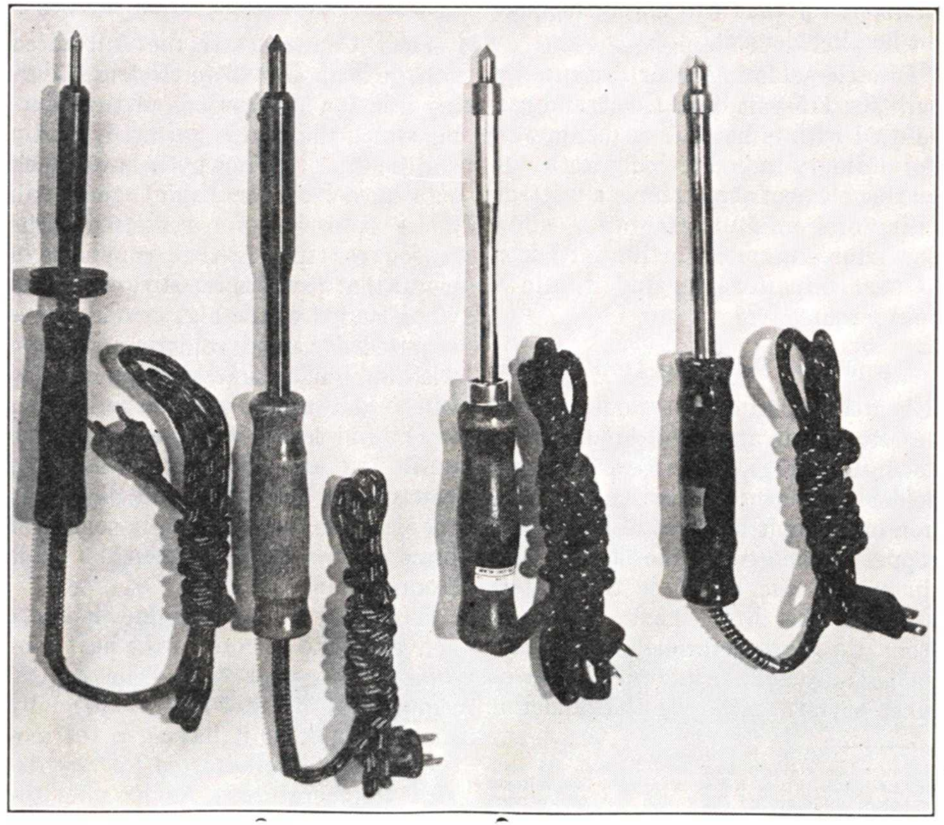


FIG. 3. These are the types of electric soldering irons most frequently used in radio work. The soldering iron (Part *1-1*) we supply in this Kit may or may not look like one of these, depending upon what we can obtain when we pack the Kit.

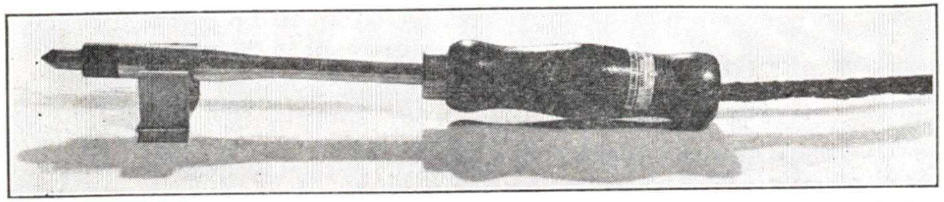


FIG. 4. This shows how to place your soldering iron on a metal holder. Note that the working tip is placed beyond the holder, so that it does not become cooler through contact with the metal which would carry off some of its heat.

Never unscrew the copper tip of the NRI electric soldering iron; the heating element inside is fragile, and is easily damaged when exposed. If the copper tip becomes loose during normal use, tighten it while the iron is cold. Do not drop your soldering iron or swing it carelessly against a hard object; more important yet, *never use your soldering iron as a hammer*, for that will surely damage the heating element.

Electric soldering irons are usually built for 115-volt operation,* and can be used with either a.c. or d.c. power. For ordinary radio servicing work, the heating element should have a wattage rating of from 50 to 60 watts. Allow about three minutes for the NRI iron to heat up after plugging it into a power source.

Purpose of Soldering Iron Holder. A heated soldering iron should always be returned to its metal holder when not in use. Fig. *4* shows a convenient holder and how to place the soldering iron on it. It is best not to let the hot copper portion touch the holder. The tip end of the barrel is the hottest part of the iron; heat conducted from the barrel through the metal holder may scorch the workbench or other surface on which the holder is resting, and heat conducted away from the barrel by the holder will tend to cool the tip.

The soldering iron holder should be kept conveniently close to your work, but never in a position where you might accidentally knock the iron out of the holder. A heated soldering iron is hot enough to do considerable damage to your hands, to your clothes, or to wooden table tops, so be careful.

Heat Controls. If the full rated voltage is applied to an electric soldering iron for long periods of time during which the iron is not used, the tip will become covered by a hard black substance (copper oxide) that will make it useless for soldering. The reason for this is that copper is a metal that oxidizes rapidly, especially when heated to the high temperatures required for good soldering. If you wish to plug your soldering iron in when you start your experimental work, and leave the iron plugged in until you are through for the day, you should form the habit of wiping the tip frequently with a cloth or piece of steel wool, to keep the oxide from forming.

You may, however, find it more convenient to use one of the heat controls shown in Fig. *5*. The control shown at *A* in Fig. *5* is a commercially manufactured unit having a thermostat that can be adjusted for any desired temperature. As long as the soldering iron is kept on this special stand, the thermostat in the base of

*Power-line voltages may vary between 110 volts and 120 volts. Up to a few years ago, line voltages at homes were around 110 volts, but today most homes have voltages approaching 120 volts. An electric soldering iron built for 115-volt operation can be used on any voltage between 110 volts and 125 volts.

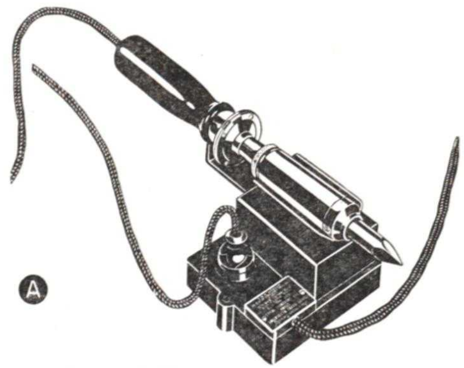
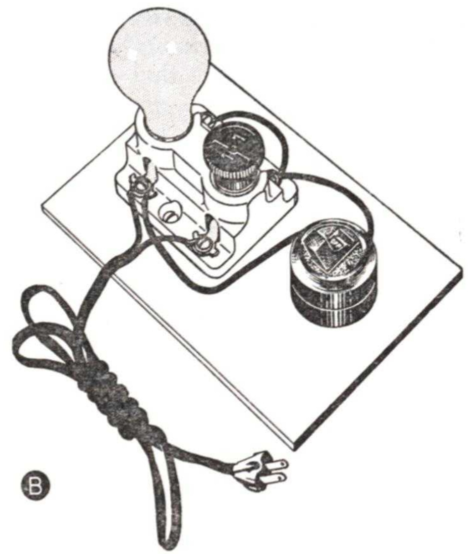


FIG. 5. A commercially manufactured heat control of the thermostat type is shown at A; one you can build yourself is shown at B.

the stand maintains the tip of the iron at the desired temperature. As soon as the iron is removed from the stand, full rated voltage is applied to the heating element, and the tip quickly reaches operating temperature.

The device shown at *B* in Fig. *5* is a thoroughly practical heat control, which you can build yourself. The wattage rating of the lamp bulb depends on the wattage rating of the iron, and should be chosen so that when the switch is *open*, the voltage applied to the iron will be between 80 and 90 volts. When the switch is open, the lamp and heating element of the iron are in series, and the iron operates at reduced voltage. This will keep the tip from oxidizing so quickly. Shortly before the iron is to be used, the switch is closed, and full voltage is applied to the iron, bringing the tip to operating temperature. Note that the switch is connected *in parallel*



with the lamp; not in series with the supply line.

Plain Soldering Iron. When electric power is not available, a plain soldering iron similar to the one shown in Fig. *6* may be used. This type of soldering iron is heated by placing the copper tip in the flame of an alcohol burner or gasoline blow torch. Once heated to the proper temperature, a plain soldering iron holds its heat long enough to make a number of soldered joints. It is then reheated for additional work.

In an emergency, you can heat the copper tip of any electric soldering iron in the flame of an alcohol burner. Radiotricians who get occasional calls from suburban or rural homes not equipped with electricity often carry

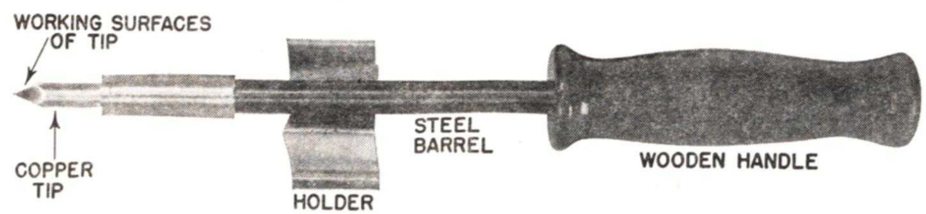


FIG. 6. This is called a plain soldering iron, as its working tip is heated in a flame. It is used where no electric power is available. A suitable heating device is described in the text.

along in their tool kit a can of special heating fuel called "canned heat," or an alcohol burner like that described later in this Manual.

Soldering Flux

When plain solder is applied to a heated piece of uncleaned brass or copper, the solder melts but rolls off immediately, without adhering. This is to be expected, for ordinary uncleaned metal is covered with a film of grease, dirt, and metal oxides which prevent the molecules of solder from getting sufficiently close to the molecules of brass or copper. Filing the surface of the brass or copper makes it appear clean, but ordinarily does little good because oxides form very rapidly on a heated metal surface. The oxygen in the air combines with the metal to form the oxide film, and heat accelerates this combining action.

If solder is to be applied successfully to a metal, the oxides must be removed from the heated metal surface as fast as they form. This can be accomplished by applying, along with the solder, an additional material called *flux*. For good radio work, this flux is always rosin (an amber-colored substance which remains after oil of turpentine is distilled out of crude turpentine). Sheet metal workers generally use an acid flux (usually some form of hydrochloric acid); this is more effective than rosin, but it *has a corrosive action which makes it unsuitable for radio work.*

Flux can be applied either in the form of a liquid or a paste, but it is more convenient to use a special radio solder having a core of the desired flux. In this way, both the solder and the flux are applied at the same time.

How Fluxes Work. Acid and rosin fluxes act in the same manner in making a lead-tin mixture (solder) adhere to another metal. These fluxes dissolve some of the oxides which are always present on a metal surface. The oxides then flow off the metal in liquid form, carrying along dirt, grease, and other oxides so as to leave a clean metal surface to which solder can adhere.

Disadvantages of Acid Flux. Although it is a well-known fact that acid flux or acid-core solder is easy to use, it is unfortunate that some of the acid *always* remains on the work and creeps over to unsoldered portions. In time, this acid will eat away the copper or brass around the joint, causing failure of the joint. The slightest presence of moisture in the air will speed up the creeping movement of acid flux. The acid may travel through the insulation between radio parts, thereby forming leakage paths for electric currents and impairing the efficiency of the circuit.

Because of its strongly corrosive action, acid flux should never be used for radio work.

Rosin Flux. Rosin is a solidified material when at normal room temperatures, but becomes liquid when heated by a soldering iron. Rosin is a fairly good insulator and has no corrosive action on metals. Rosin flux is considerably harder to use successfully than acid flux, but because of its superior insulating and non-corrosive qualities, rosin is by far the best flux for radio connections. It is generally used in the form of rosin-core solder.

Paste Fluxes. Both rosin and acid fluxes are available in the form of pastes which can be applied to the joint with a knife or a wooden splinter. A paste flux is fairly easy to use, but it is difficult to determine whether a particular paste includes corrosive ingredients which can ruin a radio

connection. Even pastes which are advertised as being non-corrosive will sometimes cause enough corrosion to ruin a delicate radio joint. For this reason *the use of paste flux should be avoided in radio work.*

Making an Alcohol Burner for Heating a Plain Soldering Iron

If you have a plain soldering iron (Part *1-1A)* in place of the electric soldering iron (Part *1-1)*, you will need a convenient source of heat. A small alcohol burner is ideal for this purpose, as it is easy to make and safe to use. Furthermore, this burner provides an alcohol flame which is ideal for removing enamel insulation from wires.

Parts Needed. The only parts needed for the alcohol burner are a plain medium-sized oil can of the type

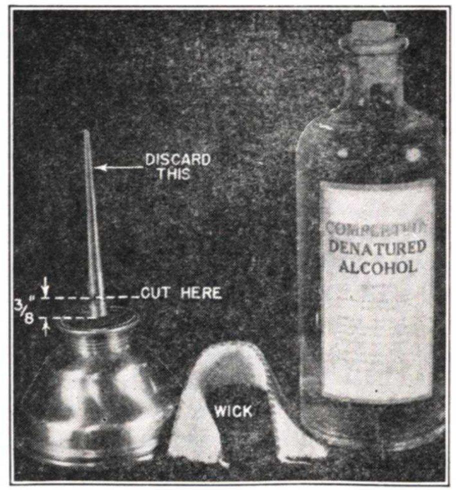


FIG. 7. **Parts needed for making an alcohol lamp, which can be used for heating a plain soldering iron, for removing enamel from wires, and for heating an electric soldering iron in locations where power is not available.**

sold for about ten cents in most dime stores and hardware stores, a lamp wick of the type used in kerosene lamps, and about a pint of denatured alcohol, wood alcohol, grain alcohol, Paco Solvent, or an equivalent alcohol product. These parts are pictured in Fig. 7.

Unscrew the spout of the oil can. With a hacksaw, cut off the spout about 3/8 inch above the base, as indicated by the dotted line in Fig. 7. You can clamp the small end of the spout in a vise while sawing, for this end will be discarded. Use a fine-tooth hacksaw blade and take light strokes to prevent excessive chattering. Smooth the saw cut with your file, and scrape off all metal burrs.

Roll the lamp wick together lengthwise at one end, and push it through the stub of the spout from the bottom. Let the wick project about 1/2 inch above the top of the spout.

Fill the can about half full of alcohol, then replace the spout and tighten it. Tip the can upside down for a few seconds so the entire wick becomes saturated with alcohol, then set the can upright and apply a lighted match to the wick. The flame should extend 2 to 4 inches above the wick. The color of the flame depends upon the type of alcohol used; pure grain alcohol will give an almost invisible blue flame, commercial alcohols give a predominantly yellow flame, with only a small blue portion.

The height and size of the flame can be adjusted by pushing the wick in or out of the spout. The more wick there is exposed and the more the wick ends are spread out, the larger will be the flame. If the flame decreases gradually in size, or flickers excessively when the burner is used for some time, loosen the cap about half a turn so that air can get in around its threads. Even a slight breeze or draft in a room will make the flame flicker; if the draft cannot be conveniently eliminated by closing windows and doors, set up boxes or boards around the burner to shield it from the air currents.

The flame can be extinguished simply by blowing it out, or by placing a thimble or small tin can momentarily over the flame to cut off its air supply.

Alcohol evaporates rapidly, so if a considerable amount is left in the can after work is finished, you can pour it back into the bottle or can in which the alcohol was sold. Keep your supply of alcohol tightly capped or corked to minimize evaporation. As an alternative to emptying the burner, you can place a small thimble over the wick.

Holder for Plain Soldering Iron. The soldering iron should always be placed so that the copper barrel is in the upper third portion of the flame. Soot will sometimes be deposited by the flame, so do not allow the flame to touch the copper tip of the iron. The iron should be in a horizontal position, or the handle should be lower than the tip during heating. Heat always travels upward; if the handle were higher than the tip, heat would travel up to the handle and make it uncomfortably hot.

A suitable holder in which the plain soldering iron can be placed *while heating* is illustrated in Fig. *8*. (This holder is used only for heating the iron; the ordinary metal holder shown in Fig. *6* is used to support the heated iron when wires or lugs are being tinned.) You can make this yourself very easily, using a large tin can, a scrap piece of wood, and a few nails, or you can design an equivalent holder from other materials which you may have at hand. Keep in mind that the two purposes of the holder are to prevent the alcohol burner from tipping and to hold the copper barrel of the soldering iron in the upper third portion of the flame.

How to Tell When the Iron Is Heated Sufficiently. An alcohol burner like that described here will ordinarily bring your soldering iron to the correct working temperature in from three to five minutes. After heating for three minutes, apply solder momentarily to a flat surface of the tip; if the solder melts readily, the iron is ready for use. If the solder melts slowly, continue heating for a while and then repeat the test. Ordinarily, it is best to heat the iron for about one minute after solder first begins to melt on the tip; extra heat is then

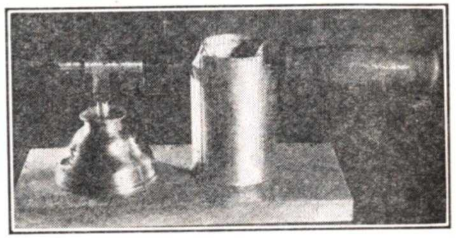


FIG. 8. Completed alcohol burner in use. The base is a wooden board of any convenient size. Three finishing nails hold the oil can in position on the base and prevent accidental tipping. A large empty tin can with notches cut in opposite sides can be used as a holder for the soldering iron, or you can cut a holder out of sheet metal for this purpose. The holder can be fastened to the base with two wood screws, in a position such that the copper barrel will be in the upper third portion of the flame.

stored in the copper barrel and tip, and a number of joints can be soldered before the iron needs reheating.

Do not overheat the iron; above all, never allow a soldering iron to become red hot. *Too hot* an iron is just as bad as *too cold* an iron insofar as good soldering is concerned, and an excessively hot iron quickly becomes corroded.

Starting the Experiments

Choosing a Place to Work. The experiments in your Practical Demonstration Course can be performed on almost any type of table or workbench which does *not* have a metal top. Students living in city apartments will find that an ordinary folding card table serves nicely. If you will be using the plain soldering iron and alcohol burner, choose a location well away from curtains and other highly inflammable materials. If you will be using the electric soldering iron, you can either place the table near a wall electric outlet, or use an extension cord to bring electric power to your table.

Performing the Experiments. Develop the correct experimental habits right from the start by following a logical procedure for each experiment. Whenever you start a new Manual, always study first the introductory discussions at the beginning of the book. After this, perform the experiments *one at a time*, in the correct order, by observing the following procedures:

1. Read through the instructions and discussions for the entire experiment once very slowly, and study any parts which are not immediately clear to you. Do not touch a single tool or radio part until you make this preliminary study.

2. Lay out on your work table the parts and tools needed for the experiment which is to be performed.

3. Carry out the experiment, one step at a time. Record your results whenever spaces are provided in the Manual for this purpose. Additional observations and comments can be written in the margins of the pages, for future reference.

4. Study the discussion at the end of the experiment very carefully, and analyze your results. After finishing an experiment, you should be able to tell in your own words exactly what you proved and how you did it.

5. Fill out the Report Statement for the experiment just completed. This statement is given at the end of each experiment, and repeated on the inside of the back cover of the Manual, and will be numbered the same as the experiment. Check the statement that completes the question correctly, and copy your answer on the last page of the Manual.

6. When you have completed all ten experiments in a Manual and have answered all of the Report Statements, cut off the last page of the Manual on the dotted line according to the instructions on that page, and mail the Report Statement to NRI for grading. *Do not send in the entire Manual.*

IMPORTANT NOTICE: In order to build the NRI Tester with the parts furnished in the first two Radio Kits, it is absolutely necessary that you perform every step in each of the ten soldering experiments in this Manual. There are about twenty-five soldered joints in the NRI Tester, and these must be made exactly in accordance with the professional soldering techniques presented in this Manual. Furthermore, the ability to make good soldered joints is required in all later experiments as well as in practical radio work. In checking student troubles, NRI has found that poor soldering is more frequently the cause of failure to get proper results than all the other causes combined.

DO NOT SKIP ANY STEPS.

EXPERIMENT 1

***Purpose:* To tin the working tip of your soldering iron.**

Step 1. To determine if plain solder alone (without flux) can be used for tinning a soldering iron, hold the heated iron horizontally in one hand, and melt a small amount (about ½ inch) of plain solder (Part *1-4*) by rubbing it lightly over the flat surface of the tip in the manner shown in Fig. *9*. Wipe off the heated solder with quick strokes of a piece of cloth, and note whether any of the solder clings to the tip. Use several thicknesses of cloth so as not to burn your fingers. If you prefer, you can tack this cloth to a small board and use it like a brush for wiping the iron.

Now file this heated flat surface until it is uniformly clean, using for this purpose the flat file specified in Fig. *2*. Usually the Radiotrician will rest the tip of the soldering iron against a non-inflammable solid object such as a brick or a stove while filing. *Never squeeze an electric soldering iron tightly in a vise.* Note how the heated copper surface changes color soon after being filed. Apply plain solder to the freshly filed surface, wipe off with the cloth, and note how much solder adheres to the tip.

In the case of a plain soldering iron, reheat the soldering iron just before filing, and file rapidly so that the iron will still be hot enough to melt solder after you have finished filing one surface.

Step 2. To determine if rosin-core solder can be used for tinning a soldering iron, file a different surface from that used in Step 1, then rub a small amount (about ½ inch) of rosin-core solder (Part *1-3*, marked with printed letters) lightly over this entire surface. Wipe off surplus solder with the piece of cloth to see if any solder remains on the tip.

Step 3. To complete the tinning of your soldering iron, file the remaining flat surfaces of the heated soldering iron tip until bright. Rub rosin-core solder (Part *1-3*) over the surfaces. Wipe off surplus solder with a cloth, then apply additional rosin-core solder to those parts of the surfaces where solder did not adhere. Repeat until these surfaces are completely tinned, then do the same for any other surfaces which are not completely tinned. Your soldering iron should now be completely tinned on all four surfaces as shown in Fig. *10*.

Step 4. To learn the radio expert's technique for shaking surplus solder off the tip of a soldering iron, apply a small extra amount (about ¼ inch) of rosin-core solder to the heated tip. Now hold the iron firmly by its handle and shake it downward over a box, a board, or newspapers. Practice this several times, until you can flip off surplus solder without getting it on your clothes or scattering it all over the room. Apply more rosin-core solder to the heated tip, but this time wipe it off with quick strokes of a cloth.

Discussion: Plain solder without flux will not ordinarily adhere to a copper surface. You proved this in Step 1 by applying the solder to the heated tip of the soldering iron both before and after filing the tip. You would secure the same results with

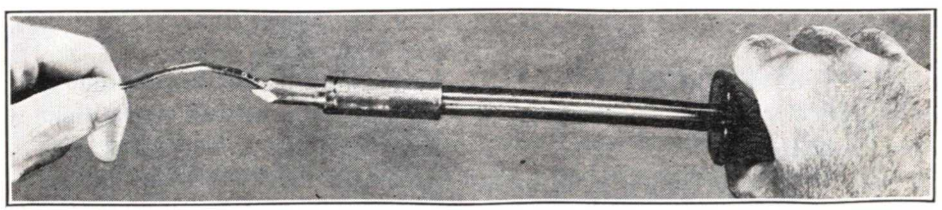


FIG. 9. Correct way to hold the soldering iron while applying solder to one flat surface of the tip for tinning purposes. By keeping the flat surface approximately level, the tendency of the molten solder to roll off the tip is minimized.

copper wire or any other heated copper surface.

The change in the color of the copper surface soon after filing was due to the formation of oxides of copper on the surface. These oxides, along with any other foreign matter which may be on the tip, prevent you from tinning the soldering iron with plain solder. There is no danger of destroying the temper of the file, for an electric soldering iron never gets hot enough to affect the hardness of steel.

In Step 2, you proved that rosin-core solder will adhere to a properly cleaned and properly heated copper surface. Only the surplus solder can

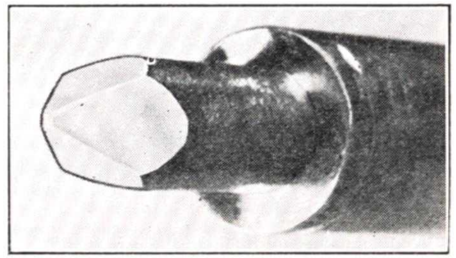


FIG. 10. Close-up photograph showing a properly tinned soldering iron tip. Note that only the flat surfaces of the copper tip are tinned.

be removed with the cloth; the bright silvery surface layer of solder adheres to the clean copper, and cannot be wiped off. In this step, therefore, you tinned one of the four working surfaces of the tip.

Because of its highly corrosive action, *acid-core solder should never be used on the joints in radio and television equipment.* Paste fluxes should also be avoided, even though they are less corrosive than acid fluxes. If you need additional flux, dissolve some powdered rosin in a little alcohol.

Surplus solder often accumulates on a soldering iron during radio work. Rosin flux evaporates quickly from hot solder, so it is usually best to discard this solder. When radio men are in a hurry, they just give the iron an expert flip as described in Step 4, so as to shake off the solder. When the iron is also a bit corroded, however, wiping off the surplus solder with a cloth will usually remove the oxides too, leaving a clean tinned tip.

Tinning serves the dual purpose of *keeping the tip of your soldering iron clean and aiding in the transfer of heat* from the iron to the work. The solder fills small irregularities in the tip and in the work, thus increasing the area of contact between the tip and the work.

A soldering iron which is untinned or only partially tinned on its flat working surfaces quickly becomes pitted and covered with crusts of copper oxide. An iron in this condition is difficult to use, for the oxide has heat-insulating characteristics and thus hinders the transfer of heat.

A certain amount of copper oxide will form even on a properly tinned iron which is used continuously for several hours. This can usually be removed by wiping the tip frequently with a cloth or steel wool as previously explained. The tip should be filed only when a considerable quantity of oxide has formed and cannot be removed by wiping or retinning.

In filing the tip of your soldering iron, always hold the file flat against the surface so as not to change the angle of the tip too much. The tip of your iron has been cut at the angle which has proved most satisfactory for radio work.

Instructions for Report Statement No. 1. The report question which checks your work on this experiment is given below, and repeated on the last page of this Manual. After you have completed the experiment and studied the discussion, read Report Statement No. 1 carefully. Check the correct answer, then copy your results on the report statement page at the end of this Manual. You are asked to specify *the type of solder* (plain or rosin-core) *with which it was the most difficult to tin your soldering iron.* Either the observations which you made during this experiment or the analysis of results in the discussion will give you the answer.

Report Statement No. 1: My untinned soldering iron was *most difficult* to tin with: *plain solder* ☐; *rosin-core solder* ☐.

EXPERIMENT 2

***Purpose:* To recognize when solder has hardened, and to see what happens when a joint is moved before the solder has hardened.**

Step 1. To demonstrate how solder changes color as it hardens, hold your heated and tinned soldering iron over a scrap piece of wood with the tip downward, and apply rosin-core solder just above the point of the tip until a solder globule about ⅛ inch in diameter drips down onto the board (the drop is shown in actual size in Fig. *11*). Watch this globule for about a minute, noting the change in color as it hardens.

Drop another globule of solder on the board in this same way, then apply the tip of the iron to the globule and apply additional solder to the tip until this second globule is about twice the size of the first. In the same way, place on the board a third globule which is about three times the size of the first one. As each globule cools, study the changing colors.

Step 2. To find whether larger amounts of molten solder take longer to cool, reheat all three globules of solder on the board one after another as quickly as you can, by applying the heated tip of your soldering iron first to the largest globule, then to the medium-sized one, and finally to the smallest one. Jerk the tip of the iron away from each globule as soon as the solder takes on a silvery molten appearance. While the three globules are cooling together, watch them carefully to see which ones harden first.

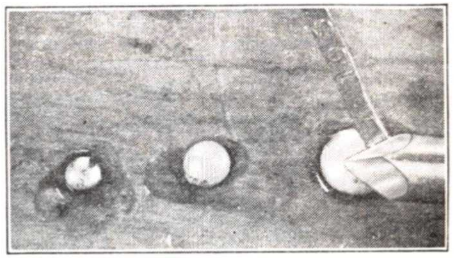


FIG. 11. Method of increasing the size of a molten globule of solder by feeding rosin-core solder to the soldering iron tip while it is in contact with the globule. The three globules used in Experiment 2 are shown clearly in this view. The darker rings on the board around each globule are formed by the surplus rosin flux, which is a yellowish liquid when heated. If you look closely, you will see your own image in the surface of a molten solder globule, just as if it were a tiny curved mirror. The image vanishes gradually as the solder hardens.

Step 3. To determine by actual test the instant when solder hardens, reheat the largest globule with the soldering iron, then remove the iron, and allow the globule to cool. Take the length of stranded enameled aerial wire (Part *1-7H)* and occasionally touch the *top* of the globule gently with it to determine when the solder hardens, while watching the changes in color. Repeat this test a few times if necessary, until you are familiar with the color corresponding to complete hardening of the solder.

Step 4. To see what happens to solder which is disturbed while it is

cooling, reheat the largest globule with the soldering iron, and hold the wire in the center of the globule while it cools. *Just before the globule turns to a dull silver color,* twist the wire so as to crack the globule.

Discussion: Step 1 showed you that solder has a bright, silvery color (much like mercury) when in a molten condition, and changes gradually in color as it hardens. This change in color serves as a "thermometer" to the Radiotrician, for it tells him when the solder has melted on a joint being unsoldered, and tells him when the solder has hardened sufficiently on a joint being soldered.

Step 2 showed clearly that a large globule of molten solder takes longer to cool than does a small globule. Likewise, you found that the larger globules took longer to heat up.

In the first two steps, we assumed that the solder was hard when it stopped changing color. In Step 3, you probe the solder with the wire, and you prove for yourself that a globule of solder has completely hardened when it changes all over to the characteristic color of hardened solder.

Step 4 demonstrates conclusively a highly important requirement of good soldering: *A soldered joint should not be moved until the solder has completely hardened.* Premature movement cracks the solder, for it is very brittle at the instant of hardening. Solder which is cracked gives very poor electrical contact between the parts of a joint. Provision for holding wires rigid while solder cools is an important part of the procedure.

Instructions for Report Statement No. 2. The test question for this experiment is a simple check of your ability to observe how solder changes in color as it hardens. A correct answer means that you have mastered one important requirement of good soldering, for these color changes tell you when solder has hardened enough to withstand movement.

After you have completed this experiment and studied the discussion, read Report Statement No. 2 carefully, place a check mark in the box which follows the answer you consider correct and copy your answer on the report statement page at the end of the Manual.

Report Statement No. 2: As molten solder becomes hard, it changes from a bright silvery color to: *a bright red color* ☐; *a dull black color* ☐; *a copper color* ☐; *a dull silver color* ☐.

EXPERIMENT 3

***Purpose:* To remove insulation from wires and clean the wires preparatory to soldering.**

Preliminary Discussion. Although there is a great variety in the size and general appearance of the conductors used to interconnect (hook up) the various parts (tube sockets, switches, transformers, condensers, etc.) of radio and television receivers and transmitters, there are only two really basic types of conductors. One is the single strand of solid metal wire familiar to everyone. Copper, because of its high conductivity and good mechanical qualities, is the metal from which the wire is drawn. The other type, known as *stranded* wire, consists of several strands of copper wire twisted together to form a single conductor.

The principal difference between the many varieties of solid hook-up wire lies in the diameter of the wire and the kind of insulation surrounding it. The insulation may be any suitable non-conducting material such as silk, cotton, rubber, or enamel. Various plastics also have suitable insulating qualities. The chief purpose of the insulation is to prevent the conducting wire from touching anything that might cause undesirable grounds or short circuits.

Solid wire having no insulation at all is also available. Running the wire through molten solder during manufacture gives it a bright, shiny appearance. Such wire is generally known as tinned bus wire. The coating of solder protects the wire from oxidization and aids in soldering. Tinned, insulated wire is the most widely used hook-up wire for interconnecting the various parts of radio and television equipment.

Stranded wire is almost always insulated, the insulation forming a convenient means of holding the strands together. The individual strands may or may not be tinned, depending on the particular type of wire. Stranded aerial wire, a sample of which is included in this first Radio Kit, does not have insulation over the entire group of wire strands. Instead, each individual strand has a coating of a protective enamel.

Insulated wire, both solid and stranded, is available in a wide variety of colors. The color is used solely for the purpose of tracing and identifying various wires and circuits. This is especially helpful when a number of wires are bound together to form a cable. The color of the insulation has nothing whatsoever to do with the characteristics of the insulation, or the current rating of the wire itself.

In radio work, so-called "push-back" wire is widely used. This is tinned, stranded, or solid wire enclosed in a simple cotton wrap, over which is the regular insulation. The insulation can be slid back when a solder connection is to be made, and then slid toward the connection to form a complete protection.

The wire supplied in your first Radio Kit is typical of the wire you will encounter in radio service work. Stranded and solid wire, tinned and untinned, are included in the Kit to give you experience with the types in general use.

Step 1. To identify the various wires supplied in this Kit, first set aside the three wires which are identical in appearance and construction. These are given the identifying part numbers *1-7A, 1-7B,* and *1-7C,* in the parts list on page 2. They are 8-inch lengths of No. 20, solid tinned push-back hook-up wire.

The length of aerial wire, Part *1-7H,* is readily identified, since it is the only one that does not have cloth-like insulation. Each of the seven strands of this wire is covered with enamel insulation.

Now identify the lamp cord, Part *1-7G.* This is the length of wire having the thickest insulation. The wire itself is made up of untinned strands; the insulation consists of a cotton braid over rubber.

Part *1-7F* is the stranded tinned wire with the glazed insulation; and Part *1-7D* is the stranded tinned wire with plain cloth insulation. Part *1-7E* is the solid untinned insulated wire. It may be necessary to cut away about ⅛-inch of the insulation on these wires to identify them positively.

When you have identified the wires according to the part numbers and descriptions given above, and in the parts list on page 2, place a small piece of ordinary adhesive tape around each

wire, and mark its part number on the tape for easy future identification.

Step 2. To remove insulation from push-back insulated hook-up wire, grasp in one hand a length of the *solid* tinned push-back insulated wire (Part *1-7A*), and push the insulation back from the end with the thumb and first finger of your other hand, as shown in the upper view in Fig. *12.* Push the insulation back far enough to expose about ¾ inch of wire. To show that the insulation can be pushed forward again after a joint is made if too much wire was originally exposed, push the insulation forward until only about ¼ inch of wire is exposed. Push back again until the full ¾ inch is exposed. Now push back the insulation on the other end of this wire the same amount (¾ inch); use long-nose pliers this time to hold the end of the wire, as illustrated in the lower view in Fig. *12.*

Also, push back the insulation for ¾ inch from both ends of the *stranded,* tinned, push-back insulated wire (Part *1-7D*). Use long-nose pliers to hold the wire, as illustrated in Fig. *12.*

Step 3. To remove insulation from ordinary insulated hook-up wire by squeezing with long-nose pliers, grasp in one hand the length of solid, untinned, insulated wire (Part *1-7E*), and use your long-nose pliers to squeeze the insulation for a distance of ¾ inch from one end. Figure *13* illustrates how this is done. You will have to apply enough pressure with the long-nose pliers to split the insulation lengthwise, so that you can pull off the strips of insulation with the pliers. The closer you get to the hinge of the pliers, the easier this will be. Loose threads of insulation can then be clipped off with side-cutting pliers or a pocket knife. Remove ¾ inch of insulation from the other end of the wire in the same way. Scrape the exposed copper wire lightly with the blade of a pocket knife as shown in Fig. *15,* to remove oxides and dirt.

In this same manner, remove ¾ inch of insulation from each end of the length of stranded, tinned, No. 20 wire, insulated with rubber and cotton braid (Part *1-7F*).

If you are unable to break the insulation by squeezing, omit this step and apply to this same wire one of the alternative methods given in the next step.

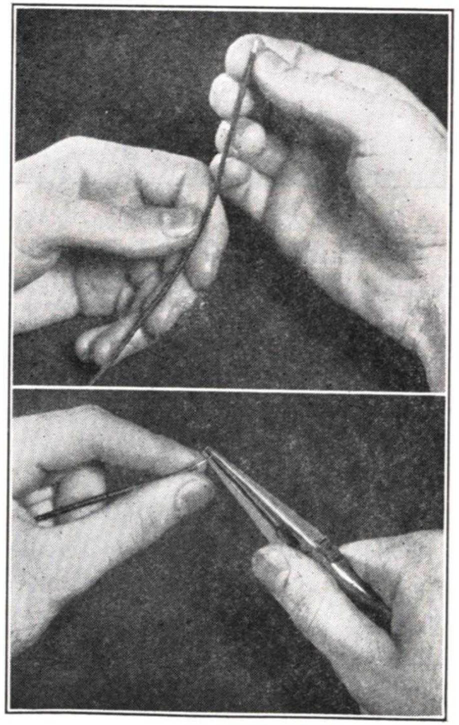


FIG. 12. The correct method of pushing back the insulation of solid push-back insulated wire with the fingers preparatory to soldering is shown in the upper view. The same method is used for stranded wire of this type. When the insulation cannot readily be pushed back far enough with the fingers, it will be easier to grasp the bare end of the wire with your long-nose pliers, as illustrated in the lower view. When holding the wire with pliers in this manner, it is a simple matter to push the insulation back with the fingers as much as desired.

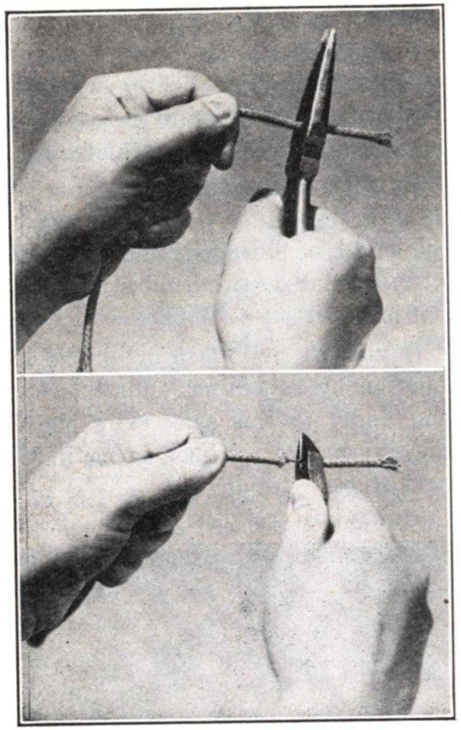


FIG. 13. This shows how to use a pair of long-nose pliers to squeeze the insulation on a piece of ordinary insulated wire so it can be removed more easily. If your pliers have wire-cutting jaws near the pivot, you will have to place the wire closer to the end of the pliers. Sometimes it is convenient to use a pair of sidecutters to remove insulation. This is done by *carefully cutting only the insulation,* and then pulling the insulation free by moving the sidecutters toward the end of the wire.

Step 4. To remove insulation from ordinary insulated wire with a pocket knife, hold the length of No. 18 stranded lamp cord (Part *1-7G*), flat upon your workbench or on a block of wood. Cut through the insulation all around the wire at a point ¾ inch from one end by moving the blade of a sharp pocket knife across the insulation with a sawing motion while rotating the wire slowly with your fingers. This is illustrated in Fig. *16.* Continue until the outer covering of woven cotton thread has been cut through all around, then slide this covering off over the end of the wire with your fingers or by pulling with long-nose pliers. Be careful not to cut through the inner rubber layer to the copper strands. Once the inner rubber insulation is partly cut through, peel it off with your fingers or a knife.

Scrape the exposed wire lightly with your knife blade if the copper appears corroded or dirty; do this several times, spreading out the strands each time so as to expose a different part of each strand to the knife.

Now take the other end of the lamp cord wire, hold it in your hands as shown in Fig. *17,* and slice off the outer braided cotton covering for a distance of ¾ inch from the end. Peel away the remaining rubber insulation with your knife and fingers,

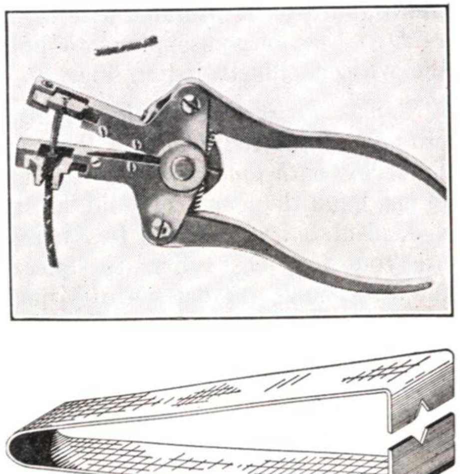


FIG. 14. These instruments are often used to remove insulation from various types of wire used in radio work. The wire strippers shown at A are generally used in production work. The bent strip of metal shown at B is a very convenient wire stripper for general radio service work.

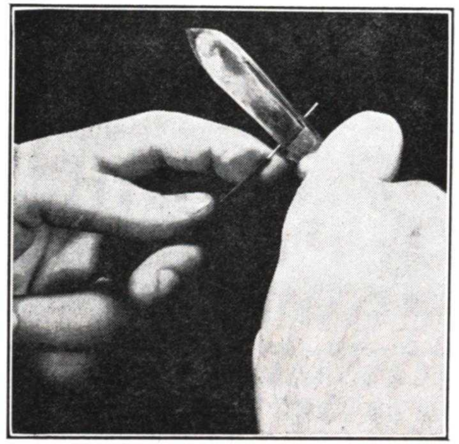


FIG 15. Always use the portion of your pocket knife blade closest to the handle for scraping oxides and dirt from exposed copper wire preparatory to soldering. This preserves the main part of the blade for purposes where sharpness is required, such as when cutting through braided cotton insulation.

and trim off loose threads. Be careful not to cut or nick any of the copper strands. Scrape the strands with the knife blade until all are clean and shiny.

Step 5. To remove enamel insulation from a wire, take the length of enameled aerial wire (Part *1-7H*) and untwist the wires for about 1½ inches at one end. Using your knife blade, scrape off the enamel from each of the seven strands of wire, one at a time, for a distance of ¾ inch from the end. Do this carefully and thoroughly, to give clean copper surfaces without nicking any of the wires. Leave the wires like this for a future experiment.

If you have an alcohol burner, use it to burn off the enamel at the other end of the aerial wire. Untwist the strands for about 1½ inches, and spread them out just enough so that none touch each other. Light the alcohol burner, and hold the spread-out strands just within the tip of the inner cone of flame, as shown in Fig. *18,* until the wires are red hot for about ¾ inch from the end. Now immerse the heated wires quickly in a little pan of alcohol. Repeat if any enamel remains on the ends of the wires and can't be rubbed off with a cloth. If you do not have an alcohoi burner, use the scraping technique for both ends of this wire.

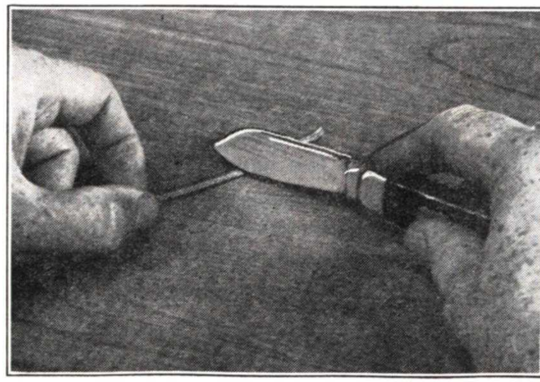


FIG. 16. When the insulation on a wire is too tough to be broken by squeezing with pliers, the pocket knife technique illustrated here is employed by some radio men for cutting through the outer braided covering on the wire. *The knife must be sharp,* and must be held lightly so as to avoid cutting too far and nicking or breaking the copper wire.

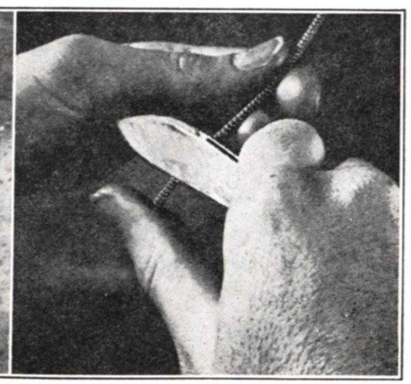


FIG. 17. This method is employed by radio men for cutting away the insulation from a wire which is anchored at its other end. The knife must be sharp, and extreme care must be used to avoid nicking solid copper wire or cutting strands in the case of stranded wire.

Discussion: Tinned push-back insulated hook-up wire, either solid or stranded, is the type of wire most commonly used by radio men. The copper wire is tinned during manufacture so that insulation slides along it readily, and the insulating cotton covering has a special weave which permits compressing the insulation. Solid push-back hook-up wire is supplied in your next radio Kit for use in hooking up practical radio circuits for demonstration purposes, so you will get plenty of experience with this type of wire.

Ordinary insulated wire (not of the push-back type) is used for the power line cords of radio receivers, and is occasionally used for receiver wiring

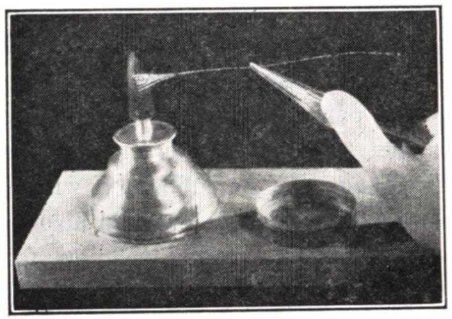


FIG 18. If enamel-covered wire is held just inside the tip of the *inner cone* of an alcohol burner flame as illustrated here, the wire will become red hot and the enamel will burn off. The inner cone appears darker in color than the outer cone. If the room is drafty due to air currents, the flame will flicker and make heating difficult; a few boxes or boards set up around the flame will prevent this flickering. Some experimentation may be necessary to find the portion of the inner cone which will heat the wires red hot, for other portions of the flame will not remove the enamel and oxides.

as well. A highly convenient way to remove insulation from wire of this type is by squeezing with pliers as explained in Step 3, but there will be times when you will have to cut away the insulation with a pocket knife as explained in Step 4. Whenever you use a knife for removing insulation or scraping wire, however, *try to avoid cutting or nicking the wire.* Even the slightest nick will weaken the wire enough to cause a break eventually at that point, if the wire is subject to considerable bending or vibration.

Scraping with a knife blade as described in Step 5 is the method used most often by radio men for removing enamel insulation from a wire. Use only a small portion of the knife blade near the handle for scraping wires, as this dulls the blade quickly. The main part of the blade should be kept as sharp as possible, for cutting purposes.

A small piece of fine sandpaper can be used for removing enamel insulation with no danger of nicking the wire. Simply fold the sandpaper over the wire, then pull the wire out from the sandpaper. Repeat as many times as necessary to remove all enamel. A few trials will tell you how hard to press the sandpaper between your fingers while drawing out the wire. Stranded enameled wire can be cleaned in this same way if the wires are spread out and are turned a little each time so as to expose all of their surfaces to the sandpaper; this is illustrated in Fig. *19*.

Burning off enamel with an alcohol burner gives a better job than scrapping, and eliminates the possibility of damaging the copper wire. The tip of the inner cone in the flame is hot enough to make the wire red hot and remove the enamel and oxides. Plunging the hot wire quickly into alcohol prevents the cleaned wire from tarnishing while cooling. The same alcohol used for the burner can serve for this purpose; the alcohol can be poured back in the bottle after you have finished with it.

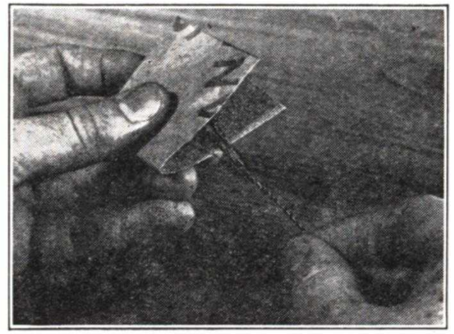


FIG. 19. Method of using fine sandpaper (about Number 00) to remove enamel insulation from stranded wire. Press the folded sandpaper (a piece about one inch wide and two inches long) together with the wire in between as indicated, then draw the wire out. Repeat this procedure until all the enamel has been removed from each strand of the portion of the wire which is to be tinned or soldered.

The samples of wire supplied you for the experiments in this Manual are long enough so that you can cut off an inch or so of wire from an end and repeat the experiment in case you accidentally damage the wire. Do not cut the wires any shorter than 5 inches, however, for you will need these wires later for practicing actual radio connections.

Instructions for Report Statement No. 3. After completing this experiment and studying the discussion, read Report Statement No. 3 carefully. Place a check mark in the box following *the type of wire which you found easiest to prepare for soldering.* Then copy your answer on the last page of this Manual.

Report Statement No. 3: The wire which I found *easiest* to prepare for soldering by pushing back or removing insulation was: solid tinned *push-back wire* ☐; *solid untinned insulated wire* ☐; *stranded untinned lamp cord* ☐.

EXPERIMENT 4

***Purpose:* To tin hook-up wire.**

Step 1. To learn how to tin solid wire properly, practice by using the *solid* untinned wire (Part *1-7E*) from which you have already removed the insulation at the ends and cleaned the exposed copper. Leave the heated soldering iron in its holder with the tip facing you. Hold the wire in one hand with one end resting on a flat surface of the soldering iron tip, then apply solder to the *wire* with the other hand, as illustrated in Fig. *20*. Slide and rotate the wire slowly between the iron and the solder until the wire is completely tinned. Shake off surplus solder from the wire. Tin the other end of this wire in the same way.

Step 2. To learn how to tin stranded wire properly, untwist the exposed and cleaned strands at one end of the lamp cord wire (Part *1-7G*) so that the strands are separated from each other for a distance of about ½ inch from

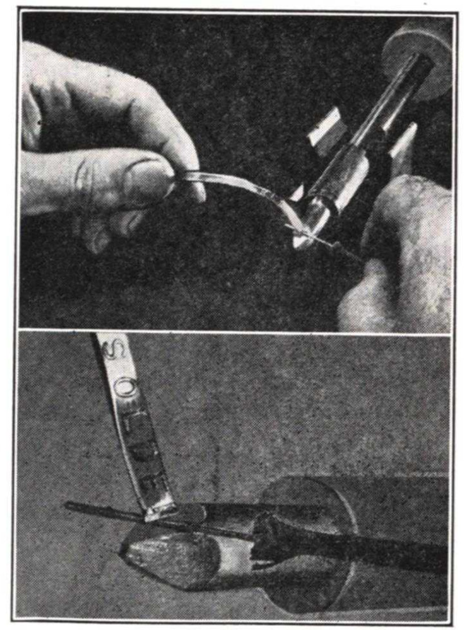


FIG. 20. Method of holding the solder and wire when tinning either solid or stranded wire. The heated soldering iron is left in its holder. The close-up photo shows a partly tinned wire. Slide the wire back and forth between the soldering iron tip and the solder until it is completely tinned for about half an inch from the end.

the end, as shown in Fig. *21*. Tin this wire by applying solder to one side of the strands while heating them from the other side with the soldering iron, just as you did in Step 1. When all strands have been tinned for ½ inch from the ends, shake off surplus solder from the strands while the solder is still in molten form, or simply tap the strands with the heated soldering iron. After the wire has cooled, twist the strands together again. If you have difficulty in getting the strands twisted tightly (see Fig. *21G*), heat them a little with the soldering iron. Stranded wire at various stages of this tinning process is illustrated in Fig. *21*. Tin one end of the 7-strand enameled aerial wire (Part *1-7H*) in this same manner.

Now tin the untinned end of the lamp cord wire (Part *1-7G*) with the strands twisted together, by following the tinning procedure given in Step 1. Tin the untinned end of the enameled aerial wire (Part *1-7H*) in this same way (with the strands twisted together).

Discussion: Solid wire is remarkably easy to tin if clean. New wire can usually be tinned without cleaning, but old wire should be scraped clean first. It is usually sufficient to tin the wire up to about ¼ inch from the insulation; if you go much closer than this with the soldering iron, there is danger of burning the insulation.

Untinned stranded wire is often difficult to tin properly unless the strands are individually cleaned and the procedure given in Step 2 is followed completely. If properly done, the tinned wire can be twisted together again. Difficulty in tinning stranded wire means that additional careful scraping is necessary.

With new and fairly clean stranded wire, it is possible to tin the wire without untwisting, just as if it were a solid wire. There are two drawbacks to this short-cut method. First and most important, *the inside strands may not be thoroughly tinned.* Second, after tinning, the wire will be so stiff that bending it to form a joint may be quite difficult.

Instructions for Report Statement No. 4 After completing this experiment and studying the discussion, read Report Statement No. 4 carefully, then place a check mark in the box following the answer which you believe tells when you will get *more thorough tinning of stranded wire.* Then copy your answer on the last page of this Manual.

Report Statement No. 4: Stranded wire can be tinned *more thoroughly: while the strands are twisted together* ☐; *while the strands are untwisted and spread out for individual tinning* ☐.

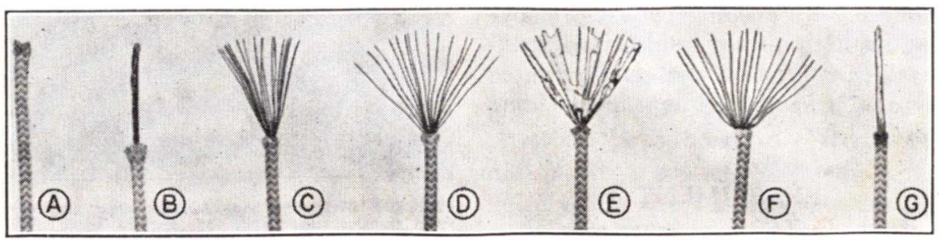


FIG. 21. Steps in preparing one end of the lamp cord (Part *1-7G*) which has rubber insulation covered with cotton braid. *A*—Original wire; *B*—Wire with insulation removed from end; *C*—Strands spread out for cleaning; *D*—Cleaned strands ready to be tinned; *E*—Completely tinned strands; *F*—Tinned strands after surplus solder has been removed; *G*—Tinned strands twisted together again.

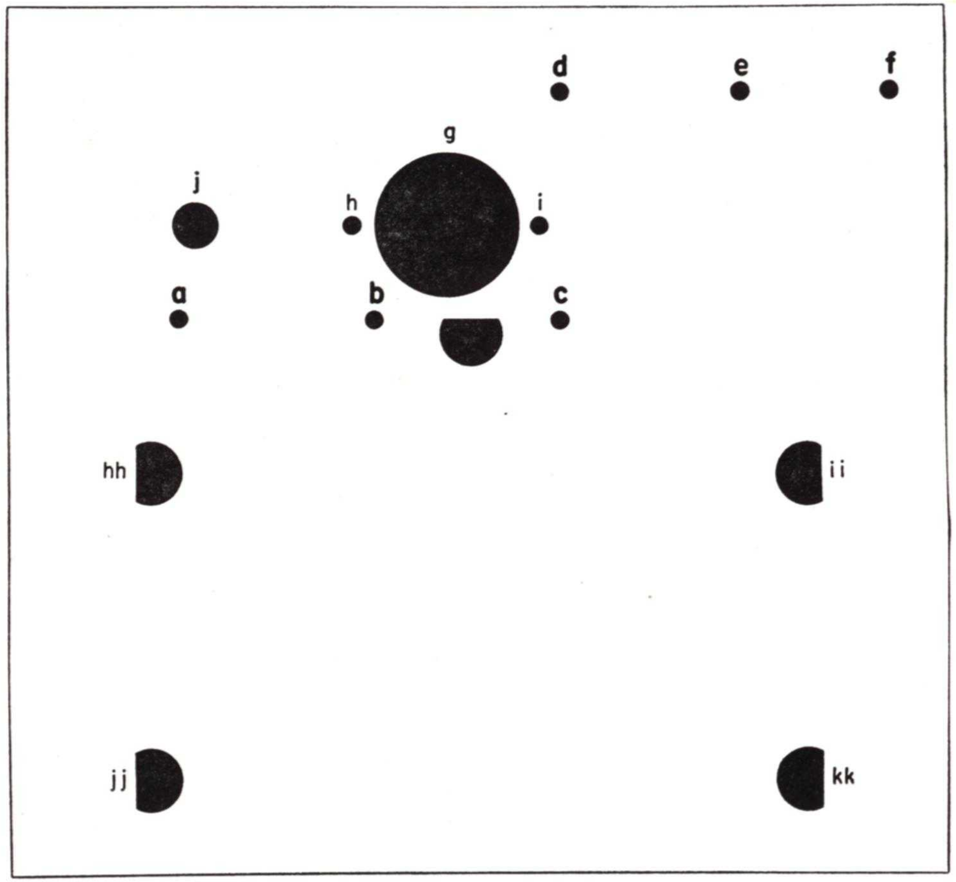


FIG. 22. Bottom view of the metal chassis, Part *1-11*. The front edge of the chassis has three holes and is bent in the same direction as the sides. The back edge of the chassis has no holes, and is bent in the opposite direction from the other three edges. The large letters *a, b, c, d, e,* and *f* can be placed alongside the holes with a metal-marking crayon, ordinary soft lead pencil, or with pen and ink.

EXPERIMENT 5

Purpose: **To mount soldering lugs on a metal chassis and prepare them for soldering.**

Step 1. Mount the three tinned soldering lugs (Parts *1-8A, 1-8B*, and *1-8C*) *in holes d, e, and f respectively on the bottom of the metal chassis* (Part *1-11*), in the following manner: Place the chassis on your table, bottom up, locate the six holes which are to be used for lugs in this experiment, and mark them with a metal-marking crayon as indicated in Fig. *22*.

Now bend a tinned lug *(1-8A)* at an angle of about 45°, using long-nose pliers as shown in Fig. *23*. Insert a machine screw (Part *1-9A*) in hole *d* from the top of the chassis, and hold the head of the screw in place with a finger. Place lug *1-8A* over the screw from the bottom of the chassis, with the bent part of the lug away from the chassis, then place a nut (Part *1-9B*) on the screw and tighten it with your fingers.

Hold the nut and lug with ordinary all-purpose pliers in the manner shown in Fig. *24A*, so that the lug points

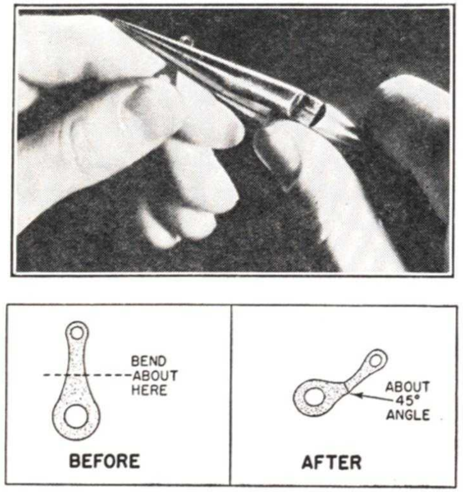


FIG. 23. Method of bending a soldering lug with long-nose pliers. Bending should be done *before* the lug is bolted to the chassis; once a flat lug is bolted to a chassis, it is difficult to pry the lug upward to a convenient soldering position.

toward the back of the chassis, and tighten the bolt head from the top of the chassis with a medium-sized screwdriver as shown in Fig. *24B*. Now bend the other two tinned lugs *(1-8B* and *1-8C)*, and fasten them in holes *e* and *f* respectively, with screws and nuts in exactly the same way. These three tinned lugs are now ready for use.

Step 2. To get experience in tinning untinned lugs before they are mounted, take untinned lug *1-8D* and file both sides of the lug at the end having the smaller hole, until the copper shows clean and bright at this end of the lug. Scraping the lug with your pocket knife blade is an alternative cleaning method. Now hold the cleaned part of the lug against a flat face of the heated soldering iron tip with long-nose pliers, and rub *a small amount* (less than ¼ inch) of rosin-core solder over the uppermost cleaned surface as shown in Fig. *25*. Turn the lug over and apply solder to the other side. Rub the lug back and forth over the iron to spread the solder and make it adhere to the cleaned surfaces.

To remove surplus solder after tinning, hold the lug with the pliers in one hand, heat the lug with the soldering iron held in the other hand, then tap the lug gently against the tip of

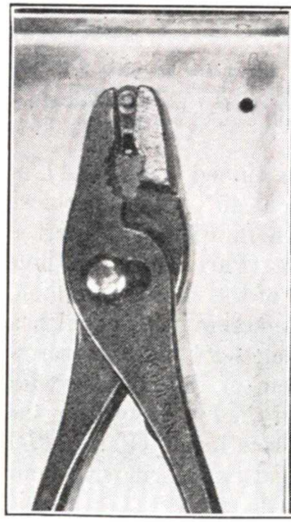


FIG. 24A. One method of using ordinary all-purpose pliers to prevent the soldering nut and lug from turning as screw is tightened.

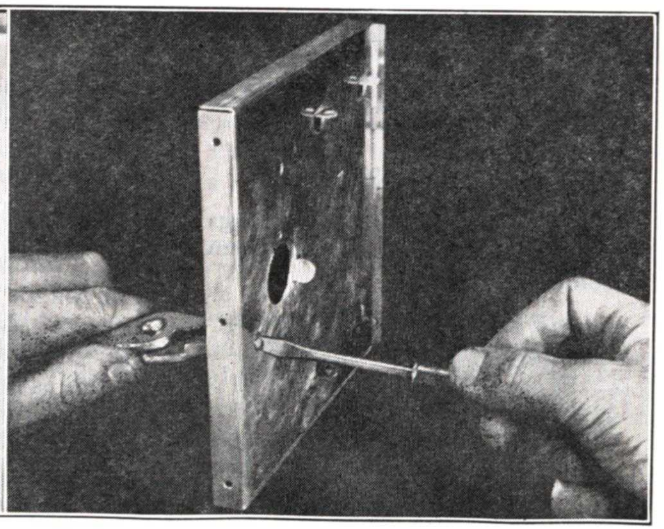


FIG. 24B. Another method of holding a nut with ordinary pliers while tightening a machine screw which is being used for mounting a soldering lug underneath the chassis. The screw should be tightened enough so that the lug cannot readily be moved with the fingers.

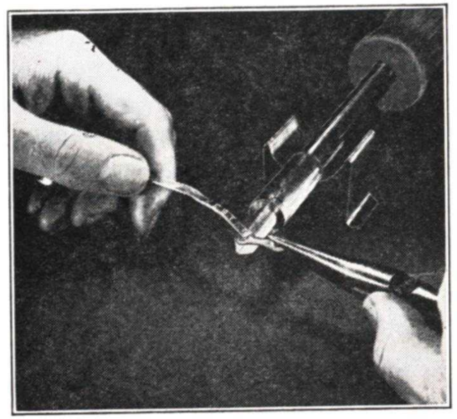


FIG. 25. Method of tinning a lug prior to mounting it on a chassis. This technique is used only for untinned lugs, or for tinned lugs which have become coated with oxides and dirt.

the iron to shake off surplus molten solder. (Sometimes it is more convenient to wipe off the surplus molten solder from the lug with a cloth.) Bend the lug approximately at its center, using pliers and fingers as shown in Fig. *23*, then mount this lug in hole *a* on the bottom of the chassis as shown in Fig. *26*.

Using the same methods, clean lug *1-8E* by filing or scraping, then proceed to tin the lug and remove surplus solder. Bend the lug at a 45° angle just as you did for the other lugs, then mount this lug in hole *b* on the chassis.

Step 3. To get experience in tinning an untinned lug which is already mounted on a chassis, bend lug *1-8F* in its center about half as much as you bent the other lugs, then mount this lug in hole *c* on the bottom of the chassis. Scrape the exposed upper half of the lug with the knife blade until clean, then hold the heated soldering iron against the top of the lug for a few seconds. Now slide the soldering iron down along the lug far enough so you can apply rosin-core solder directly to the top of the lug, and rub the solder over the lug by sliding the iron back and forth. Apply additional solder if some parts of the lug near the small hole are untinned, but use as little solder as possible in order to avoid having surplus solder roll down the lug to the nut.

Step 4. To practice removing surplus solder from a mounted soldering lug, use a cloth to wipe as much surplus solder as possible from the tip of

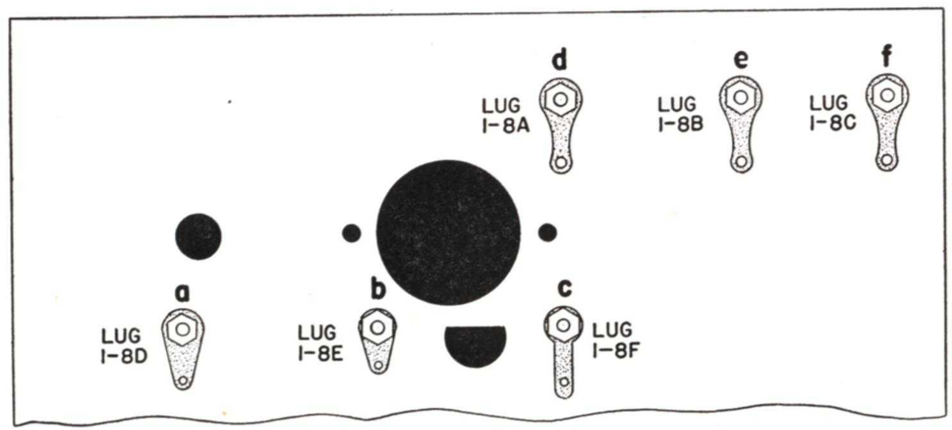


FIG. 26. Upon completion of Experiment 5, you should have six soldering lugs, all tinned, mounted on the chassis exactly as shown here, and with the ends of the lugs bent upward as shown in Fig. 23. Note that the letters in the part numbers identifying the various lugs do *not* correspond to the letters identifying the chassis holes in which the lugs have been mounted.

the heated soldering iron, then apply the iron to lug *1-8F* so as to pick up some of the surplus solder on the lug. Wipe this solder from the iron, then repeat the process as many times as are necessary to get the solder out of the small hole in the lug. Sometimes solder can be poked out of the hole by inserting the cleaned tip of the soldering iron in the hole. The six lugs should now appear as shown in Fig. *26*.

Discussion: Separate soldering lugs like those supplied in this Radio Kit are used chiefly for making connections to a metal chassis. Wire could be soldered directly to the chassis in some cases, but chassis metals are usually difficult to tin, and require more heat than can be supplied by the average radio soldering iron. Furthermore, a soldered connection to a flat metal surface is usually messy in appearance. Remember that tinned soldering lugs similar to those you mounted in Step 1, or lugs which you have previously tinned, should be used for making soldered connections to a chassis or any other large metal surface.

It is generally easier to bend soldering lugs before they are mounted. Bending a lug away from the chassis makes it easier for you to attach wires to the lug. As a general rule, bend a lug approximately in its center. Hold the small end of the lug with the pliers, for you can bend the large end more readily with your fingers.

When using a soldering lug, you ordinarily apply solder only to the bent-up half of the lug, hence only this portion need be cleaned and tinned. When the lug is unmounted, it is best to clean and tin both sides in the vicinity of the smaller hole. When a lug is mounted on a chassis, only the uppermost surface is cleaned and tinned, for it is difficult to work on the underneath surface.

Some soldering lugs which appear to be tinned are actually coated with nickel, a metal to which rosin-core solder does not readily adhere. With lugs like this, scrape or file away the nickel surface so as to expose the brass or copper underneath.

The secret of tinning a soldering lug properly lies in applying the rosin-core solder directly to the lug, a small distance away from the soldering iron tip. The rosin flux can then act on the lug. If the solder rolls off, the lug is too hot and should be allowed to cool for a few seconds. Insufficient cleaning and tinning is indicated when you can wipe off solder completely from parts of the lug. Rubbing the soldering iron tip back and forth over the top of the lug helps to make the solder adhere.

When a soldering lug is being tinned, the hole in its small end usually fills with solder. This hole must be opened to permit looping the connecting wire through the hole. Brushing out the solder is bad practice, for it scatters molten solder in all directions and may result in short circuits. One technique for getting out this solder is given in Step 4; practice this several times by filling the holes again with solder after you have cleaned them out, and you will soon find yourself lifting off surplus solder just as speedily as does an experienced serviceman. Incidentally, some servicemen do not bother to remove surplus solder from the hole; when ready to make a connection, they simply apply the soldering iron to melt the solder, then poke the wire through the hole. Shake surplus solder from the iron whenever necessary, and wipe the soldering iron

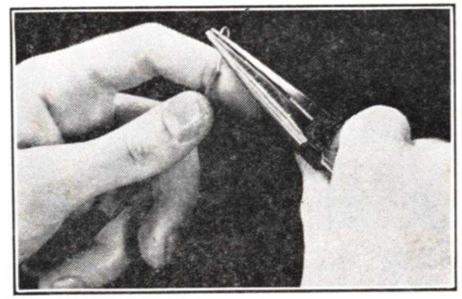


FIG. 27. Forming a hook on solid wire with long-nose pliers, preparatory to making a soldered hook joint.

frequently with a cloth. The less solder on the iron, the more solder you can pick up.

Instructions for Report Statement No. 5. After completing this experiment and studying the discussion, read Report Statement No. 5 carefully, place a check mark in the box following *the correct method of connecting a hook-up wire to the metal chassis of a radio receiver.* Then copy your answer onto the last page.

Report Statement No. 5: When a wire is to be connected to the chassis of a radio receiver, the wire should be: *soldered directly to the chassis* □; ***soldered to a tinned lug which has been bolted to the chassis*** □; *pushed into any convenient hole in the chassis and soldered* □.

EXPERIMENT 6

***Purpose:* To secure practical experience in making temporary and permanent soldered connections to lugs.**

Step 1. To make a temporary hook joint to a soldering lug with solid wire, bend one end of a length of the solid, tinned push-back wire (we will designate this as Part *1-7A*) into a hook by using long-nose pliers, as illustrated in Fig. *27*. Insert this hook in the hole in *lug 1-8D,* starting from the bottom of the lug as shown in Fig. *28A*. Bend the hook a little more after inserting, if there is any tendency for the wire to fall out, but do not pinch the hook together for this temporary joint.

Now apply the hot soldering iron to one side of the wire in the lug, and apply rosin-core solder directly to the wire and to the lug, as in Fig. *28B*. Apply just enough solder to fill the gap between the lug and the upper part of the hooked wire, then remove the soldering iron. Do not move the wire until the solder has hardened. The finished temporary hook joint is shown in Fig. *28C*.

IMPORTANT. The soldering tip must make good contact with both the lug and the wire, so as to heat and solder both parts of the joint.

Step 2. To make a temporary hook joint to a soldering lug with stranded wire, take the stranded push-back wire (Part *1-7D*), twist the strands

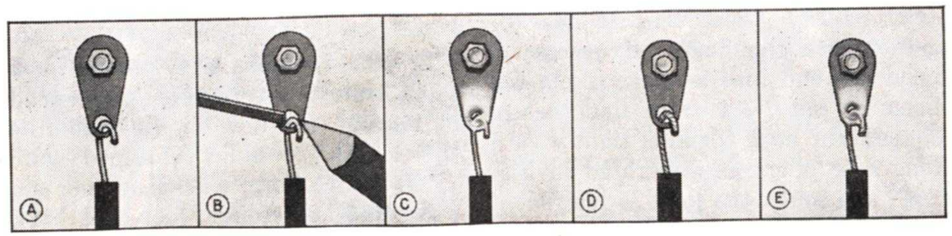


FIG. 28. Temporary connections to soldering lugs. *A*—Temporary hook joint to a soldering lug with solid wire, before soldering; *B*—Method of soldering a hook joint on a soldering lug. Note that the soldering iron is held on top of the lug, on one side of the wire, and solder is applied to the other side of the wire; *C*—Your temporary hook joint with solid wire should appear like this after soldering; *D*—Temporary hook joint with stranded wire, before soldering; *E*—Temporary hook joint with stranded wire, after soldering.

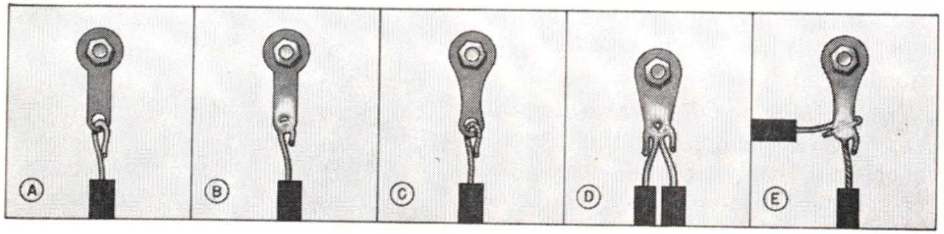


FIG. 29. These illustrations show essential features of various soldering lug connections. Note how the solder joins the wire and the lug into a single unit. This is possible only when the *work* is heated sufficiently to melt the solder into a liquid. *A*—Permanent hook joint with solid wire, before soldering; *B*—Permanent hook joint with solid wire, after soldering; *C*—Permanent hook joint with stranded wire, before soldering; *D*—Two temporary hook joints to a lug with solid wire, after soldering; *E*—Two permanent hook joints to a lug, after soldering.

together with your fingers if they have become unraveled, bend the end into a hook, insert the hook in *lug 1-8E* from underneath as shown in Fig. *28D*, and solder the joint exactly as instructed in Step 1. The soldered joint should appear as in Fig. *28E*,

Step 3. To make a permanent hook joint to a soldering lug with solid wire, take another length of solid push-back wire (we will designate this as Part *1-7C*), bend a hook in one end with long-nose pliers, and insert the hook in *lug 1-8F* from underneath just as you did in Step 1. Squeeze the hook together with long-nose pliers so that it resembles Fig. *29A*, then solder the joint according to the instructions in Step 1. The final soldered joint is shown in Fig. *29B*.

Step 4. To make a permanent hook joint to a soldering lug with stranded wire, take the stranded hook-up wire (Part *1-7F*), twist the strands together with the fingers if necessary, bend the end into a hook, insert the hook in *lug 1-8A* from underneath, squeeze the hook together tightly with long-nose pliers as illustrated in Fig. *29C*, and solder the joint as instructed in Step 1.

Now take the stranded lamp cord wire (Part *1-7G*) and make the same type of permanent hook joint to *lug 1-8B*, using that end of the wire which was tinned *without untwisting the strands.*

Finally, take the stranded enameled aerial wire (Part *1-7H*) and make a permanent hook joint with either end of it to *lug 1-8C*, then solder it.

Step 5. To make a temporary hook joint to a soldering lug which already has one connecting wire, take the remaining length of solid push-back wire (this will be designated as Part *1-7B*) and form a hook at one end with long-nose pliers. Apply the heated soldering iron to the solder at the top of *lug 1-8D* so as to melt the solder, then insert the hook of your wire in this hole from underneath while holding the soldering iron on the top or side of the lug so as to keep the solder in a molten state. When both wires are hooked through the hole in the lug as shown in Fig. *29D*, remove the soldering iron and allow the joint to cool.

Step 6. To make a permanent hook joint around a soldering lug instead of through the hole in the lug, take the length of solid untinned wire (Part *1-7E*), form a hook at one end with long-nose pliers, loop this hook around *lug 1-8A* just behind the existing connection to this lug, as shown in Fig. *29E*, squeeze the hook tightly over the lug with long-nose pliers, then apply rosin-core solder to one side of the hook and to the lug while holding the heated soldering iron on the other side of the hook.

Step 7. To secure practice in "dressing" wires neatly, first compare your work carefully with the illustration in Fig. *30* to make sure that your wires are on the correct lugs (again note that letters identifying the chassis holes and the solder lugs do not correspond), then straighten out each wire with your fingers and arrange them all neatly in the manner shown in Fig. *30* so they will be ready for the next experiment.

Now apply the heated soldering iron to lug *1-8A* so as to melt the solder on stranded wire *1-7F*, then grasp this wire with long-nose pliers and hold it rigidly in position at the angle shown in Fig. *30*, while the solder is hardening. Rest either your hand or the pliers on the chassis.

Discussion: Soldered connections to soldering lugs are among the most common which you will make in your radio work. In this experiment, you make such a wide variety of connections to soldering lugs that you are prepared for just about any type of soldering lug connection you may require in professional radio work.

A temporary connection is made only when you are reasonably sure that you will have to remove the wire in the near future. A permanent joint differs from a temporary joint only in the squeezing of the hook prior to soldering. A permanent connection is always more satisfactory, and should be used whenever there is any chance at all that the joint may be in use for some time. The permanent connection possesses mechanical strength as well as good electrical contact; thus, a good permanent connection will withstand pulling and will serve its electrical purpose even before it is soldered.

To avoid burning the insulation on a wire when soldering, it is best to bend the hook in such a way that all insulation will be at least 1/8 inch away from the lug when the wire is in soldering position. In the case of push-back wire, this insulation can be pushed right up to the lug after the joint is soldered; with other types of wire, the insulation cannot be moved.

Remember, *a joint must not be disturbed while the solder is hardening.* If the wire will not remain in position by itself during this time, hold it rigid with your hand. If you rest your hand on the chassis when doing this, you will have no difficulty in holding a wire without appreciable movement for the few seconds required for the solder to harden. Joints must often be remelted to change the positions of wires, so the experience you secure in Step 7 is particularly valuable.

Solder which is on a lug or wire hardens far more rapidly than a globule of solder on a board, because lugs and wires conduct heat away from the solder and speed up the cooling.

Instructions for Report Statement No. 6. After completing this experiment and studying the discussion, read Report Statement No. 6 carefully, then place a check mark in the box following *the correct method of making a temporary soldered connection to a soldering lug.* Copy your answer onto the last page of this Manual.

Report Statement No. 6: In a *temporary* soldered connection to a soldering lug, the wire is: *threaded twice through the hole in the lug* ☐; *hooked through the hole in the lug and squeezed before soldering* ☐; *hooked through the hole in the lug but not squeezed* ☐.

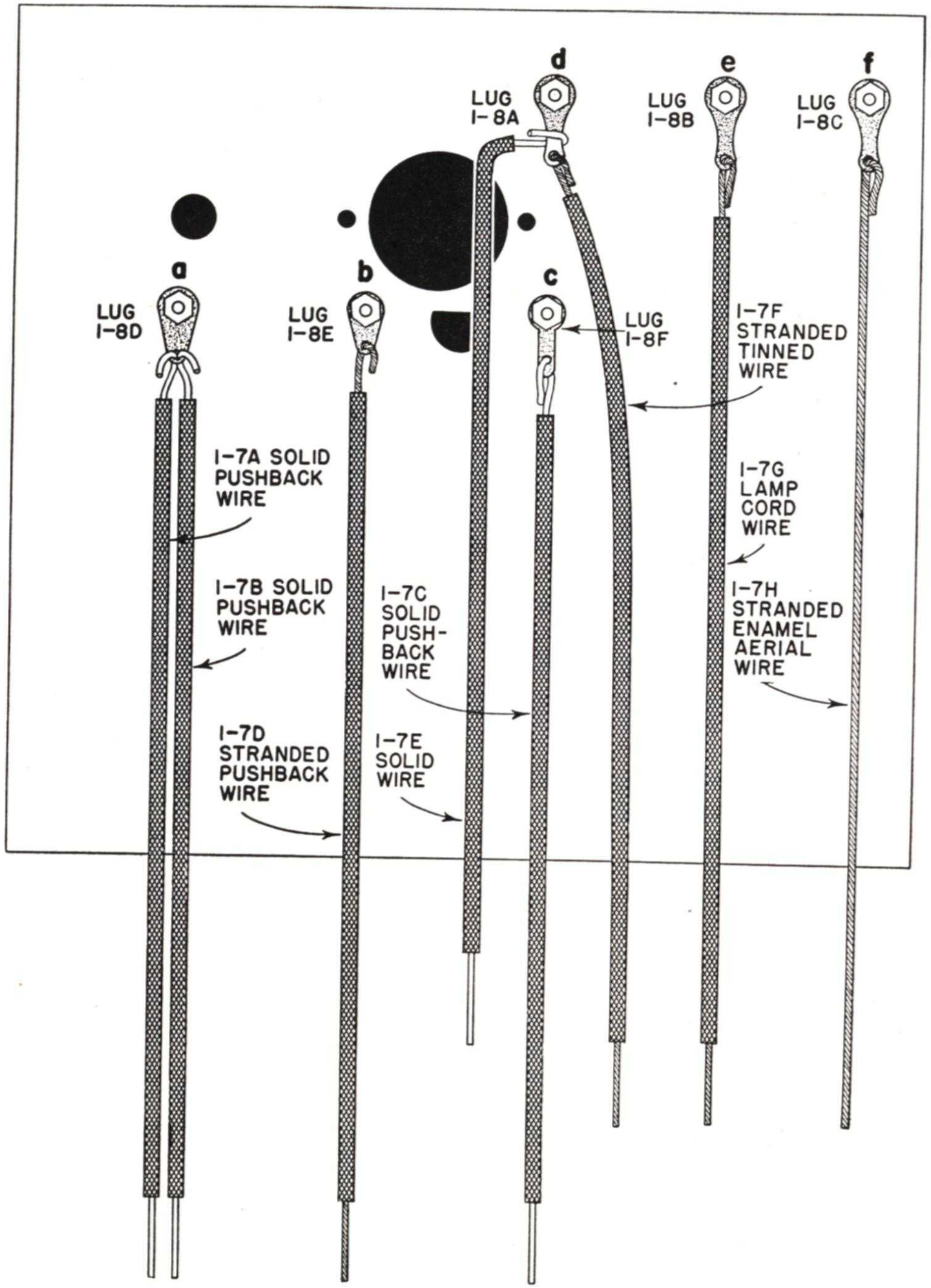


FIG. 30. Appearance of bottom of chassis after completion of Experiment 6. The actual soldering, of course, is not shown here. Each of the soldering lug connections commonly used by radio men is included in this experiment.

EXPERIMENT 7

***Purpose:* To secure practical experience in soldering two wires together temporarily and permanently.**

Step 1. To make a temporary hook joint between two wires, locate wire 1-7B and wire 1-7E on the chassis (by referring to Fig. *30)* and bend a hook in the free end of each with long-nose pliers. Hook together the free ends of the two wires as indicated in Fig. *31A*. If you first spread out the two wires, they will not fall apart when hooked together. Hold the heated soldering iron on one side of the joint for a few seconds, then apply rosin-core solder to the wires, starting at the soldering iron and then moving the solder away from it along the wires (see Fig. *31A)*. Remove the solder and the iron, and allow the joint to cool without disturbing it. The completed joint should resemble that shown in Figs. *31B* and *37*.

Step 2. To connect together two wires by means of a professional Western Union splice, locate wire *1-7A* and wire *1-7C*, and push back the insulation far enough to expose at least 1½ inches of wire at each free end (if the insulation cannot readily be pushed back this amount, remove the required amount of insulation by squeezing with pliers or by cutting with a pocket knife).

Grasp wire *1-7A* in your left hand, grasp wire *1-7C* in your right hand, and cross them in the manner shown in Fig. *32A*. The wires and the positions of the hands in this illustration are exactly as you would see them when looking at your work. Observe that wire *1-7A* is between you and wire *1-7C*.

Holding both wires between the thumb and forefinger of your right hand as shown in Fig. *32B*, twist the end of wire *1-7C* around the other wire with the thumb and forefinger of your left hand. Leave a little space between the turns so solder will flow readily between the wires. Continue twisting until only about ¼ inch of wire *1-7C* is left.

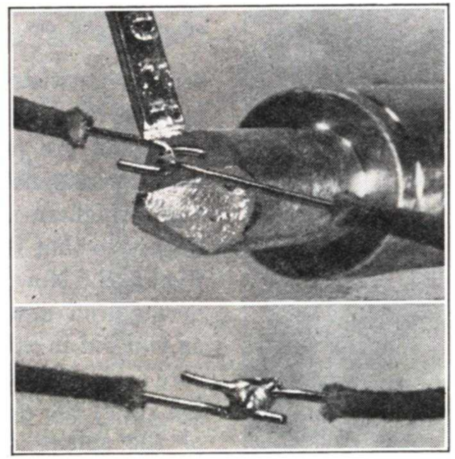


FIG. 31A (above). Correct way to solder a temporary hook joint. The tip of the iron is held under the joint, and the solder is applied to the wire from above.
FIG. 31B (below). Completely soldered temporary hook joint. Note that the hooks are *not* closed.

Now grasp the twisted part in your left hand and proceed to twist the free end of wire *1-7A* over the other wire in the *opposite* direction with your right hand, as illustrated in Fig. *32C*. Again allow about ¼ inch of wire to remain untwisted, so that the splice appears as shown in Fig. *32D*.

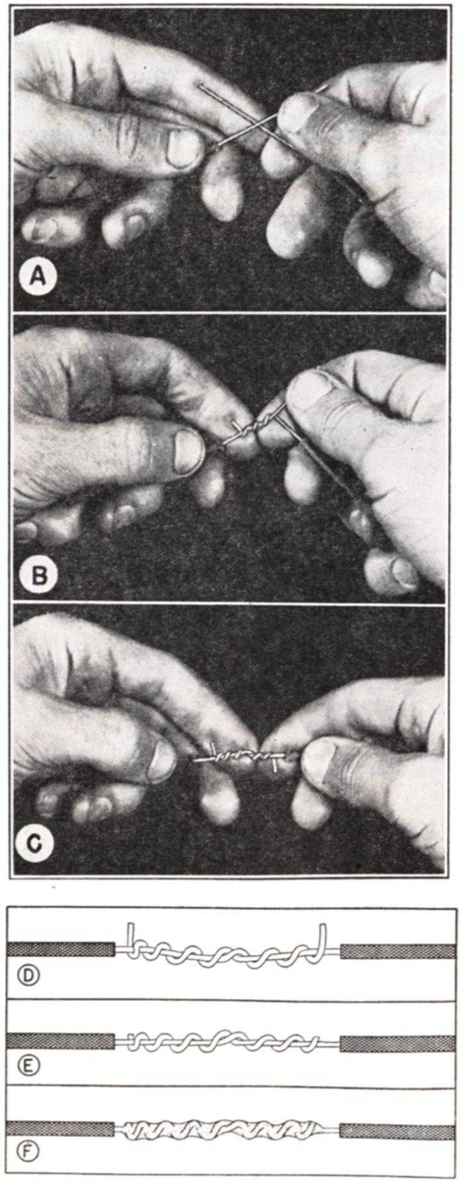


FIG. 32. Steps in connecting two wires together permanently by means of a Western Union soldered splice.

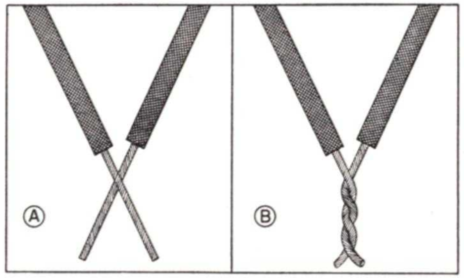


FIG. 33. Steps in making a common twist splice. This permanent joint is also known as a *Bell splice*, since it is used extensively by Bell Telephone linemen and switchboard men for connecting telephone wires together. When making this joint with solid wire, remove insulation for about 1½ inches from the end of each wire, twist up to about ¼ inch from the ends, solder the joint securely, then cut off the surplus wire with your side-cutting pliers.

Cut off the projecting ends of the wires with your side-cutting pliers, and straighten up the splice with the fingers so that it appears as shown in Fig. *32E*. Now hold the heated soldering iron alongside the splice just as you did in Step 1, and apply rosin-core solder first between the splice and the tip of the iron, then over all parts of the splice. Slide both the solder and the soldering iron along the splice to speed up the process, until the entire twisted portion of the splice is covered with solder. The completed splice should appear as shown in Fig. *32F*.

Step 3. To connect two wires together by means of a permanent Bell splice, locate stranded wire *1-7F* and the stranded lamp cord wire *1-7G* on the chassis, cross the bare end of the wires as shown in Fig. *33A*, then proceed to twist the wires together *with the fingers* so that the result appears as shown in Fig. *33B*. Cut off about 1/16 inch from the end of the splice with side-cutting pliers to give a neat joint, then solder the splice as instructed in Step 1.

Step 4. To make a permanent T type joint to some point on wire *1-7C*, take your pocket knife and cut through the insulation at a point near the center of this wire, being careful not to damage the wire itself. Now push the insulation apart at this point so as to expose about 1 inch of wire. (Do not discard the wire if you accidentally nick it, for the soldered joint will bridge across the nick in the wire.) Take the stranded wire *1-7D*, shorten it as shown in Fig. *37* by winding the wire a few times around a pencil, then twist together the strands at its free end, and wind this end around wire *1-7C* with your fingers. Space the turns apart a small amount as shown in Fig. *34*. Trim off the ends of the strands with side-cutting pliers, then solder the joint as instructed in Step 1. Now push the insulation on wire *1-7C* up to this T joint on both sides.

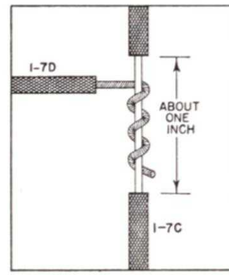


FIG. 34. Permanent T type joint between two insulated wires.

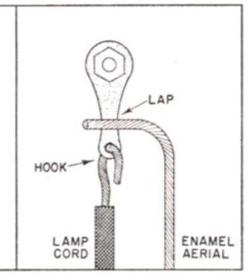


FIG. 35. Temporary lap joint on top of a soldering lug.

Step 5. To make a temporary lap joint between one wire and a lug or between two wires, take enameled wire *1-7H* and apply additional solder to its free end by employing the same technique used for tinning solid wires. Next, apply a small amount of solder to the top of lug *1-8B*, just behind the joint already on this lug. Now hold the free end of the wire over the lug just behind the joint, as shown in Fig. *35*, press your heated soldering iron over rosin-core solder so it will pick up some solder on its lower face, then apply the soldering iron to the top of wire *1-7H* so as to fuse together the solder on the wire and the solder on the lug. Remove the soldering iron when fusion occurs, but continue holding wire *1-7H* rigid until the solder has hardened. The completed joint is shown in Fig. *37*.

Discussion: Radio servicemen probably use the temporary hook joint more often than any other joint for connecting together two wires. The reason is simply that this joint can be unsoldered and separated very easily. The joint can be made more permanent, yet still be unsoldered fairly easily, by squeezing the two hooks together with long-nosed pliers just before soldering.

As a general rule, a joint between two wires should always be covered with friction tape when left permanently in a radio receiver. Radio men prefer to use a special narrow type of friction tape, obtainable in ⅜-inch wide rolls at radio supply houses, for the standard ¾-inch tape is awkward to use on small joints.

When a joint is taped, all exposed wires are covered with at least two thicknesses of the friction tape, and the surrounding insulation is also covered with friction tape for about ½ inch on each side of the joint. Typical taped joints are shown in Fig. *36*.

Figure *37* is presented for reference purposes, to show you how your chassis should look after completing this experiment. Whenever you are in doubt as to the position in which a particular joint is to be made, refer to this illustration.

The hook joint is not suitable for use where considerable force may be applied to the wires. The Western Union splice described in Step 2 is preferred by radio men when mechanical strength is required. Telegraph lines on poles are joined together by means of this splice.

The Bell splice described in Step 3 is usually easier to make in a crowded radio chassis than is the Western Union splice. When made with stranded wire, the Bell splice is readily formed with the fingers; with solid wire, it can either be twisted with the fingers up to about ¼ inch from the end, and the surplus wire then cut off, or the twisting can be completed with long-nosed pliers. Study the illustrations carefully, to determine just how much of a twist each type of splice should have.

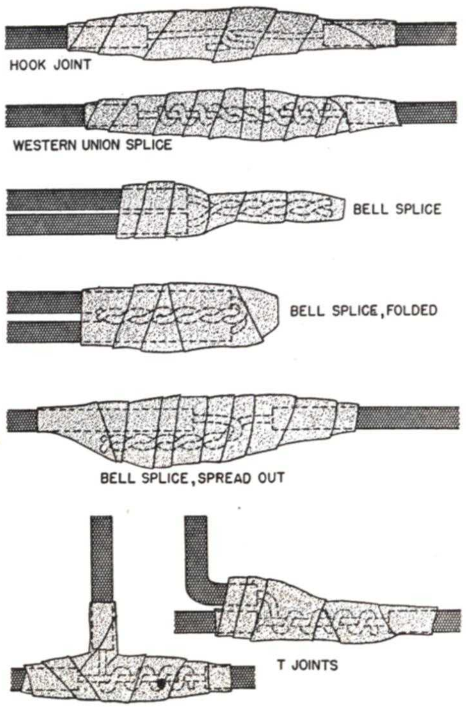


FIG. 36. Methods of taping the various types of soldered joints taken up in this manual. These diagrams are presented for future reference only, since you do not have to tape any of the joints used in your Practical Demonstration Course.

The permanent T joint described in Step 4 is occasionally required in radio work, for it permits connecting one wire to any point along another wire. The important factor in this joint is the removal of the insulation along the wire without damaging the wire itself. With push-back wire, only a single cut need be made, for the insulation can then be pushed apart. With other types of insulation, however, the insulation must be sliced off carefully with a knife, or squeezed with pliers and then trimmed off.

The temporary lap joint covered in Step 5 is widely used by radio men for test purposes. You will use it extensively in future experiments in your demonstration course. This joint can be made just as well to another soldered connection or to a wire; it was made to a soldering lug in this step merely for convenience. The secrets of a good lap joint are applying the solder to the individual parts *before* placing them together, and holding the wire perfectly rigid while the solder is hardening.

In soldering any joint, first make a secure mechanical connection, and then be sure that the solder flows in between the turns or twists of the wire. If the wire has previously been tinned properly, there should be no difficulty in accomplishing this.

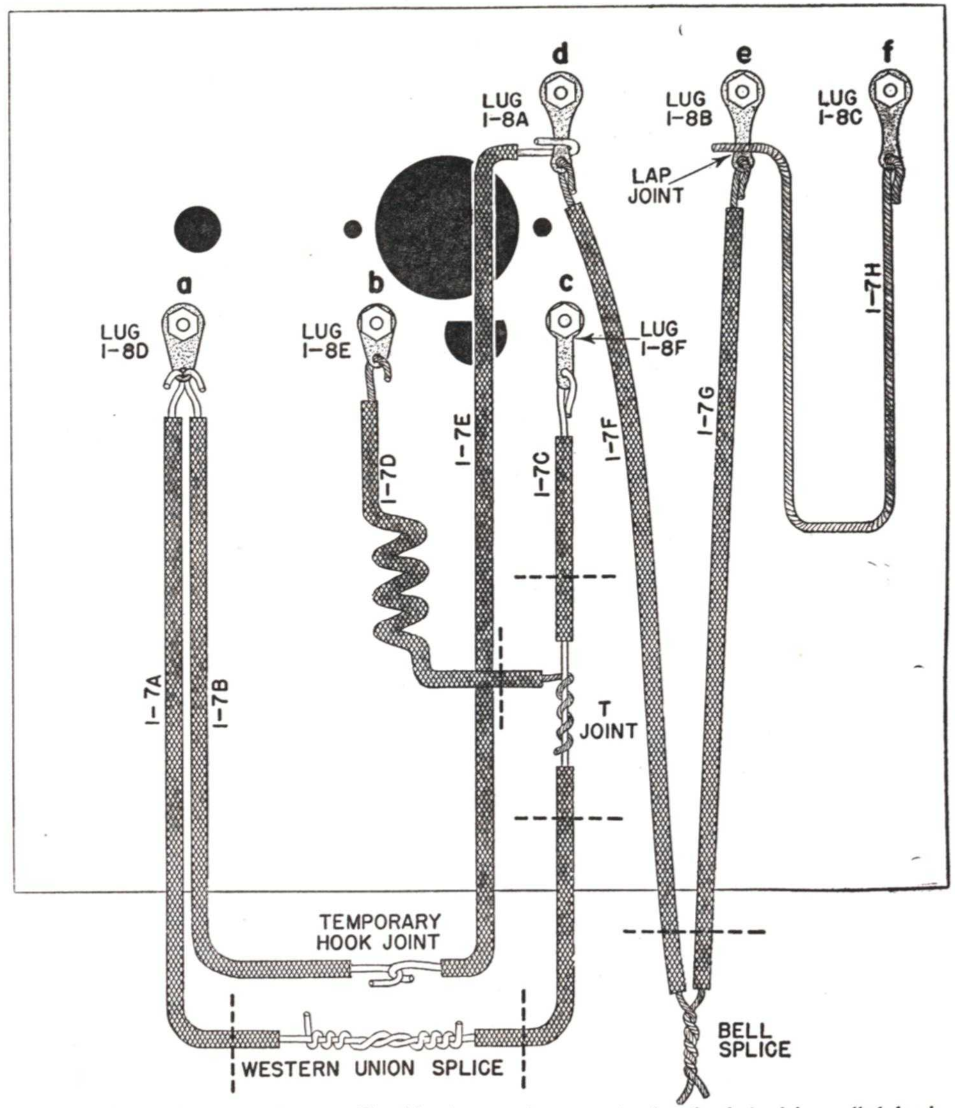


FIG. 37. Your chassis should appear like this after you have completed each of the joints called for in this experiment. The dotted lines indicate the approximate positions at which cuts should be made to remove the splices after completing the experiment.

Any connection which depends upon solder for adequate mechanical strength and electrical conductivity is known as a *joint*. A connection between two wires which gives adequate mechanical strength and electrical conductivity initially without solder is known as a *splice*. Solder is used on a true splice chiefly to prevent corrosion with age from affecting the original electrical conductivity.

The only two splices which are used to any extent in radio work are the Western Union splice and the Bell splice, both of which you made in this experiment. All other radio connections can be considered as joints. You thus see that the great majority of joints made by professional radio men require soldering for effectiveness.

Instructions for Report Statement No. 7. After completing this experiment and studying the discussion read Report Statement No. 7 carefully, then place a check mark in the box following the answer which you believe *will give the greatest mechanical strength,* when used to connect wires together end to end. Copy your answer onto the last page of the Manual.

Report Statement No. 7: When connecting two wires together where great mechanical strength is required, I would use a: *lap joint* ☐; *Bell splice* ☐; *Western Union splice* ☐; *hook joint* ☐.

EXPERIMENT 8

***Purpose:* To secure experience in unsoldering the various types of temporary and permanent connections encountered in radio work.**

Step 1. To secure experience in disconnecting splices and permanent joints between two wires, try unsoldering the Western Union splice by any means you desire. Yes, this joint is very difficult to unsolder; in fact, radio men never bother unsoldering it. Therefore, proceed to cut out this joint with your side-cutting pliers as indicated by the dotted lines in Fig. *37.* Try also to unsolder the Bell splice. It, too, is difficult to unsolder. Cut it out of the lead as you did the Western Union splice. Finally, cut out the T joint by making three cuts with your side-cutting pliers as indicated by the dotted lines in Fig. *37.*

Step 2. To secure experience in unsoldering temporary joints, unsolder the temporary hook joint between wire *1-7B* and wire *1-7E,* by applying the heated soldering iron to the joint and unhooking the wires as soon as the solder has melted. Using this same procedure of holding the soldering iron against a joint to melt the solder, proceed to unhook the wires from *lugs 1-8D* and *1-8E.* Next, unsolder the lap joint on *lug 1-8B.*

Step 3. To secure experience in unsoldering permanent joints, hold your heated soldering iron in one hand and apply it to lug *1-8A* while pulling open the hook at the end of wire *1-7E* with your long-nose pliers. Slide the wire off the lug as soon as the hook has opened sufficiently for this purpose.

Now open the hook in wire *1-7F* (on this same lug) with long-nose pliers while heating with the soldering iron, and unhook the wire. Be sure to save this wire, because it is a specially insulated wire which you will need later. This professional unsoldering procedure is illustrated in Fig. *38.*

To practice the technique employed by radio men for unsoldering wires which are difficult to bend open, melt the solder on lug *1-8B* with the soldering iron, then wiggle the *1-7G* lamp cord vigorously while the wire is cooling. Spread out the hook as much as possible with long-nose pliers after the joint has cooled, then repeat the heating and wiggling procedure until the wire is separated from the lug.

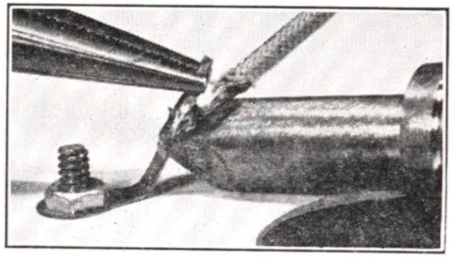


FIG. 38. Method of unsoldering a permanent hook joint on a soldered lug. Spread open the hook with long-nose pliers while keeping the solder molten by holding the soldering iron under the lug.

Use this same wiggling and unbending procedure for enamel wire *1-7H* on *lug 1-8C* and for wire *1-7C* on *lug 1-8F.*

Finally, lift off surplus solder from the lugs on the chassis with the cleaned, heated soldering iron, as instructed in Step 4 of Experiment 5. When there is a great deal of solder on a lug, you can speed up this step by holding the soldering iron tip alongside or under the lug so as to keep the solder molten, and wiping off this solder with quick strokes of a cloth.

Discussion: As you learned by actual trial in Step 1, it is very difficult to unsolder a properly formed splice. In an emergency, you could untwist the splice bit by bit with long-nose pliers while keeping the solder molten with the soldering iron, but this tedious procedure is required only when the wires must be used again and would be too short if cut off. The Radiotrician invariably snips off splices and T joints with the side-cutting pliers, just as you did in this step.

Step 2 demonstrated to you that a temporary soldered joint can be disconnected simply by applying the heated soldering iron to melt the solder, then unhooking the joint. Only when working in awkward and crowded positions is it necessary to spread apart the hook in a temporary joint. Lap joints are the easiest to unsolder of all joints.

When working on radio receivers, most of the joints which you unsolder will be of the type you practiced with in Step 3. These invariably must be spread apart with long-nose pliers before the wire can be unhooked from the lug. Sometimes it will be necessary to remove surplus solder from the joint before you can grip the end of the wire with long-nose pliers.

During unsoldering, surplus solder will accumulate on the soldering iron. Shake this off from time to time, but remember that a *little* extra solder on the iron will speed up transfer of heat to the joint being unsoldered. Sliding the soldering iron back and forth a bit over the joint also speeds up unsoldering, for this tends to break through the coating of oxide and dirt on old solder.

Instructions for Report Statement No. 8. After completing this experiment and studying the discussion, read Report Statement No. 8 carefully, then place a check mark in the box following *the type of joint which you found easiest to unsolder* when you unsoldered these *three* joints in Steps 2 and 3. Copy your answer onto the last page.

Report Statement No. 8: I found it easiest to unsolder a: *lap joint* ☐; *temporary hook joint to a lug* ☐; *permanent hook joint to a lug* ☐.

EXPERIMENT 9

***Purpose:* To secure practical experience in connecting actual radio parts to soldering lugs by means of temporary and permanent soldered connections just as you would do when servicing radio receivers.**

Step 1. To mount the tube socket (Part *1-10) on the chassis* in preparation for this experiment, take one machine screw (Part *1-9A)* and insert it in hole *h* (Fig *39) from the top* of the chassis. Holding one finger on the head of this screw to keep it in the hole, turn the chassis over and place the tube socket in position in the manner illustrated in Fig. *39*, so that the aligning slot in the center hole of the socket is next to this screw. After pushing the metal mounting flange of the socket over the screw, place a hexagonal nut (Part *1-9B*) on the screw and tighten partially with the fingers. Now take another machine screw, insert it through hole *i* from the top of the chassis and through the other mounting hole of the tube socket, then place a hexagonal nut on this screw. Hold this nut with long-nose pliers, then tighten the screw from the other side of the chassis with a medium-sized screwdriver. Tighten the other socket mounting screw in the same manner.

The tube socket has six terminal lugs, each identified by a number molded into the Bakelite base alongside the lug. The numbers are *2*, *3*, *4*, *5*, *6*, and *7*. To speed up future work on this socket, take a crayon or pencil and mark the number of each lug clearly, directly alongside the lug on the bottom of the chassis. The portion of the chassis on which you will work in this experiment should now appear as shown in Fig. *40*.

Step 2. To connect a condenser temporarily between two soldering lugs, take the .05-mfd. condenser (Part *1-13)* and bend an open hook in the end of each lead with long-nose pliers. Bend the condenser leads with your fingers approximately to the shape shown for Part *1-13* in Fig. *41*. Now hook the condenser leads into the holes in lugs *1-8C* and *1-8E* from the bottom and allow the condenser to rest on the chassis, as in Fig. *41*.

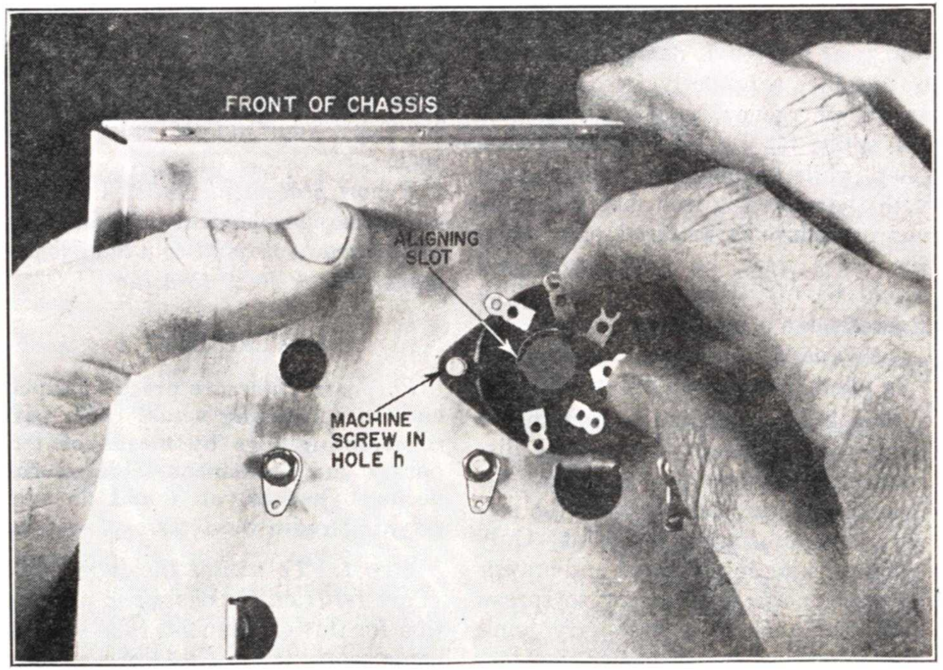


FIG. 39. Method of mounting the tube socket on the chassis. The terminal lugs of the socket should be underneath the chassis, and the aligning slot should be at the left (near hole *h*) when the chassis is held as shown in this illustration. Hold the machine screw in position with a finger of your left hand.

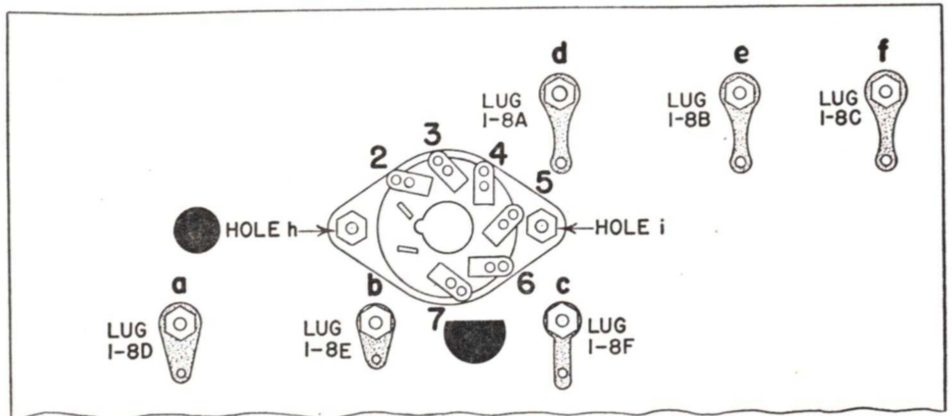


FIG. 40. Your chassis should appear exactly like this after you complete Step 1 in Experiment 9. Note that the socket has been fastened to the *under* side of the chassis.

Solder each condenser lead by applying the heated soldering iron to the top of the lug on one side of the wire, and applying rosin-core solder to the other side of the wire and to the lug.

IMPORTANT: The soldering iron tip must make good contact with both the lug and the wire, so as to heat and solder both parts of the joint.

Step 3. To connect a condenser permanently between two lugs of a tube socket, take the .03 mfd. condenser (Part *1-12)*, bend an open hook in the end of each lead, then bend the leads themselves approximately to the shapes indicated for Part *1-12* in Fig. *41*. Hook the condenser leads through the outermost holes in lugs *2* and *7* of the tube socket, by inserting the ends of the leads through the holes in the lugs from underneath, and squeeze each hook together with long-nose pliers, as indicated in Fig. *41*.

Solder the condenser lead which is on lug *7* of the tube socket. Leave the lead on lug *2* unsoldered.

Step 4. To connect a resistor temporarily between two lugs, take the .1-megohm resistor (Part *1-15*) and bend a hook in the end of one lead with long-nose pliers. With your fingers, bend the leads for this resistor approximately as indicated for Part *1-15* in Fig. *41*, then insert the hook into the outermost hole in socket lug *4* from underneath. Push the other resistor lead into the hole in soldering lug *1-8B* from above, then bend the end of the lead up with long-nose pliers to form a hook, as shown on lug *1-8B* in Fig. *41*. Now solder both of the joints for resistor *1-15*.

In the same manner, bend one lead of 18,000-ohm resistor *1-16* into a hook and insert it in lug *1-8D* from underneath as indicated in Fig. *41*, then bend the other lead (as shown in the illustration), push it through the outermost hole in tube socket lug *6* from underneath, then bend the end of the lead back with long-nose pliers to form a hook. Solder both of the joints now for resistor *1-16*.

Step 5. To connect a resistor permanently between two tube socket lugs, take .24-megohm resistor *1-14*, bend its leads approximately as shown in Fig. *41*, form a hook in the end of each lead, then hook the leads through the holes in tube socket lugs *2* and *3* from underneath. This places two leads in lug *2*. If you have difficulty

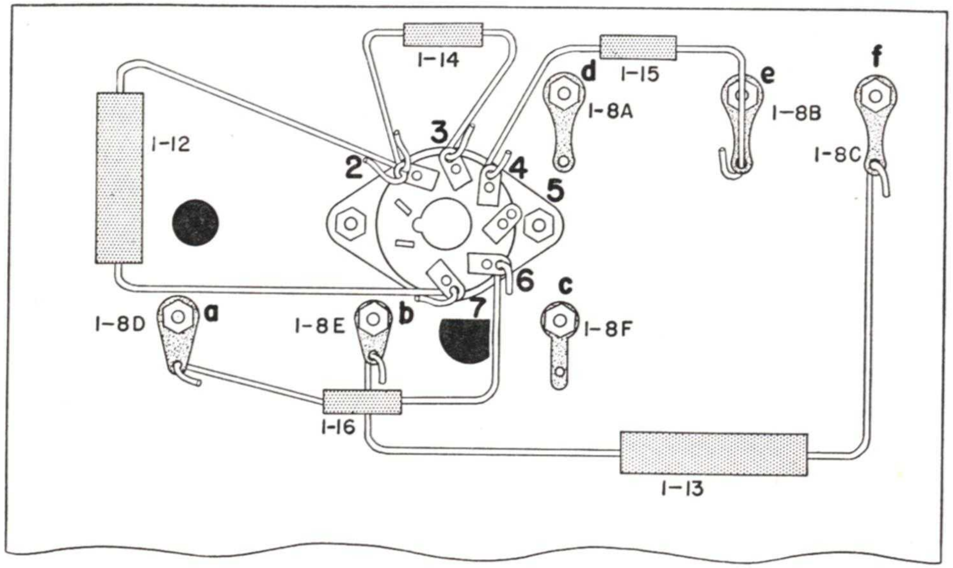


FIG. 41. The five radio parts which you connect to lugs in Experiment 9 are shown here ready for soldering. If you prefer, you can prepare all the parts in this manner, and then solder all the joints at once instead of soldering each part separately as called for in the experiment. WARNING: Bends in resistor and condenser leads should be *gradual* (not sharp), and should begin at least one-quarter inch away from the body of the part; otherwise, the leads will break off.

in inserting the lead in the outermost hole of tube socket lug *2* even though this lug has not yet been soldered, use the other hole in this lug. Squeeze the hooks together tightly with long-nose pliers, then proceed to solder lugs *2* and *3*.

Discussion: With radio parts like the condensers and resistors included in this radio Kit, the bending of the leads to their proper shapes is an important part of the connecting process. Do not intentionally make sharp-cornered bends in leads by means of pliers, however, for this may weaken the wire. Make the bends with your fingers, and use pliers only when forming hooks in the ends of wires. Bends in leads should always start at least ¼ inch away from a resistor or condenser for the same reason.

Bend each lead carefully, checking your work continually by fitting the leads to the correct lugs on the chassis. Additional bending may be done after the leads have been soldered; in fact, the leads should always be bent away from the chassis after this is done, to minimize the possibility of bare wires shorting to the chassis. The leads to these condensers and resistors are stiff enough to support the parts in air.

A permanent joint differs from a temporary joint only in the squeezing of the hook with long-nose pliers prior to soldering. The ends of permanent hook joints should be cut off after the joint has been soldered and allowed to cool, so that accidental short-circuits and grounds cannot occur. You will find that this little extra step makes a great deal of difference as regards the ease with which a joint can be unsoldered.

In this experiment, you have connected radio parts exactly as they would be connected by professional radio servicemen. With the repeated practice in soldering which you will

secure in future experiments, you will soon find yourself able to make soldered connections with professional skill, speed, and efficiency.

Instructions for Report Statement No. 9. After completing this experiment and studying the discussion, read Report Statement No. 9 carefully, then place a check mark in the box following *the splice or joint which is most often used in radio work for connecting the leads or radio parts to soldering lugs.* Then copy your answer onto the last page of the Manual.

Report Statement No. 9: The leads of radio parts are usually connected to soldering lugs by means of: *Western Union splices* □; *Bell splices* □; *hook joints* □.

EXPERIMENT 10

***Purpose:* To secure experience in unsoldering connections like those encountered in radio receivers, just as you would do when removing a defective part from a receiver.**

Step 1. To remove .1-megohm resistor 1-15 from your chassis, apply the heated soldering iron to one side of lug *1-8B*, unbend the hook with long-nose pliers while the solder is molten, then pull this lead out of the lug by pulling on the lead with long-nose pliers. Now apply the soldering iron to tube socket lug *4*, and unhook the other resistor lead from this lug.

Step 2. To remove 18,000-ohm resistor 1-16 from your chassis, use your long-nose pliers to open up the hook in lug *1-8D* while applying the soldering iron to this lug so as to melt the solder. When the end of the lead is straight up and down, pull the wire out of the hole in the lug with your long-nose pliers while keeping the solder molten with the soldering iron. Now apply the soldering iron to lug *6*, and unhook the resistor lead going to this lug.

Step 3. To remove .05-mfd. condenser 1-13 from your chassis, apply the soldering iron to lug *1-8E* while grasping with long-nose pliers the lead going to this lug. Unhook the lead from this lug. This will undoubtedly cause bends in both condenser leads, but you can readily straighten these out after the part has been removed. Now melt the solder on lug *1-8C*, and unhook the lead from this lug in the same manner.

Step 4. To remove .03-mfd. condenser 1-12 and .24-megohm resistor 1-14 from your chassis, first apply the heated soldering iron to lug *7*, and pry open the hook in the condenser lead going to this lug. Do not expect to do this in one trial, for it is usually quite difficult to get a good grip upon the end of the wire with pliers. Continue unbending the hook until you can push the wire out of the lug. The other lead of this condenser will be somewhat more difficult to unsolder, since it goes to a lug *(2)* which has two connections; use exactly the same technique, however.

Part *1-14* also has permanent connections, so unsolder its leads from lugs *2* and *3* in the same manner.

Step 5. Remove surplus solder from all six soldering lugs and from the lugs on the tube socket, either by wiping off the molten solder with a cloth or by lifting it off with the clean soldering iron. Melt and shake off surplus solder from the leads of the five radio parts used in this experiment, then straighten out the leads with your fingers as well as you can. If the ends of any leads have been damaged by the long-nose pliers, cut off about ¼ inch from each end.

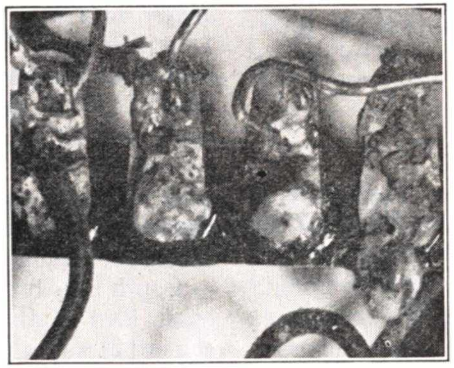
Simply straighten out the hooks in the remaining leads if the wires themselves are in good condition, so that all parts are clean and ready for use again in future experiments. Now remove the six soldering lugs *(1-8A, 1-8B, 1-8C, 1-8D, 1-8E,* and *1-8F)* and the six screws and nuts from the chassis with your screwdriver and long-nose pliers, then set aside the lugs, screws, and nuts for future use. Leave the tube socket on the chassis.

Discussion: In this experiment, you demonstrated for yourself the fact that hook joints which are not squeezed prior to soldering are fairly easy to unsolder. You found that sometimes the leads can be removed from a lug without unbending the hook, while in other cases it was necessary to unbend the hook somewhat with long-nose pliers before the lead could be pulled away from the lug.

You also found that permanent soldered connections can be unsoldered fairly easily once you get the knack of prying open the hook with long-nose pliers. As you undoubtedly realize now, it is quite a trick to hold a heated soldering iron against one part of a lug while prying open a wire on that lug with long-nose pliers. You will become quite proficient in this work, however, by the time you have completed your home demonstration course.

Whenever a permanent hook joint has been squeezed so tightly that it is very difficult to get a grip on the end of the wire with long-nose pliers, servicemen will usually snip off the wire as close as possible to the soldering lug with side-cutting pliers. The portion of the wire remaining in the lug can either be pushed out with the tip of the soldering iron after this is done, or can be cut again with side-cutting pliers so it will fall out when the soldering iron is applied. You may use this procedure if you have difficulty in unsoldering any of the joints.

Sometimes the wire will come out after only a part of the hook is cut off. Then again, it may be possible to spread the hook apart with a small screwdriver or with the blade of a pocket knife.



An example of poor soldering. The lumpy, cracked appearance shows too much solder was used and the joints were not heated enough.

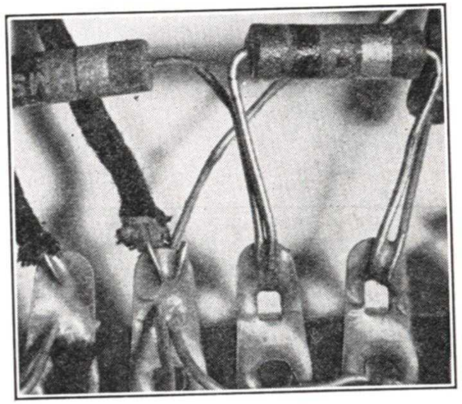
Instructions for Report Statement No. 10. After completing this experiment and studying the discussion, read Report Statement No. 10 carefully. Place a check mark in the box following the statement that describes the condition of the solder which makes it easier to disconnect a permanent hook joint. Then copy your answer onto the last page of the Manual.

Report Statement No. 10: When disconnecting a permanent soldered hook joint, the hook is easier to pry open with long-nose pliers while the solder is: *hard* ☐; *molten* ☐.

Requirements of a Good Soldered Joint

The seven important requirements of a good soldered radio joint are reviewed in convenient reference form in Fig. 42. If you understand and follow each of these requirements, you should have no difficulty in making professional soldered joints once you have practiced as instructed in your home demonstration course.

In the case of plain soldering irons, which must be heated by an alcohol burner, we have the additional requirement that the soldering iron be at the correct temperature. (This requirement is taken care of automatically in an electric soldering iron by the original design of the heating element.) If the soldering iron is too cold, a joint made with it may look good but be mechanically and electrically weak because hardened rosin is the chief bonding material. The resulting "rosin" joint (one in which there is little or no solder connecting the two parts together) is unsatisfactory and can actually be an open connection. In any event, a rosin joint will eventually break apart and cause trouble.



Good soldering produces a smooth, even coating of solder. The joints have been heated sufficiently to melt the solder and just enough solder has been used to coat the joint thinly.

Too hot a soldering iron is equally unsatisfactory, for excessive heat will evaporate the rosin flux before it has a chance to act upon the work, and will make the solder flow too rapidly away from the joint. Furthermore, excessive heat will travel around the joint through the copper wire and burn insulation or loosen adjacent soldered joints.

Looking Forward

Having mastered professional soldering techniques, you are ready to set up real radio circuits with soldered joints, and demonstrate basic radio principles for yourself. In your next

REQUIREMENTS OF A GOOD SOLDERED JOINT
1. KEEP YOUR SOLDERING IRON CLEAN AND WELL TINNED
2. REMOVE INSULATION FROM WIRES, AND SCRAPE OFF EXCESSIVE DIRT. AVOID NICKING THE WIRE WITH THE SCRAPING TOOL
3. USE ONLY ROSIN-CORE SOLDER FOR RADIO WORK.
4. TIN EACH PART SEPARATELY IF ORIGINALLY UNTINNED.
5. MAKE GOOD MECHANICAL CONTACT BETWEEN THE PARTS BEING SOLDERED
6. APPLY THE SOLDER TO THE LUG OR WIRE, NOT TO THE SOLDERING IRON.
7. DO NOT MOVE THE JOINT UNTIL THE SOLDER HARDENS.

FIG. 42. Observance of these seven basic requirements is the secret of making professional soldered joints for radio equipment.

radio Kit will be another fascinating collection of actual radio parts, including a milliammeter and a vacuum tube. With these additional parts you will assemble simple electrical and radio circuits and trace electron flow through them. You will make measurements of current and voltage in these circuits, and see for yourself that current, voltage, and resistance in a circuit always have values which agree with Ohm's Law.

Finally, after completing Experiment 20, you will assemble the NRI Tester on its attractively designed panel and chassis. This is a specially designed measuring instrument which is equivalent to eighteen separate ordinary meters. You will use the NRI Tester a great deal in future experiments.

IMPORTANT

Be sure to save ALL PARTS from this Radio Kit, including the soldering lugs, screws, and nuts, because you will need them later. Keep small parts in individual envelopes or boxes.