Study Group 1

ELECTRONIC FUNDAMENTALS

Theory Lesson 1:	Wave Motion and Communication
Experiment Lesson 1:	How to Solder
Theory Lesson 2:	Schematic Symbols and How to Use Them
Experiment Lesson 2:	How to Do Advanced Soldering

RCA INSTITUTES, INC.

A SERVICE OF RADIO CORPORATION OF AMERICA

New York, N. Y.

ELECTRONIC FUNDAMENTALS

THEORY LESSON 1

WAVE MOTION AND COMMUNICATION

RCA INSTITUTES, INC.
A SERVICE OF RADIO CORPORATION OF AMERICA
HOME STUDY SCHOOL
350 West 4th Street, New York 14, N. Y.

Theory Lesson 1

INTRODUCTION

Communication is the term for sending information from one person to another. There are two basic methods of communication: the visible method and the audible method. The visible methods requires the use of our eyes to receive information, as in the case of signaling with lights, flags, or smoke, waving our arms, or reading the words on this page. The audible method of communication is being used when our ears receive the information being communicated by shouting, speaking, ringing a bell, beating a drum, or blowing a horn. In other words, we are communicating audibly when we use sound to carry our meaning to one another. We are going to study audible communication in this lesson.

1-1. SOUND

Anything that can be heard is *sound.* You may be reading this in a quiet room. If so, stop a moment and listen. The chances are that you'll hear sounds that you were not conscious of when your mind was occupied with reading. Unless you visit a completely sound-proof room someday, you'll spend an entire lifetime surrounded by sounds.

1-2. WAVE MOTION

Just what happens when a sound is produced? Actually, sound is a form of *wave motion.* You are familiar with the wave motion caused by dropping a stone into a still pond or lake. Seen from above, as from a bridge or boat, the waves look like the illustration in Fig. 1-1. Seen from the water level, they look more like Fig. 1-2. Part *a* of the figure shows a stone dropping toward the water. Part *b* shows the stone pushing aside the water in its path. This brings the water level up around the stone and starts the first wave circling out from the stone. In part *c*, the stone has sunk below the water level, and waves are traveling out along the surface of the water.

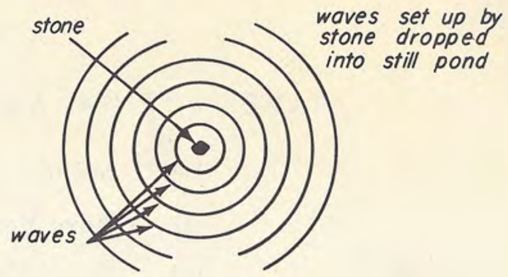

Fig. 1-1

1-3. SOUND WAVES

Like waves in a pond, sound waves in air radiate (go out) in all directions from the source of the sound. But we cannot see these waves; we can only hear them. A sound may be produced by a tuning fork, as shown in Fig. 1-3. The rapid to-and-fro movement, or vibration, of the tuning fork first presses the surrounding air into a small space, causing *compression,* and then spreads it over a large space, causing *rarefaction.* This alternate compression and rarefaction of the surrounding air is repeated, over and over again, until the vibration stops. This

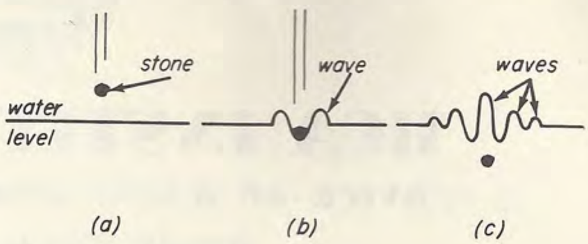

Fig. 1-2

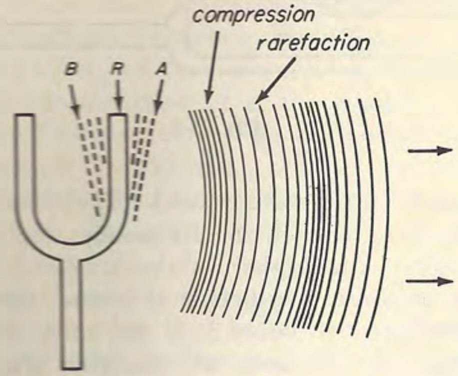

Fig. 1-3

is very important, so let's break it down and see exactly what happens. First of all, the picture shows only one prong of the tuning fork vibrating. Actually, both prongs vibrate, but, to simplify the picture, only one of them is shown in motion and the air to the right of *R* is considered. The letter *R* shows the prong at rest – when it is not vibrating. When the fork is struck, the prong moves from *R* to *A*. When it does this, it pushes nearby particles of air closer together; that is, it *compresses* the air. Maximum compression results at *A*. Then the prong starts moving back. It passes through the position of rest *R* and continues on to *B*. As this happens, the particles of air are spread. That is, the particles of air become more *rare*. At *B* maximum rarefaction occurs. Then the prong changes direction again and moves from *B* to *A*, passing through *R* on the way. Note that the air is compressed when the prong moves from *R* to *A* and back to *R*, and that the air is rarefied when the prong moves from *R* to *B* and back to *R*. This back-and-forth movement is

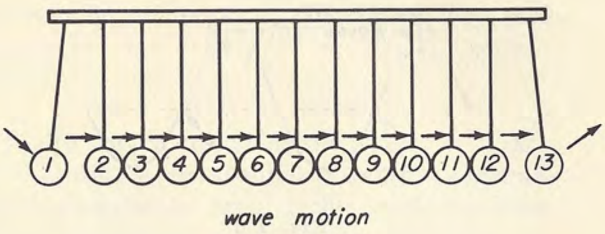

Fig. 1-4

repeated over and over until the fork stops vibrating.

The changing motion of the air set up by the tuning fork travels out in all directions from the source of sound in the same way that waves spread in water. This does not mean that the air next to the tuning fork actually travels to the ear of the listener. Instead, the motion or energy is passed from one particle of air to the next and finally reaches the listening ear. The action is much the same as that shown in Fig. 1-4. When ball #1 is moved in the direction shown, it passes this motion on to ball #2. Ball #2 passes it on to #3, #3 to #4, and so on, until it reaches ball #13. The balls in the middle of the string remain where they were; only the movement travels away from the source until it reaches the last ball.

1-4 WAVELENGTH AND CYCLE

If a prong of a vibrating tuning fork is pulled in a straight line across a smoked-glass plate, it will leave a wavy trail like that shown in Fig. 1-5. This wavy trail looks

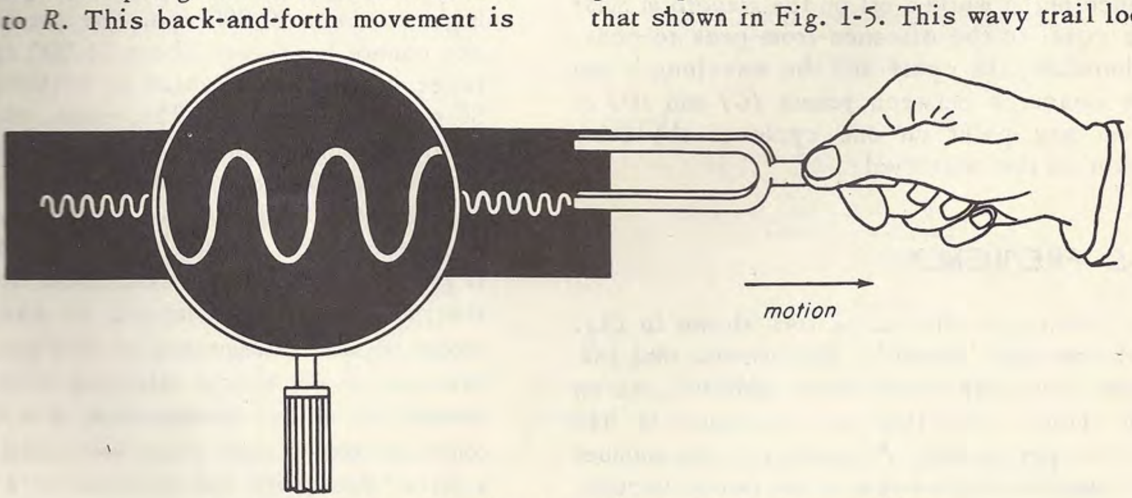

Fig. 1-5

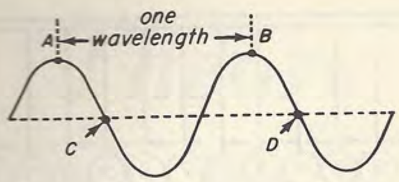

Fig. 1-6

like the waves formed by a falling stone in a still pond. This waveform appears again and again in this course, so let's take a closer look at it in Fig. 1-6. The broken line represents the trail that would have been drawn if the tuning fork had not been vibrating, but had been in the *at rest* position, like the *R* position in Fig. 1-3. The wavy line shows the amount of movement made by the vibrating prong, first in one direction, then the other; in other words, the wavy line is a graph of a sound wave. The straight line distance between the peak *(A)* on the wavy line and the next peak *(B)* is called the wavelength. (If we were to measure a wavelength in water, we would measure the length of a straight line drawn between the highest point of one wave and the highest point of the next one.) The actual path of the wavy trail from *(A)* to *(B)* is called a *cycle.* (In water, we would trace a cycle by starting at the top of a wave and moving along the surface of the water, down into the trough between waves, and up to the top of the next wave.)

Both wavelengths and cycles may be marked off from points other than the peaks of waves. However, remember that the distance being marked off on the waveform must be equal to the distance from peak to peak. Therefore, the cycle and the wavelength can be measured between points *(C)* and *(D)* or from any point on one cycle to the same point on the next cycle.

1-5. FREQUENCY

Looking at the tuning fork shown in Fig. 1-7, we find "A-440". That means that the tone it produces is *A* above middle *C*, as on the piano, and that its frequency is 440 cycles per second. *Frequency* is the number of complete cycles that occur in one second. The frequency of middle *C* is 262 cycles per second (abbreviated *cps*). The lower the note, the lower is the frequency; the higher the note, the higher is the frequency. The rate of travel (velocity) of sound waves is 1,100 feet per second. If we know the frequency of a sound, we can find its wavelength. For instance, the frequency of *A* above middle *C*, as we know, is 440 cps. (The tuning fork will go through one cycle in 1/440 second.) The wavelength can be found by dividing the velocity by the frequency. That will give us the wavelength in feet.

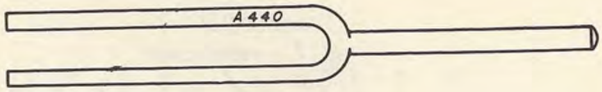

Fig. 1-7

Example:

$$\text{Wavelength} = \frac{\text{Velocity}}{\text{Frequency}}$$

$$= \frac{1,100}{440}$$

$$= 2.5 \text{ feet}$$

1-6. AUDIO FREQUENCIES

Audio frequencies (frequencies we can hear) may be as low as about 20 cps and as high as about 20,000 cps. The average person cannot hear much above 16,000 cps. The range of the human voice is between about 80 cps and 1,200 cps. The piano, which has a wider range than most instruments, goes from about 30 cps to about 4,000 cps in its *fundamental* frequencies. *Fundamental,* as it is used here, means *basic.* For example, if the key for *A* above middle *C* is struck on the piano, the fundamental or basic note produced has a frequency of 440 cps. However, we do not hear a pure tone of 440 cps. Instead we hear a combination of a 440-cps tone and some other frequencies called *harmonics. Harmonics are multiples* of a tone – that is, they are one time its frequency, twice

its frequency, three times its frequency, four or five times its frequency, etc. The note itself is called the fundamental, or the *first harmonic*. In the case of *A* above middle *C*, the *second harmonic* is twice the fundamental frequency, or 2 x 440 cps. The *third harmonic* is 3 x 440 cps, and so on. This can be seen in Table *A*. The note heard from the piano would be made up of a combination of the fundamental and its harmonics. In radio frequencies, we also find harmonics. For that reason, we must understand what is meant by the term.

TABLE A

First harmonic (fundamental)	440 cps (1 x 440)
Second harmonic	880 cps (2 x 440)
Third harmonic	1,320 cps (3 x 440)
Fourth harmonic	1,760 cps (4 x 440)
Fifth harmonic	2,200 cps (5 x 440)
Etc.	

1-7. RADIO FREQUENCIES

Audio waves by themselves can travel only for limited distances. However, we can use radio and telephone equipment to carry audio waves over great distances. When radio equipment is used, audio waves can be sent all over the earth and they can be heard by millions of people at the same time. Radio transmitters send out electrical waves that carry the audio waves. We call these electrical waves the *radio-frequency carrier;* we abbreviate this phrase as r-f carrier. The r-f carrier waves have wavelength, velocity, and frequency, just as do sound waves, but they are very much higher in frequency than sound waves. The standard broadcast band of assigned frequencies starts at 535,000 cps and ends at 1,620,000 cps. To simplify speaking and writing about these frequencies, we use two prefixes: *kilo*, which means *thousand*, and *mega*, which means *million*. We then say 535 *kilocycles* instead of 535,000 cycles, and either 1.62 *megacycles* or 1,620 *kilocycles* instead of 1,620,000 cycles. We abbreviate kilocycles *kc*, and megacycles *mc*. The "per second" is understood.

Radio waves travel at the speed of light: 186,000 miles per second. A radio wave can travel completely around the world in less than a seventh of a second. If the frequency of a radio wave is known, we can find the wavelength with the same formula we used for finding the wavelength of an audio frequency:

$$\text{Wavelength} = \frac{\text{Velocity}}{\text{Frequency}}$$

Customarily, we measure wavelengths of radio waves in meters, but other units may be used (miles, feet, etc.). So, we must change 186,000 miles into meters before we can use the formula. We know that there are 5,280 feet in a mile, 12 inches in a foot, and 39.37 inches in a meter. So we find meters per second as follows:

$$\text{186,000 miles per second} = \frac{186{,}000 \times 5{,}280 \times 12}{39.37}$$

$$= \text{300,000,000 meters per second (approx.)}$$

The symbol for wavelength is λ (Lambda), which is the Greek letter *L* and the symbol for frequency is *f*. The formula for wavelength then becomes:

$$\lambda = \frac{\text{300,000,000 (meters per second)}}{f \quad \text{(cycles per second)}}$$

Example:

If f = 500,000 cps:

$$\lambda = \frac{300{,}000{,}000}{500{,}000}$$

$$= 600 \text{ meters}$$

To find the frequency when the wavelength is known, we change the formula around to:

$$f = \frac{\text{300,000,000 (meters per second)}}{\lambda \quad \text{(wavelength in meters)}}$$

Example:

If $\lambda = 200$ meters:

$$f = \frac{300,000,000}{200}$$

$$= 1,500,000 \text{ cps or}$$

$$1500 \text{ kc or } 1.5 \text{ mc}$$

If you want a simple way to remember the formulas above, try using the circle in Fig. 1-8*a*. To use it, just place your finger over the quantity you want to find, and what remains uncovered shows what you must do to find the answer.

1-8. THE RADIO COMMUNICATION SYSTEM

People who listen to radio programs may be in houses, restaurants, clubs, automobiles, or at the beach, many miles from the broadcasting studios that send out the programs. How the music, story, or news gets from the studio to the listener may be told very simply. *Why* it happens the way it does is something that you must learn. In this lesson you are getting a start toward that knowledge.

Here is a simple explanation of the way one note, *A* above middle *C*, travels from a broadcasting station to the home of a listener. Refer to Fig. 1-9 while you read this explanation.

Figure 1-9 is a block diagram of the route taken by the audio-frequency signal from the microphone to the listener's loudspeaker. It is called a block diagram because it is made up of blocks, each of which represents a large section of the broadcasting

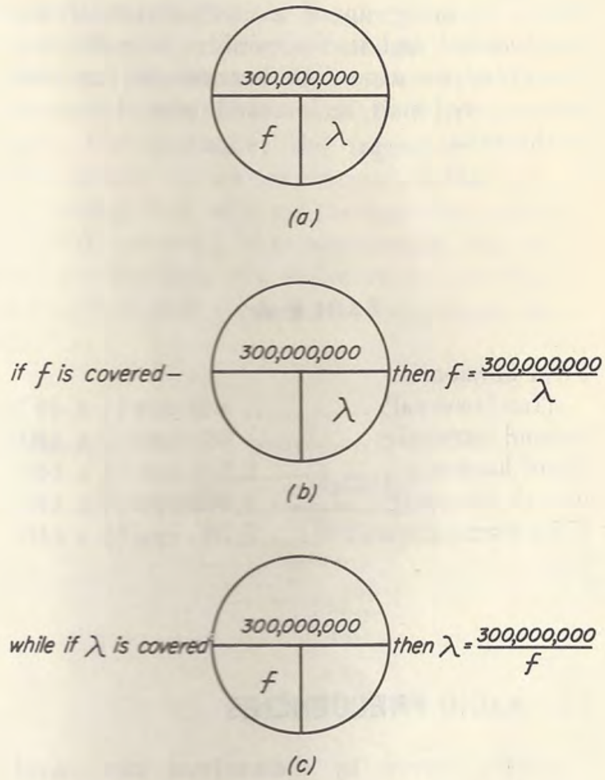

Fig. 1-8

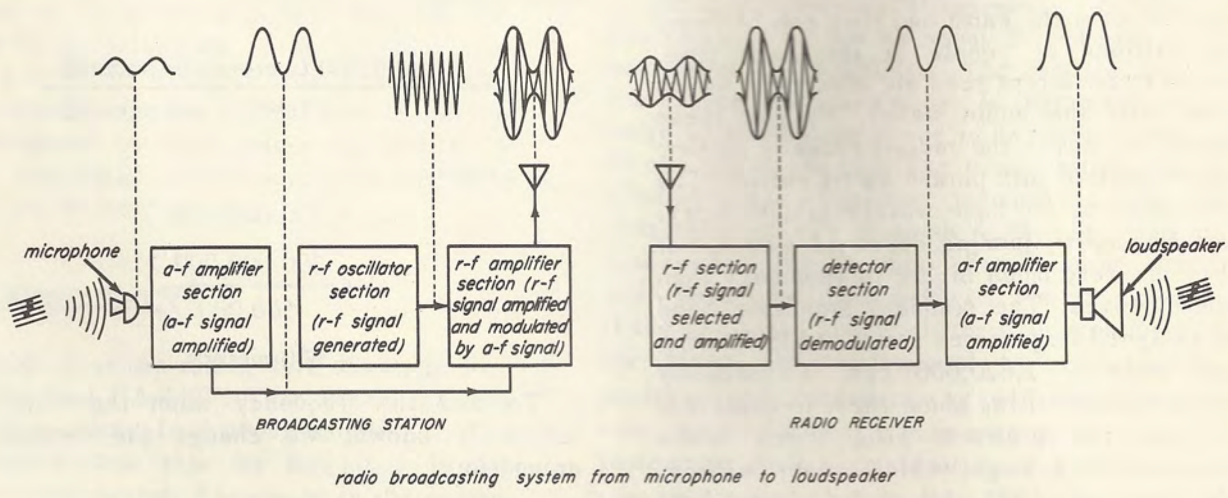

Fig. 1-9

system. Block diagrams are easy to follow because they do not show a lot of confusing apparatus. Notice that *audio frequency* is abbreviated *a-f,* and *radio-frequency* is abbreviated *r-f.*

In Studio A of Station WXXX, one of the musicians of a world-famous orchestra sounds his *A* so that the orchestra can tune up before the concert. As servicemen, we would, of course, refer to *A* as a 440-cycle audio-frequency signal. This wave travelling at the speed of sound in air is picked up by a microphone (where it is changed to electrical energy that travels almost as fast as light). This small amount of electrical energy is carried by wire to a glassed-in booth next to the studio. In the *monitor room*, as the booth is called, an engineer sees that the 440-cycle signal is fed into an *audio-amplifier section.* An audio amplifier is a device used to increase the power of weak audio frequencies, because the very small amount of electrical energy produced when the microphone picks up the audio signal must be increased in power so it can be sent out over the air. On the block diagram, you can see that a small amount of electrical energy goes from the microphone to the audio amplifier. However, it is much greater when it leaves the amplifier on the next stage of its journey. This can be seen by the waveforms above the blocks, which show in a general way the shape and strength of the signal at different points. When the peaks of the waves are higher, the signal is stronger.

The second block in the diagram, the r-f *oscillator section,* represents the device that produces the radio-frequency energy. This energy has no connection with the audio energy at this point. It is produced independently by the r-f oscillator section. This frequency cannot be heard, but it is very powerful. It is called the *carrier frequency,* since, because of it, the 440-cycle note is able to travel to the listener's home. It is the frequency assigned to Station WXXX by the Federal Communications Commission. Each broadcasting station is given a certain frequency to operate on, so that its programs will not interfere with other stations broadcasting at the same time. Station WRCA, in New York, operates on 660 kc; WBBM, in Chicago, operates on 780 kc; KFI, in Los Angeles, on 640 kc; and WFAA, in Dallas, on 820 kc. This system makes it possible to choose the station we want to listen to.

The third block in the diagram is labelled *r-f amplifier* section. In this section, the *r-f carrier wave* is amplified. It is also mixed with the audio-frequency signal in this section. This mixing is called *modulation.* The modulated signal (the mixture of the audio frequency and the carrier frequency) then goes to WXXX's antenna, and travels out into space.

The listener, in his home, is tuned to WXXX's frequency. A small portion of the energy broadcast by the radio station is picked up on the listener's antenna, and from there it travels to his radio receiver. The block diagram shows that it enters the *radio-frequency section.* It can enter this stage because the receiver is tuned to its frequency. The weak r-f signal is amplified in this section, so that it is much stronger when it leaves. Then it travels to the *detector section,* where the radio frequency is *demodulated,* or *detected.* This means that the audio frequency is separated from the radio-frequency carrier. This process is called *detection.* After this takes place, only the 440-cycle audio frequency is left. It is still too weak to be heard over the loudspeaker, so it travels through an *audio-frequency amplifier* section to be built up. Leaving the amplifier, it goes to the loudspeaker and causes the speaker to vibrate at the rate of 440 cps. As a result, the listener hears the musical tone *A* above middle *C.*

1-9. NEED FOR BASIC ELECTRICAL KNOWLEDGE

The explanation you just read of the broadcasting system is very simple. It does not explain the *how* and the *why* of the radio apparatus mentioned. To understand a full explanation of radio systems, you must have

a complete knowledge of the principles of electricity and electronics. No one would try to build a skyscraper like the Empire State Building, a bridge like the Golden Gate Bridge, or a dam like Hoover Dam without first learning all he could about bricks, stone, cement, structural steel, cables, and so on. Just as a builder would have to know about these things, so a serviceman has to know about resistors, capacitors, inductors, and electron tubes before he can understand radio and television.

In the lessons that follow, you will learn something about electricity and electron tubes. You must do this before you can understand how and why radio and TV circuits work. With the knowledge obtained in these early lessons, you will be able to study and work with radio and TV circuits. However, this knowledge won't be yours unless you try, and keep on trying, to learn everything that will contribute to a better understanding of basic theory. In the beginning, you may find that it takes a lot of effort to master the basic principles. However, when you do master them, you'll find the later lessons much easier to understand. Remember – a thorough knowledge of radio and TV is very valuable. It is worth all the effort you put into it.

ELECTRONIC FUNDAMENTALS

EXPERIMENT LESSON 1

HOW TO SOLDER

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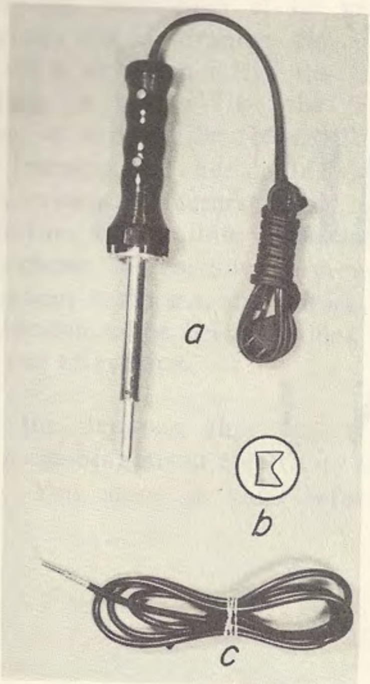
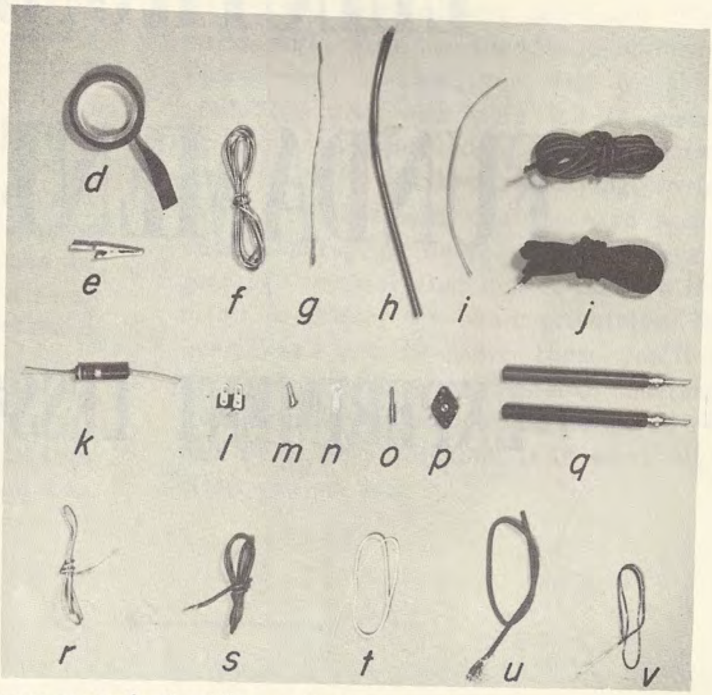




Note: If two or more parts look alike, only one is shown

All the parts in Kit 1 are listed below. Check the parts you receive against this list. Make sure you have the correct quantity of every item. If a part is either missing or defective upon arrival, request a replacement from Department R, Home Study School, RCA Institutes, Inc., 350 West 4th Street, New York 14, N.Y. *Your request must include your name and student number, the complete name and description of the part copied from the Item column below, the Quantity missing or defective, and the reason you are asking for a new part.*

KIT 1

BILL OF MATERIALS

Quantity	Item
1.	a. Soldering iron
1	b. Stand for soldering iron
3′	c. Coaxial cable
1	d. Roll of plastic electrician's tape
6	e. Alligator clip
10′	f. Rosin-core solder
6″	g. Solid solder
6″	h. Large spaghetti
1′	i. Small spaghetti
2	j. Test-lead wires (4′ each) 1 red, 1 black
6	k. Resistor, 5%
	To read resistor values, hold resistor with bands to left, as shown in Figure. Read bands from left to right. (Gold band = 5% tolerance, Silver band = 10% tolerance, No band = 20% tolerance)
	(1) Brown, Black, Brown = 100 ohms
	(1) Red, Red, Brown = 220 ohms
	(1) Orange, Orange, Brown = 330 ohms
	(1) Brown, Black, Red = 1,000 ohms
	(1) Brown, Black, Orange = 10,000 ohms
	(1) Brown, Black, Yellow = 100,000 ohms
2	k. Resistor, 20%
	(1) Brown, Black, Orange = 10,000 ohms
	(1) Brown, Black, Yellow = 100,000 ohms
2	l. Two-lug terminal strip
18	m. Wood screws (#6)
2	m. Wood screws (#4)
13	n. Ground lug
4	o. Phone tip
1	p. 7-pin miniature tube socket
2	q. Test prod (1 red, 1 black)
1′	r. Shielded phono lead
1′	s. Stranded pushback wire
1′	t. Solid tinned pushback wire
1′	u. Rubber-covered stranded fixture wire (untinned)
1′	v. Enameled solid wire (untinned)

If you get a part slightly different from a part described in this list, the substitute part will not interfere electrically or mechanically with your experiments or equipment.

Experiment Lesson 1

OBJECT

The object of the experiments in this lesson is to learn:

1. How to solder with an electric soldering iron.
2. How to tell when solder has properly set (hardened) by looking at it.
3. How to prepare materials for soldering.
4. How to join wires together.
5. How to make soldered connections.
6. How to unsolder connections.

INFORMATION

Of all the practical things a serviceman must know how to do, nothing is more important than knowing how to solder. Look at any radio or television chassis and see all the soldered connections. The people who make these receivers know that soldered connections last longer and cause less trouble than connections made in any other way. To maintain and repair such equipment, you must know how to solder and unsolder.

Soldering is the uniting of metals with solder. Solder is a fusible alloy. In plain words, solder is a combination of metals that melts at a lower temperature than the metals it will hold together. There are two main classes of solder: hard solder and soft solder. Soft solder is usually used in radio and other electronic equipment.

Soft solder is usually a mixture of tin and lead. The most popular solder among servicemen is a combination of 50 percent tin and 50 percent lead, which is usually written 50/50. The first figure always indicates the percentage of tin, and the second figure the percentage of lead. Chart A shows that 50/50 solder starts to melt at 361 degrees F and is liquid at 414 degrees F. Between these two temperatures, it is said to be in a *plastic* state. Looking at Chart A again, we find that some combinations of tin and lead are plastic for a greater change in temperature, while others are plastic for a smaller change in temperature. Those that have a

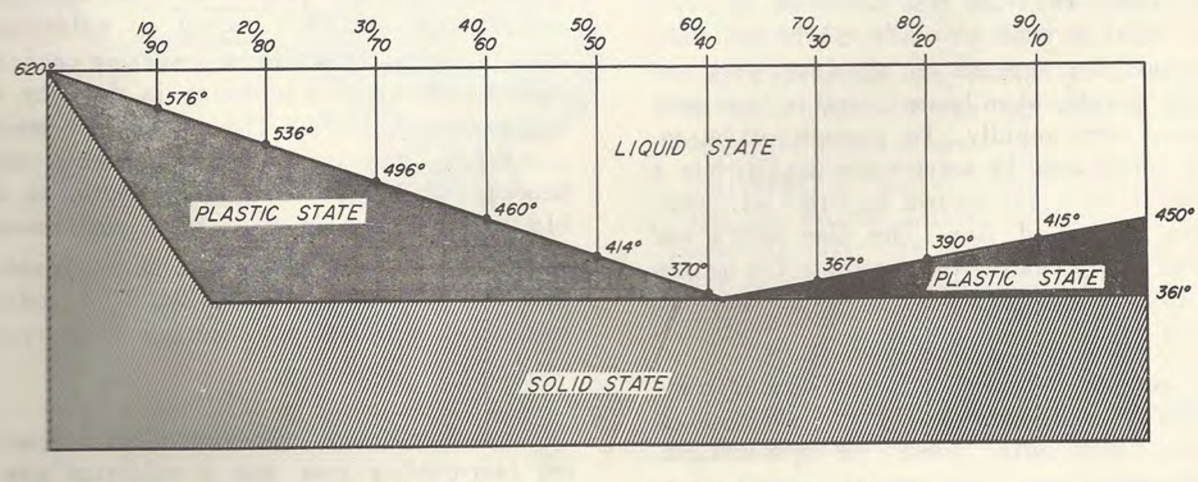


CHART A – TIN-LEAD RATIO CHART

greater change in temperature during the plastic period take longer to harden than those with a smaller change. For example, 20/80 and 30/70 solders harden very slowly; 40/60, 50/50, 70/30, and 80/20 solders harden more quickly, and 63/37 solder hardens almost instantly. Notice that some combinations of tin and lead melt at a lower temperature than either of these metals melts at by itself.

In choosing a solder, remember:

1. Slow-cooling solders tend to make smoother joints.

2. When work is held upright, the solder tends to flow down, away from the joint. Therefore, quick-hardening solders should be used when the parts to be joined cannot be held flat.

3. Solders containing from 55 percent to 70 percent tin are stronger than those containing more lead.

4. The best solder you can buy is usually the cheapest in the long run. There is less waste.

Most servicemen use 50/50 solder because it is the best single combination for all the requirements listed above.

Flux. The surface of a metal tends to combine with the oxygen of the air to form an *oxide.* The rust that forms on iron and and steel is such an oxide. So is the white coating that appears on aluminum pots and pans. Metals, when heated, tend to form such oxides very rapidly. To prevent oxidation, the solder used by servicemen usually has a core of rosin, as shown in Fig. 1-1. This rosin is called *flux.* The flux melts and forms a thin coating that protects the metals of the joint from oxidizing while they are being heated.

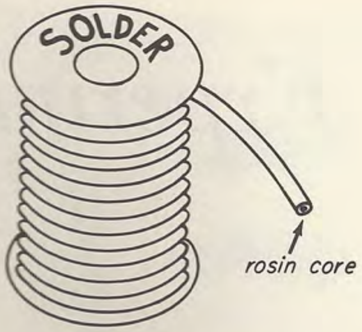


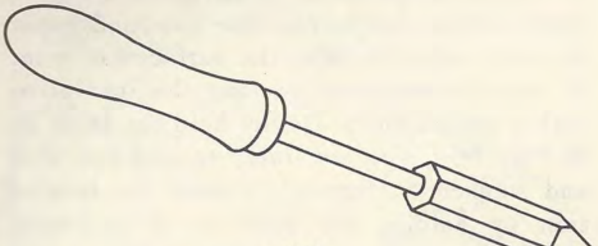
Fig. 1-1

There are two main classes of flux: *corrosive* and *noncorrosive*. The corrosive fluxes most often used are hydrochloric acid (sometimes called muriatic acid), zinc chloride, and sal ammoniac. These fluxes are not used in radio wiring because it is practically impossible to clean away all the acid after the joint is made. If acid remains, it eats away at the joint and, sooner or later, causes trouble. The most popular noncorrosive fluxes are rosin and tallow. In addition, paste fluxes, which are said to be noncorrosive, are made. However, unless all paste flux is carefully removed after the joint cools, dust collects around the joint and absorbs moisture. This may cause a chemical action that may produce an *open circuit.* If not, the electrical joint may be come so poor that it causes the receiver to be noisy. For soldering copper and brass in radio work, rosin is by far the best flux that we know of.

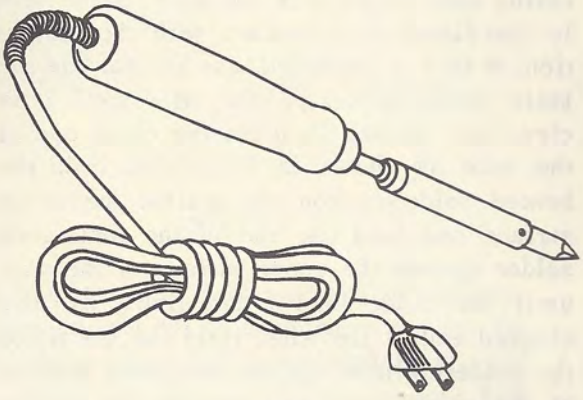
Solder comes in many forms: in solid 1-1/2-pound bars, as solid solder wire, as flux-core solder wire, in pellets, and in special shapes made to order.

Soldering Irons. While the tool used in soldering is generally called a *soldering iron,* it could be called a *soldering copper,* because the actual soldering is done by a heated copper tip. There are two main classes of soldering irons: those that are heated by a gas flame, live coals, or a blowtorch (shown in Fig. 1-2*a*), and those that are heated by an electric heater inside the iron (shown in Fig. 1-2*b*). Most radio work is done with an electric iron – the type sent you in Kit 1.

Some servicemen who want a quick-heating fast-cooling iron use a soldering gun (shown in Fig. 1-3) on service calls or for occasional use at the workbench. However,



(a)



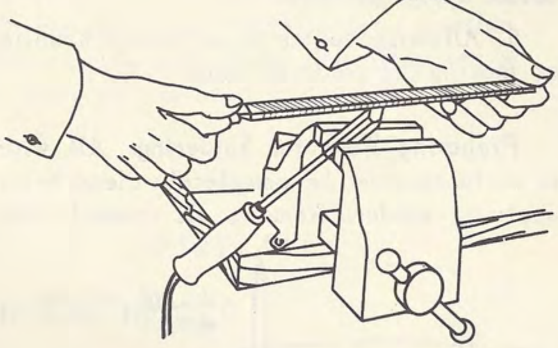
(b)

Fig. 1-2

soldering guns are expensive and not suited for continuous duty. If you do a lot of soldering at a time, use a soldering iron.

Tinning the Soldering Iron. The tip of a soldering iron must be coated with solder. This is called *tinning*. Unless the tip is kept clean and well tinned, the copper surface becomes oxidized and pitted. When this happens, the iron does not supply enough

Fig. 1-3



filing soldering iron tip

Fig. 1-4

heat to solder properly. To do good soldering, keep your iron clean and well tinned. When not in use, the iron should be disconnected from the electric outlet, or it will tend to overheat and oxidize. When the tip of your iron is dirty, or has a dull color, wipe it with a clean cloth so that the tip looks shiny. If wiping does not give the tip a shiny look, the tip is oxidized or pitted; file it smooth and then tin the tip before starting to solder.

Tin the iron by carefully following these steps:

1. Let the iron heat up. While it is hot, file one side of the tip (see Fig. 1-4) until the copper looks bright and clean.

2. Immediately apply rosin-core solder to the clean surface until the side of the tip is coated with a thin layer of solder.

3. Repeat the first two steps for each of the other sides of the tip. Use a file to smooth the rough edges.

4. When all sides of the tip are tinned, wipe the excess solder and flux off with a clean rag. Wipe the tip after soldering each joint and it will remain clean longer.

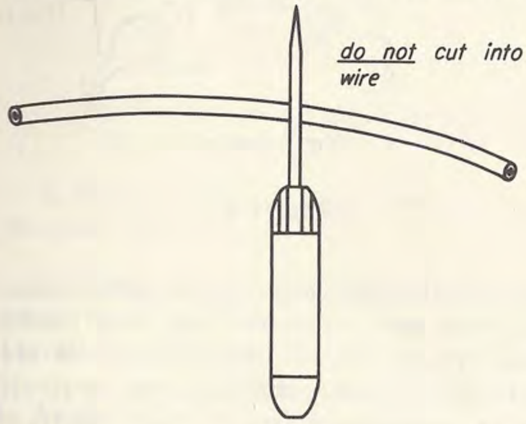
A well-soldered joint depends on:

1. Soldering with a clean, well-tinned tip
2. Cleaning wires or parts to be soldered
3. Making a good mechanical joint before soldering

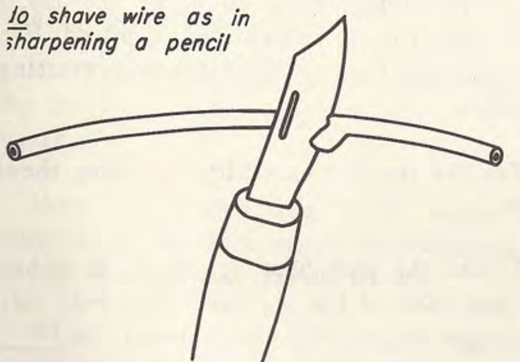
4. Allowing the joint to get hot enough before applying solder

5. Allowing solder to set before handling or moving the soldered parts

Preparing Work for Soldering. All wires or surfaces must be completely clean before applying solder. Remove all enamel, dirt, scale, or oxidation by sanding or scraping down to the bare metal. Use fine sandpaper or emery paper to clean flat surfaces or wire. If wire is insulated, remove the insulation with a pocket knife. Do not hold the knife as in Fig. 1-5*a*; you are liable to nick the wire and weaken it. Instead, remove the insulation by holding the knife as if you were sharpening a pencil (as shown in Fig. 1-5*b*), taking care not to nick the wire. If the wire is discolored from contact with the insulation, or if it is enameled, use the back of the knife blade to scrape the wire until it is clean and bright. Then tin the clean end of the wire as shown in Fig. 1-5*c*. Hold the heated soldering-iron tip against the under surface and hold the end of the rosin-core solder against the upper surface of the wire until the solder melts and flows on the cleaned end of the wire. Hold the hot tip of the soldering iron against the under surface of the tinned wire and remove the excess solder by letting it flow down on the tip. When properly tinned, the exposed surface of the wire should be covered with a thin, even coating of solder.



(a)



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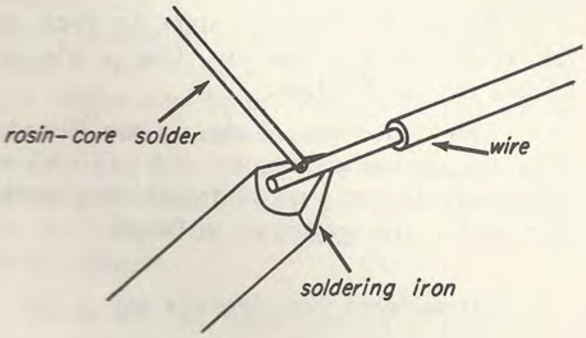


(c)

Fig. 1-5

Making a Good Mechanical Joint. Unless you are making a temporary joint, the next step is to make a good mechanical connection between the parts to be soldered. For instance, wrap wire carefully and tightly around a soldering terminal or soldering lug. Bend wire and make connections with long-nose pliers – not with your fingers. Oil or grease from your fingers will cause the solder to run off the joint instead of sticking to the metal. When connecting two wires together, make a tight *splice* (a joining together) before soldering. Figure 1-6 shows how some of these connections look when they are properly made. When a good mechanical contact is made, you are ready for the actual soldering.

Soldering A Joint. The next step is to apply the soldering iron to the joint. In soldering a wire splice, hold the iron below the splice and apply rosin-core solder to the top of the splice, as shown in Fig. 1-7. If the tip of the iron has a little bit of melted solder on the side held against the splice,

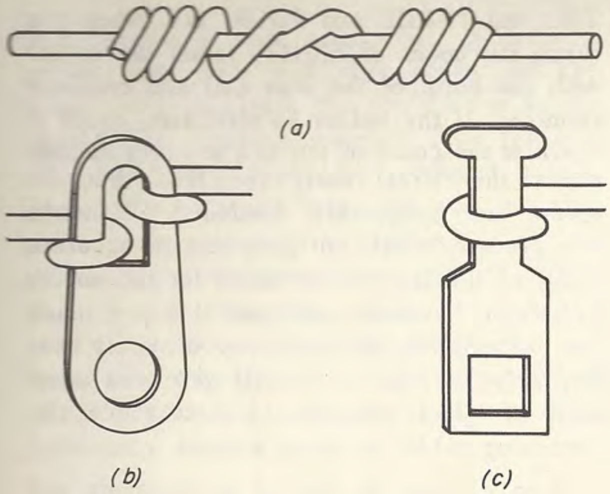


Fig. 1-6

heat is transferred more readily to the splice, and the soldering is done more easily. Be sure not to disturb the soldered joint until the solder has had a chance to set. With 50/50 solder, it may take a couple of seconds or more for the solder to set, depending upon the amount of solder used in making the joint.

METHOD

In the experiments that follow, you will find out how to tell when solder has hardened properly and what happens when it hasn't. You will also be shown the proper methods to use in soldering different kinds of wire. In addition, you will solder radio resistors to terminals mounted on a *breadboard* for use in later lessons. Servicemen call the

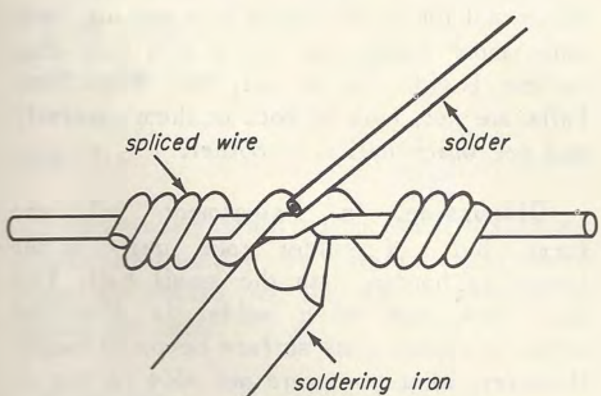


Fig. 1-7

wooden board on which they mount parts temporarily for experimental purposes a *breadboard*. So, when these lessons mention breadboard, you will know that it means a board such as you used in the first part of this lesson.

PART ONE

EQUIPMENT NEEDED

Soldering iron and stand from Kit 1
Rosin-core solder from Kit 1
Piece of cloth for cleaning iron
Piece of box wood or other board about 4" x 9"
Nail, two or three inches long

EXPERIMENT 1-1

To melt some solder and watch it change appearance as it hardens.

Procedure.

Step 1. Connect your soldering iron to an electric outlet. Allow it to heat for several minutes.

Step 2. Unroll about five inches of the rosin-core solder.

Step 3. Test the temperature of the iron by touching one side of the tip with the end of the solder, as shown in Fig. 1-8*a*. The solder should melt freely.

Step 4. Hold the iron over the board with the tip down, as in Fig. 1-8*b*. Touch the solder to the tip of the iron and let a small ball of solder form and roll off onto the wooden board, as shown in Fig. 1-8*b*. Immediately, watch the solder as it hardens.

Discussion. As you watched the solder harden in Experiment 1-1, you noticed that the melted solder was, at first, shiny as a mirror. After a few seconds, the entire ball

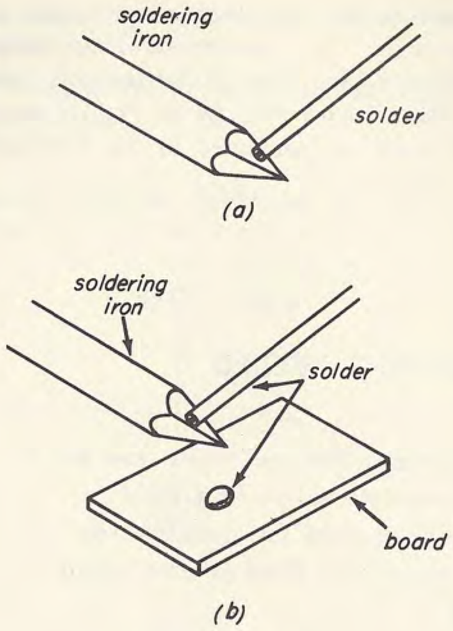


Fig. 1-8

gradually changed to a slightly dull silver, starting from the bottom and working up. The last part to change was at the top. When a soldered joint is cooling, this change in color always takes place. Then the change is rapid, because the metals that are soldered together rapidly draw off the heat from the hardened solder. It is important that you learn to know when a soldered joint is hardened just by looking at it. In this way, you will avoid disturbing solder before it is hardened.

EXPERIMENT 1-2

To discover how long it takes 50/50 melted solder to harden. To learn what happens when solder is disturbed before it hardens and how it appears when it is impure.

Procedure.

Step 1. Heat the ball of solder again until it is melted and then quickly remove the iron. Immediately start counting the seconds it takes for the solder to harden. If you do not have a watch or clock with a second hand, try counting slowly: ONE and TWO and THREE and FOUR, etc. When you reach the count of EIGHT, touch the solder with the point of the iron nail and continue counting. If the solder is still soft, touch it again at the count of ten and at every second count thereafter, until you find that the solder is completely hardened. Although this procedure will not give you an accurate count of the seconds it takes for the solder to harden, because each time that you touch the solder with the nail, you draw off heat and help to cool it, it will give you some idea of when you should first touch the hardening solder in the next step.

Step 2. Heat the ball of solder again and start counting as before. Touch the solder with the point of the nail when you reach the *highest count* you made in Step 1. The solder may still be a little soft, so, as you continue your count, touch it at every second count until the solder is completely hardened. Repeat this several times until you find that the solder is hardened on your first touch with the nail.

Step 3. Melt some solder with your iron and let it roll off on to the board until you have a ball three or four times as large as the first one. Immediately start counting and, as before, see how long it takes for this larger ball of solder to harden.

Step 4. Heat the larger ball of solder again and touch it with the point of the nail several times as it hardens. Look closely at this solder so that you will know how solder looks when it has been disturbed before hardening.

Step 5. Heat the smaller ball of solder again and let it set. While it is setting, heat some more solder and let a new ball drop on the board. Let it set, too. When both balls are set, look at both of them carefully and see which ball is smoother.

Discussion. In Experiment 1-2, the large ball of solder took quite a bit longer to harden than the small ball. You also saw that when solder is disturbed before it hardens, its surface becomes rough. However, what you were not able to see is that solder that is disturbed while hardening tends to break up, lose a lot of its strength,

and become a poor conductor. In Step 5, unless your iron was very clean and the board was very clean, the new ball of solder should have looked smoother than the one that had been resoldered several times. The solder that had been reheated probably picked up impurities from the wood, the iron, and the air. It was not as good as it was when first melted. For that reason, it does not pay to resolder old solder droppings and reuse them in your soldering. The impurities in the solder may cause weak, noisy, high resistance joints.

PART TWO

EQUIPMENT NEEDED.

Length of tinned solid pushback wire from Kit 1

Length of untinned enameled solid wire from Kit 1

Length of tinned stranded pushback wire from Kit 1

Length of rubber-covered stranded fixture wire from Kit 1

Plain wire solder from Kit 1

Pocket knife

Piece of fine sandpaper

Equipment used in Part One

12 wood screws from Kit 1

12 lugs from Kit 1

Long-nose pliers

Awl or scriber

JOB 1-1

To compare plain solder with rosin-core solder for tinning. To join two pieces of wire, one tinned and the other untinned. To solder the joint.

Procedure.

Step 1. Take the tinned solid pushback wire and pull back the insulation so that about two inches of wire shows. Hold the wire with your long-nose pliers as you pull the insulation back.

Step 2. With a knife, remove about two inches of insulation from the enameled solid wire. Be careful not to cut or nick the wire.

Step 3. After the insulation is removed, clean the exposed wire with the back of the knife blade or with sandpaper. Clean it until the copper shows brightly.

Step 4. Using the plain wire solder, try to tin the wire you just cleaned. You will find that plain solder, without flux, makes soldering very difficult. Clean the wire again and try tinning it with the rosin-core solder. You should find it much easier to do. Wipe the tinned wire and, if necessary, continue tinning.

Step 5. With the tinned pushback wire and the wire you just tinned, form the splice shown in Fig. 1-9.

Step 6. When the splice is completed, solder the joint. Do not move either wire until the solder sets.

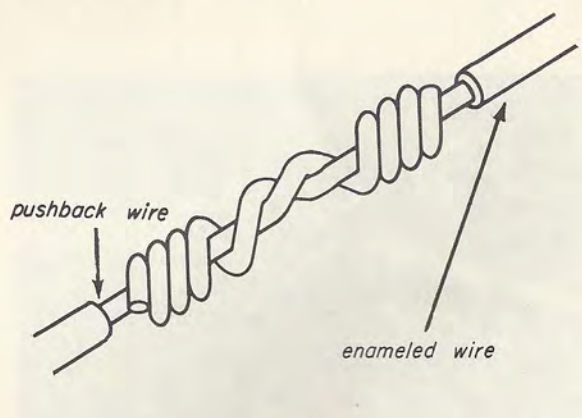


Fig. 1-9

JOB 1-2

To make a splice with two kinds of stranded wire.

Procedure.

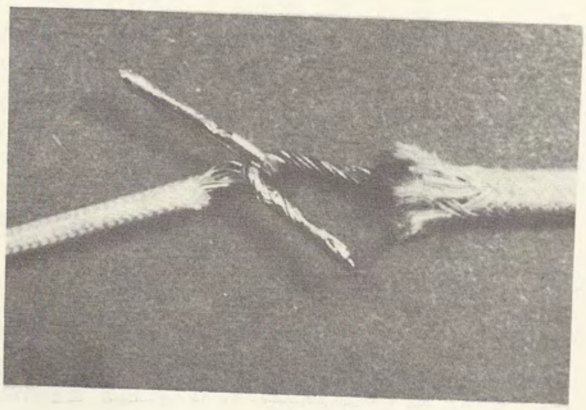
Step 1. Expose about one inch of the tinned pushback wire. Twist the strands tightly together and tin the twisted strands.

Step 2. With a knife, remove one inch of insulation from the rubber-covered fixture wire. Fan the strands, as shown in Fig. 1-10*a*, and clean each strand carefully with sandpaper, until it shines brightly.

Step 3. Tin the strands of the fixture wire and remove the excess solder with the cloth. Twist the strands together and tin them again.

Step 4. With long-nose pliers, form a hook with the exposed end of each of the two wires you have prepared. Had you not tinned both wires, the strands would have loosened as you formed the hooks. Hook them together as shown in Fig. 1-10*b*. Melt some solder on the tip of the iron and solder the joint. This is a temporary joint used by servicemen while making tests or when connecting parts for a short time only. This joint can easily be unsoldered.

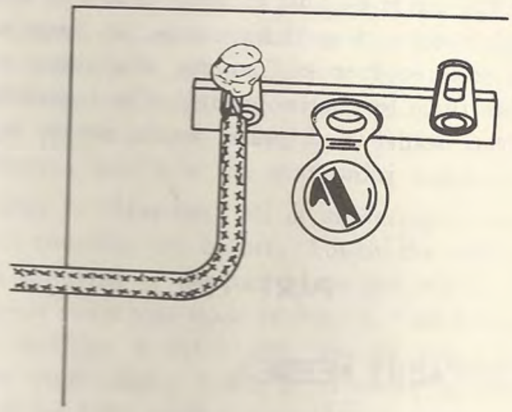
(a)



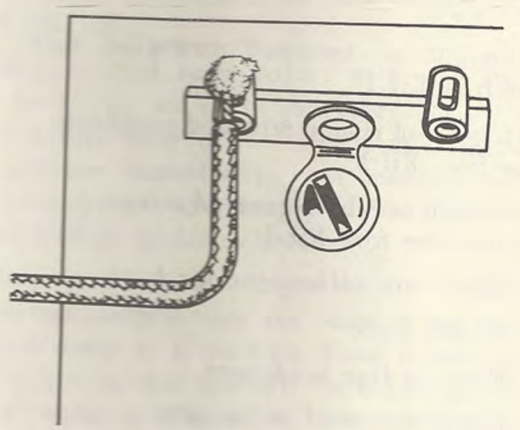
(b)

Fig. 1-10

Information. Now let us consider the appearance of the joint after it is soldered. A well-soldered joint starts off as a tight mechanical joint before solder is applied. No more solder is used than is necessary. A large gob of solder, as in Fig. 1-11*a*, is a sign of poor soldering. When the surface of the solder is rough, as it is in Fig. 1-11*b*, it usually means that the iron was not hot enough, that the iron was not kept on the joint long enough to heat it properly, or that the joint was disturbed



(a)



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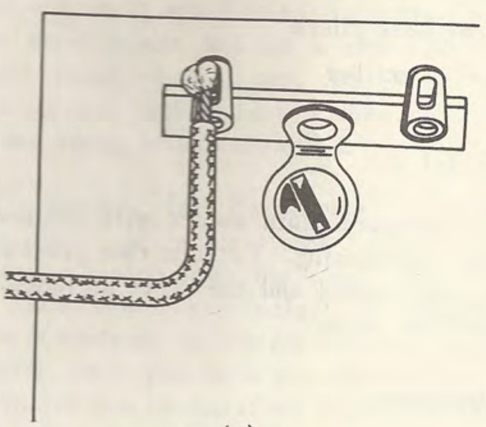


(c)

Fig. 1-11

before the solder hardened. Well-soldered joints look like those in Fig. 1-11*c*. Try to make joints tight and with a smooth, even coating of solder.

The last paragraph says that one reason for poorly soldered joints is that the hot soldering iron is not kept on the joint long enough to heat it properly. However, there are times during the soldering of parts used in radio and TV receivers when, if the iron is kept on the joint too long, the part may change value or may become so badly damaged by overheating that it must be replaced by a new part. For example, during the soldering of carbon composition resistors, overheating may permanently change the value of a resistor. This change in value may be so great that the resistor may cause the circuit to operate incorrectly. Many phono players and radio combinations use a crystal in the phono pick-up arm (the part at the end of the pick-up arm that is connected to a needle that rides in the record grooves). When too much heat is applied to a phono crystal, it may become completely destroyed and need to be replaced by another crystal. Too much heat applied to rotary-switch contacts may cause them to lose springiness and make poor connection with the switch arm or blade.

In such cases, the technician has the problem of heating the connection long enough to have the solder flow properly, and, at the same time, of heating it fast enough so that the part being soldered does not become overheated. From this, you can see that soldering is not simply a matter of keeping the soldering iron on the joint long enough for the solder to flow. Good soldering also requires knowing something about the effects of too much heat on certain parts, so that each step in the making of a joint may be planned before the actual soldering begins. In this way, the soldering may be done efficiently and well in the least amount of time.

JOB 1-3

To mount twelve lugs on a breadboard and to make soldered connections to them.

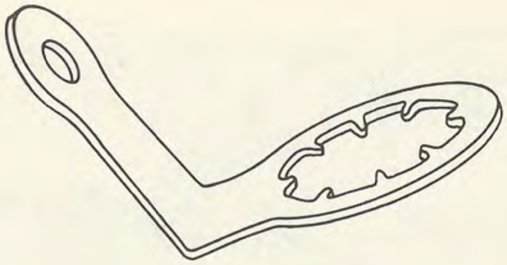


Fig. 1-12

Procedure.

Step 1. Take each of the 12 soldering lugs and, with your long-nose pliers and fingers, bend it about 90 degrees, as shown in Fig. 1-12.

Step 2. The 12 lugs are to be mounted on the 4 x 9-inch breadboard. So, with a pencil, mark off two rows of six dots, as shown in Fig. 1-13.

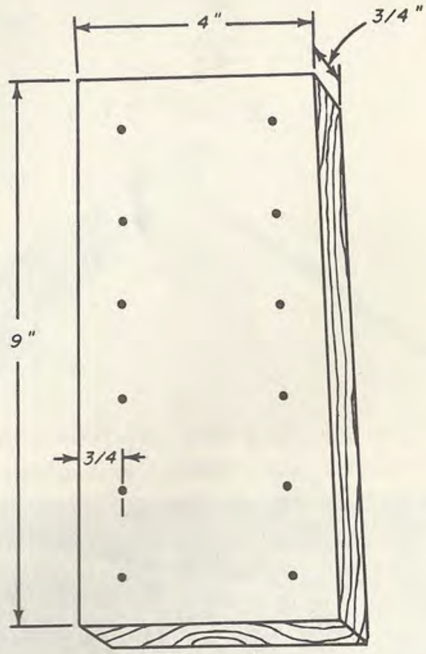


Fig. 1-13

Step 3. With your awl or scriber, make a starting hole about 1/8-inch deep in the center of each dot.

Step 4. Using the small round-head wood screws, mount each of the 12 lugs at the points marked on the breadboard. Face each lug in the direction shown in Fig. 1-14.

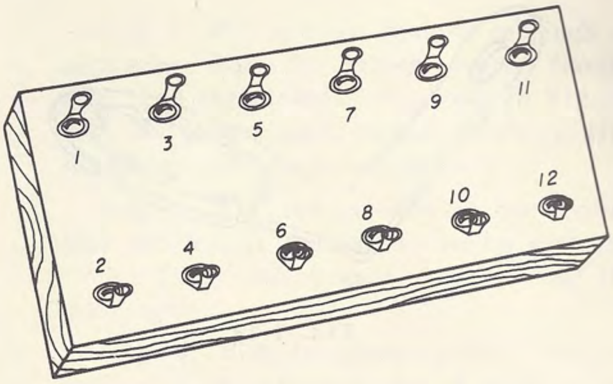


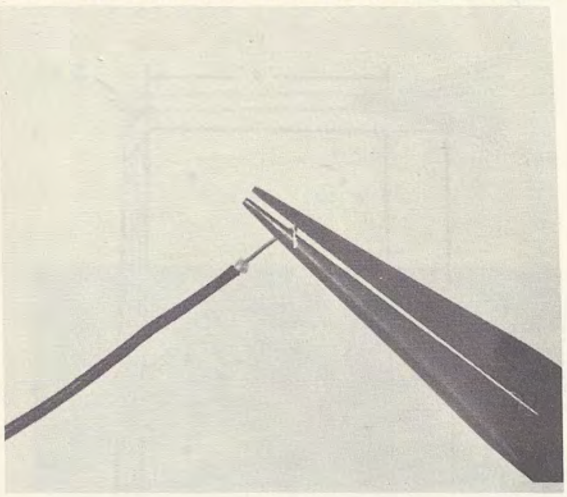
Fig. 1-14

Step 5. Cut away the joints between the two solid wires and between the two stranded wires that you soldered in Jobs 1-1 and 1-2 This will leave about eight inches of each wire.

Step 6. Push back about 1/2-inch of insulation from each end of the solid tinned hook-up wire. With your long-nose pliers, bend one end to form a hook, as shown in Fig. 1-15*a*.

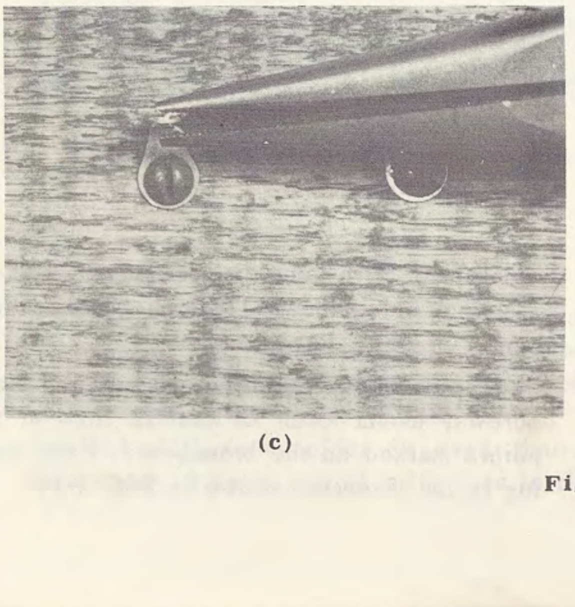
Step 7. Insert the hook in lug #1 and solder it as shown in Fig. 1-15*b*. This is a temporary joint, because a good mechanical joint was not made before soldering.

Step 8. Form a hook at the other end of the same wire and slip the hook into the second lug. With your long-nose pliers, squeeze the hook together tightly, as shown in Fig. 1-15*c*. Solder this connection. Be



(a)

(b)



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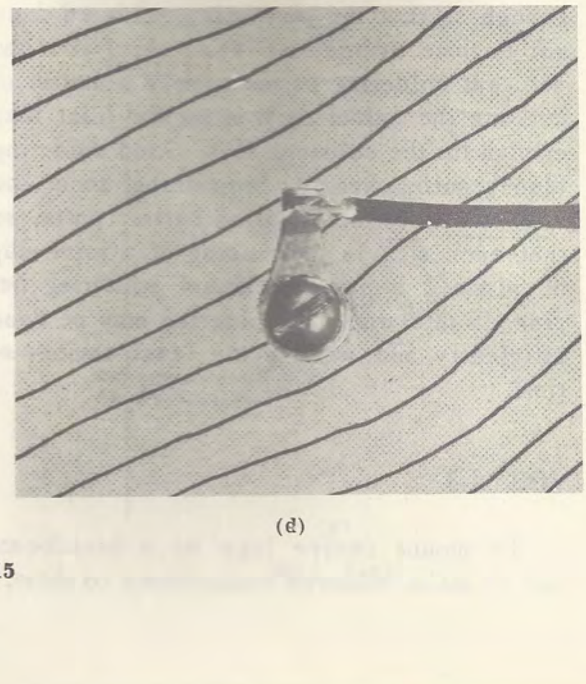


(d)

Fig. 1-15

sure not to use too much solder. When you are through, it should look like the joint shown in Fig. 1-15*d*.

Step 9. Push back about 1/2 inch of insulation from each end of the eight-inch length of stranded hook-up wire.

Step 10. Twist the strands together tightly at each end of this lead and tin each twisted end.

Step 11. With your long-nose pliers, form a hook at each end, as you did with the solid wire. Slip the hook of one end into the third lug and solder the connection. This, too, is a temporary soldered joint because a good mechanical joint was not made before soldering.

Step 12. Slip the hook of the other end into the fourth lug. Squeeze the connection together with your long-nose pliers to make a good tight connection. Solder this connection.

Discussion. Stranded wire should always be twisted tightly and tinned before connecting to a lug or tie terminal. Unless you do this, stranded wire tends to unravel as you bend it and as the hot solder cools after the joint is made. This may produce a cold-soldered joint. In any event, it will produce a poor-looking joint.

In soldering connections like those you have made to the four lugs on the breadboard, always be careful not to touch the insulation with the tip of the hot iron. The heat of iron may burn or melt the insulation. It is a good idea to push insulation back so that it is at least 1/4 inch from the joint to be soldered. After the joint is made and has hardened, the insulation may be pushed back until it meets the joint.

When making temporary connections, and sometimes even when making permanent connections, it is necessary to keep a little tension on the wire. This is done so that the hook is held tightly against the lug while soldering and, particularly, while the soldered joint is cooling. One way to do this is to place a weight on the free end of the wire, as shown in Fig. 1-16, to hold the wire taut as you solder the connection.

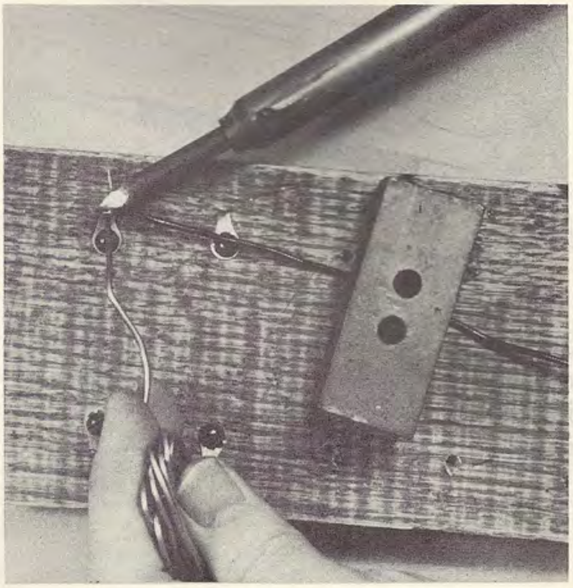


Fig. 1-16

PART THREE

EQUIPMENT NEEDED

The equipment used in Part Two

INFORMATION

In Part Three, you will get some experience in unsoldering connections. Servicemen often must unsolder parts to test or replace them. Unless great care is taken while unsoldering, good parts may be broken and have to be replaced needlessly. For example, the lugs on tube sockets, tie terminals, switches, and other parts may break off while a good, tight connection is being unsoldered. Also, the leads of small resistors and capacitors may break off if they are not handled carefully. In addition, unsoldering of resistors and other parts affected by heat must be done carefully and quickly to prevent damaging these parts. Therefore, it is just as important for you to know how to unsolder a connection as to know how to

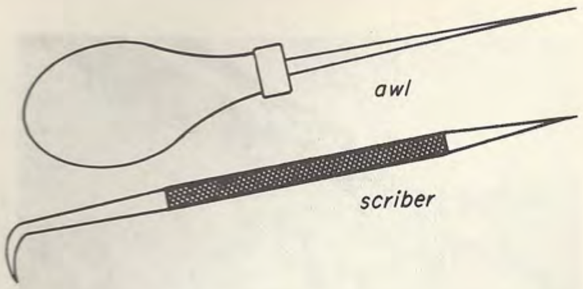


Fig. 1-17

solder a connection. So, in this lesson and in the next lesson, you will get some practice in unsoldering as well as in soldering.

JOB 1-4

To unsolder the four connections made on the breadboard.

Procedure.

Step 1. Put a small bit of solder on one side of your hot soldering-iron tip. (The melted solder on the tip helps to heat the joint more quickly.) Press this side of the tip against the temporary joint on lug #1. Because this is a temporary joint, the wire will unhook easily as soon as the solder melts. Clean the solder from the lug by applying the hot iron until the solder is melted and then by immediately wiping the lug with the cloth.

Step 2. Apply the hot tip against the joint on lug #2. When the solder is melted, insert the scriber or the awl (Fig. 1-17) in the loop of the wire (Fig. 1-18). Carefully open the loop without bending or breaking the lug. When the loop is opened wide enough, slip the wire off the lug. Clean the solder off the lug with the cloth.

Step 3. Using the same method as in Steps 1 and 2, remove the stranded wire from lugs #3 and #4. Clean the lugs.

Discussion. When unsoldering connections and parts in radio and TV equipment, there are several things you must remember:

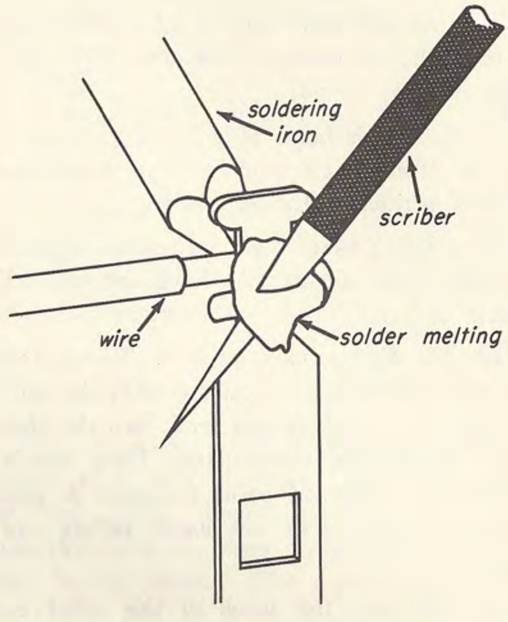


Fig. 1-18

1. Use a "wet" soldering iron tip. In other words, be sure that there is a little melted solder on the face of the tip so that the joint may be heated more quickly.

2. When the solder on the joint is melted, you must work quickly and carefully to loosen the connection. Remember that resistors and some other parts may be damaged by overheating.

3. When loosening a wire lead with an awl, ice-pick, or scriber, be careful not to bend the lug or tie point to which it is attached. Apply pressure evenly between the lug and the wire. Do not try to pull or shake the wire loose from the lug.

4. When unsoldering connections from a tube socket, hold the work in such a position that the solder cannot flow down into the socket.

PART FOUR

EQUIPMENT NEEDED

Six carbon composition 5% resistors from Kit 1 in the following values:

100 ohms

220 ohms

330 ohms

1,000 ohms

10,000 ohms

100,000 ohms

Equipment used in Part Two

INFORMATION

In this part of the lesson, you will wire a resistor breadboard that you will use in later experiment lessons. Right now, you will apply some of the knowledge of soldering that you have gained thus far in the lesson. You will mount each resistor between two tie lugs and solder it in place. The resistors are the same kind you would find in any good grade of radio or TV receiver. It is very important that you mount each resistor in the order given in the instructions that follow.

JOB 1-5

To mount six resistors between the twelve lugs on the breadboard.

Procedure.

Step 1. Mount the 100-ohm resistor on the breadboard between the first two lugs, as shown in Fig. 1-19. Be sure to make a good, tight joint. Then solder each resistor lead to its tie terminal.

Step 2. Solder the 220-ohm resistor to the next two terminals.

Step 3. Solder the 330-ohm resistor to the next two terminals.

Step 4. Solder the 1,000-ohm resistor to the next two terminals.

Step 5. Solder the 10,000-ohm resistor to the next two terminals.

Step 6. Solder the 100,000-ohm resistor to the last two terminals.

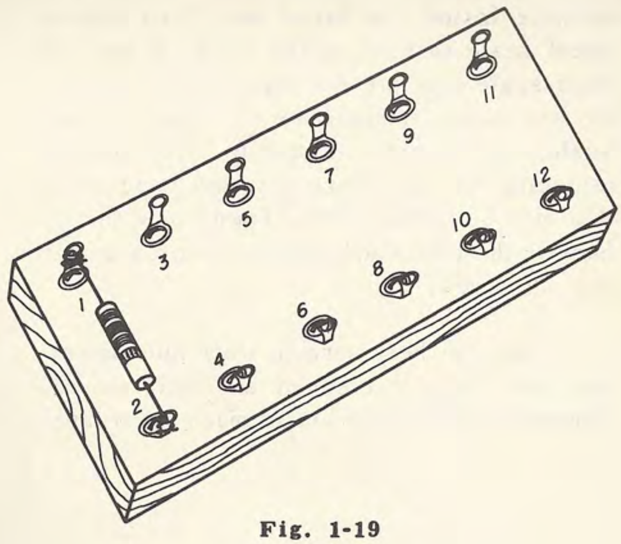
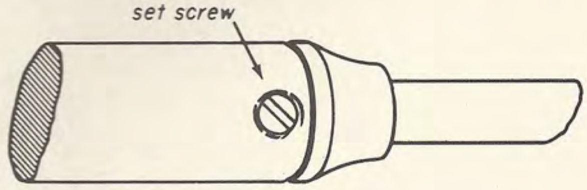


Fig. 1-19

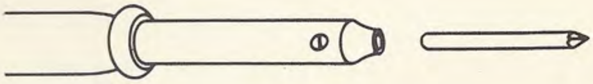
Inspect Your Work. Inspect each of the twelve soldered joints you have made on the resistor breadboard. Be sure that the surface of the solder in each joint is smooth, with just enough solder to make a good joint. This breadboard will be used many times in later lessons, so put it away where you can find it when you want it.

CARE OF YOUR SOLDERING IRON

Examine the tip end of your soldering iron closely. You will see, as shown in Fig. 1-20*a*, that a set screw holds the copper tip firmly in the barrel of the soldering iron. Loosen this screw about once a week and remove the tip from the barrel, as shown in Fig. 1-20*b*. Heat from the heating



(a)



(b)

Fig. 1-20

element inside the barrel may have caused metal scale to form on the shank of the tip. Such scale may prevent the tip from heating to its proper temperature. If there is any scale, be sure to scrape it away. Before replacing the tip, shake out any loose scale that may be in the barrel. Then place the tip back in the barrel and tighten it in place with the set screw.

To get the best service from your soldering iron, keep it cleaned and well tinned. Remember that oxidation is much more rapid when the iron is hot, so do not keep it heated for long periods of time unless you are using it. Do not try to cool it rapidly with ice, snow, or water. If you do, the heating element may be damaged and need to be replaced, or water may get into the barrel and cause rust. Take care of your soldering iron and it will give you many years of useful service.

Replacement tips for your soldering iron may be bought from most radio and electronic parts distributors.

ELECTRONIC FUNDAMENTALS

THEORY LESSON 2

SCHEMATIC SYMBOLS AND HOW TO USE THEM

RCA INSTITUTES, INC.

A SERVICE OF RADIO CORPORATION OF AMERICA

HOME STUDY SCHOOL

350 West 4th Street, New York 14, N. Y.

Theory Lesson 2

INTRODUCTION

You have probably noticed that radio and TV sets have many parts. Different models have parts arranged in different ways. If you were asked to describe all the parts of a radio or TV set and how they are connected together, you would find it difficult to put in words. Even if you succeeded, your description would probably be very long. Yet there is a need for descriptions of radio and TV circuits. When an engineer working for a manufacturer designs a new receiver, he must be able to give the production department, which actually makes the set, all the details of how it is to be put together. After the set has been placed on the market, the servicemen who will keep the set in repair must know how the radio or TV set is put together and what components it uses.

The details of a radio, for example, might be shown by photographs of the set. Figure 2-1 uses this method, showing how parts are connected together in the radio receiver you will assemble later in this course. But this method, while it has its uses, is not practical for showing all the connections and parts in a radio receiver. If you have ever examined the underside of a radio chassis, you will understand why. In many cases, parts are placed above one another, and some of the parts and some of the connections are hidden from view.

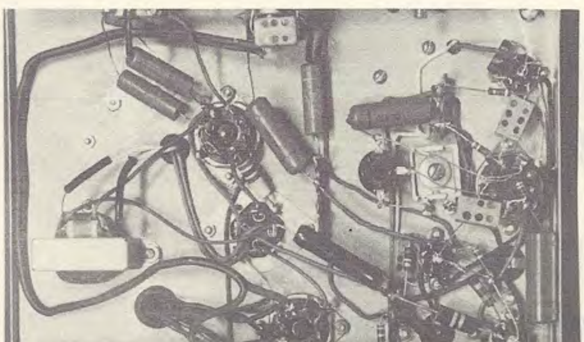


Fig. 2-1

Using another method, we could take pictures of the radio parts and, by drawing lines between the parts, show how they are connected together. In fact, such a method is used frequently in factories to show the people who wire the chassis how the parts are to be connected. We call such a diagram a *wiring diagram*. Figure 2-2 shows a wiring diagram of a small audio amplifier. Such a diagram is very helpful when assembling the amplifier, but it is not of much use in trying to understand the operation of a new circuit.

2-1. SCHEMATIC SYMBOLS

Engineers, technicians, and servicemen make use of symbols to represent the various parts that make up a radio or TV set. Some time or other, you may have returned from a hike or trip and wanted to tell a friend about it. Probably you drew a map, because you found that it was much easier to tell about your trip with a map than to use only words. In much the same way, an engineer draws something like a map of the circuit that he designs. Just as the map-maker has certain symbols that stand for certain types of roads, county boundaries, bridges, and other parts that make up a map, so the engineer uses symbols to represent the parts that make up a radio or TV set. Such symbols were used to draw the circuit diagram, shown in Fig. 2-3, of the audio amplifier that you saw in Fig. 2-2.

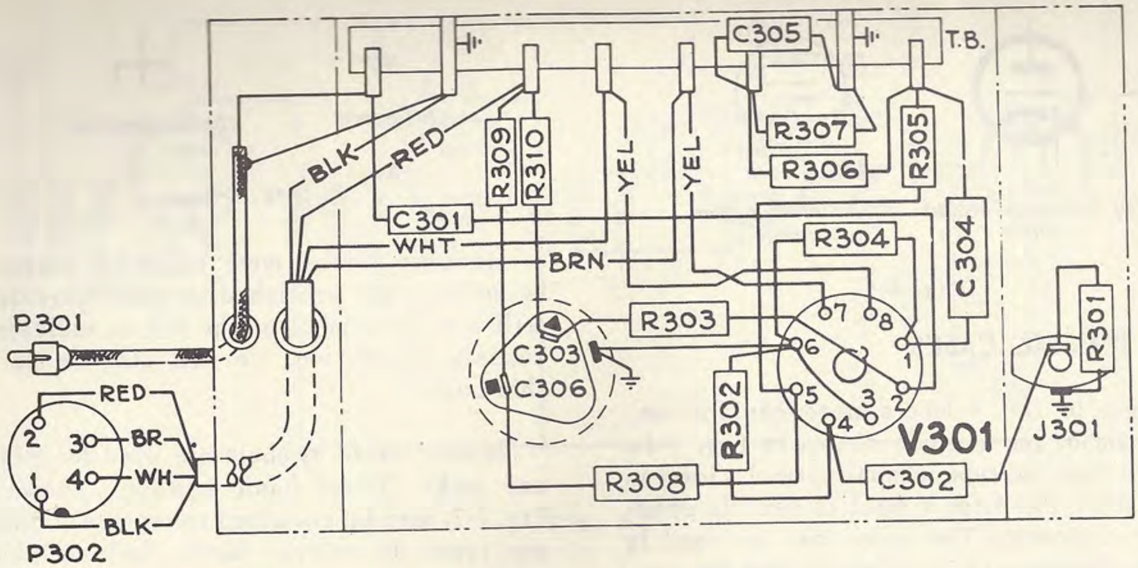


Fig. 2-2

In Experiment Lesson 3, in many lessons to come, and in your work after you complete the course, a knowledge of symbols and how to read circuit diagrams is necessary. A well-drawn circuit diagram, or *schematic*, as it is often called, can be very helpful in enabling you to understand circuits and to locate receiver troubles. As you learn more and more about electricity and electronics, you will appreciate how useful a good circuit diagram really is.

All of the symbols that you are likely to find in radio and TV receiver diagrams have been included in this lesson. A list of many common symbols appears at the end of this lesson. At the time this lesson was written, they were recognized as standard for the radio and TV industry. But, standards tend to change, so it is a good idea to check up from time to time on any new changes that may be made. The source of most of the symbols shown in this lesson is the Institute of Radio Engineers, one of the foremost professional radio organizations in the world. These symbols are in agreement with those recommended by the American Standards Association and the Army-Navy-Air Force standards. Right now, some of the symbols will not mean much to you. Don't worry about it; the more you learn of radio and television, the more of the symbols you will remember. Finally, you will recognize them as easily as you recognize the words you're reading now.

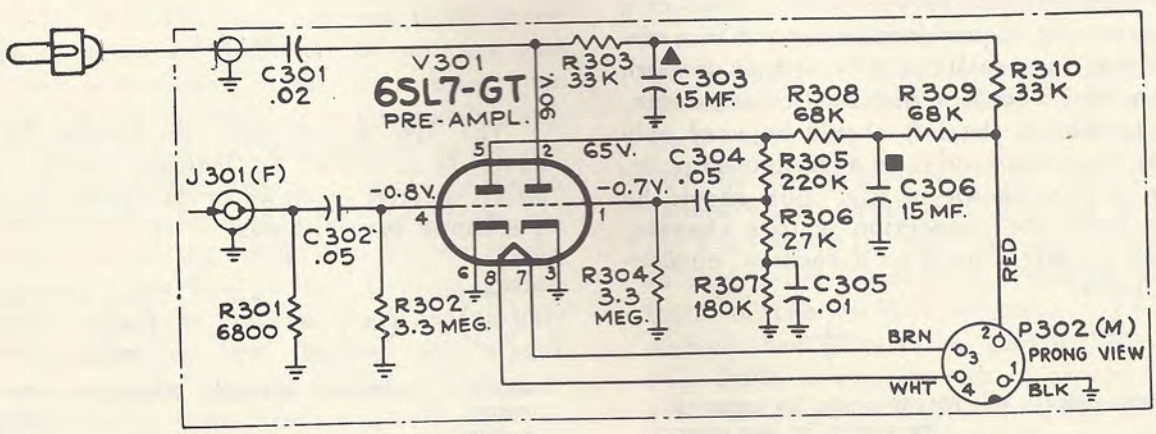
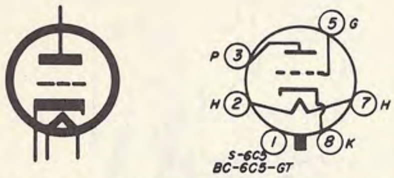


Fig. 2-3



(a) indirectly heated triode *(b) indirectly heated triode*

Fig. 2-4

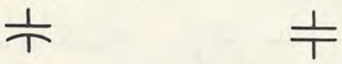
2-2. SPECIAL CASES

Some of the symbols need explanation. The symbol for a triode shown in Fig. 2-4*a* differs from the tube manual symbol shown in Fig. 2-4*b*. The first symbol is used in schematic diagrams. The other may be used in wiring diagrams to show which tube pin connects to each tube element and also how they are arranged around the socket.

The present symbol for a capacitor looks like Fig. 2-5*a*. You may find a capacitor symbol that looks like Fig. 2-5*b*. This symbol is now used to show an open contact in a switch or simple relay. This change will not cause you much confusion. You will soon know enough about circuits to tell what the symbol stands for.

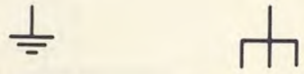
The symbol shown in Fig. 2-6*a* is in common use as a "ground symbol", that is, a point to which many common connections are made. The chassis is usually used for these common connections, and the symbol in Fig. 2-6*a* is in general use to signify the chassis.

The Institute of Radio Engineers (IRE) now distinguishes between connections to a chassis, and connections to a point in a circuit that is actually at true ground or earth potential. To conform with the IRE standards, the symbol at the left should be used only when the connection is to a true ground point. The symbol shown in Fig. 2-6*b* should be used when the connection is to a chassis, which is merely used as a common connection point.



(a) capacitor *(b) old symbol for capacitor (new symbol for open contact)*

Fig. 2-5

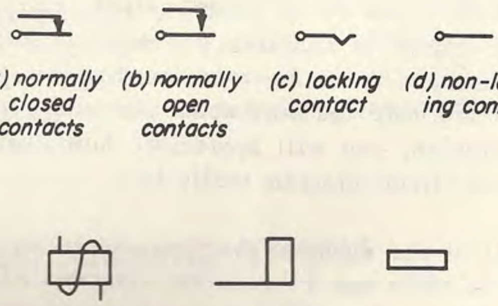


(a) ground *(b) counterpoise*

Fig. 2-6

However, since most diagrams prepared by industry and published by trade magazines still use the symbol on the left to indicate a chassis connection, we will also do so in this course.

Several basic symbols are used for relays and jacks. These basic symbols, shown in Fig. 2-7, may be combined to represent different types of relays, jacks, and switches. There are so many different kinds manufactured that it is practically impossible to show them all, so only a few are shown in the list of symbols. The basic symbols are shown so that you may know what each part stands for, no matter how they are put together.



(a) normally closed contacts *(b) normally open contacts* *(c) locking contact* *(d) non-locking contact*

(e) relay winding *(f) metal sleeve (used in jacks)* *(g) insulator for jack relays and keys*

Fig. 2-7

The list shows that the symbol for a meter is a circle. To indicate the type of meter, a letter is drawn in the circle. Figure 2-8 shows several kinds.

basic meter symbol *ammeter* *voltmeter* *ohmmeter* *frequency meter*

Fig. 2-8

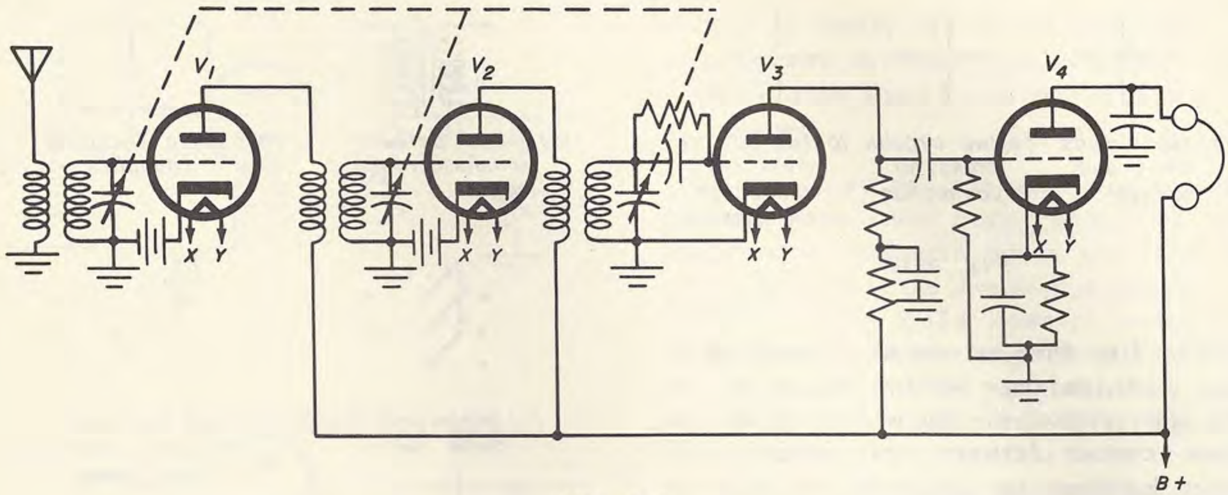


Fig. 2-9

2-3. SCHEMATIC DIAGRAMS

Actually, nobody has yet made up strict rules for the use of circuit symbols in circuit diagrams. There are, however, certain methods of putting together symbols that most engineers and engineering draftsmen follow. These unwritten rules are few and easy to understand.

1. Schematics or circuit diagrams should read from left to right. Each piece of electronic equipment has an *input* and an *output*. For example, the input to a radio receiver would be either a built-in antenna or the leads or binding posts that connect it with the outside antenna or ground wires. The output of the same receiver would be either a built-in speaker, where there is one, or the jack or binding posts to which the speaker or headset is connected. Therefore, in the drawing of a circuit diagram, the antenna and ground connections of the input would be shown at the extreme left of the drawing and the speaker or output connections at the extreme right of the drawing. Figure 2-9 shows a circuit diagram of a simple broadcast receiver. All of the things that happen to the incoming signal from the broadcasting station take place in the electron tubes and the circuits connected with them as the signal travels from the input at the left to the loudspeaker at the right. Electron tube *1* receives the signal and passes it on to tube *2*, through *3*, and then *4*, before it reaches the headset.

2. In many cases, the symbols for the parts of a receiver that normally appear near the top of the receiver chassis, such as antenna, electron tubes, r-f transformers, and loudspeaker, are shown near the top of the schematic. Parts normally found in the underpart of the chassis are usually shown in the lower portion of the schematic. For example, a circuit diagram for a commercial radio receiver that showed the antenna at the lower part of input and the ground at the upper part of the input would be very unusual. Sometimes, however, it is not possible to show all of the electron tubes and parts that appear at the top of the chassis at the top of the circuit diagram. There are times when the draftsman finds it more convenient to place them elsewhere.

3. Lines that connect one symbol with another are either vertical (straight up and down) or horizontal (straight across). They are generally not slanted, except in drawings of selector switches with many points. When the line of one circuit crosses over the line of another circuit and they are connected, the connection is shown by drawing a dot where the two lines meet, as shown in Fig. 2-10*a*. When it is necessary for the lines of two circuits to cross each other without any connection between them, as Fig. 2-10*b* shows, the dot is omitted. However, not all schematics and circuit diagrams agree with this standard. Some draftsmen and engineers draw a curve when crossing

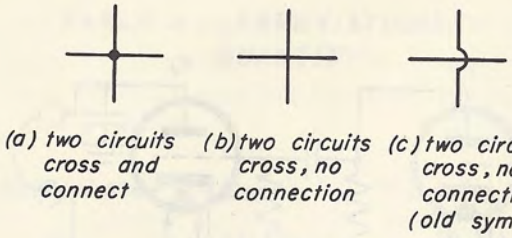


Fig. 2-10

another line when no contact is made, as in Fig. 2-10*c*, and draw one line straight across the other without the dot when they want to show contact between two circuits. Still other draftsmen and engineers use a dot to show a connection and a little curve to show no connection between two circuits. Usually you can tell which system is being used by noticing which combination of dots, little curves, or lines simply crossing each other is being used.

4. A dashed or broken line is used to show a metal shield between two parts or two sections of one part, as shown in Fig. 2-11*a*, or is drawn around a part to show a shield enclosing a part, as in Fig. 2-11*b*. A broken line is also used to show mechanical linking between two or more parts. For example, the tuning capacitor of a radio receiver may have two, three, or more sec-

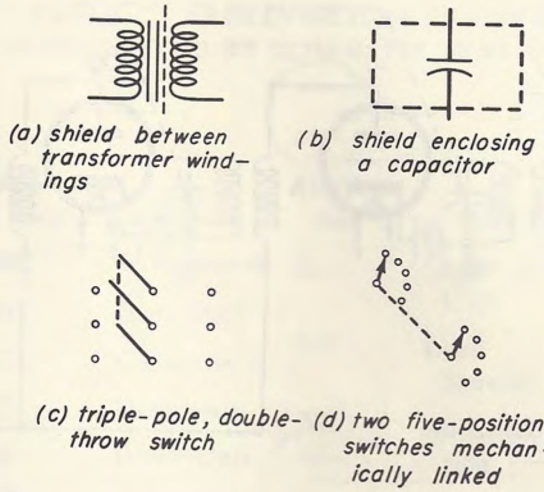


Fig. 2-11

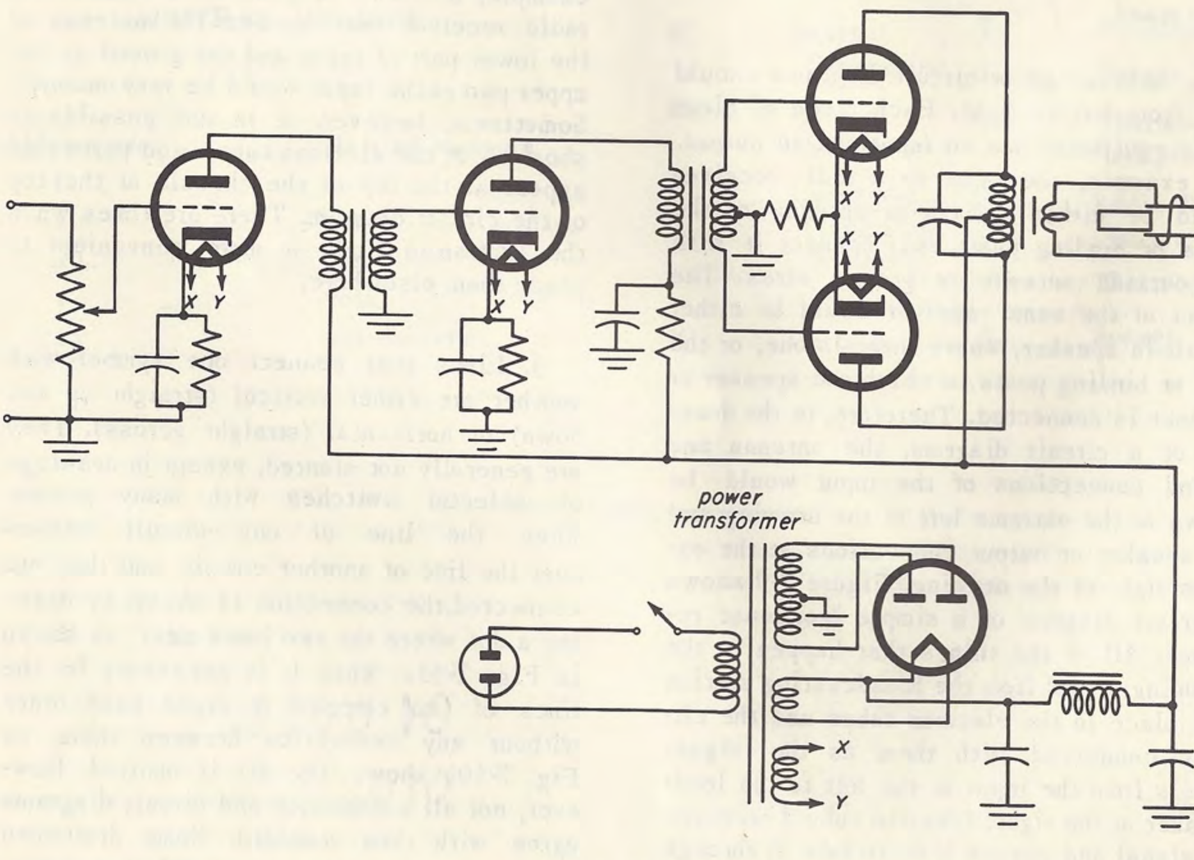


Fig. 2-12

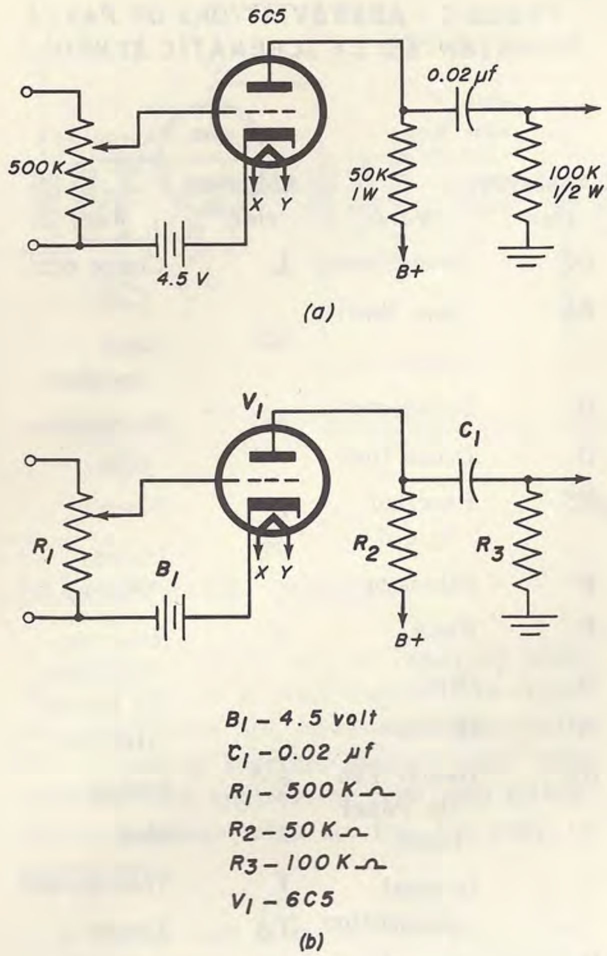


Fig. 2-13

tions. All of these sections may be tuned by one knob that is attached to one shaft. This type of tuning is shown in some schematics as it is shown in Fig. 2-9; slanted broken lines are drawn from all the parts that are mechanically linked (ganged) to some common point. This method is often used to show the linking of switches. In Fig. 2-11*c*, the broken line indicates that the three parts of the double throw switch are linked. The two separate five position switches shown in Fig. 2-11*d* are mechanically linked switches.

The ideal circuit diagram is the one that shows all the circuits and yet uses the fewest lines. Sometimes, in order to simplify a diagram, the draftsman does not show all the wires, as in Fig. 2-12. Here, instead of connecting all the electron tube heaters with a pair of lines, the heater terminals are lettered with an *X* and *Y*, showing that they connect to the *X* and *Y* terminals of the power transformer.

Parts shown on schematic diagrams are identified in two ways. Sometimes the engineer or draftsman marks the value of each part next to the symbol representing it, as shown in Fig. 2-13*a*. However, sometimes a schematic diagram may show a circuit with a large number of parts and many connections between these parts. If the engineer or draftsman tried to mark the value of each part next to the symbol representing it, he would find that he had cluttered up the drawing so much that it was difficult to read. In such cases, the symbols are given a letter abbreviation and number. The number and letter given to each symbol are identified in a parts list that is printed in a clear space on the schematic diagram, as shown in Fig. 2-13*b*. This second method is not as convenient as the first method for the person who tries to learn the part values. However, sometimes there is no other convenient way to make a schematic diagram.

Remember that there are no set rules for making circuit diagrams. You will find many diagrams that do not follow all the ideas suggested here. Once you have the basic idea of circuit diagrams, you should not have great difficulty in figuring out the tough ones.

Tables *A*, *B*, and *C* show the abbreviations most often used to identify parts in schematic diagrams. The abbreviations given in these three tables are used in articles and books about radio and television work as well as in schematic diagrams. It will be worth your while to study these tables until you know what the abbreviations stand for. It will make your studies of the lessons to come much easier, and you will be able to look at schematic diagrams with much greater understanding. As you progress in your studies, you will find that these symbols will become as familiar to you as many words you use every day.

TABLE A - ABBREVIATIONS OF QUANTITY

Abbreviation	Word	Power of 10
$\mu\mu$	micromicro	10^{-12}
μ	micro	10^{-6}
m	milli	10^{-3}
c	centi	10^{-2}
K or k	Kilo	10^{3}
M	Mega	10^{6}
KM or kM	Kilomega	10^{9}
MM	megamega	10^{12}

TABLE B - ABBREVIATIONS OF UNITS OF MEASURE

Abbreviation	Unit of Measure
f	farad
h	henry
Ω	ohm
v	volt
va	volt-ampere

.000010

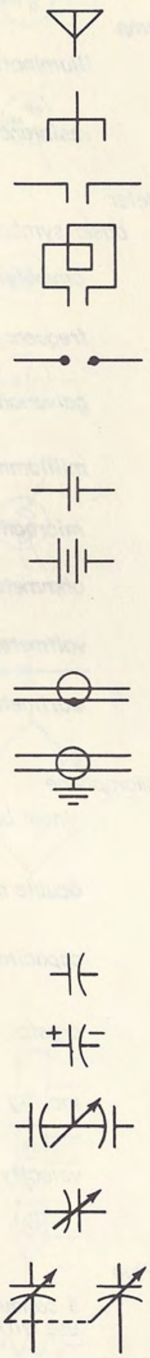
.010

TABLE C - ABBREVIATIONS OF PARTS REPRESENTED BY SCHEMATIC SYMBOLS

Abbreviation	Word	Abbreviation	Word
BC	Base Sleeve	L	Choke or Coil
BS	Base Shell	LS	Loud Speaker
C	Capacitor	NC	No Connection
D	Dynamotor	P	Plate
D	Diode Unit	PU	Phono Pickup
ES	External Shield	R	Resistor, Rheostat, or Potentiometer
F	Filament	S	Switch
F	Fuse	S	Shell
G	Grid	T	Transformer
H	Heater	TA	Target
HL	Heater Tap for Panel Lamp	TC	Thermocouple
IC	Internal Connection	TR	Radio Transmitter
IS	Internal Shield	V	Electron Tube
J	Connector (Jack, Plug, or Receptacle)	X	Socket
K	Cathode		

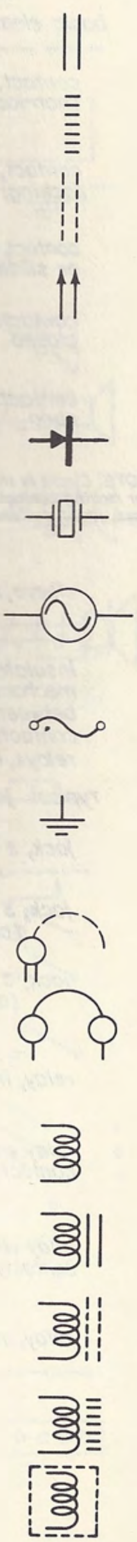
APPENDIX

COMPONENT	*SYMBOL*
Antenna	
general	
counterpoise	
dipole	
loop	
Arrester, lightning	
Battery	
single cell	
multicell	
Cable	
coaxial	
2 conductor cable with shield grounded	
Capacitor	
general	
electrolytic	
split stator variable	
variable	
variable with mechanical linkage	



NOTE: The curved element represents the outside electrode in fixed paper dielectric and ceramic dielectric capacitors, the negative electrode in electrolytic capacitors, and the moving element in variable and adjustable capacitors.
When it is necessary to indicate trimmer capacitors, the letter t appears adjacent to the symbol.

COMPONENT	*SYMBOL*
Core	
air	*no symbol*
iron	
non-ferrous metal	
powdered iron	
variable or movable core	
Crystal	
detector	
piezoelectric	
source of a.c.	
Fuse	
Ground	
Headphone	
single	
double	
Inductor	
fixed	
magnetic core	
powdered iron core	
non-ferrous metal core	
shielded	



COMPONENT — *SYMBOL*

- *variable inductor*
- *variable core*

Jack and Relay

- *basic elements*
  - *contact, moving (non-locking)*
  - *contact, moving (locking)*
  - *contact, adjustable or sliding*
  - *contacts normally closed*
  - *contacts normally open*

NOTE: Circle is the pivot point for moving contacts for relays, keys, jacks, switches etc.

  - *sleeve, metal*
  - *insulator for mechanical coupling between moving contacts on jacks, relays, keys etc.*
- *typical jacks & relays*
  - *jack, 2 conductor*
  - *jack, 3 conductor (closed)*
  - *jack, 3 conductor (open)*
  - *relay, inductive*
  - *relay with break contacts*
  - *relay with make contacts*
  - *relay, magnetic*

COMPONENT — *SYMBOL*

Key

- *telegraph*

Lamp

- *illuminating*
- *resistance (ballast)*

Meter

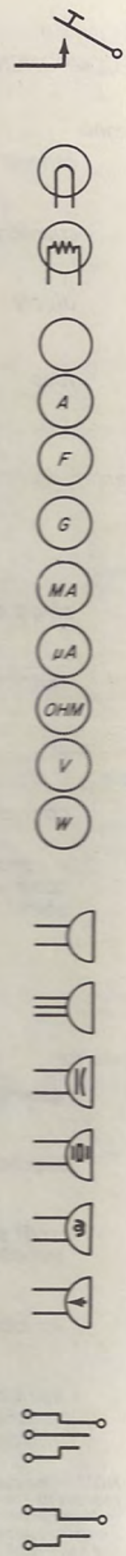
- *basic symbol*
  - *ammeter*
  - *frequency*
  - *galvanometer*
  - *milliammeter*
  - *microammeter*
  - *ohmmeter*
  - *voltmeter*
  - *wattmeter*

Microphone

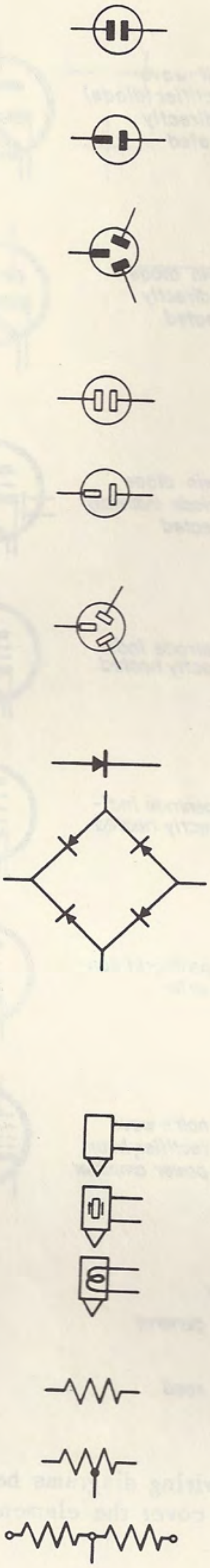
- *single button*
- *double button*
- *capacitor*
- *crystal*
- *moving coil*
- *velocity*

Plug

- *3 conductor (for use with jack)*
- *2 conductor (for use with jack)*

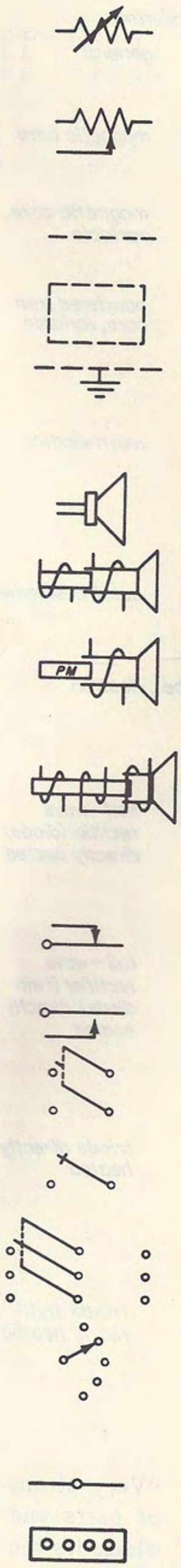


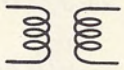
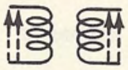
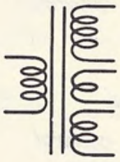
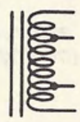
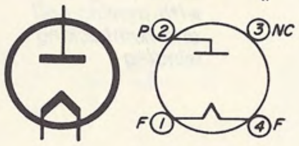
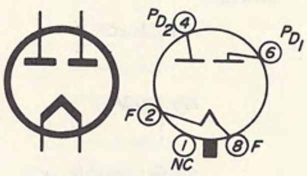
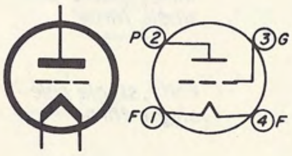
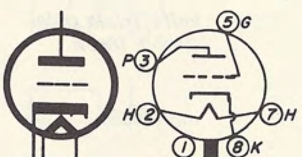
COMPONENT	SYMBOL
2-conductor not polarized	
2-conductor polarized	
3-conductor polarized	
Receptacle	
2-conductor not polarized	
2-conductor polarized	
3-conductor polarized	
Rectifier (not electron tube)	
half wave	
full wave (bridge type)	
Reproducer	
general	
crystal	
electromagnetic	
Resistor	
fixed	
tapped, with leads	
tapped, with terminals	

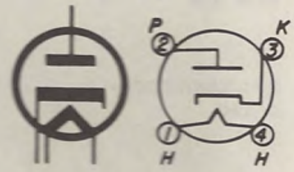
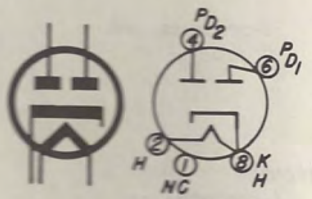
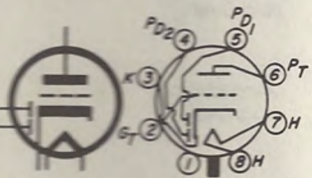
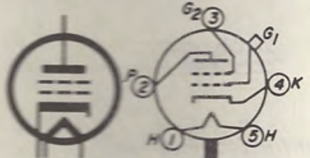
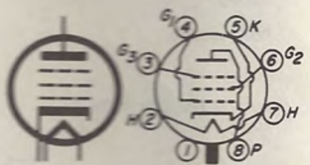
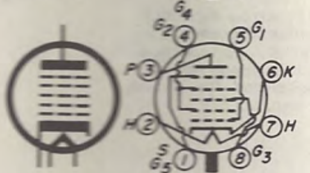
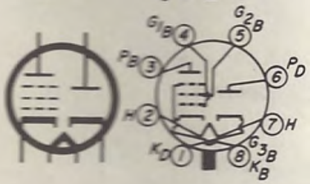
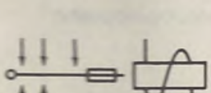


NOTE: Arrow indicates direction of forward (conventional) current flow. The lines represent the cathodes and the arrows, the anodes.

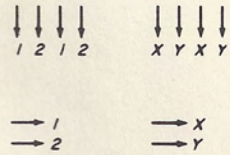
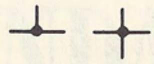
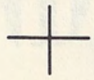
COMPONENT	SYMBOL
variable (rheostat)	
variable (potentiometer)	
Shield	
general	
enclosing	
grounded	
Speaker	
general	
electromagnetic (moving coil)	
permanent-magnet (moving coil)	
electromagnetic with moving coil and humbucking winding	
Switch	
key (break)	
key (make)	
knife, double pole single throw	
knife, single pole-single throw	
knife, triple pole-double throw	
multipoint	
terminal	
single	
strip	



COMPONENT	SYMBOL
Transformer	
general	
magnetic core	
magnetic core, variable	
powdered iron core, variable	
multiwinding	
autotransformer	
Tube, electron	used for schematic diagrams / typical symbols used in tube manual and wiring diagrams *
half-wave rectifier (diode) directly heated	
full-wave rectifier (twin diode) directly heated	
triode directly heated	
triode indirectly heated	

COMPONENT	SYMBOL
half-wave rectifier (diode) indirectly heated	
twin diode indirectly heated	
twin dioae triode indirectly heated	
tetrode indirectly heated	
pentode indirectly heated	
pentagrid converter	
half-wave rectifier, beam power amplifier	
vibrator	
general	
reed	

*Very often, the tube elements are not shown in wiring diagrams because the placement of parts and wires across the tube symbol would cover the elements. For example, the elements are not shown in Fig. 2-2.

COMPONENT	*SYMBOL*	*COMPONENT*	*SYMBOL*
wiring		*wires omitted (wiring between letters or numbers is understood)*	
wires connected			
wires crossing but not connected			

ELECTRONIC FUNDAMENTALS

EXPERIMENT LESSON 2

HOW TO DO ADVANCED SOLDERING

RCA INSTITUTES, INC.
A SERVICE OF RADIO CORPORATION OF AMERICA
HOME STUDY SCHOOL
350 West 4th Street, New York 14, N. Y.

Experiment Lesson 2

OBJECT

To apply your knowledge of soldering by:

1. Making several connections between tie terminals and a tube socket.

2. Soldering shielded cable and coaxial cable.

3. Making test leads, shielded leads, and clip leads.

INTRODUCTION

In building and servicing a radio receiver, there are two basic kinds of connections made: permanent connections and temporary connections.

A *permanent connection* is one that is made to last for a long time. Most permanent connections made in radio receivers are soldered. For example, a resistor soldered in place in a radio receiver is permanently connected. Each part that is soldered in place is permanently connected until it breaks down and is replaced with a new part.

However, there are times when permanent connections are not soldered. For example, radio tubes are not usually soldered in place. Instead, a special connecting device is used. This device, called a tube socket, is a permanent part of the receiver. Although circuit connections to the socket are soldered, the connections between the electron tube and the socket, while they are very tight mechanically, are not soldered. This makes it easy to disconnect tubes from the receiver for test and replacement.

There are many kinds and sizes of tube sockets used in radio receivers. No one radio uses all types, but later on you should become familiar with most of them. Fig. 2-1 shows several types.

Fig. 2-1

There are other unsoldered permanent connectors used in radio receivers; for example, the attachment plug at the end of the receiver's line cord, which goes into an electric outlet and connects the receiver to the power line. In a console radio, the speaker may connect to the receiver by means of a special plug and socket. In a phono-radio combination, the phonograph may be connected to a radio chassis by means of a cord and a phono jack or plug. Figure 2-2 shows some of these connectors.

Most *temporary connections* used in testing a receiver are made to last for no more than a few hours at the most. Usually, a temporary connection is made in locating trouble when something has gone wrong with the radio; for example, connections made between a multimeter and receiver circuits, which usually last no more than a few

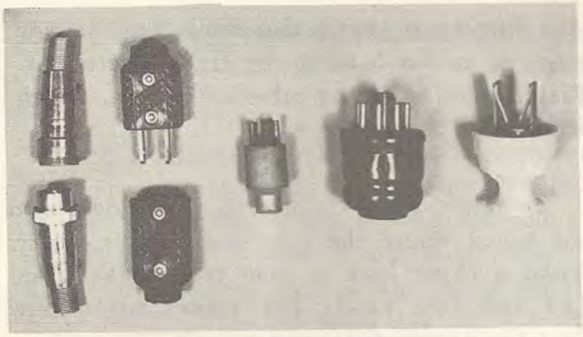


Fig. 2-2

seconds, and connections from a test oscillator or signal generator to a receiver, which may last for a few minutes or for an hour or more.

Connectors used in making temporary connections must meet certain requirements:

1. They should protect the user (the technician) from an accidental shock, burn, or other injury.

2. The connector, and the wire or cable connected to it, should not change the wave shapes or reduce the values of the electrical currents flowing through them while tests are being made.

3. The connection between each temporary connector and its wire or cable should be either soldered or mechanically tight.

4. The connector and the wire or cable connected to it should be insulated to prevent accidental shorting of electrical and radio circuits during tests.

The test leads and connectors that you will make in this lesson will meet these requirements only if you follow carefully all the directions in each job assignment.

METHOD

In the first part of this lesson, you will solder permanent connections between the lugs of two tie terminals and the lugs of a miniature 7-prong tube socket. It is easier to make connections to a large socket than to the small socket you will use; if you find that you can make good soldered connections to this miniature socket, you may be sure that you can do equally good work on any of the larger types. You will work with two kinds of shielded cable and learn two different ways of making soldered connections with them. In addition, you will assemble the following: test leads for use with the multimeter that you will start to assemble in the next lesson, a shielded test lead for use with the signal generator you will make later in the course, and a clip-to-clip lead for use in later lessons.

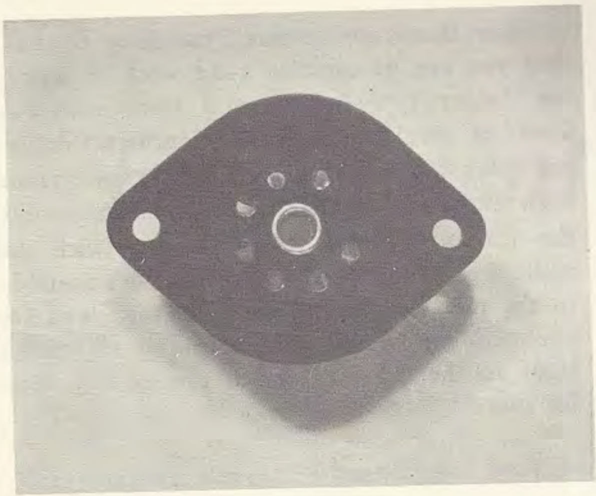
JOB 2-1

To make some soldered connections between a 7-pin miniature tube socket and some tie terminals.

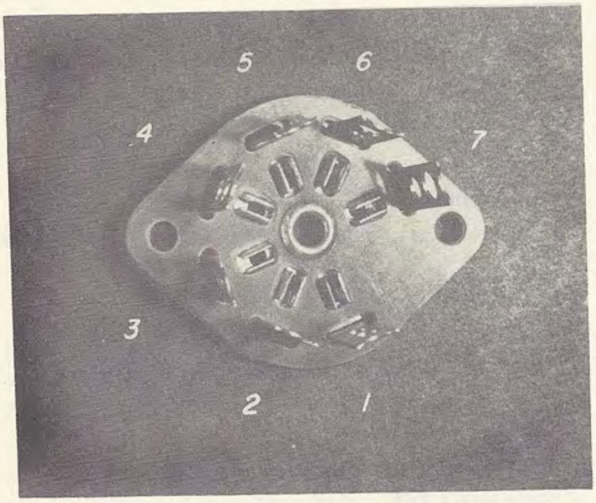
Equipment Needed.

One 7-pin miniature socket
Two wood screws (to hold socket in place)
One lug
Solid pushback wire
Spaghetti (insulated sleeving)
Soldering iron
Clean rag
Rosin-core solder
Piece of wood about 4″ x 9″

Information. Look at the small tube socket you received in Kit 1. It is called a 7-pin miniature socket because it has seven connections and is used to connect a miniature-based tube to the proper circuits in a radio. Fig. 2-3*a* shows one view of this socket. Hold the socket upside down and you will get the view of the socket shown in Fig. 2-3*b*. Now you can see seven lugs. If you examine them closely, you can see that each lug has one or two small openings into which wires may be connected and soldered. The other end of each lug forms a gripping contact in the socket base. Each of these contacts grips one of the pins on the base of the tube that is inserted in the socket. At each end of the socket is a hole that is used,



(a)



(b)

Fig. 2-3

with a rivet or a small screw and nut, to mount the socket on a receiver chassis. Notice, in Fig. 2-3*b*, that each lug is numbered. Tube manuals and radio schematics number the base pins of electron tubes and the contacts of tube sockets in a clockwise direction *when the tube or socket is viewed from the bottom.* You will notice that there is a wide space between two of the socket lugs; the socket contacts are numbered in a clockwise direction, *starting at this space.* Lug *#1* is always next to this space. Other types of electron-tube sockets are numbered in a similar way. As each type is discussed in this course, you will be shown how it is numbered.

Wire leads, resistors, and other small parts may be soldered to the lugs of your tube socket in much the same way as you soldered to the lugs in the first experiment. When soldering to any tube-socket lug, watch out for two things:

1. Don't allow solder to flow down into the holes where the tube pins are inserted. Take a close look at your tube-socket; you can see how easily hot solder might flow into the gripping contact.

2. Place connecting wires low on each lug so that you can make other connections to the same lug later on, if necessary.

Sometimes bare wire is used in wiring a radio receiver because it is easier to work with. However, if the wire is left bare, it may cause a short circuit. In such cases, insulation is added to the wire. A tubular sleeving called *spaghetti* is the insulation used. It comes in many sizes and several thicknesses and is made from a wide variety of insulating materials. It is best, usually, to use the smallest size that will slip over the wire on which you want to use it. Two lengths of spaghetti were sent to you with Kit 1.

When using spaghetti, first cut off the amount that you need and slip it over the wire before any soldering is done. While soldering, keep the spaghetti back from the joint and away from the soldering iron to prevent melting or burning it.

Be sure that the tip of your soldering iron is cleaned and tinned before you start to solder.

Procedure.

Step 1. Turn the tube socket upside down, so that the lugs are facing you and the top of the socket rests on the piece of wood (breadboard). With an awl or scriber, make holes to start the wood screws in the centers of the spaces enclosed by the socket mounting holes. Put the lug underneath the screw hole nearest to lug #7 before you put the screw through the socket mounting hole. Then start and tighten both screws so that

the socket itself cannot slide around. Figure 2-4 shows you how this arrangement should look.

Step 2. Take a piece of single-conductor hook-up wire and push back about 1/4 inch of the insulation. Form a hook as you did in Experiment Lesson 1 and then push the hook through the opening in lug #1 on the tube socket. Try to keep the wire at the lower end of the opening. (If you received a socket with two holes in each lug, use the lower hole.) Now squeeze the hook to the lug with your long-nose pliers, just as you did in Lesson 1. If the end of the wire sticks out past the edge of the lug, cut it off with a pair of cutting pliers.

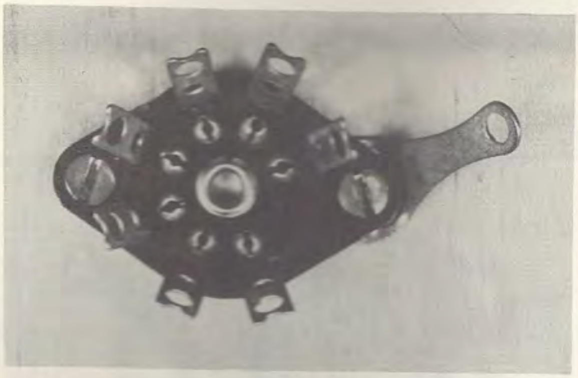


Fig. 2-4

Step 3. If the wire has moved up on the lug, push it down again and tighten it with a pair of long-nose pliers. The finished job should look like Fig. 2-5. Then solder the wire. Don't use so much solder that the entire hole is covered; use just enough to make a good soldered joint. Be careful not to let any solder flow down into the tube-pin opening.

Step 4. Cut the wire about an inch from the connection you have just made and pull off the insulation from the piece that is still connected to the socket. Take care not to bend the lug. You now have a piece of bare wire connected to the socket.

Step 5. Slide a long piece of spaghetti over the bare wire. Notice that if you tried to cut the spaghetti now, you wouldn't know where the end of the wire is located. Remove the spaghetti and hold it close to the wire,

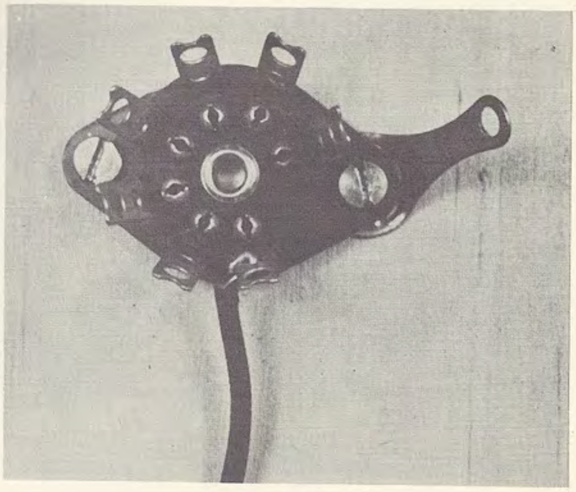


Fig. 2-5

as shown in Fig. 2-6. Cut off a piece of spaghetti that is 1/2 inch shorter than the wire itself and place this short piece of spaghetti on the wire.

Step 6. Make a hook on the bare end of the wire and then push the wire through lug #3, just as you did with lug #1. Now solder this connection. The socket should look like

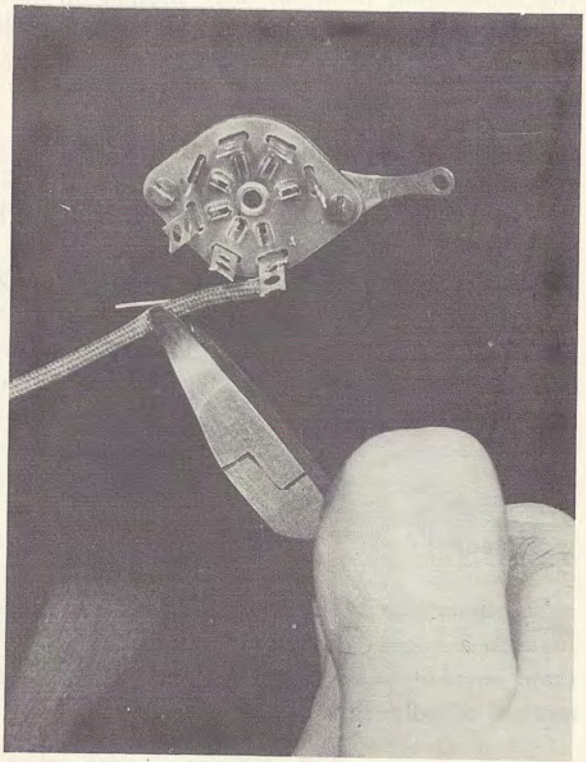


Fig. 2-6

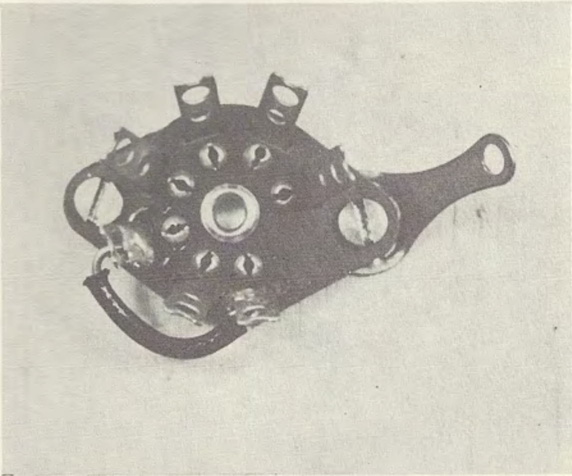


Fig. 2-7

Fig. 2-7. Notice that the wire is a bit slack. It's possible to make a tighter, neater looking job, so let's do it in a slightly different way.

Step 7. Lug #2 is a blank, unused lug between the two lugs you just soldered. Solder a piece of hook-up wire to the upper hole of this lug in the same way you did to lug #*1*. Before you cut the wire and remove the insulation, bend the wire around so that it passes lug #*3* and lug #*4*. About 1/4 inch past lug *4*, cut the wire and remove the insulation.

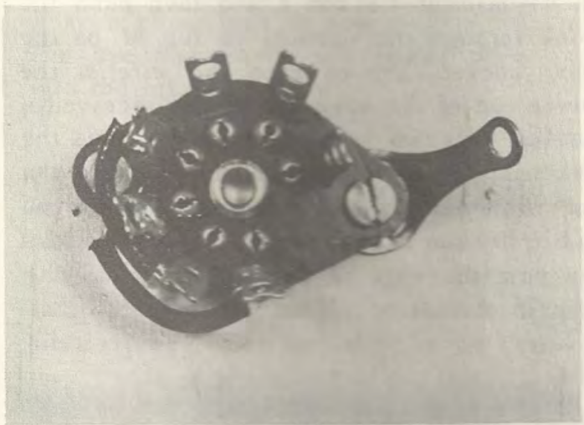
Step 8. Cut off a piece of spaghetti for this piece of wire, the same way you did for the first one. Be sure to put the spaghetti on the wire. Then solder the wire to lug #4, as shown in Fig. 2-8*a*, remembering to hook it first and squeeze it with your long-nose pliers. If you have worked carefully, you can see that this second connection looks neater than the first one.

Notes:

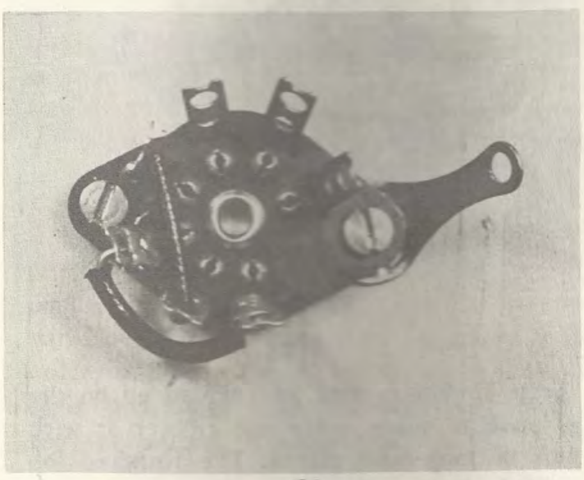
1. Sometimes the wire connecting two lugs on a socket runs inside the lugs, rather than outside, as shown in Fig. 2-8*b*. The method of soldering is the same.

2. If two lugs that are next to each other, such as lugs #*1* and #*2*, are to be connected, no spaghetti is used.

3. When connecting two lugs opposite each other, it's easier to go across the socket than all the way around it, as shown in Fig. 2-8*c*. Spaghetti should be used in such a connection.



(a)



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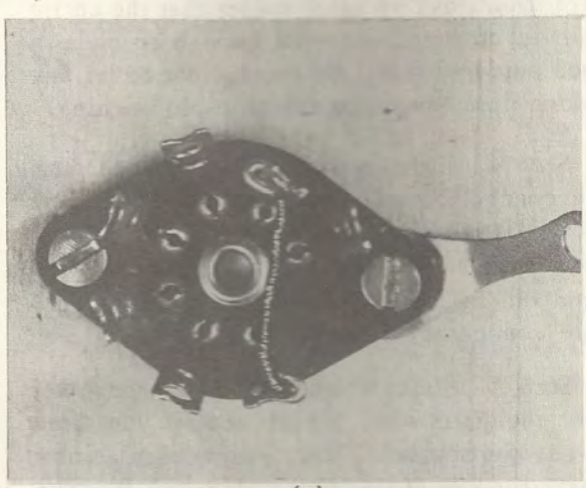


(c)

Fig. 2-8

JOB 2-2

To solder a resistor between the tube socket and a tie terminal.

Equipment Needed.

The equipment used in the last experiment

One tie terminal (terminal strip)

One wood screw

Two resistors remaining from Kit 1

Procedure.

Step 1. There are still three blank lugs on the tube socket you are using. Mount the tie terminal, with the wood screw, about one inch away from the socket, with the broad side of the strip facing lugs #5, #6, and #7. Figure 2-9 shows how this arrangement should look.

Step 2. Insert the wire lead on one end of one resistor in lug #5 on the tube socket. Then, insert the wire on the other end of the resistor through either one of the lugs on the tie terminal. Center the resistor in the space between the tube socket and the tie terminal, as shown in Fig. 2-10.

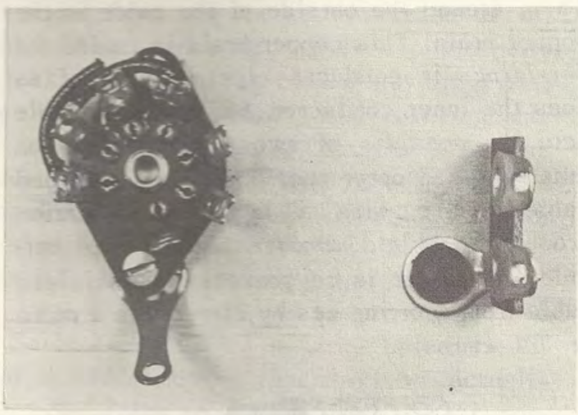


Fig. 2-9

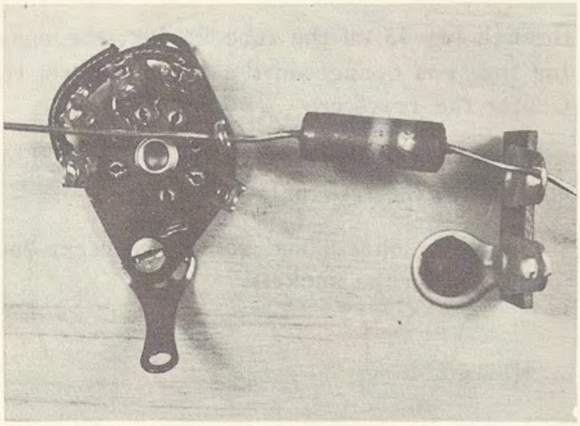


Fig. 2-10

Step 3. Hold the resistor in place with one hand while you hook the end of the wire around the lug on the tie terminal. Press the hooked end together to make a good tight connection. Remember to cut off any excess wire that sticks out past the edge of the lug.

Step 4. Make sure that the wire is down at the bottom of the lug and solder the connection.

Step 5. In the same way, connect and solder the other end of the resistor to the lug on the tube socket. The work should look like what is shown in Fig. 2-11.

Step 6. Push one end of the remaining resistor through the other lug on the tie terminal. Push the other end of the resistor

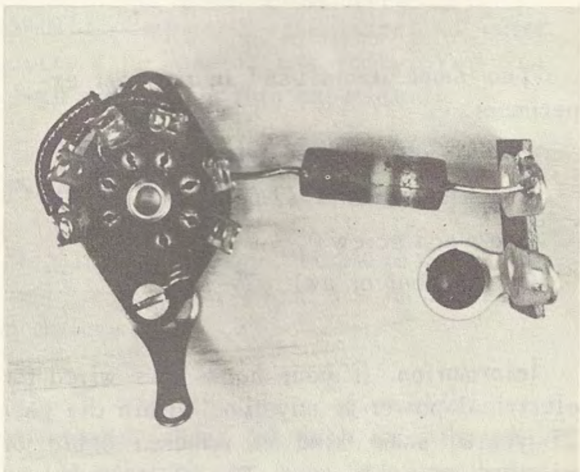


Fig. 2-11

through lug #5 on the tube socket, the same lug that you connected the other resistor to. Center the resistor.

Step 7. As before, connect and solder one end to the terminal.

Step 8. Connect and solder the other end to the lug on the socket.

Notes:

1. Any wire connected to a hole in a lug should be kept at the bottom of the lug to leave room for more wires to be connected later.

2. Always solder a connection as you make it. In that way, you won't leave any connections unsoldered. For example, you might have connected the first resistor to the tube socket and then waited until you connected the second one before soldering. However, if there had been no second connection, you might have forgotten to solder the first.

JOB 2-3

To connect and solder shielded wire.

Equipment Needed.

The same items used in the last experiment.

Length of shielded wire

One tie terminal (2-position)

One wood screw

One scriber or awl

Information. If your home was wired for electrical power at any time within the past 25 years, some kind of armored cable or wire was probably used. The electrician who did the wiring may have used wire that was protected by a curled metal covering. This wire is called *BX cable* and is shown in

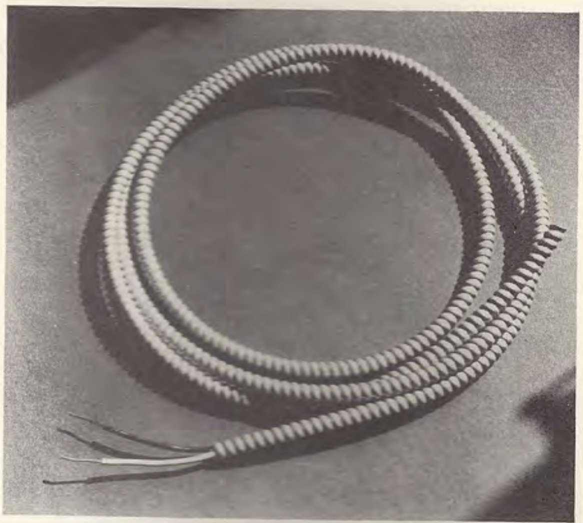


Fig. 2-12

Fig. 2-12. Metal covering is used to protect wire from injury and to protect the house from fire if the wires become shorted.

In radio and TV, a special kind of wire, called *shielded wire* or *shielded cable*, is often used. It is similar in some ways to BX cable. Like BX, the inner wire or wires of shielded cable are covered by a metal tubing, as shown in Fig. 2-13. This metal tubing is much more flexible than the spiral steel tubing wound around. BX cable; it is usually made from tinned strands of copper wire braided together. Look at the piece of shielded cable sent to you in Kit 1. You will see, in the center of the cable, an inner conductor that is very much like stranded hookup wire, protected by a layer of insulation. Then, around the outside of the cable is the copper braid. This copper braid is called the *shielding;* it conducts electricity, just as does the inner conductor. So, shielded cable actually consists of two conductors – an inner one and outer one. Sometimes shielded cable comes with a layer of insulation around the shield. One reason for this outside insulation is to prevent the shielded cable from shorting nearby circuits in a radio or TV chassis.

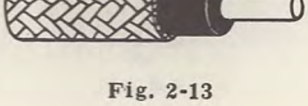


Fig. 2-13

Shielded cable comes with one, two, three, or more inner conductors. In most cases, the insulation used for shielded cable is rubber, although in some cases it may be plastic.

A very special form of shielded cable, used in radio and TV circuits, is called *coaxial cable.*

You remember from your study of geography that the earth revolves on its *axis.* The axis of the earth is an imaginary line drawn through the center of the earth from the North Pole to the South Pole, as shown in Fig. 2-14*a*. A wire, too, has an axis. A line drawn to show the axis or exact center of a length of conducting wire is shown in Fig. 2-14*b*. A line drawn to show the axis of a length of tubular copper braiding is shown in Fig. 2-14*c*. If we combine the two conductors into a length of coaxial cable, the axis of the inner conductor, as shown in Fig. 2-14*d*, is exactly the same as the axis of the outer braided conductor. So we say that such cable is *coaxial*, because the inner and outer conductors have the same axis.

Examine the length of coaxial cable, sent to you in Kit 1. The insulating material between the inner conductor and the outer metal braid of coaxial cable is made of plastic. In making coaxial cable, great care is taken to keep the thickness of this plastic insulation the same throughout its length. In this way, the inner conductor is the same distance from the outer conductor at all times. Your piece of *co-ax* (pronounced KO-AX) has a woven-cotton covering over the metal shield. This outer covering may be of either rubber or plastic. Put this cable aside now. You will use it later in this lesson to make a shielded lead, which you will use with the signal generator that you will make later during this course.

Soldering shielded wire is not difficult. You should remember that there are actually two conductors to solder. Before it is possible to get at the inner conductor, it must be separated from the outer braid. After this is done, the inner conductor can be treated just like any other wire. There are two methods for separating the inner and outer conductors in common use today. You will try both methods in this experiment.

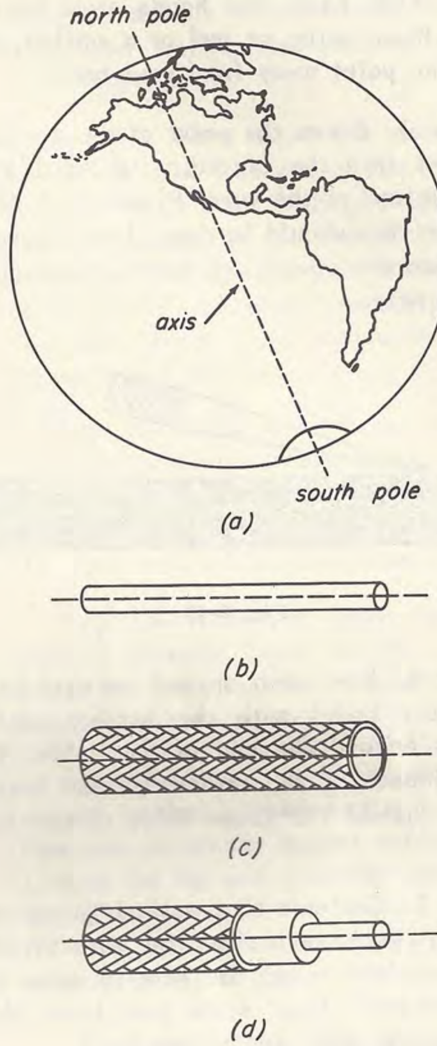


Fig. 2-14

Procedure.

Step 1. Use the wood screw to mount the second tie terminal about six inches away from the socket.

Step 2. Hold the piece of shielded wire in your hand, about one inch from the end. Point the one-inch end away from your body.

Caution: In the next step, you will use either a scriber or an awl. Each has a

sharp point. Keep your hands away from the point. When using an awl or a scriber, work with the point away from your body.

Step 3. Force the point of the scriber or the awl into the shielding about 1/4-inch from the end of the wire. Figure 2-15 shows you how this should be done. Don't force the pick into the insulation; push it through the shield only.

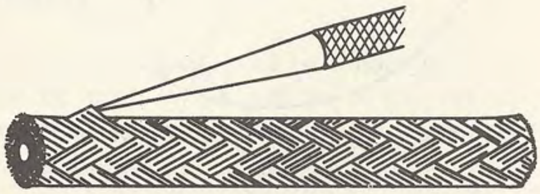


Fig. 2-15

Step 4. Now push up and outward (away from your body) with the scriber until it reaches beyond the end of the cable. This starts loosening the strands of the braided shield. Spread the loose ends of the braid apart.

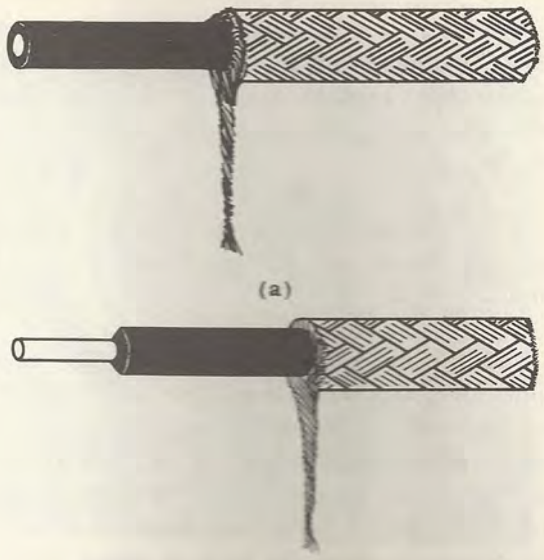
Step 5. Continue this method, going back about 1/4 inch each time. Be sure to move your hand back along the wire to avoid cutting yourself. Stop when you have about 1 inch of the shielding removed.

Step 6. Hold the 1-inch piece of the inner conductor in one hand and, with the other hand, twist the shielding so that it forms a stranded wire, as shown in Fig. 2-16*a*.

Step 7. Tin the inch of shielding that you just twisted. If you are careful, you can tin it all the way back to where it joins the inner conductor. However, be sure not to burn the insulation.

Step 8. Strip about 1/2 inch of the insulation from the inner conductor in the same way that you would strip any other wire. If the inner conductor is a stranded wire, twist it and tin it. The cable end should now look as shown in Fig. 2-16*b*.

Step 9. Hook the tinned shield and push it through one of the lugs on the tie terminal



(a)

(b)

Fig. 2-16

that you mounted in Step 1. Press the hook together tightly with your long-nose pliers. Cut off any excess and then solder the connection.

Step 10. Connect the inner conductor to the other lug on the terminal strip and solder it. Figure 2-17 shows the two connections you have made.

Step 11. Hold the other end of the shielded cable about two inches from the end. Push the shielding back just as you would insulation on pushback wire. Then pull it back almost to its original position. Bend the cable. This loosens the braid. About one inch from this end, use the awl or scriber to start a hole in the braided shielding. Do this by spreading the braided

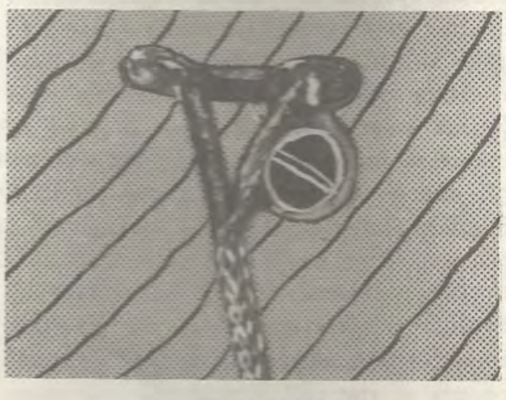
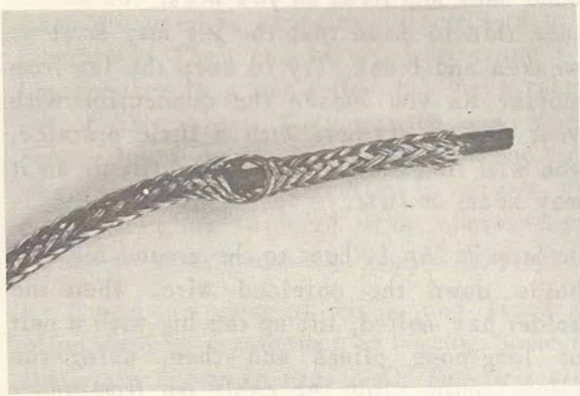
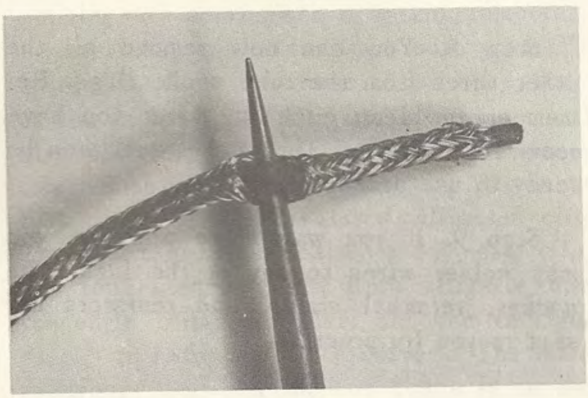


Fig. 2-17

strands apart. Work the point back and forth carefully until the hole is large enough to pull the inner conductor through. See Fig. 2-18*a* and *b*.



(a)



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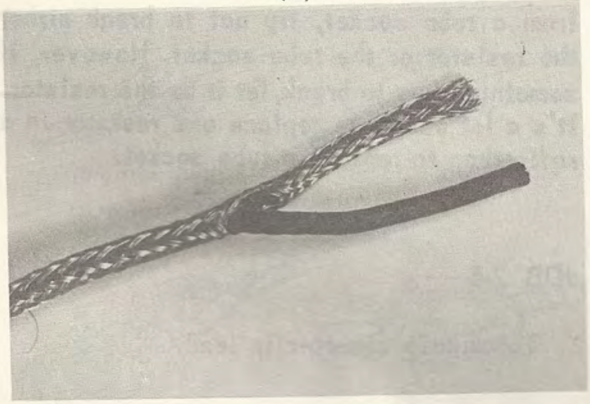


(c)

Fig. 2-18

Step 12. Now push the point of your awl *under* the inner conductor. Be careful not to damage the insulation as you pull the inner conductor out through the hole you have made in the braid, as shown in Fig. 2-18*b*.

As soon as the wire is partly through the hole, you may finish working it out with your fingers.

Step 13. When all of the inner conductor is out, pull the free end of the braid so that it looks as it does in Fig. 2-18*c*. You now have two leads, as you had at the other end. Twist together any loose strands at the end of the shield and tin it. Now strip back about 1/2-inch of the inner conductor, twist the strands, and tin them.

Step 14. Make a hook in the shielding and then push it through lug #6 on the tube socket. Press the hook together with your long-nose pliers. Cut off any excess wire at the joint and solder the connection.

Step 15. Hook the inner conductor and push it through lug #7 on the tube socket. Press the hook together, cut off any excess, and solder the connection.

Step 16. Bend the entire shielded cable around so that it passes near the ground lug that you put on the socket screw in Job 2-1. Lift up the lug and push the cable under the lug. Then bend the lug around the cable as far as it will go, as shown in Fig. 2-19. Now solder the lug to the shielding of the cable.

Caution: Make this soldered connection as quickly as possible to avoid melting

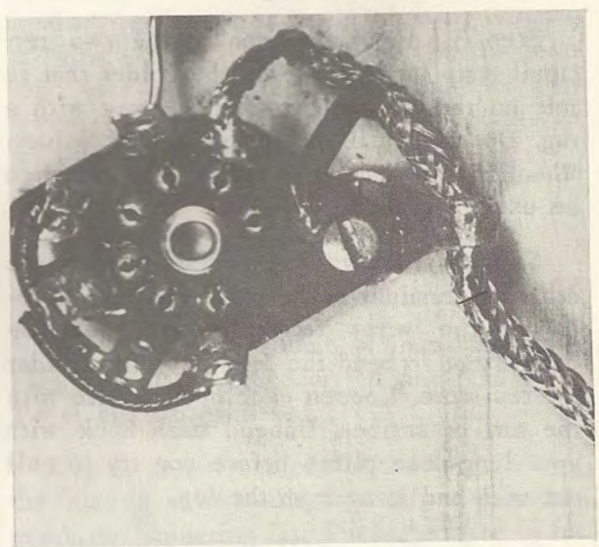


Fig. 2-19

or burning the insulation. If you do not make a good joint the first time, allow the lug and shielding to cool off before heating the joint again.

JOB 2-4

To unsolder all connections made so far in this lesson.

Equipment Needed.

Same as in the last experiment.

Caution: Hot solder may splatter as you pull out a wire from a connection. Keep your eyes as far away as possible and tug gently on the wire.

Procedure.

Step 1. Apply your soldering iron to the lug on the tie terminal to which you soldered the shielding. When the solder starts to melt, loosen the hooked end, using the scriber or awl, as you did in Lesson 1. Loosen the joint. Then, use the long-nose pliers to grasp the end of the wire, and pull the shield out.

Step 2. After you have removed the shield from the lug, unsolder the inner conductor from the other lug in the same way.

Step 3. Apply the iron to the two terminal strip lugs again. As the solder that is left on the lug melts, wipe it away with a rag. Do this until the lug is free of solder. When this is done, the lug will be ready to be used again.

Step 4. Remove the resistors from the other tie terminal in the same way as you removed the wires from the first one. Be careful not to bend the lugs as you unsolder the resistors. Loosen each hooked wire with the awl or scriber. Unbend each hook with your long-nose pliers before you try to pull the wire end away from the lug.

Step 5. After you have removed the resistors, clean the tie terminal as you did the other one.

Step 6. Now remove the resistors from the tube-socket lug. This will be even a little more difficult than removing the resistors from the terminal strip lugs. If you see the lug on the tube socket starting to bend back and forth as you work, you should take this to mean that the lug may start to weaken and break. Try to keep the lug from moving as you loosen the connection with your awl or scriber. With a little practice, you will find that it is not as difficult as it may seem at first.

Step 7. Apply heat to the ground lug that holds down the shielded wire. When the solder has melted, lift up the lug with a pair of long-nose pliers and then, using the pliers again, slide the cable out from under the lug.

Step 8. You can now remove all the other wires from the tube socket lugs. Remember to clean each lug after you have removed the wires. The socket will then be ready to use again.

Step 9. If you want more practice, you may solder wires to any of the lugs. The socket, terminal strips, and resistors are sent to you for practice.

Caution: When you unsolder a resistor from a tube socket, try not to break either the resistor or the tube socket. However, if something has to break, let it be the resistor. It's a lot easier to replace one resistor in a radio than to replace a tube socket.

JOB 2-5

To make a clip-to-clip lead.

Equipment Needed.

Breadboard

Wood screw

Piece of test-lead wire about 1 foot long (cut from the 4-foot length of red testing wire sent you)

Two alligator clips

Nail set or screwdriver

Information. Test clips are used on wire leads that connect test equipment to a radio. They are used in experimental circuits in a laboratory. They can be used to connect a loudspeaker to a radio that has been taken out of its cabinet. They may be used when connecting a good part in place of a bad part when testing radio circuits. In almost all cases, they are soldered to or otherwise attached to wires connected to test equipment.

There are several kinds and sizes of clips used by servicemen in testing. Some of these are shown in Fig. 2-20. The first clip shown, called an *alligator clip,* is very popular with servicemen in making temporary connections while testing radio and TV receivers. Some of these clips were sent to you in Kit 1. An alligator clip is a small clip with long, slender jaws and a convenient thumb grip. The second clip shown in Fig. 2-20 is an *insulated alligator clip.* The next clip shown, called a *crocodile clip,* has long slender jaws. Both alligator and crocodile clips are ideal for use in tight places in radio and TV receivers. The main difference between the two types is in the way in which the jaws hinge. In the alligator clip, only the upper jaw, attached to the thumb grip, moves; in the crocodile clip, both jaws move. The next clip shown is the *Pee-Wee Clip,* which is very handy in making temporary connections to screw terminals and to binding posts. Larger sizes of the same type of clip are used in making temporary connections to storage batteries. The next clip shown is the *Twin Clip,* which is handy in making temporary connections between two or more wires or wire leads. The last clip shown is the *Wee-Pee-Wee Clip.* This clip is very small and slender and, because it is made of phosphor bronze and not of iron or steel, can be used in testing radio coils without becoming magnetized.

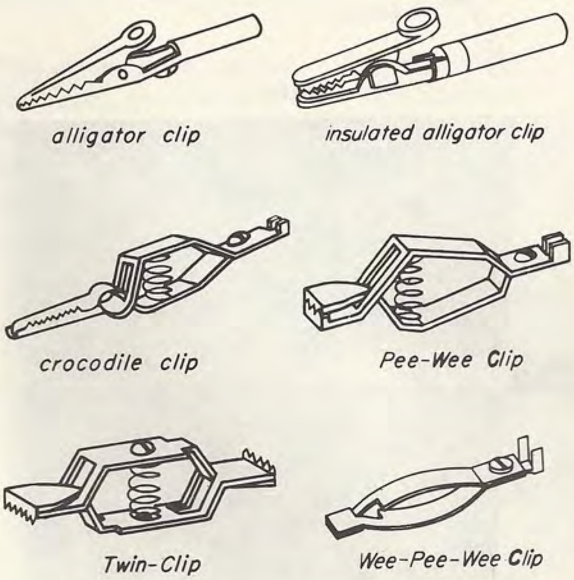


Fig. 2-20

If necessary, almost any kind of wire found around a radio shop may be used with test clips for making temporary test connections. However, for making handy clip leads and other test leads, a special type of wire, called *test-lead wire,* is used by radio and TV technicians. Some test lead wire was sent to you in Kit 1.

Look at a piece of the test lead wire that was sent to you. You will see that the insulation around it is heavier than the insulation around the other wire in your kit. The wire itself is quite thick. The heavy insulation helps to protect the user from shock.

Test-lead wire is made of many strands of wire twisted together. This makes test-lead wire much more flexible than ordinary wires, so that it always tends to return to its original shape, even if twisted.

Procedure

Step 1. Strip 1/2 inch of insulation from each end of the piece of red test-lead wire. Twist and tin each end.

Step 2. Insert one end of the wire through the sleeve of the alligator clip and underneath the soldering lip. Push the wire in far enough so that the insulation on the wire goes about 1/4 inch into the sleeve.

Step 3. Tighten the connection by pressing the lip back toward the rear of the clip with a nail set or screwdriver blade, as shown in Fig. 2-21*a*.

Step 4. Solder the wire and lip, as shown in Fig. 2-21*b*. Be sure to clean off any excess solder with a rag. Make the soldered joint as smooth as you can. Figure 2-21*c* shows how it should look.

Step 5. Attach the other alligator clip to the other end of the wire in the same manner.

Notes:

1. Do not take the clip-to-clip lead apart. You will use it in later experiments.

2. Save the other alligator clips for use in later lessons.

JOB 2-6

To make a pair of test leads.

Equipment Needed.

Two test prods

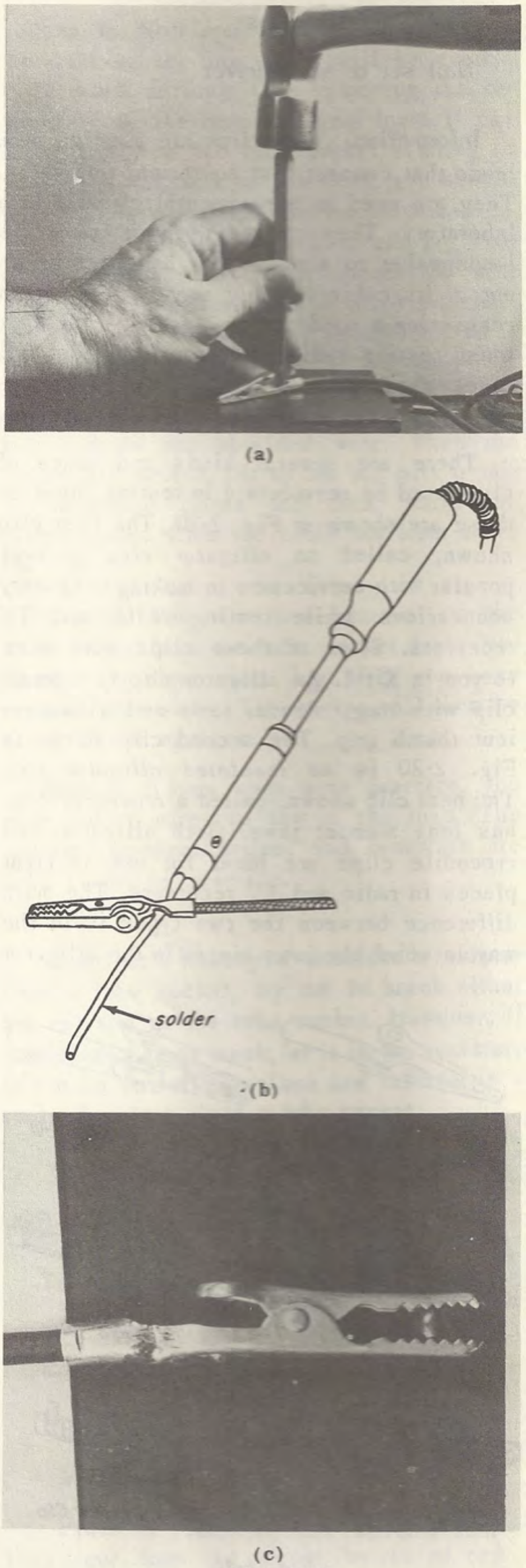
Two phone tips

Two pieces of test-lead wire (3-foot lengths)

Breadboard

Nail of same thickness as thin end of phone tip

Information. A *test prod* or *test probe* is often used in tight places. A test prod is shown in Fig. 2-22. A simple test prod has tips instead of clips, so you must hold a test prod in place with your hand. Look at one of the test prods sent to you in Kit 1. The body is insulated and long so that it may be held without danger of electric shock. Notice also that it is easy to hold with the hand. Test prods are made in several colors, but black and red are the most popular.



(a) (b) (c)
Fig. 2-21

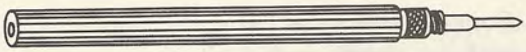


Fig. 2-22

Different colors allow you to tell one prod from the other when testing a radio or TV receiver. Test prods are often more convenient than alligator clips, as you will learn later on in the course.

There are two basic ways to connect a wire to a test prod. The bodies of some prods can be unscrewed, and the wire can be soldered to a small cup-like piece at the shank of the prod, as shown in Fig. 2-23*a*. Another type of prod, such as the one you received in your kit, has a small knurled nut screwed on the shank. This nut can be removed, exposing a small hole. The wire is pushed through the body of the prod until it comes out of the hole. It is then bent around the shank and the nut is replaced. This is an easy method of connecting a wire to the prod.

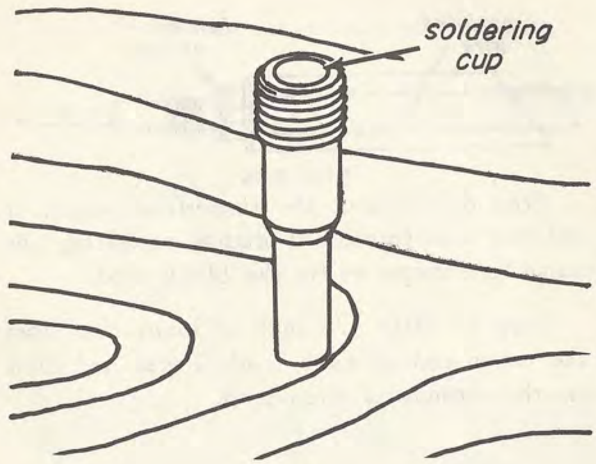
Phone tips are often used in making temporary connections. A phone tip, like those you received in the kit, is just a piece of conducting metal with an opening at the top into which a wire can be soldered. It makes a good connector because it is very rigid. Phone tips fit into an opening known as a *tip jack* or *pin jack*, shown in Fig. 2-23*b*.

Some phone tips are made very much like a test prod, except that they are shorter. Their only advantage is that they have insulated bodies. Electrically, they make no better connection than the plain type, and they are much easier to damage.

Procedure.

Step 1. Cut one 3-foot length of black test-lead wire from the 4-foot length sent you and strip one inch of the insulation from one end. Twist the strands together and tin the wire.

Step 2. Remove the knurled nut on the shank of the black test prod by twisting it counterclockwise. Notice that there is a small hole in the shank, up near the start of the body.



(a)

(b)

Fig. 2-23

Step 3. Put a slight curve on the tinned end of the wire and push it into the body of the test prod. The object here is to make the wire come out of the small hole. If you are lucky, it will come out immediately. If the wire doesn't come right through, hold the wire and turn the test prod slowly until you feel the wire catch in the hole. Then push it all the way through.

Step 4. Pull the end out as far as it will go and then bend the wire around the shank, just under the lip that appears above the hole, as shown in Fig. 2-24.

Step 5. The nut is made to fit over the wire you just bent around the shank. Replace the nut on the shank and be sure to tighten it exactly as it was before you removed it.

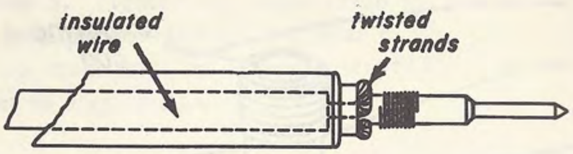


Fig. 2-24

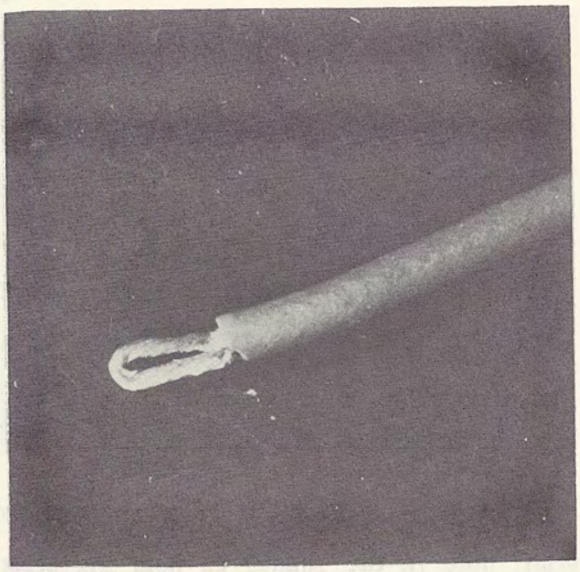
Step 6. Connect the three-foot length of red test lead to the red prod by repeating the same five steps as for the black prod.

Step 7. Strip 3/4 inch of insulation from the other end of each lead. Twist and then tin the strands of each lead.

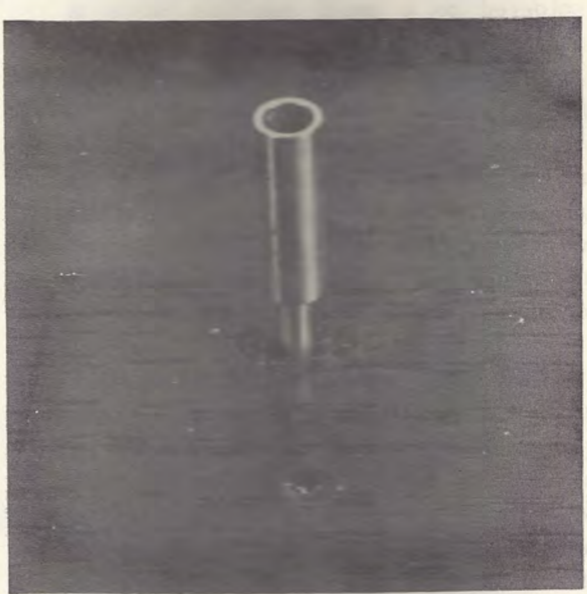
Step 8. Bend the tinned end of each lead in half, as shown in Fig. 2-25*a*.

Step 9. Drive a nail of the same thickness as the thin end of the phone tip part way (about 1/2 inch) into the breadboard. Then remove the nail from the board. The hole in the breadboard will provide a support for the phone tip while you solder it.

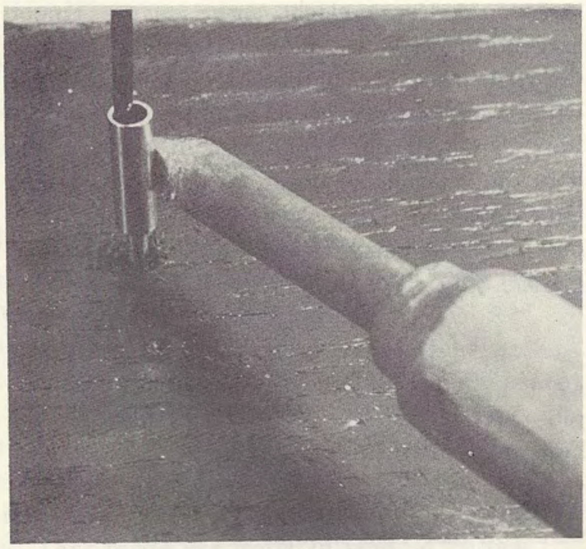
Step 10. Place one of the phone tips in this hole. Be sure that it is held rigidly and the open end faces you, as shown in Fig. 2-25*b*.



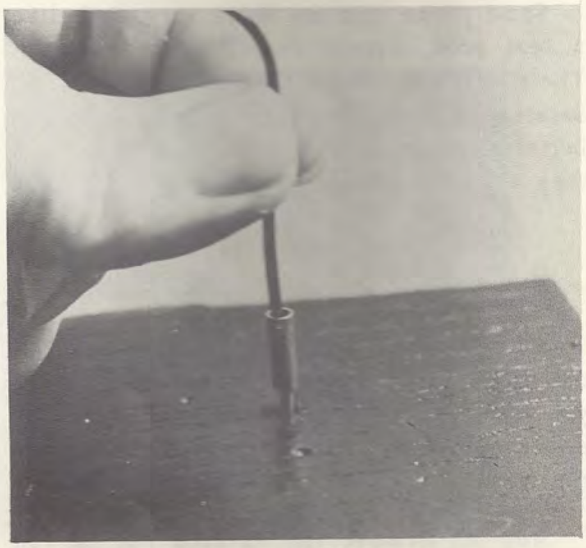
(a)



(b)



(c)



(d)

Fig. 2-25

Caution: In the following steps, some hot solder may splatter. Keep your eyes a good distance from the phone tip while you solder it.

Step 11. Cut a piece of solder just long enough to fit inside the phone tip. Place it in the open end of the tip.

Step 12. Hold the iron against the side of the tip, as in Fig. 2-25*c*, until the solder inside melts. Then insert the folded end of one test lead slowly into the opening of the tip. Allow it to go in as far as possible and then, as you remove the iron, hold the wire in place, as shown in Fig. 2-25*d*. Allow the phone tip to cool off for a minute; then remove the tip from the breadboard and test it by tugging gently at the wire while holding the phone tip with a pair of pliers. If the wire comes loose, you will have to repeat the soldering operation.

Step 13. In the same way, solder a phone tip to the tinned end of the other test lead.

Notes:

1. In soldering a phone tip, hold it tightly so that it cannot move and possibly cause a cold-soldered joint.

2. Clamping a phone tip in a vise is not recommended, because the metal jaws of the vise conduct the heat away from the phone tip.

3. The test leads you have just assembled are for use with your multimeter. Do not take them apart. When they are not in use, you might fold them as shown in Fig. 2-26.

JOB 2-7

To remove two-inches of insulation from each end of your three-foot lengths of coaxial cable.

Equipment Needed.

Two alligator clips

Two phone tips

One 3-foot length of coaxial cable

Length of test-lead wire (remaining 1-foot length of black test lead wire)

Spaghetti

Short length of board

Nail

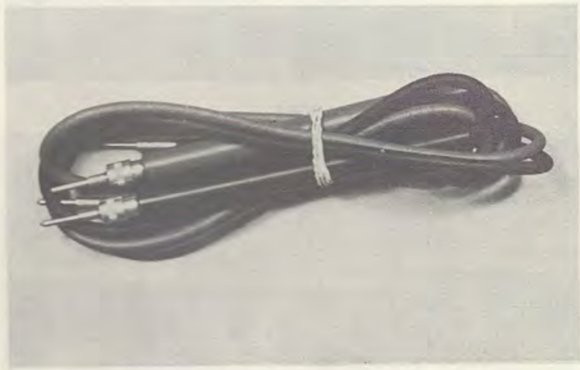


Fig. 2-26

Information.

Until now, we have suggested that you always remove insulation by a method that looks very much like whittling. It is the best method to use in most cases. However, the outer covering of your *co-ax* is made from a very tough plastic or rubber. The neat removal of such material calls for a different method, which you will try now.

Procedure.

Step 1. Mark off a line two inches from the end of the breadboard, as shown in Fig. 2-27*a*.

Step 2. Place the end of the cable even with the end of the board. Then hold your knife edge on the outer insulation of the cable at the two-inch line as you hold the cable flat against the surface of the wood with your other hand, as shown in Fig. 2-27*b*. Your object, at this point, is to cut part way through the outer insulation. Keep a steady, even, and light pressure with your knife against the insulation as you roll the cable

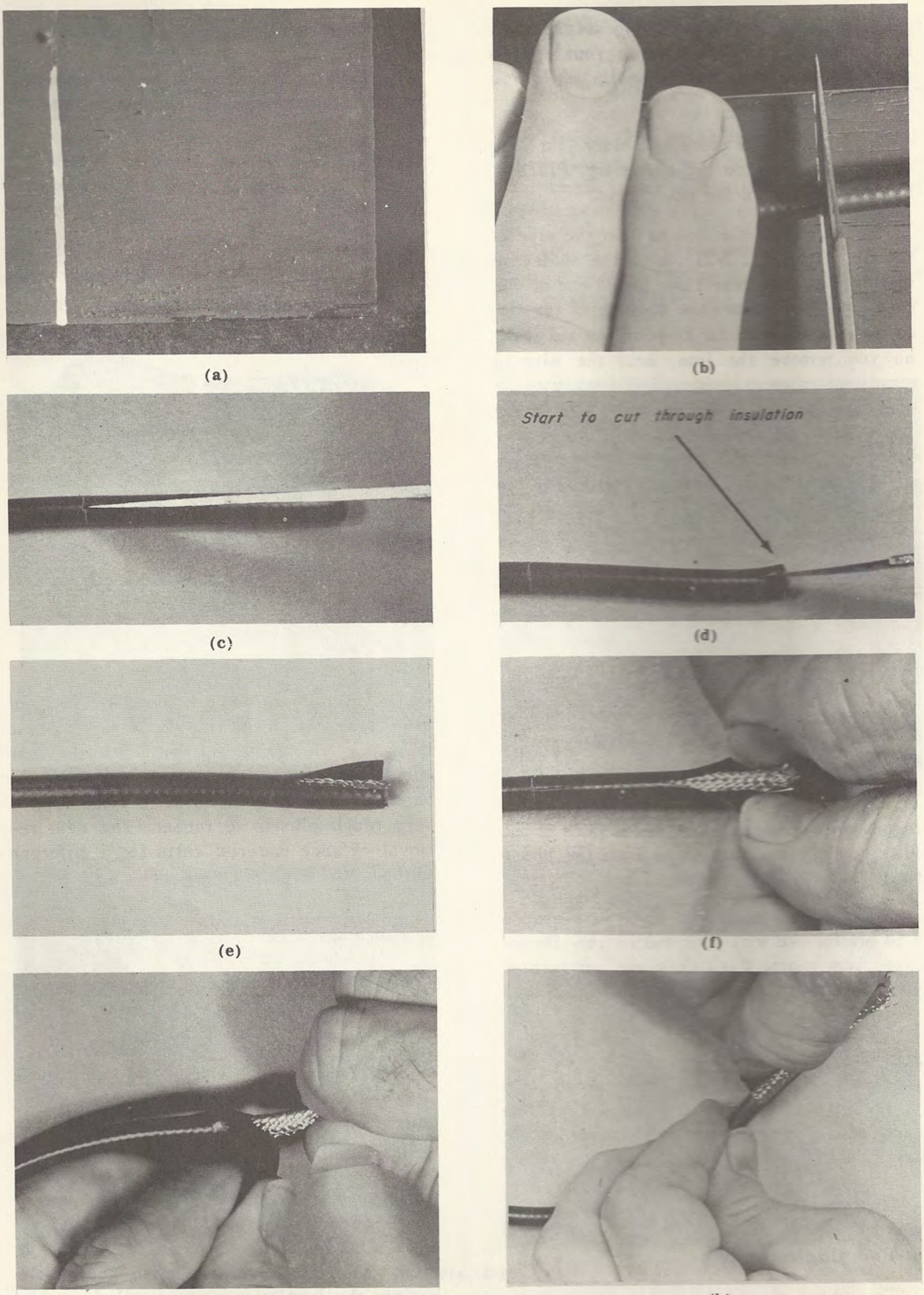


Fig. 2-27

back and forth with your other hand. Be careful not to cut too deeply into the insulation.

Step 3. Next, hold the cable as shown in in Fig. 2-27*c*, and, using the same pressure as before, draw your knife from the circular cut you just made back to the end of the cable. It is better to take several light strokes rather than to cut through the insulation and possibly tear the shielding.

Step 4. Starting at the very end of this cut and working back about 1/4-inch from the cable end, cut the insulation all the way through, as shown in Fig. 2-27*d*. Be careful not to cut the shielding.

Step 5. As soon as the insulation has been cut through, force your thumbnail under the insulation and, with your thumb and forefinger, pull away the insulation from the cable, forming a small triangular flap, as shown in Fig. 2-27*e*. Form a similar flap at the other side of the cut, so that, when you are through, you can use the thumb and forefinger of each hand to tear the insulation along the line of the long cut, as shown in Fig. 2-27*f*.

Step 6. When you have loosened the insulation a distance of about 1/2 inch, hold the loosened flap in one hand and the inner shielded cable with the other hand and pull back, as shown in Fig. 2-27*g*, toward the two-inch line.

Step 7. At this point, the insulation may tear away completely up to the two-inch line. If not, tear the insulation away along the two-inch line, as shown in Fig. 2-27*h*.

This job takes longer to tell about than to do, although you may find it more difficult to do the first time you try it than you will later on.

Step 8. In the same manner, remove two inches of insulation from the other end of the cable.

JOB 2-8

To make a shielded test cable.

Procedure.

Step 1. Pull the inner conductor through the shielding as you did when you used the second method of Job 2-3. Do this for both ends of the cable. You will find that this inner conductor is a little stiff to work with, because it is solid wire.

Step 2. Draw the braided shield out carefully to its normal length by gently pulling on it. Do this at both ends of the cable. Twist the end of each braid as you would twist stranded wire.

Step 3. Tin each of these loose ends of braid back for about one inch from the end. The plastic used in the inner insulation melts at a low temperature, so be very careful not to get the iron too close to it. At this point, each end should look like the picture in Fig. 2-28.

Step 4. Remove about 1/4 inch of the plastic insulation from one end of the inner conductor of the cable, using the usual whittling method. You will find that this plastic insulation is more difficult to remove, so work carefully and don't be impatient. In this way, you will avoid cutting yourself or nicking the inner wire.

Step 5. Carefully tin the exposed copper wire without melting the plastic insulation.

Step 6. Insert the tinned wire through the sleeve and under the soldering lip of one of

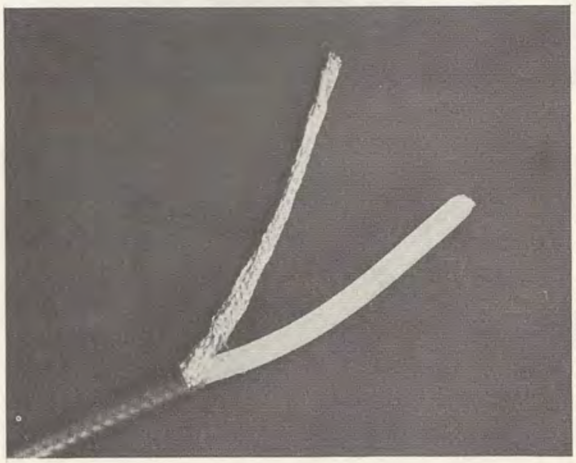


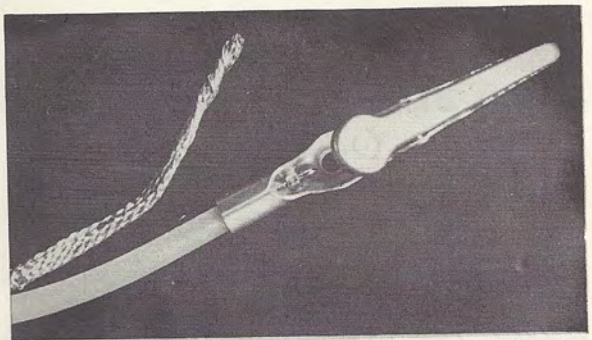
Fig. 2-28

the alligator clips. The wire will be inserted far enough when about 1/4 inch of plastic insulation is inside the sleeve of the clip. With the wire in this position, hold the clip flat on the board, as illustrated in Fig. 2-21*a*. With a nail set or a screwdriver blade, force the soldering lip down toward the wire and toward the back of the clip. If you do this properly, there should be a good mechanical connection between the wire and the clip.

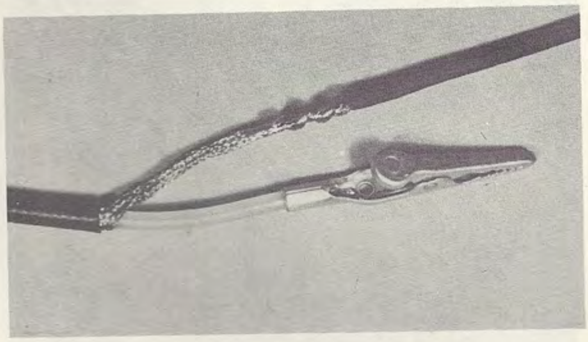
Step 7. Clip the alligator clip to the nail on the breadboard, as you did when you made the clip-to-clip lead. Using only the point of the iron on the underside of the clip, quickly solder the connection.

Step 8. Cut your 1-foot length of black test lead wire in half. Put one piece away; you'll need it in a later lesson. Remove 1-inch of insulation from one end of the other 6-inch length. Solder this end to the end of the loose braid next to the clip, as shown in Fig. 2-29*b*.

Step 9. Cut a 2-inch length of the wide spaghetti and slip it over the test-lead wire, up over the joint you have just soldered, until it reaches the plastic insulation.



(a)



(b)

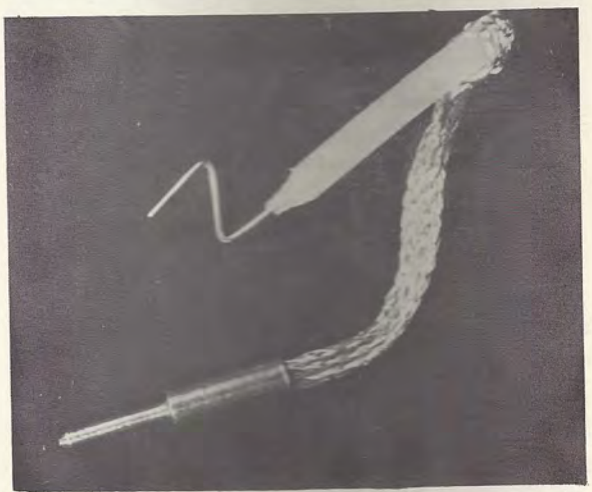
Fig. 2-29

Step 10. Remove 1/4 inch of insulation from the other end of the 6-inch length of test lead. Twist the strands together and tin them.

Step 11. Slip this tinned wire through the sleeve and under the soldering lip of the remaining alligator clip until the insulation is just before the end of the sleeve, so that you can see the wire on both sides of the soldering lip. With the wire in this position, make a good mechanical connection as before and then solder it.

Step 12. Solder a phone tip to the end of tinned braid at the other end of the cable.

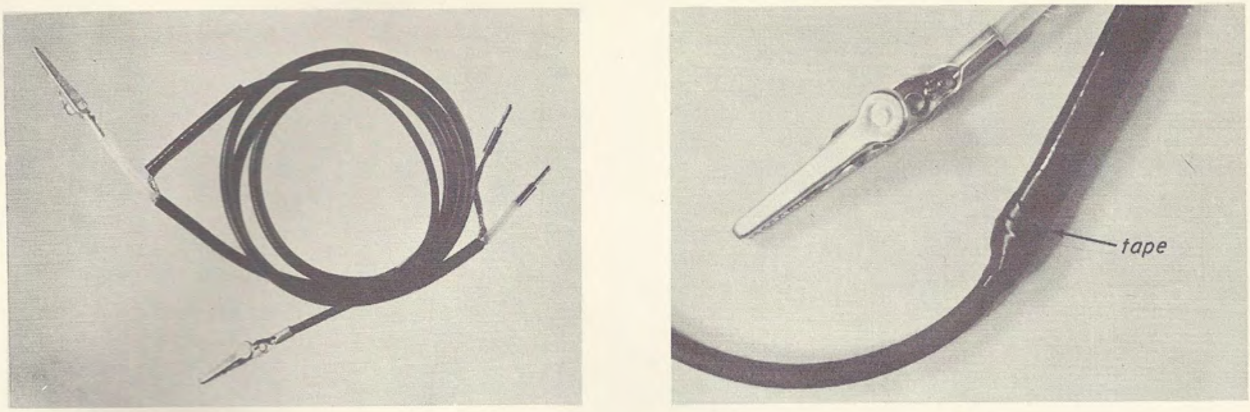
Step 13. Remove 1 inch of plastic insulation from the inner conductor at the same end of the cable. Be careful not to nick the wire.



(a)

(b)

Fig. 2-30



(a) Fig. 2-31 (b)

Step 14. Tin this exposed wire and bend it in the shape shown in Fig. 2-30*a*. Make the first bend at the end of the wire, and the second bend (in the opposite direction) about 2/3" from the end of the wire. Press the Z-bend together until it looks like the bend in Fig. 2-30*b*. You can tell that it is close enough together when the Z-bend just fits into the open end of the phone tips.

Step 15. Solder the tinned end of the wire that you bent in Step 14 into the phone tip. Be careful when you are soldering that you do not apply too much heat or you will melt the plastic insulation.

Notes:

1. You have just made a shielded cable that you will use later with your signal generator and in other test work. Do not take it apart. Coil it, as shown in Fig. 2-31*a*, and keep it with your test leads.

2. If the spaghetti sleeving tends to slip away from the joint, you can keep it in place by wrapping about 1 inch of black plastic electrician's tape (some was sent to you in in Kit 1) around it, as shown in Fig. 2-31*b*.

3. Put away the black plastic electrician's tape, because you will need it again in Experiment Lesson 5.