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how to build electronic kits

an easy guide for beginners

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HOW TO BUILD ELECTRONIC KITS

An Easy Guide for Beginners

**Written Under the Direction of
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PREFACE

Building electronic kits is great fun. It's instructive, too. Best of all, it's a way to become the owner of high-quality electronic equipment at costs substantially below those for equivalent factory-built units. A finished kit will give you a sense of pride, the satisfaction of accomplishment. If you take care to build your kits well, they will serve you faithfully for years.

Almost any type of electronic equipment is available in kit form—components for high-fidelity music systems, test instruments, amateur gear and Citizens Band transceivers, short-wave receivers, transistor radios, intercoms, light meters and even automobile engine analyzers—just to name a few.

Anyone who thinks about building a kit for the first time may wonder whether he can do it without special knowledge or training. Possibly you are asking yourself this question and perhaps that's why you are reading this book. Stop worrying right now! Anyone can do it simply by following instructions. In planning and producing kits, manufacturers go to great lengths to make sure the finished product will be everything the builder hoped for.

The fact is, you don't need this book to be successful in building kits. But it can help you while you are building a kit from step-by-step instructions by letting you know that what you are doing is right.

To insure success with your first kit, there are some basic techniques with which you should become familiar. These include use of the few simple tools needed and—very important—how to make good solder connections. This book will help you master these techniques.

In the following pages you will learn about the kinds of kits that are available. Words and pictures will show you how to build three kits. You will learn how to identify electronic components and how to recognize their symbols in a wiring diagram. Also, you will become familiar with pictorial diagrams, a wonderful technique for showing how to mount and wire the parts that make up a kit.

As the country's largest distributors of electronic parts and equipment, Allied Radio has marketed the products of a great many kit manufacturers in addition to its own line of Knight-Kits. (Knight-Kits are engineered, designed and produced by Allied's manufacturing subsidiary, Knight Electronics Corporation.)

Allied's first kits, including a "3-tube Cockaday" and the "5-tube Neutrodyne," well-known to old timers, were offered in the company's catalogs of the early 1920's.

This book is based on Allied's experience with every kind of kit building and with hundreds of thousands of kit builders.

When you select your first kit and complete the exciting new adventure that is the good fortune of all first-time kit-builders, you will know the answer to the question, "Can I build an electronic kit?" is without a doubt—YES!

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CHAPTER ONE

THE VALUES OF KIT BUILDING

Kits, designed to be assembled by the user, serve many purposes—to provide the builder with practical knowledge and experience, to save the user the cost of factory assembly, to offer the more particular buyer an opportunity to hand-craft his own equipment. Most of all, however, kits are popular because of the pleasure and feeling of accomplishment experienced by builder-users. This explains why hobbyists and experimenters build more kits than anyone else.

In part, the sense of pride developed from building a kit stems from the special knowledge gained as a by-product. Amateur and Citizens Band radio enthusiasts, for example, are proud of their special knowledge. They speak of such things as impedance match, modulation and spurious oscillation like graduate engineers. Yet some of them are not yet high school age! Hi-fi enthusiasts become experts on wow and flutter, frequency response, resonance, roll-off, attenuation and other such terms.

Why Kits Are So Popular

Almost anything that is manufactured can be bought in kit form. This includes such major items as houses, boats, sailplanes and, of course, electronic equipment. Why are kits so popular? Basically, most of us are do-it-yourselfers at heart. Many homeowners build cabinets and bookshelves. Some become adept enough to build an additional room, even an entire house from precut materials.

You probably are a do-it yourselfer with somewhat less grandiose plans. If you have already built a kit, you can remember how you enjoyed the project, even though it may have robbed you of some sleep when you burned the midnight oil. Remember your excitement when the package arrived? Then came the joyful time of going over the manual, laying out the parts and starting the magical process of assembly.

Finally the job was done. And, because you followed instructions, it looked pretty good. Pretty proud of the fruit of your labors, weren't you? Undoubtedly you soon were looking forward to your next project.

So, why are kits so popular?

First, because of the long-lasting sense of satisfaction you get from demonstrating to yourself and to others that you are capable of creating something useful and worthwhile. *You* create—and you have a right to be proud of your craftsmanship.

Second, you add measurably to your store of knowledge and experience. You learn how to use new tools, make adjustments and measurements, form new and finished shapes out of various forms of raw materials. Without a doubt, you gain in prestige, becoming an expert in the eyes of those who have not had your experience.

Third, the economics are highly attractive. By using your own time and energies, you obtain new equipment at considerably less than the cost of a manufactured product. And the kit you build cannot be distinguished from a factory-built unit.

Satisfaction, accomplishment, enjoyment, experience, knowledge and economy without sacrificing quality—all this and more is to be gained by the kit-builder.

Types of Electronic Kits

If you glance through some of the catalogs published by electronic equipment distributors, you will be amazed at the wide range of kits offered. There was a time when electronic kits were specialty items for technicians and ham-radio operators. Once upon a time you had to know a great deal about electronics to build the kits available. But that was long ago. Thanks to the widespread interest in electronics among men and women of all backgrounds and all ages, kit manufacturers have concentrated their efforts on eliminating the mysteries of construction. The construction manual of a well-designed kit makes it virtually impossible to go wrong. Table I-1 lists examples of the many electronic devices available in kit form. For almost anything you can buy in factory-wired form, there probably is a kit to fulfill your need.

Table I-1. Examples of Equipment Available in Kit Form

APPLICATION	TYPE OF EQUIPMENT
Automotive and Marine	Tachometers, transistor ignition systems, ignition analyzers, battery checkers, battery chargers, DC-AC converters, AM-FM radios, depth sounders, direction finders, CB transceivers, electronic megaphones, marine band receivers.
Business	Computers, intercoms, CB transceivers, burglar alarms, public address and paging systems.
Home Entertainment	Black-and-white TV sets, color TV sets, music and intercom systems, photoelectric relay devices, radios of all types, high-fidelity units, electronic organs, burglar alarms.
Ham and CB	Transmitters and receivers of all types, SWR bridges, field-strength meters, mobile power supplies, code practice oscillators, RF converters, RF preselectors.
Laboratory and Service	Oscilloscopes, VOMs, VTVMs, voltage calibrators, sweep generators, signal generators, tube testers, transistor testers, battery eliminators, signal tracers, capacitor analyzers, Q-meters, inductance bridges, R-C substitution boxes, grid-dip meters, CRT checkers, flyback testers, electronic switches.
Other Hobbies & Miscellaneous	Starter kits for educational purposes, photo exposure meters, variable power controls.

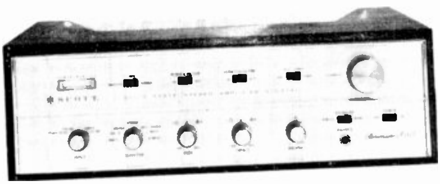
How to Choose Your Kit

There are a large number of kit manufacturers today. Many make the same types of items; features may vary but applications are the same. So how do you choose the brand of kit best suited to your needs? Well, one way to make a wise decision is to use the same procedure you would follow in buying any product you know little about. Considering that the choice you make will be a very important step, it's certainly worth some thought. After all, if the kit is poorly designed, if the components are inferior, if the instructions are poorly written and presented, if the manufacturer makes no provision for follow-through service, you will

Knight-Kit KG-663
Solid-State Power Supply

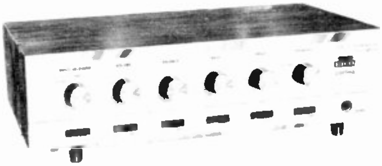
Knight-Kit Solid-State
Power Inverter/Charger

RCA WO-33A Oscilloscope

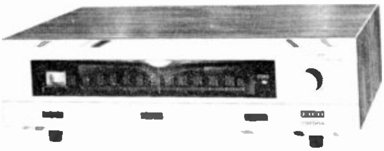


Scott LK-60B Stereo Amplifier

Scott LT-112B Stereo Tuner



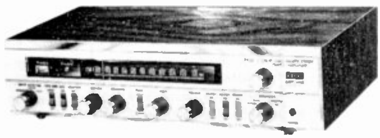
Eico 3070 Stereo Amplifier



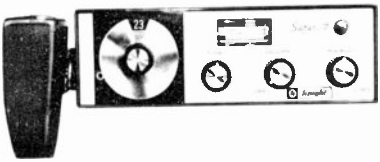
Eico 3200 Stereo Tuner

Knight-Kit VHF-FM Monitor

Knight-Kit KG-600B Tube Checker



Eico 3570 Stereo Receiver



Knight-Kit Safari III Citizens
Band Receiver

EICO 460 Oscilloscope

Knight-Kit KG-275
Exposure Meter

EICO 667 Tube &
Transistor Checker

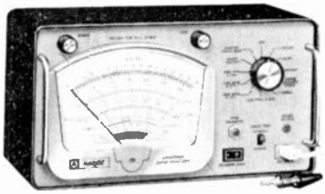
Knight-Kit KG-870 Solid-State Amplifier

Knight-Kit KG-980 Solid-State Receiver

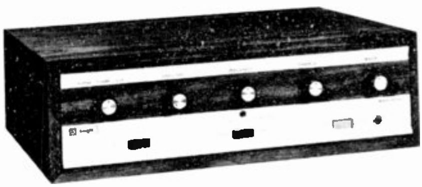
Dyna SCA-35 Stereo Amplifier

Knight-Kit KG-371 Automobile Timing Light

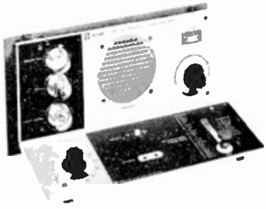
Dynakit Stereo 120 Basic Amplifier



Knight-Kit KG-375A Auto Analyzer



Knight-Kit KG-865 Solid-State Stereo Amplifier



Knight-Kit 100-in-1 Electronic Lab Kit

Available in Kit Form

never be satisfied with the appearance of the finished kit or the way it performs.

However, it doesn't have to work out that way. If you select your kits the same way you would any merchandise about which you have limited knowledge, you won't be disappointed.

First, ask your friends what they know, what their experience has been. Second, remember that you rarely can go wrong with nationally-known brand-name products. They have gained recognition because of their superiority and the integrity of the manufacturers. Because of their high-volume sales, they can use better quality components—one additional assurance of superior performance and long equipment life. Also, the well-known suppliers have had more experience in designing kits and are financially in a position to back up their products. They often have a highly developed, efficient and skilled customer service department to answer your questions or handle problems you may run into during the kit construction. One of the finest benefits of doing business with a large and well-known kit manufacturer is found in the instruction manual that comes with each kit. The good ones are masterpieces of clarity.

The preparation of a good instruction manual is a developmental process. Only through years of first-hand experience in overcoming customer problems can a kit manufacturer develop the special techniques required in preparing instruction manuals. Only with clear, concise, complete and accurate stey-by-step procedures can an inexperienced builder assemble many of the electronic kits available today. It is the instruction manual that makes them easy to build. No short cuts by the manufacturer—no headaches for you! Those specifications will narrow down the list of kit manufacturers rather quickly.

Ask your TV service dealer, a friendly ham, an electronic technician or engineer, or a science or industrial arts teacher for a list of names of the leading kit manufacturers for a starter. Write to companies who are distributors for a number of kit manufacturers. Ask for their catalogs and use the information they provide to determine which kits may best suit your needs.

Thinking about a stereo hi-fi amplifier kit? Say in a price range up to $50? It's a practical thought. Okay, let's say you already have made a list of preferred kit manufacturers by name. Now list those that make hi-fi kits within your price range. This narrows the list still further so you now can compare the possibilities. Maybe you eliminate some because of physical appearance. Styling may not be attractive to you. That's a subjective matter that only you can resolve. If a choice is still available you can examine the technical specifications and check them against your needs.

Suppose you decide you want at least 10 watts per channel in stereo operation with inputs for an AM-FM tuner, a record player and a tape recorder. You probably want separate bass and treble tone controls, stereo-reverse switching, preamplifier circuits with DC-operated heaters to minimize hum and noise. And you want the best audio performance you can get for the money—low distortion at full power output and wide frequency range. Make your own table of specifications for each of the makes and models that might satisfy you, selected from only best-known and well-recommended brands. Make a separate column for your own hypothetical specifications. Then make comparisons and draw your own conclusions. This is a realistic approach to evaluation—one that enables you to make a choice that will give you maximum assurance of complete satisfaction.

Maybe you are considering a short-wave receiver so you can tune in international broadcasts, hams, Citizens Band stations, airplanes, ships at sea and all the other exciting sounds of world-wide radio listening. Looking through Allied Radio's catalog, you'll find a description of the Knight-Kit "*Star Roamer*®, a compact and low-cost superhet receiver that has many features usually found in more expensive communications sets. In addition to the short-wave bands, it covers the AM broadcast band and long-wave (200 to 400 kc.) Marine and aircraft radionavigational bands. The *Star Roamer* has electrical bandspread for fine tuning, an illuminated S-meter to show signal strength of incoming stations, a sensitivity control, automatic noise limiter, a beat note for code signals, a built-in 4″ loudspeaker, transformer power supply, antenna trimmer for peaking the set to each incoming signal, a slide-rule type tuning dial and many other valuable features. It looks smart, too, in its handsome metal cabinet. Knight-Kit is a famous, nationally known name. The total price of the kit is only $39.95.

When you order a kit don't forget needed building tools that you do not already have (see Chapter 3). The *Star Roamer* is a typical kit that will be used as one of our subjects on kit building in a later chapter. Before your first kit arrives you can use the time to learn about electronic components and how to make perfect solder connections, one of the most important secrets to successful kit building.

CHAPTER TWO

ELECTRONIC COMPONENTS

It is not necessary to know anything about electronic components to build a kit successfully. However, knowing how to identify components and knowing something of what they do and how they do it adds immeasurably to the fun of electronic kit building. So this chapter is sort of a short course on components. Should you be inclined to learn more about them, we suggest the companion volume, "Getting Started in Electronics," also published by Allied Radio.

Electronic components are the parts that, when connected according to specific plans, form electronic circuits. The circuits, each with its own job, control electric currents and voltages to achieve the desired purpose. Kits also contain hardware, the metals, fibres, plastics, screws, nuts, washers and insulators used to serve mechanical functions. Basically, there are only a couple of dozen types of electronic components but they come in thousands of sizes and shapes. No doubt you've heard the names of several but you may not have seen them. Or if you have seen them you may not be able to identify them. Read on—a few pages from now you will be able to describe them like a veteran and be able to recognize them in your radio, TV or hi-fi set.

Capacitors

You've probably heard the word *capacitor*, or at least the outmoded term *condenser*. One form is connected across the breaker points in the distributor of an automobile ignition system. So you hear mechanics say, "The points and condenser need replacing." Basically, a capacitor consists of two conductive surfaces separated by a nonconductor (insulator), as shown in Fig. 2-1. The nonconductor is called a *dielectric*. Usually the dielectric material is air, ceramic, glass, mica, plastic or treated paper. A capacitor is capable of storing electrical energy supplied to it by a power source, such as a battery. When the power source is disconnected the energy stored by the capacitor can be released into a circuit, or *load*, as needed.

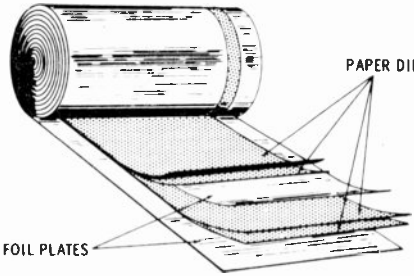


Fig. 2-1. Basic construction of a paper capacitor.

Take the automobile breaker-point, for example. When the points close high voltage is fed to one of the spark plugs. When the points open the high voltage could jump (arc) across the breaker points. Breaker point arcing is undesirable, though, because it causes the contact surfaces of the points to burn and become pitted. A condenser or capacitor, connected across the breaker circuit minimizes the arcing. When the breaker circuit closes, the dielectric material does not allow current to flow through the capacitor (but it does pass through the closed breaker circuit). When the breaker circuit opens, the surge of electrical enegy is absorbed by the capacitor, greatly reducing the arc across the points.

Used in this manner, such capacitors are referred to as *filter* capacitors. Also, because of their internal wet construction, they are also known as *electrolytic* capacitors. They often are used in power supplies, storing energy when the demand is low, releasing it when the demand increases. The construction of a typical electrolytic capacitor is illustrated in Fig. 2-2.

Two conductors of electrolytic capacitors are termed anode and cathode. Dielectric is thin film of insulating material on one side of aluminum-foil anode. Electrolyte is conductive liquid, together with second strip of aluminum foil, forms cathode.

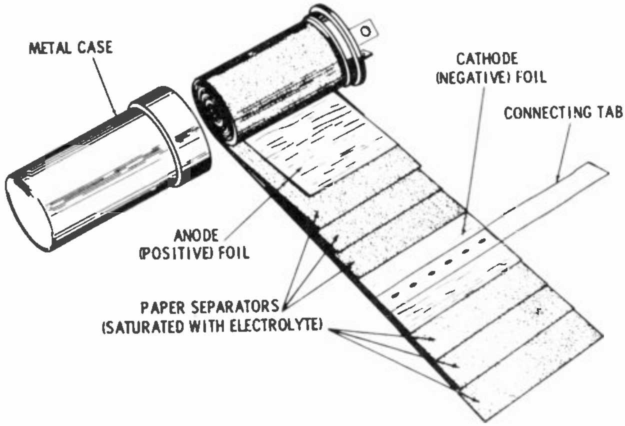


Fig. 2-2. Construction of an electrolytic capacitor.

A characteristic of capacitors is the ability to block the flow of electric current, although they wiil permit voltage *changes* which take place at one terminal to appear at the other terminal. So if you have both DC and AC voltages present in a circuit but want to pass only the AC signals, a *blocking* capacitor is what you use. Thus, capacitors often are used in connecting the output of one circuit to the input of another, such as a series of amplifier circuits (or *stages*, as individual circuits are called). DC voltages from the power supply to each stage will be kept separated while AC voltages (representing voice signals, for example), will pass from one stage to another. Blocking capacitors usually are smaller than electrolytic types. Several physical shapes are used for various purposes. Depending on design and application, they have been termed as disc, ceramic, paper tubular, mica and mylar capacitors. Several types are shown in Fig. 2-3.

The *capacitance*, or electrical value, of a capacitor is given in units of the farad. But the farad is a huge value. So values of capacitance are expressed in millionths of a farad, using the term *microfarad*, and *micromicrofarad*, for mil-


Can Electrolytic


Tubular Electrolytic


Disc Ceramic


Paper Tubular


Mica

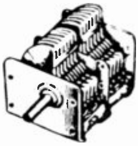

Mylar

Fig. 2-3. Various types of capacitors.

lionth of a millionth. The Greek symbol μ (pronounced mu) often is used as an abbreviation for *micro*. Thus, μf or μfd may be used as the abbreviation for microfarad and $\mu\mu$f or $\mu\mu$fd for micromicrofarad. Also commonly used are *mfd* and *mmf*. And the latest standards designate use of the term *picofarad* in place of micromicrofarad; the abbreviation for picofarad is *pf*.

There are *variable* capacitors, too, designed to permit the capacitance value to be changed over a wide range. Did you know that you adjust such a component when you tune your radio? The dielectric for this type of variable capacitor is plain air. When tuned, the plates are made to intermesh, or close, to increase capacitance; when the plates are open, or unmeshed, capacitance is at minimum. Some examples of variable capacitors are shown in Fig. 2-4.

Another type of variable capacitor is the *trimmer*, two plates separated by a thin wafer of mica. A screwdriver


Variable tuning capacitor

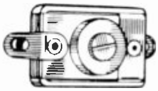

Trimmer capacitor

Fig. 2-4. Air-type variable capacitors.

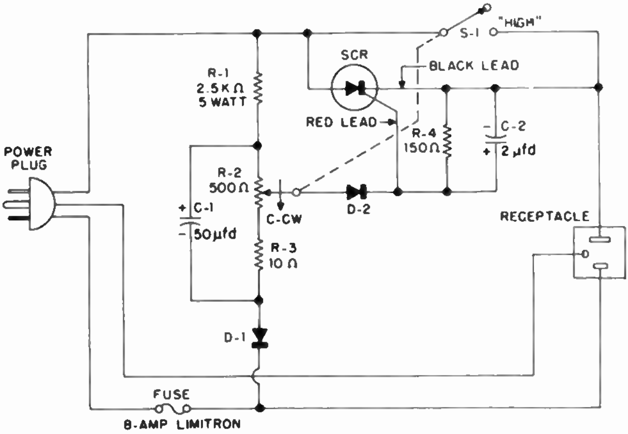


Fig. 2-5. Diagram for motor-speed/light-control device.

adjustment is provided so the distance between the plates can be varied by a fraction of an inch. Capacitance value is at minimum when the plates are farthest apart, maximum when they are closest.

Instruction manuals supplied with kits usually identify capacitors in two ways—by the capacitance value, which also is printed on the body of the component, and by the letter *C* followed by a simple digit. Take a look at Fig. 2-5, for example. It shows the wiring diagram of an electronic device for controlling the speed of electric motors and the brilliance of lights. Just to the right of the power plug, you'll see C-1, 50μfd. The *C* merely identifies the component as a capacitor and the *1* is a reference number. Its value, of course, is 50 microfarads. Another capacitor in this circuit is seen toward the right, C-2, with a value of 2 microfarads. You'll learn about the other parts of the circuit as you read on, but if you want to know about the other symbols in Fig. 2-5 in the meantime, their identities are given in Table II-2.

Part of the circuit diagram of Fig. 2-5 is shown in Fig. 2-6 in pictorial form. The components are drawn to scale with respect to each other. You easily can see where to make electrical connections and how to position the compo-

SYMBOL	COMPONENT	SYMBOL	COMPONENT
	Capacitor (fixed type)		Fuse
	Capacitor (variable)		Switch
	Resistor		Electrical Connection
	Potentiometer		No Connection
	Diode (semiconductor)		Silicon Controlled Rectifier

nents. It is usual in pictorial diagrams to label each part with the electrical value as well as with the letter-digit notation of the wiring diagram.

Resistors

Resistors restrict the flow of current in a circuit. They resist. They are used to reduce current and voltage values, to isolate one section of a circuit electrically from another and to serve as signal loads. The most commonly used resistors are cylindrical in shape with connecting leads protruding from each end (see Fig. 2-7). Size depends on the

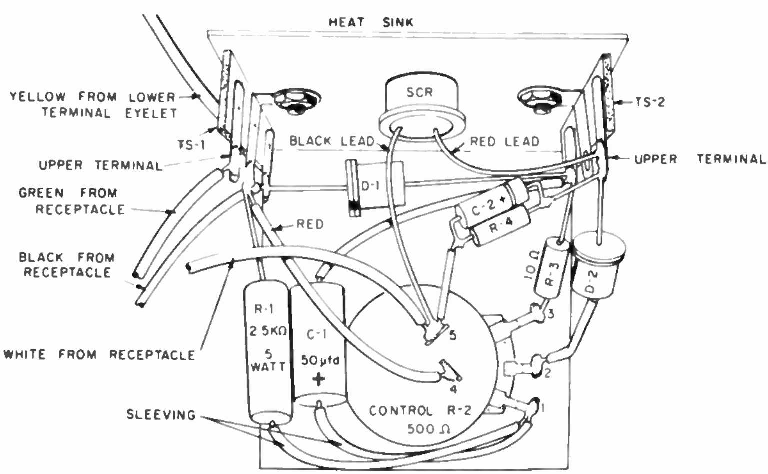


Fig. 2-6. Pictorial layout of circuit in Fig. 2-5.

amount of power a resistor is designed to handle and ranges from about ⅛″ in diameter for the ¼-watt sizes commonly used in transistor circuits to about ⅜″ in diameter for common 5- and 10-watt sizes used in power circuits.

The unit of electrical resistance is the *ohm*. Unlike a farad, which is a large unit of capacitance, the ohm is a fairly small unit. It is common for resistors to have electrical values in the order of thousands or even several millions of ohms. The numerical value sometimes is pretty small, too—as low as 10 ohms or less. The letter *K*, standing for *kilo*, is used to designate 1,000 ohms. Thus, a 4,700-ohm resistor can be designated as 4.7K. *M*, for *mega*, is used to designate a million ohms. Thus, 4.7M (sometimes 4.7 meg) stands for 4.7 million ohms. The symbol for the ohm is the Greek letter omega (Ω). In wiring diagrams the letter *R* is used to identify resistors. The instruction manual, therefore, might refer to "R-12, 4.7K resistor . . ."

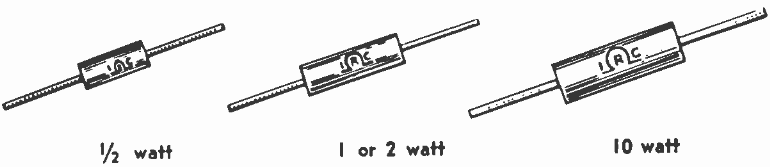


Fig. 2-7. Typical resistors.

Resistor values sometimes are stamped on the body of the component. More often, however, the value is given by a color code—three or four bands of color around the body at one end. Ten different colors are used for the first three bands (counting from the band nearest the end of the resistor body). Each color represents a number from 0 to 9. Two additional colors—gold and silver—are assigned for the fourth band, if used. This band indicates how close the measured value is to the specific value. A gold band means the actual value is within 5% of that specified by the color code. A silver band indicates the tolerance is 10%. If there is no fourth band, the value can be plus or minus 20% of that specified.

Table II-2 shows the color code used throughout the electronic industry. In Knight-Kits such as the *Star Roamer,* resistors are supplied on cards with such identification as "R1, R2, R3, etc." These cards also list the band colors plus the resistor values specified in the manual for each step calling for use of a resistor. Thus, when building a Knight-Kit, it is not necessary for the builder to memorize the code. However, it will pay to become familiar with the code, especially if you plan to build many kits or do other things in electronics.

Table II-2. Standard Resistor Color Code Guide.

COLOR	1st and 2nd Band DIGITS	3rd Band (MULTIPLIER)	REMARKS
Black	0	1	The 1st two color bands identify the 1st two digits of the numerical value. The third band is a multiplier, indicating the number of zeros to be added. For example, brown, green, orange is the code for a 15,000-ohm resistor.
Brown	1	10	
Red	2	100	
Orange	3	1,000	
Yellow	4	10,000	
Green	5	100,000	
Blue	6	1,000,000	
Violet	7	10,000,000	
Gray	8	100,000,000	
White	9		

TOLERANCE BANDS (Fourth band) *Color*	*Tolerance*	
Gold	5%	Note: if the *third* band is gold, the multiplier is .1, if it is silver, the multiplier is .01.
Silver	10%	
No Band	20%	

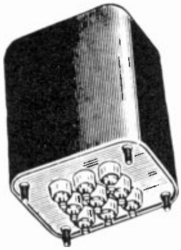
A *potentiometer,* more often called a *pot,* is a variable resistor. It incorporates a shaft which can be rotated to change resistance value (see Fig. 2-8). Pots commonly are

Fig. 2-8. Typical potentiometer.

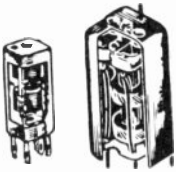
used as volume controls and tone controls. All pots are also identified by the letter *R* in wiring diagrams and parts lists. Pots are not color-coded. The value usually is stamped or printed on the body of the component.

Transformers

You undoubtedly have heard of *transformers* and may even have a general idea that they transform electricity. A simple transformer consists of two coils of wire wound closely together. However, the wire is insulated so there is no direct electrical connection between the coils. The turns of wire within the individual coils also are insulated from each other. Thus, electric current can flow through the individual coils but not from one to the other.



Power Transformer

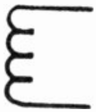


IF Transformers

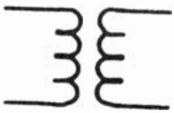
Fig. 2-9. Typical transformers.

Current flowing through a coil produces a magnetic field around it. If a wire is moved through this field, electric current will flow through it. The same effect is produced if the wire is stationary and the magnetic field is moved past it. The magnetic field of a coil will build up and collapse—or move—when alternating current (AC) flows through its turns of wire. In a transformer, the magnetic field of one coil in moving across the turns of the other coil will cause a current to be *induced* in the second coil. (A direct current—DC—is steady and continuous; therefore, it does not produce a fluctuating magnetic field and, as a result, does not produce an induced current.)

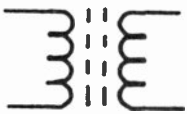
The important thing to remember about transformers is that the amount of current induced from one coil to the other depends on the ratio between the number of turns each has. A transformer can be designed, for example, so that the current or voltage induced into the secondary coil will be many times more, or many times less, than that in



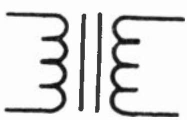
The symbols shown in circuit diagrams for transformers indicate a coil of wire this way.



When we place two coils physically close to each other with air as the dielectric material, this is the electrical symbol used.



To enhance certain characteristics of two coils which are capable of transformer action, a core of powdered and compressed iron may be inserted in the center of each coil. This is indicated by broken lines.



A powdered-iron or ferrite core material usually is used in transformers designed to operate far above audible frequencies. Power and audio-frequency transformers usually are wound or installed on cores made of laminated layers of magnetic material and are symbolized this way.

the primary. Another point to remember is that DC current cannot produce transformer action.

As shown in Fig. 2-9, there are many kinds of transformers, each best suited to a specific job. There are three basic types you will encounter in building electronic kits. These are (1) power transformers, intended to convert power-supply voltages and currents to desired values; (2) audio-frequency, or AF transformers, used to couple one audio signal circuit to another, allowing the alternating signal to be transferred while blocking DC voltages and currents; (3) radio-frequency, or RF transformers, which transfer signal energy between high-frequency stages. (A special form of RF transformer is known as the intermediate-frequency, or IF, type. It operates at a lower frequency than the RF type but still in the radio frequency range.) There are other types of transformers, some quite sophisticated in design and application. Should you want to know more about their theory of operation, the companion volume, "Getting Started in Electronics," will be of interest to you.

Tubes and Transistors

As you build different kinds of kits, you will work with both tubes and transistors. Each fulfills a purpose in the scheme of electronics. In many applications, tubes and transistors are used for the same purposes, with somewhat different circuit designs and component values, naturally. In other applications, transistors are not capable of satisfying the design requirements as thoroughly as tubes. It is not accurate to think that transistors are universally better than tubes. Perhaps some day tubes will be obsolete and only transistors or semiconductor devices of some kind will be used. But it is not true today and tubes will continue to serve a need for some time to come. Therefore, don't let anyone lead you to believe that a kit is antique just because it uses tubes. Then, too, you may want to build a kit which uses tubes for the experience you will gain.

Vacuum Tubes

Tubes commonly are identified by the number of elements they have, disregarding the heater element, or filament, used in most tubes. A 3-element tube is called a *triode*. It has a *plate*, or anode, that is designed to receive electric current (electrons) produced by the *cathode* element. The flow of current is controlled by a fence-like element called the *control grid*, physically positioned between the plate and cathode, in the path of the tube current. (See Fig. 2-10.)

The voltage at the control grid controls the amount of current which reaches the plate. Current can be varied from zero (termed the tube *cutoff* condition) to maximum (referred to as plate *saturation*) with only a change of perhaps a dozen volts on the grid. Thus, a relatively small change in grid voltage can cause a larger change in tube current. This is the basis for amplification. A small signal variation at the grid can be made to produce a large signal variation at the plate. An audio signal voltage, for example, impressed on the grid of a tube, appears much larger in magnitude at the plate. Using three or four such tube stages in succession, a signal can be amplified several thousand times. (Consider, for example, that each stage increases the signal only 10 times, a relatively small amplification factor. Three successive stages would provide an amplification factor of 10 × 10 × 10, or 1,000.)

A diode tube has only two elements, a cathode and an anode. Because it has no grid, it is incapable of amplification. But it serves a useful purpose. It is used as a

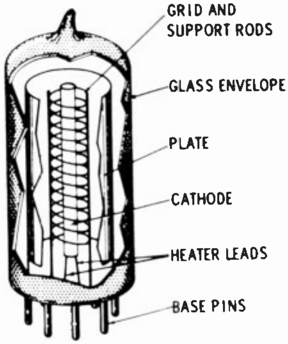


Fig. 2-10. Construction of a triode vacuum tube.

simple gate, providing *rectification* of alternating current, converting it to direct-current impulses. In fact, in this application, it is called a *rectifier*.

There are multiple-element tubes beyond the triode, containing additional grids for greater efficiency of operation. These additional elements are termed *screen grid* and *suppressor grid*. As shown in Fig. 2-11, these grids are physically and electrically located between the control grid

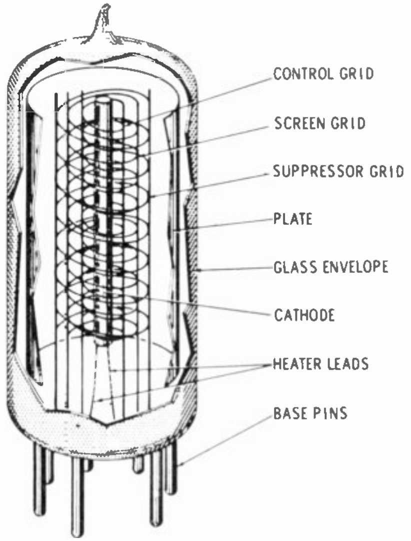


Fig. 2-11. Construction of a multi-element tube (pentode).

and the plate. Note from the circuit symbols shown in Fig. 2-12 that the elements terminate at circles. These are numbered and represent the tube pins and their related socket connections.

The most frequently encountered tubes are 7- and 9-pin miniatures and 8-pin (octal) designs. Most tubes use glass envelopes to provide the vacuum needed for proper operation. Some do have a metal jacket. Sometimes for certain applications it is desirable or even necessary to shield the tube elements electrically from stray electrostatic or electromagnetic fields. For this reason, tubes used in such sensitive applications are equipped with integral metal jackets. This is true only of the octal types. Since none of the 7- or

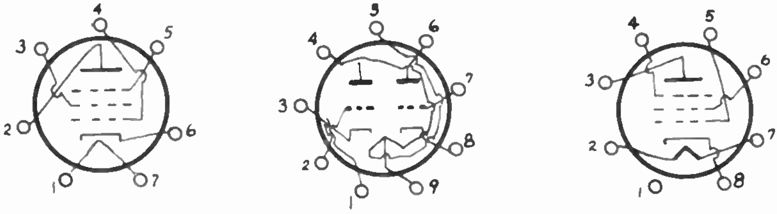


Fig. 2-12. Circuit symbols for vacuum tubes, showing element pin connections.

NPN PNP

Fig. 2-13. Two basic types of transistors, showing direction of electron flow.

9-pin miniature types have metal jackets, separate metal shields are used in the mechanical design of the chassis or board on which the tubes are installed. Generally speaking, there is no reason to attribute better qualities of one type over the other—at least in kit building this is true.

Transistors

Transistors also are capable of providing signal amplification. The most common are 3-element types which, in operation, serve the same purpose as triodes. The three elements are called the *collector*, *emitter* and *base*. The collector fulfills the same purpose as the plate of a triode. It normally is the output end of the device. The emitter is the current source and the base serves as the current-controlling element. The base, therefore, is the input of the transistor in its most common circuit applications.

There are two basic types of transistors—the PNP and the NPN types. The middle initial provides the key to the polarity of the supply voltage normally applied to the collector, N for negative and P for positive. As seen in Fig. 2-13, the symbols for the two transistors are similar but the direction of the arrow on the emitter points inward for the PNP, and outward for the NPN.

The main difference between the two types is the direction of current flow. In the NPN transistor, electron flow is "in" at the emitter, and "out" at the base and collector. In the PNP transistor, electron flow is exactly the opposite —"out" at the emitter, and "in" at the collector and base.

Another solid-state, or semiconductor, component one often works with in electronic kit building is the diode.

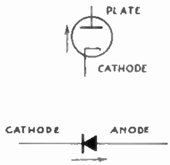


Fig. 2-14. Semiconductor diode conducts electrons from cathode to anode.

Like the vacuum tube with the same name, it has two elements called the cathode and the anode. The circuit symbol is shown in Fig. 2-14. The semiconductor diode, like the tube, conducts in only one direction and is not capable of providing amplification.

Unlike vacuum tubes, a transistor has no vacuum—its elements are solid. (Hence, the reason why it is commonly referred to as a solid-state device.) Moreover, it operates at relatively low voltages, such as those provided by transistor radio batteries. A common transistor radio battery rating is 9 volts, but some supplies range down to as low as 6 volts while others may be as high as 24 volts.

A transistor has no heater or filament, as do vacuum tubes; thus, a transistorized circuit requires no separate heater current supply. Also, the common everyday variety of transistor draws considerably less current than a standard vacuum tube. And today, the cost of a transistor is usually less than that of a tube required to do a comparable job. What's more, tubes require sockets, and the associated mechanical mounting hardware; transistors can be mounted without sockets. All these transistor characteristics make them ideal components for use in building kits.

Once you have built a kit or two using transistors, you may be encouraged to learn a little more about how they work. The fact is that the basic principles of transistor operation are extremely simple, requiring little more than a knowledge of positive and negative polarities to understand them. However, since the purpose of this book is devoted to building kits, we refer you to other publications in the Allied Electronics library for more details on transistors and how they work.

Before You Go On . . .

A word of encouragement at this point. Don't be discouraged by points that appear complicated. As we said, you don't *have* to know anything about electronic components or what they do and how they do it. However, it is only natural to be concerned about what may be the relatively unknown at this stage, so we again point out that many kits have been assembled by thousands of builders who knew absolutely nothing about electronics. Kit designs and the associated instruction manuals are better than ever. What you have learned thus far about electronic components can only increase your understanding of what makes a kit tick and certainly increase your enjoyment of its performance.

CHAPTER THREE

TOOLS AND SOLDERING

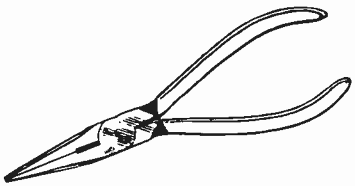
Electronic kit building will be easier and the finished project neater when you use the right tools. The knack of using them is acquired easily. No special workshop is needed. In fact, it is unnecessary to have a workshop at all, although you should have some place where your materials will not be disturbed. Some of the best kits have been put together on kitchen tables, card tables and even on a workshelf in a large closet. Any convenient flat surface will do.

Good tools are a wise investment. They enable you to do a better job. Care of your tools is important, too. Try to keep them clean and lubricated with a light oil. A good set of starter tools includes:

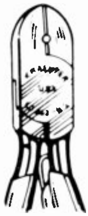
1. Long-nose pliers
2. Diagonal wire cutters
3. Screwdriver with 3/32" blade
4. Screwdriver with 3/16" blade
5. 1/4" hex-nut driver
6. 1/2" hex-nut driver
7. Solder
8. Soldering iron
9. Tool box

Long-Nose Pliers

Long-nose pliers are used to connect parts, to hold leads to be soldered and for many other jobs. They have a long, tapered nose that is exceptionally useful for getting into places you can't reach with your fingers or other tools. The thin tips are used to twist wires around terminals



Long-Nose Pliers



Diagonal Cutters

prior to soldering—also for bending or shaping the leads of capacitors and resistors. A 5" or 6" pair will serve most all your needs in kit building.

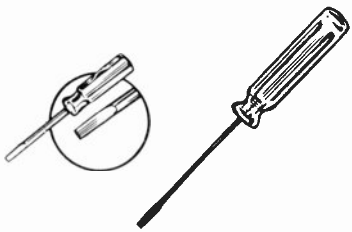
Diagonal Wire Cutters

The diagonal cutter has a short, blunt nose. The inside edges of its jaws are sharp, intended for cutting wires and component leads to the prescribed lengths for connections between terminals. They are not made for cutting nails or screws. Other, heavier-duty tools serve that purpose. An excellent size for electronic kit building is the 5" diagonal wire cutter.

Many experienced kit builders and technicians use diagonal cutters for baring wires and stripping off insulation, in preparation for making solder connections. Using cutters for this job takes a lot of practice to avoid nicking the wire beneath the insulation. There are special tools called wire-strippers that simplify the job of baring the ends of hookup wire. Knight-Kits include cut-to-length and stripped hookup wires, ready for soldering into the circuit. The wires in Knight-Kits also are color-coded for quick identification.

Screwdrivers

For electronics work, screwdrivers must have insulated handles. The handles can be made of wood, hard plastic, hard rubber or other nonconductive material. The size of the working end of the screwdriver is related to the width and length of the slot in the screw head. Too small a screwdriver can mutilate the slot of the screw and make it diffi-



Screwdrivers

Hex-Nut Drivers

cult to fasten the hardware securely. Too large a screwdriver may not fit the relatively narrow slot of the screw. In electronic kit building you will find a 3/16″ size best suited for most needs. Some knobs for potentiometers, switches and tuning controls are tapped and fitted with a *set screw*. A 3/32″ screwdriver blade is appropriate for fastening knobs to control shafts with the small set screw.

Hex-Nut Drivers

Like other tools, there is a multitude of lengths and sizes for hex-nut drivers. A good starter set should include ¼″ and a ½″ sizes. The hex-nut driver is a great tool for holding nuts while a screwdriver is used to tighten the bolts. The smaller ¼″ driver is useful in mounting parts, panels and other hardware held in position by the popular 6-32 size machine screw and nut combination.

The larger ½″ driver is for securing potentiometers and other controls using ⅜″ inner diameter hex nuts. The length of the driver is not too important. It simply should be long enough for you to get a comfortable grip on the handle. The 6″ length is popular; however, inexpensive stubby nut-drivers also are available. The temptation always is great to use the long-nose pliers to hold nuts while their screws are being tightened. This is not good practice and will tend to shorten the useful life of the pliers.

HOW TO SOLDER PROPERLY

Some people think of soldering as an art. Others call it a skill. Most who have learned to solder well call it easy.

Like any other art or skill, once you've learned the basics of good soldering, the rest is a matter of practice. It doesn't take much practice to become an expert at making permanent, strong solder joints—provided you practice what is about to be preached.

What is solder? It's an alloy of lead and tin. For electronics work, the preferred alloy contains a ratio of 60 or 65 percent tin to 40 or 35 percent lead. It is referred to by the ratio: 60/40 solder, 65/35 solder, 50/50, etc. The reason for using a high-tin-content solder is to provide a low melting point. The higher heat required to melt 50/50 or 40/60 solder could damage or destroy some electronic components as they are soldered in place.

When solder melts and flows over the joint being soldered it bonds the wires together and provides a large area of extremely low electrical resistance at the points of contact among the soldered parts or wires. Further, it prevents movement and chafing actions which could cause intermittent operation and noise in the circuit and make the equipment unreliable if not inoperative.

Spool of Solder

Coiled Solder in Dispenser

Solder is sold in spools or coils, either by footage or by weight. It is like soft wire that can be broken merely by a strong tug. Solder for electronic kit building has a core which is filled with rosin. Rosin vaporizes as it is heated. It serves as a flux to keep the joint clean. Without rosin the heat of the soldering iron would tarnish most metals or cause an oxide coating to form quickly. Such oxidation increases the electrical resistance of the junction, an undesirable result. Also, it prevents the solder from adhering securely to the metal surfaces being joined.

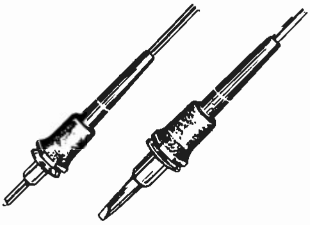
Never use acid-core soldre in electronic kit building. It may result in a cleaner looking solder joint but in time the acid that is not vaporized when the joint is formed will corrode the metal surfaces to which it adheres. All kit manufacturers declare their warrantees to be void if the kit is wired with acid-core solder. Knight-Kit and other leading manufacturers supply a coil of rosin-core solder with each kit. Thus you are assured of having the right solder when you deal with a reputable kit supplier.

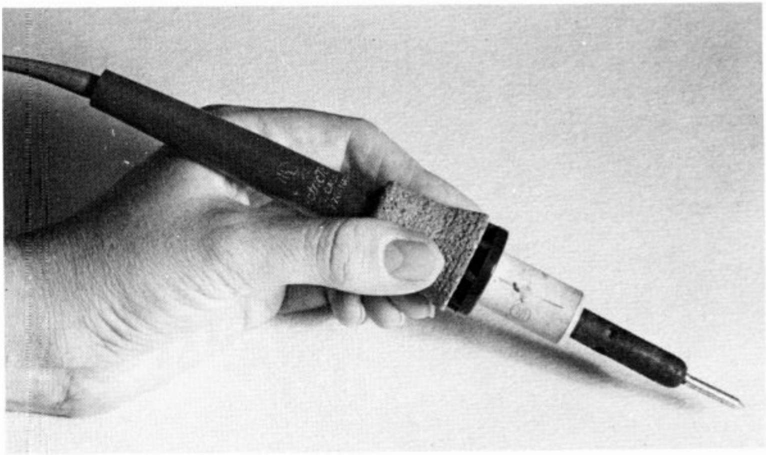
Soldering Iron

There are several types of soldering tools available so it is important for you to choose the one best suited for kit-building work. There are light, medium and heavy-duty irons; they are small, medium and large in both physical size and wattage. Some irons have to be heated by a blow torch or direct flame each time you want to solder a joint. This type is excellent for repairing or installing plumbing. But *never* use it for electronics work. There also is a type of iron that is shaped like a pistol and is called a soldering *gun.* They heat rapidly and are useful in electronics work. You may want to own one some day. But there is one type of soldering iron used in factories and by other professionals who depend on their soldering quality and whose work must pass quality-control inspections. This type of iron, shown in Fig. 3-1, is known as a soldering *pencil.* It is held like a pencil, not like a screwdriver.

The pencil iron is light in weight and uses small-diameter tips that permit the iron to be used in tight quarters. Pen-

Fig. 3-1. 27½-watt soldering pencil with interchangeable tip.





Proper method of holding a soldering pencil.

cil irons of different wattage ratings are available. The wattage determines the amount of heat provided at the soldering tip. Irons rated between 25 and 40 watts, fitted with either a 1/4" chisel or a pyramid tip, are well suited to electronic kit building. Inside the stem of the iron is a resistance wire that becomes hot when plugged into a suitable source of electric power. The heat of the wire is conducted to the tip, which usually reaches temperatures between 450° to 900°F.

How to Solder

If you are starting with a brand-new iron, it is important to make sure that the tip is properly *tinned.* Tinning removes the tarnish and oxidation from the tip. Oxidation prevents efficient transfer of heat from the tip of the iron to the joint. *Most tips for pencil-type irons come pre-tinned or plated and require no preparatory effort on your part.*

If the tip does not have a shiny silver appearance, follow this procedure:

(1). Use a fine file or sandpaper to clean the tip of the soldering iron, making it smooth and shiny

(2). Plug the iron into the power source and allow it to become good and hot. This should not take more than a few minutes.

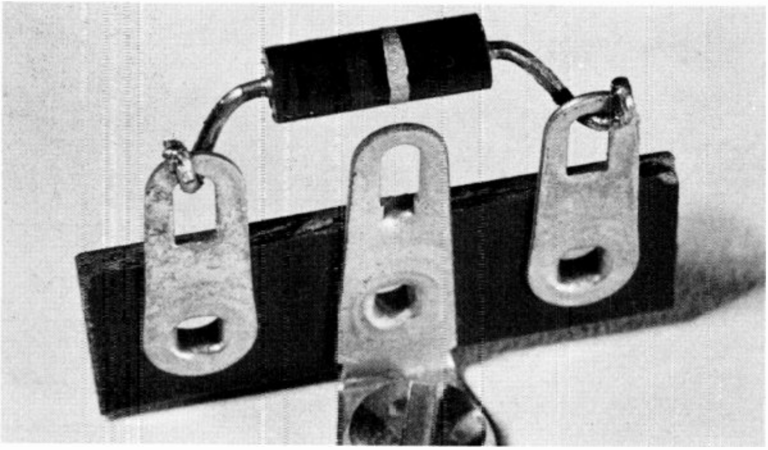


Fig. 3-2. Electrical connections must be mechanically secure.

(3). When the tip of the iron has become hot, briefly rerub the tip with the file or sandpaper to remove any oxidation that may have been newly formed as the iron was heating. Touch the end of the solder to the tip of the iron and, as soon as the solder begins to melt, lightly rub it onto the tip so that it becomes coated with the melted solder.

(4). Quickly take a small piece of cloth and wipe the tip of the iron to remove excess solder and flux. The tip will now appear bright and shiny and is ready for use.

Keep a soft cloth handy so that you can frequently wipe the tip clean of residue and oxidized materials. Should you find that the residue has caked after the iron has been allowed to stand for a while, use the file or sandpaper to restore the smooth, clean surface. Then apply solder to the tip to renew the tinned surface. This is the only time you apply solder directly to the iron.

Mechanical Connections First

Before you actually solder a wire or connect a lead from a component to a terminal, the connection must be mechanically secure (see Fig. 3-2). This will insure that the joint will remain rigid during soldering, an important factor in

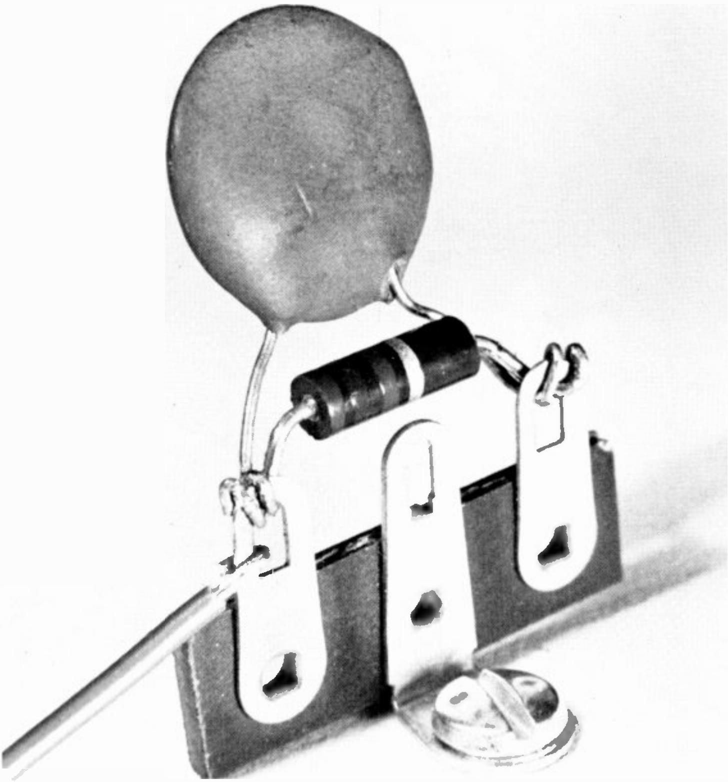


Fig. 3-3. Example of multiple component connections prior to soldering.

making a good electrical connection. Moreover, the connection will be physically stronger. Also, since several connections often are made to a terminal, secure mechanical connections will hold the components in place until the joint is ready for soldering.

Try it with a piece of hookup wire. Strip the end of a length of hookup wire to bare 1/4" of the wire. Insert the bared end of the wire through the hole in the metal tab of a terminal strip. With long-nose pliers, clamp the end around the tab. Squeeze the connection with the pliers so the wire is fastened securely to the tab (see Fig. 3-3). Cut off the excess wire at the terminal end. Do the same with another piece of wire. At this point you are ready to solder the connections.

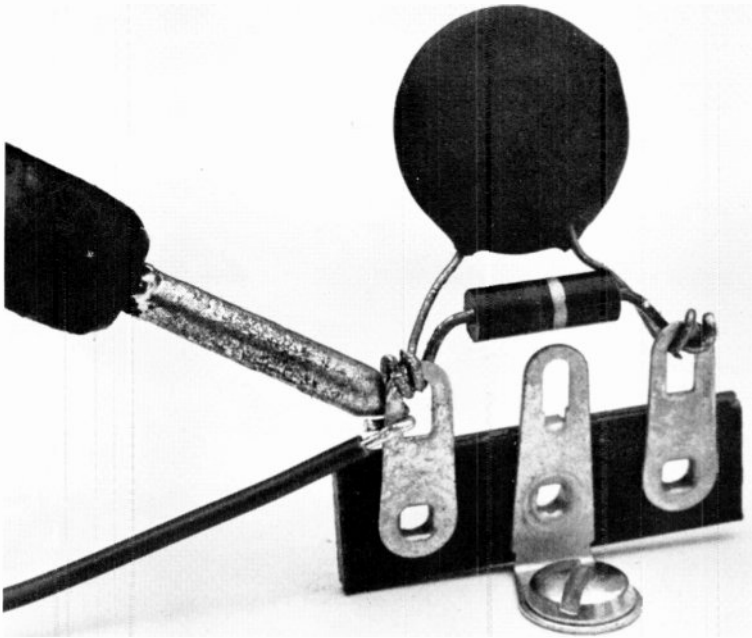


Fig. 3-4. Correct method of applying heat to a joint.

Hold the soldering pencil as you would a pencil for writing. Place the hot tip against the joint to be soldered, as shown in Fig. 3-4. Hold it steady and firm while counting, "One America, Two America, Three America." Do not remove the iron from the joint.

Touch the end of the solder *to the junction* (not to the tip of the soldering pencil), as shown in Fig. 3-5. Count, "Four America, Five America," and lift the iron and solder away from the joint.

Do not move any parts or wires until the solder has hardened. This takes a count again to "Three America."

Do not use the tip of the iron as a brush to spread the solder. Heat and gravity alone must do the job of spreading.

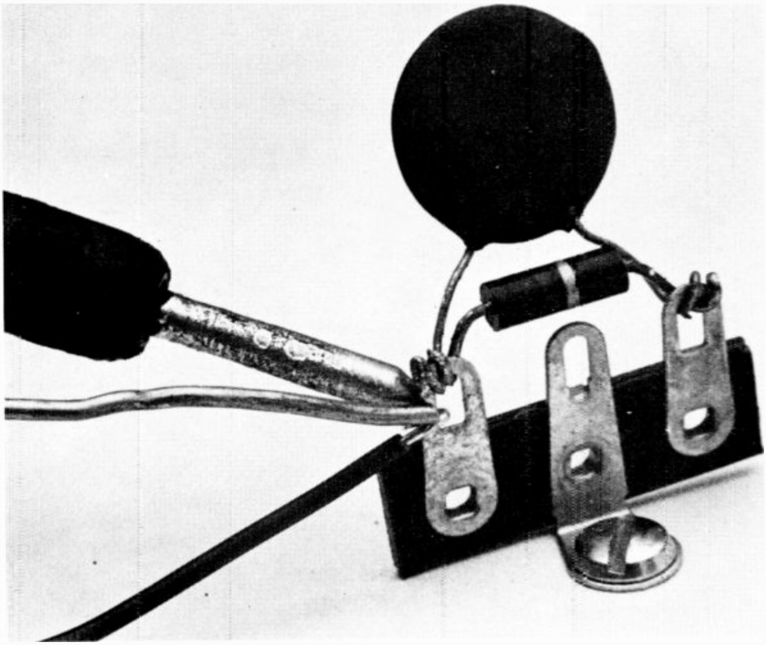


Fig. 3-5. Correct method of applying solder to a joint.

If you accidentally move the connections or parts before the solder has cooled and solidified, touch the tip of the iron to the joint again and remelt the solder. Then remove the iron and keep everything steady until the joint cools.

The procedure just described is most important in achieving success in kit building. Experience indicates that faulty soldering is the most frequent cause of poor performance of the finished kit. Note that the solder was not melted by direct contact with the iron. The joint and the wires were *preheated* so that they did the primary job of melting the solder. The iron was kept in place during the 4 and 5 count to maintain joint temperature and allow the solder to flow into all points of the junction. The metal of the junction—not the iron—must melt the solder.

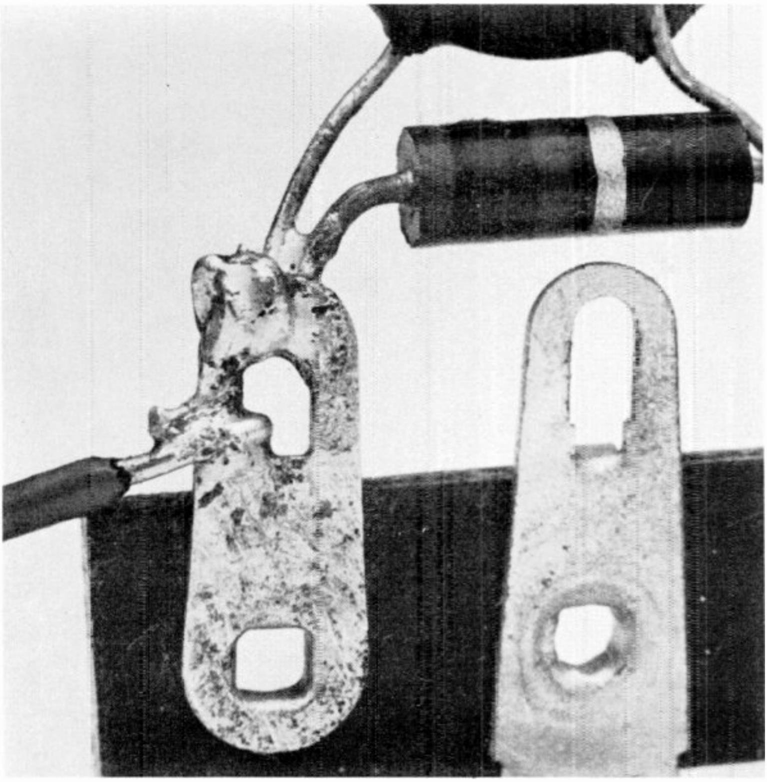


Fig. 3-6. A properly soldered junction.

How to Inspect a Solder Connection

If the soldered connection looks smooth and shiny and if the solder has formed a solid junction, you have used the proper amount of heat and have held steady while the solder cooled and hardened. A properly soldered junction is pictured in Fig. 3-6.

If you can see the outline or shape of the wires beneath the solder, you have used the right amount of solder.

On the other hand, if the solder at the connection looks grainy, flaky or rough or has a crystallized appearance, the junction was not heated properly or the leads were allowed to move before the solder cooled and hardened. If the solder has formed a ball or conceals the shapes of the wires, too much solder was used.

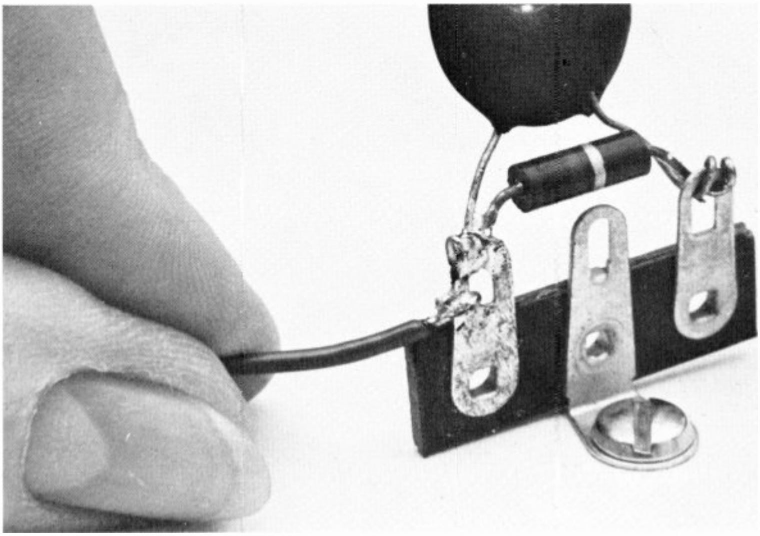


Fig. 3-7. Making sure solder joint is secure.

Tug gently at the wires at the solder joint to make certain they are attached firmly by the solder (Fig. 3-7). If any wires come loose, consider yourself lucky to find out about it then and there. It could have been a source of serious trouble in the performance of a finished kit. Reheat the joint, counting up to "Three America" and inspect it again.

Some components are especially sensitive to heat. Conduction of heat to their bodies must be reduced during the soldering operation. Knight-Kit instructions advise you when this is so. The long-nose pliers are useful in protecting components that are heat sensitive. But since both hands are needed during the application of the soldering iron and the solder, it is best to use a *heat-sink* clamp to conduct the heat away. These clamps are available from electronic parts suppliers such as Allied Radio. Another method is to clamp the long-nose pliers in place with a heavy rubber band (see Fig. 3-8).

The heat sink is secured to the wire lead close to the body of the heat-sensitive component and kept in place while the lead is being soldered to the terminal. The clamp must

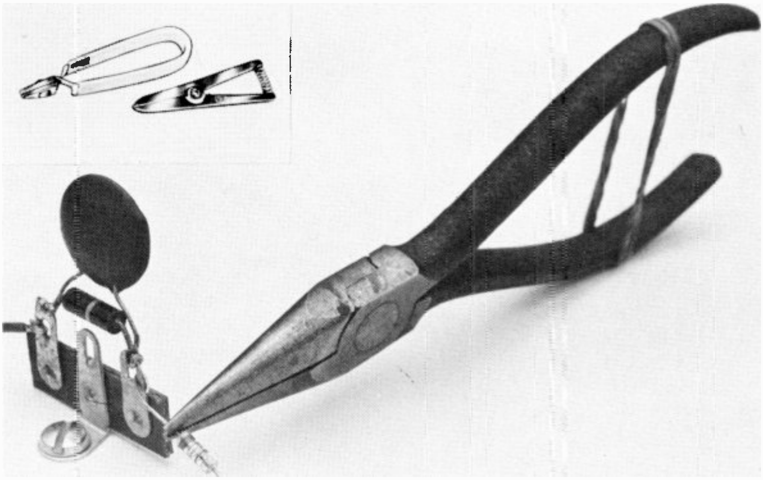


Fig. 3-8. Heat-sink clamps are commercially available, or long-nose pliers can be used.

be positioned so it will not move of its own accord during the heating and cooling steps.

Printed-Circuit Soldering

Printed-circuit boards consist of a nonconductive base board about 1 16″ thick. A thin sheet of copper is laminated to the board. Etching techniques remove all copper but that which makes up the wiring and terminals for the circuit (see Fig. 3-9).

Holes are drilled through the board at terminal points. The components are mounted on the side of the board without the etched copper conductors. Component leads are bent down so they protrude through the holes in the board. The leads are then bent with long-nose pliers and trimmed with diagonal wire cutters. Soldering the leads to their terminals is accomplished as described previously, with special care to use the solder sparingly.

In wiring or soldering to printed-circuit boards, make certain there are no solder tails crossing over from one printed electrical path of copper to another. Remember, solder is an excellent conductor. Should these tails go un-

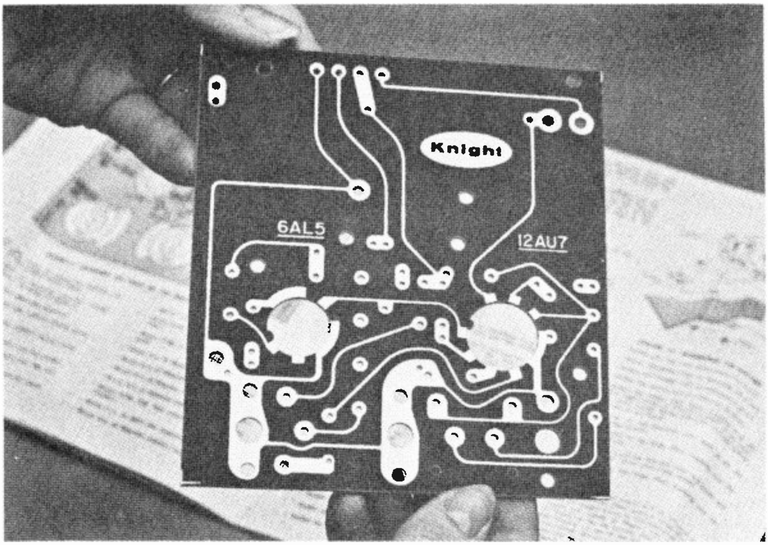


Fig. 3-9. Example of a printed-circuit board.

detected, short circuits could result in an inoperative or malfunctioning kit.

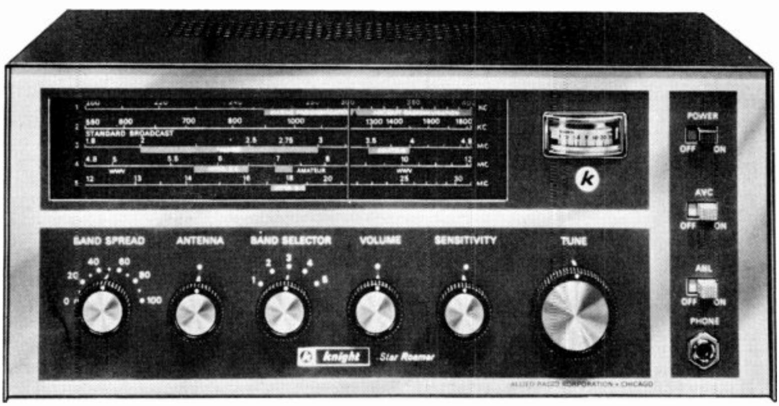
In all cases, when wiring or soldering to terminals or tie points, make certain solder has not run down the joint to create a potential short circuit between the terminal and chassis or printed board.

You will be able to recognize when you have made a good solder joint just by glancing at it. You will know when it is being done properly by the way it feels while you are doing it. If in doubt about the heat sensitivity of a component, use the heat sink to conduct heat away. Although appearance of the soldered joint is one of the criteria for determining the quality of the work, it is not done merely for the sake of appearance. However, it is coincidental that a good-looking solder joint usually is a good electrical joint.

CHAPTER FOUR

BUILDING THE KNIGHT-KIT "STAR ROAMER"

We will assume at this point that you have decided to order a Star Roamer kit. When it arrives it may look smaller than expected. But when you start removing the small boxes, envelopes, packets, panels, booklets and the chassis from the shipping carton, you may wonder how a kit manufacturer can give you so much material for so little money. That, of course, is one of the advantages of building your own equipment from a kit. The labor you normally would have to pay for in a factory-built 5-band



Knight-Kit "Star Roamer" as it arrives from the factory.

Contents of the Knight-Kit "Star Roamer" package.

short-wave receiver is excluded as an element of cost. You get real value for your money. The Knight-Kit *Star Roamer* is an excellent example of kit-building made easy by the manufacturer.

When the package arrives, spread the contents out so you can check them against the parts list in the instruction manual. In the *Star Roamer* the resistors are mounted on two cards which are marked with numbers that correspond to directions in the instruction manual. For example, the manual says, "Connect R4 to . . ." To locate R4 you look at the card, pick out the resistor mounted over the "R4" designation and wire it accordingly.

A paper bag contains all the wire you need. The wires are color-coded and precut to size. The ends already are bared for use. At the lower left in the photo are several transparent envelopes. These contain tuning coils. Each of the coils has a color dot on it which is used as a simple means of identification. It is almost impossible to make a mistake in coils. Because of the transparent envelopes you don't even have to unwrap the coils to identify them.

The small boxes at the upper right in the picture contain other transparent envelopes. Inside are hardware, small capacitors and miscellaneous materials. Again, the transparent envelopes make it easy to identify materials. You don't have to empty the envelopes to locate a 4-40 nut, for instance. You can find it at a glance.

The chassis and the metal cover that becomes the cabinet are at the rear of the photograph. The chassis is pre-punched so you don't have to drill holes. In the instruction manual, chassis cut-outs are identified by letters. Large drawings, some of them life-size, show hole locations and parts placement, minimizing the possibilities of error.

The handsome metal front panel and the glass dial with silk-screen markings are protected by individual plastic wrappers. These should not be removed until the instruction book tells you to do so. Relatively delicate parts, such as the variable capacitors, are individually wrapped and placed in a corrugated box. All rotary switches, potentiometers and variable capacitors are fitted with 1/4" diameter shafts, precut to the proper length. The knobs fit on the shafts just as they come out of the box.

The *Star Roamer* kit comes with all the literature you

Fig. 4-1. Complete assembly and operating instructions are provided.

need to use, as well as to build, the receiver (see Fig. 4-1). A sheet with life-size photographs of key parts is included. No guessing on your part as to what anything is for. You also get a sheet with pictures and descriptions of electronic components. And when you finally settle down to the thrills of short-wave listening, the 24-Hour Short-Wave Schedule tells you how to tune in different countries and what time the broadcasts occur.

Read the Instructions

The first step for the beginning kit builder is to open the manual and read every line of the introduction. In the manual supplied with the *Star Roamer*, there are three pages of introduction. These include electrical specifications for the receiver to provide the technically sophisticated reader with data for the performance objectives of a kit built according to instructions.

Very important to all readers are the paragraphs on page 2 that give construction hints. It is especially vital to adhere to the advice given in the first paragraph of the Hints:

> "The step-by-step instructions must be followed exactly. Occasionally, several parts are mounted with the same hardware, so be sure to read the entire step. For your convenience, a box is provided to check off each step after you have completed it."

Also, as a double check on your knowledge of soldering, the second and third pages review How To Care For Your Soldering Iron and how to solder properly.

Page 4 contains a slightly smaller than life-size pictorial diagram of major components mounted in position on the underside of the chassis. Almost every page after that has at least one drawing to show how and where switches, brackets, coils and so on are installed. Each action or connection is given as a separate step, an individual paragraph. Squares are provided alongside each step, to be checked after you complete all the action called for in that particular step. (Never check a square *before* you complete the action, regardless of how simple the step may be or how sure you are of yourself. You might be interrupted before you complete the work and, if you have already checked the square before you have completed all the action, you may wind up trouble-shooting an inoperative receiver. This is true of all electronic kits, not just the *Star Roamer*.)

Work With a Fresh Mind

Having examined the kit and the instruction manual, you will be anxious to start building. However, you would be well advised to plan the project in several steps, preferably

Fig. 4-2. Check the squares as each chassis part is mounted.

about two hours at a time. You'll work much better, faster and will more thoroughly enjoy the experience you are about to gain when you feel fresh and eager, rather than tired and anxious.

To avoid becoming fatigued, divide the work into several sessions. Restrain your enthusiasm to rush the kit to completion. It's understandable that you want to plug it in and use it, but care and attention to what you are doing, especially the first time you build a kit, will pay handsome rewards in the end. You will have a finished receiver that probably will work perfectly as soon as you plug it in, free of troubles or bugs. With Knight-Kits, the instructions are presented in several phases, providing natural stopping points.

Building the Kit

When you are ready for your first construction session, open the instruction manual and prepare for the step-by-step procedure of "Mounting Parts on the Chassis." Keep a pencil handy to check the squares as you complete each step (Fig. 4-2).

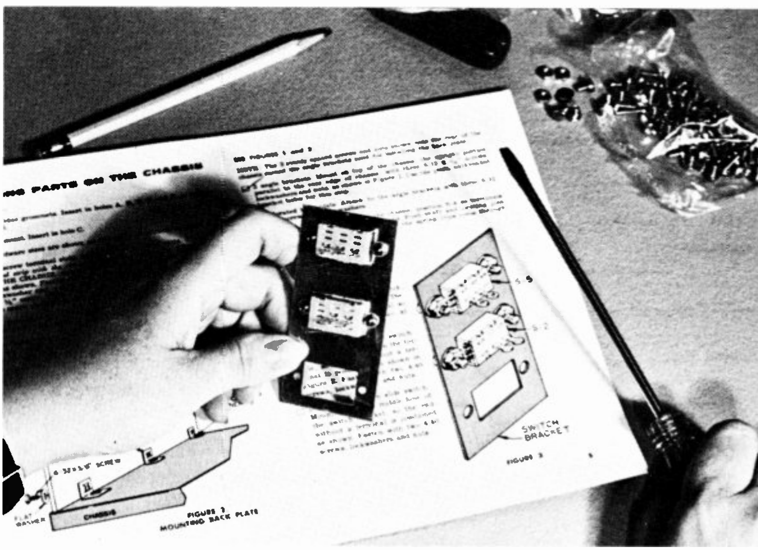


Fig. 4-3. The parts look like the diagrams in the manual.

Pictorial diagrams in the instruction manual often are life-size and sufficiently detailed to make parts identification and mounting simple. For example, switches in the Star Roamer for AC power and for AVC (automatic volume control) fit on a sub-panel which later will be mounted on the front panel. Fig. 4-3 shows how the actual work looks like the pictorial diagram.

As you move along, pictorial diagrams are repeated with new parts added. This eliminates the need to refer back to previous pages each time you want to check or identify

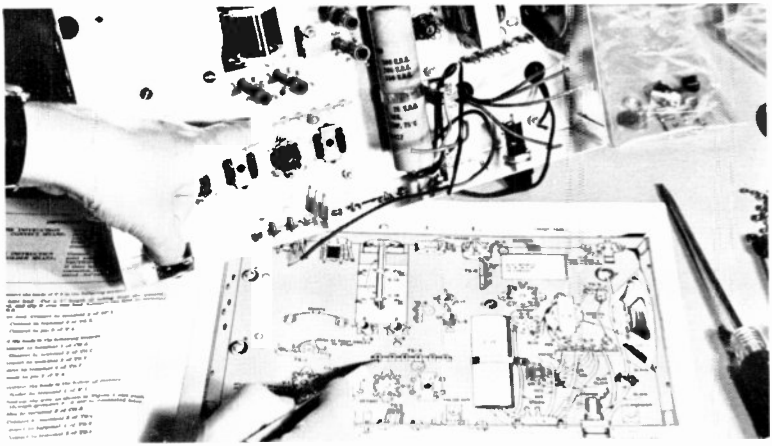


Fig. 4-4. Check each completed step against the diagram.

a terminal referred to in one of the steps. It is wise to double-check each completed step visually against the diagram (Fig. 4-4).

As you progress, the tuning coils are installed in a metal bracket and wired together according to instructions in the paragraphs and pictures (see Fig. 4-5). This assembly is set aside. Later on in the manual it will be called for with instructions for mounting it on the chassis.

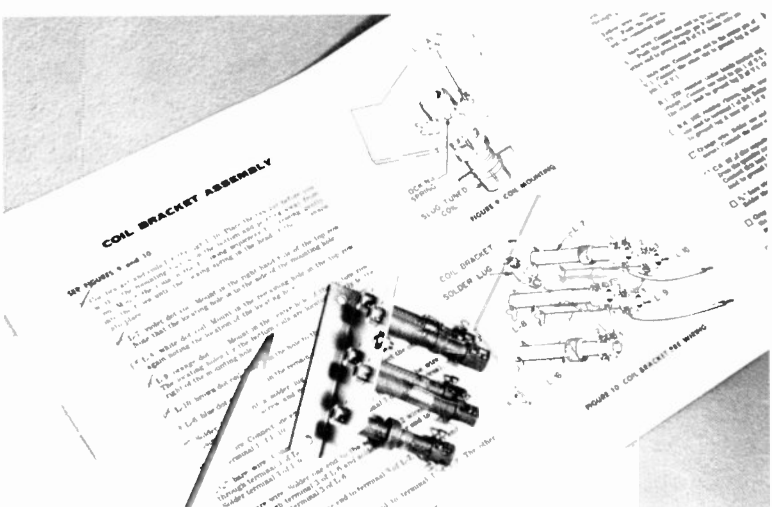


Fig. 4-5. Tuning coil assembly and wiring

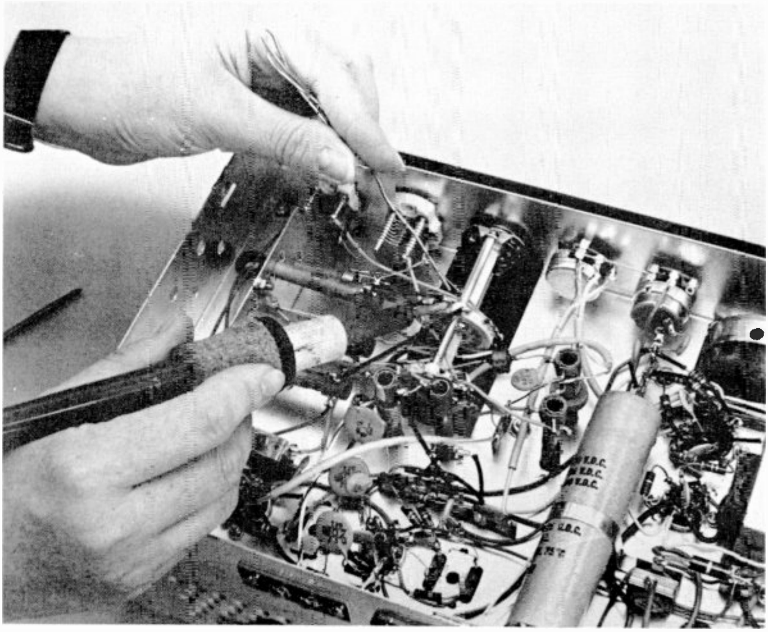


Fig. 4-6. Connecting the tuning coils to the band-switch.

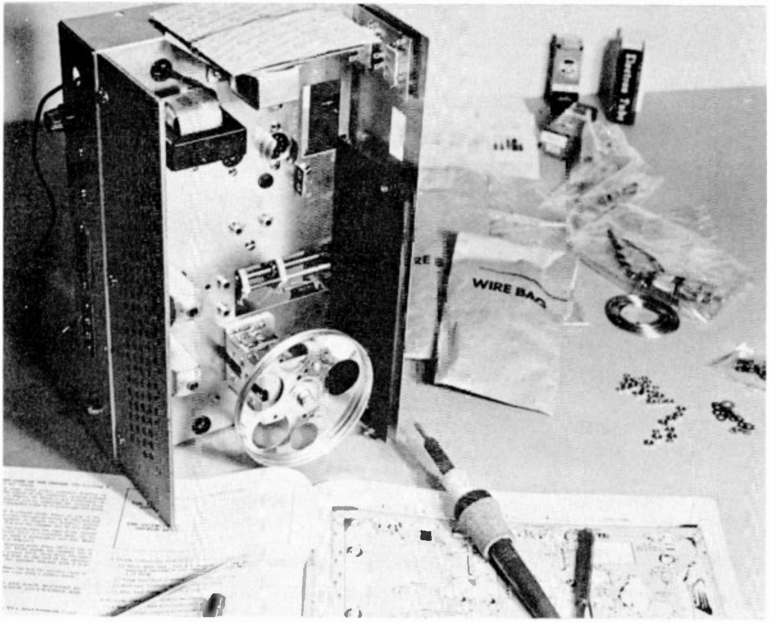


Fig. 4-7. Front and rear panels in place, speaker covered with cardboard.

The photo in Fig. 4-6 shows the construction well under way. The coil assembly bracket has been mounted inside the main chassis and, using the proper soldering technique, wired to the band-switch.

Fig. 4-7 shows the chassis with front and rear panels in place. The chassis has been turned on its side in preparation for some mechanical work in the step-by-step procedure. Note the square of cardboard held in place by a rubber

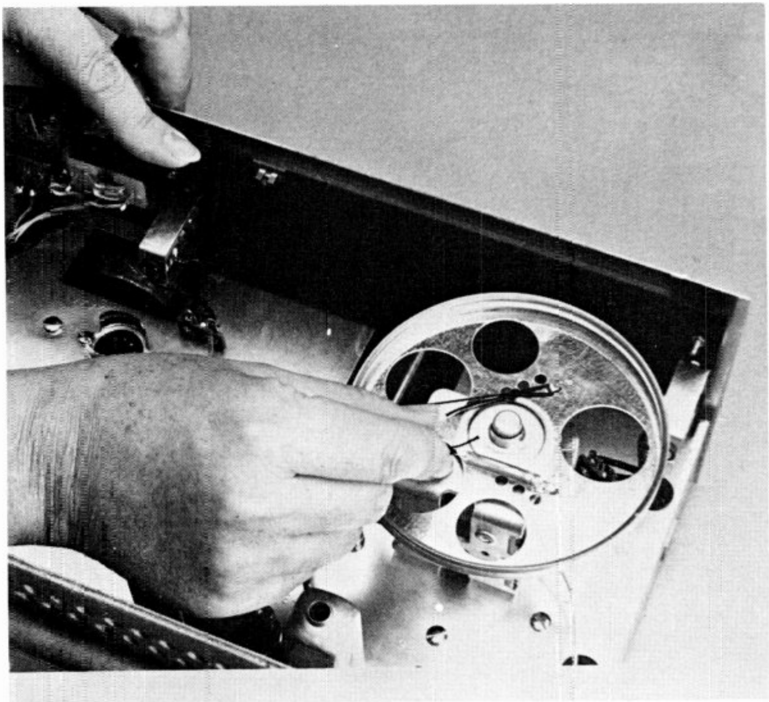


Fig. 4-8. Installing the dial cable.

band at the top of the picture. This protects the loudspeaker cone against damage during construction. It will be removed before the cover is put on the chassis.

The next step is to attach the dial cable, under spring tension, to a wheel (see Fig. 4-8). Friction moves the cable, as the *Tune* knob on the front panel is rotated. Simultaneously, the cable pulls the pointer across the dial and rotates the main tuning capacitor.

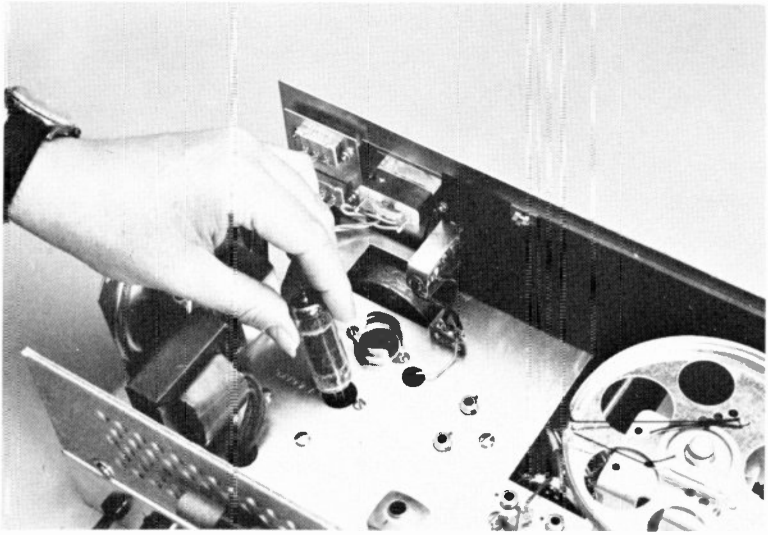


Fig. 4-9. Plugging the tubes in their sockets.

In the next step, the tubes are plugged in (see Fig. 4-9). No mistakes are possible here. The diagrams make it clear and the tube numbers are stamped into the chassis.

Some tubes require metal shields. As shown in Fig. 4-10, these are supplied with the kit and are slipped over the tube.

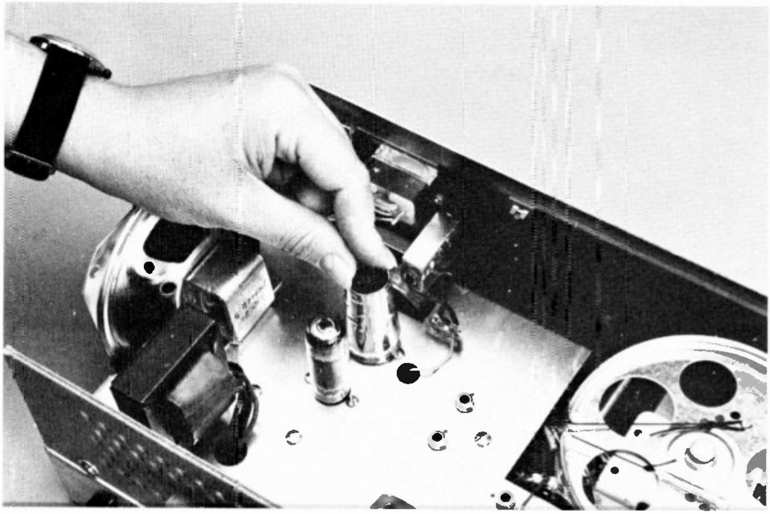


Fig. 4-10. Putting metal tube shield in place.

Fig. 4-11. The assembled Star Roamer, ready for the knobs.

Fig. 4-11 shows the kit wired and assembled, ready for the knobs to be slipped onto the shafts of all the controls.

Fig. 4-12 shows how a screwdriver with a 3/32" blade is used to tighten the set screws in the knobs. This fastens the knobs securely to the shafts.

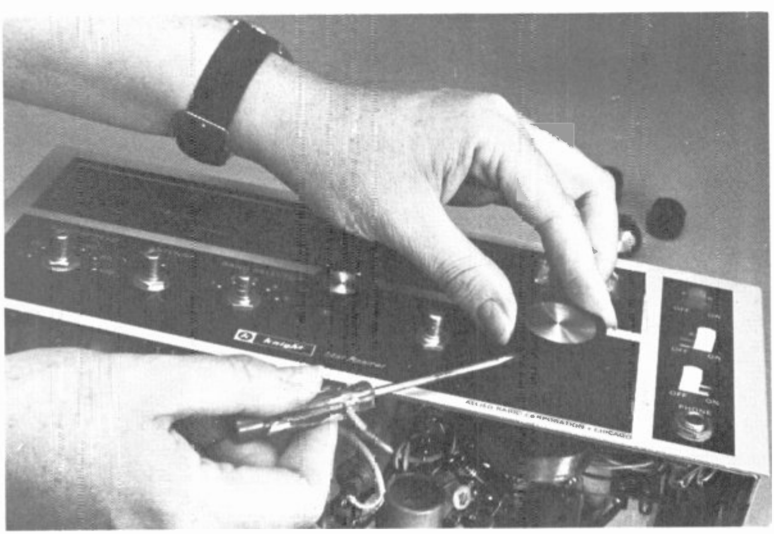


Fig. 4-12. Using 3/32" blade screwdriver to tighten knob set screws.

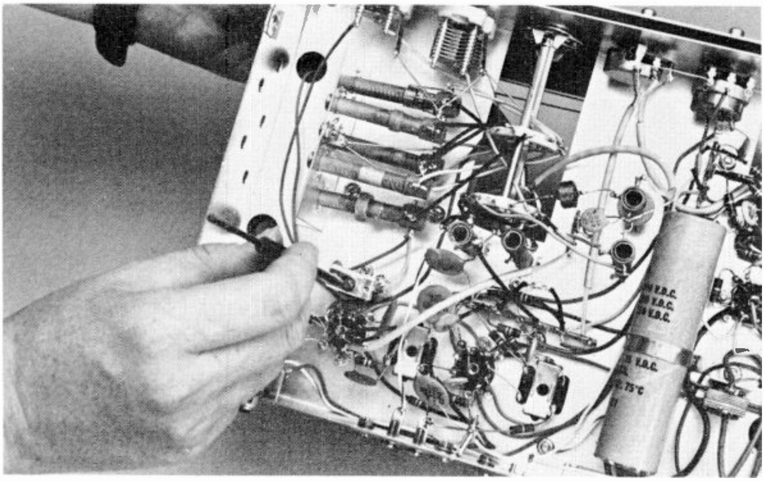


Fig. 4-13A. Adjusting the trimmer capacitor.

Aligning or adjusting the tuning coils, peaking them for best performance, can be done without test instruments (see Fig. 4-13). The instruction manual tells you how to do it. Only one special tool is needed—an all-plastic or non-metal combination screwdriver and Allen wrench . . . and it comes with the kit.

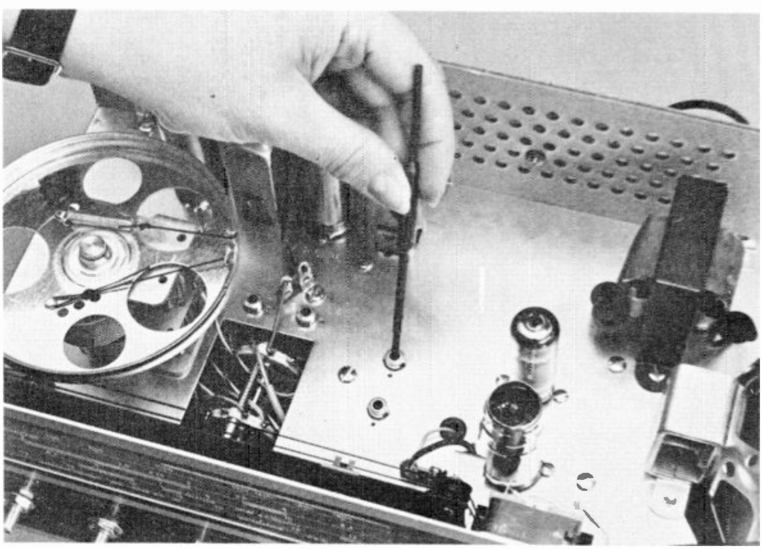


Fig. 4-13B. Adjusting the tuning coils.

When the kit is finished it is advisable to make one last mechanical check before you plug the set into an outlet. Even though you have been careful and neat as you moved along in the kit construction, make a visual check for loose bits of solder, for wire ends that might not have been trimmed and could be touching other components or the metal chassis, and for connections that might not have been soldered properly or not soldered at all through some oversight. Pick the chassis up and, holding it firmly in both hands, shake it vigorously to dislodge any bits of unwanted material that might have escaped notice.

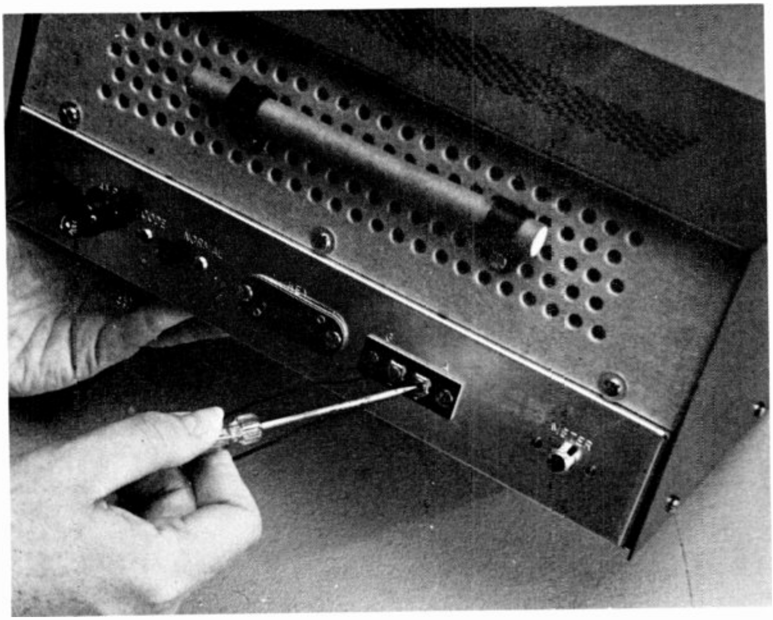


Fig. 4-14. Connecting the antenna to the terminal board.

The last step in building the *Star Roamer* is to put the cover on the receiver and connect the antenna to the terminal at the rear apron of the chassis (Fig. 4-14). You don't need an outside antenna for the AM broadcast band. Instead, you use the built-in ferrite rod antenna. This rod is mounted in a tube which can be seen attached to the perforated backboard of the receiver.

CHAPTER FIVE

BUILDING A STEREO MUSIC AMPLIFIER

One of the most thrilling experiences in kit building is "starting from scratch," using a raw, unmarked and undrilled chassis and individually selected components. That's the way earlier hobbyists had to do it when they wanted to build electronic equipment that wasn't available in ready-made kits. This chapter tells you how to build a 4-transistor stereo-amplifier, capable of filling a good-sized room

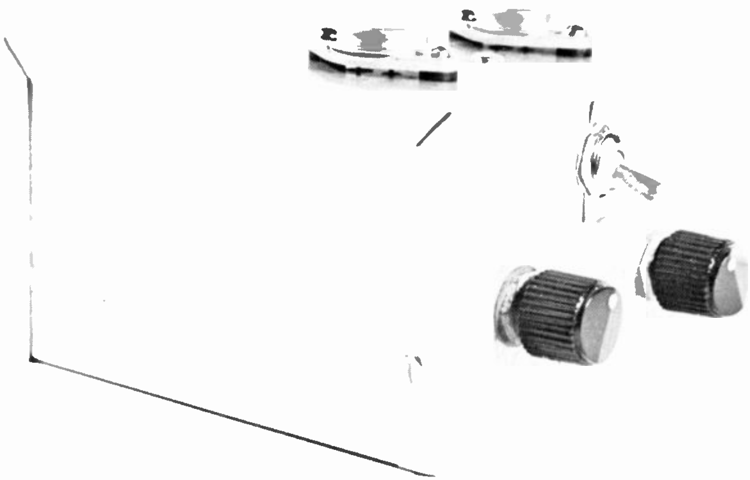


Fig. 5-1. Two transistors on the outside and two more on the inside add up to electronic kit-building fun and stereo listening pleasure. All components are built into a 3 x 4 x 5" aluminum box.

with high quality sound when connected to the output of any commercial or kit-built multiplex-FM tuner. You use standard electronic components for this project. All the information you need, complete with pictures of the original model, is included here to guide you in building your own amplifier.

As shown in Fig. 5-1, the amplifier is container on a 3″ x 4″ x 5″ aluminum box. This type of box is made especially for electronic projects such as this. The box separates into two pieces, one forming the chassis and the other acting as a sort of cover. These boxes are extremely popular among

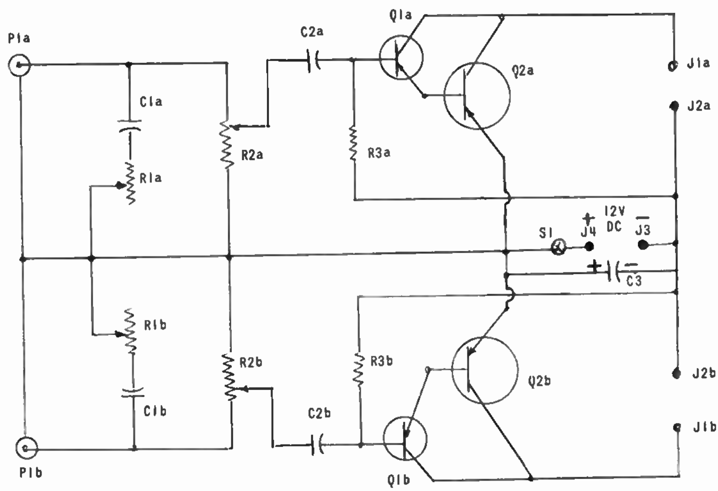


Fig. 5-2. Schematic diagram of the 4-transistor stereophonic amplifier shows simplicity of design and easy-to-build circuitry.

hobbyists. They are inexpensive, easy to work with, durable and attractive—a fine combination.

You will build into the box a small number of capacitors, resistors, transistors, and electronic hardware such as switches and terminals. You will be surprised at the work done by so few components. The amplifier has the capability of driving large bass-woofer speakers or even 3-way loudspeaker systems. And, because the box actually contains a matched pair of amplifiers, you can feed two such loudspeaker systems for stereophonic sound.

For the sake of simplicity, a battery is used as the power source. Any battery or series of batteries that will supply 6 to 12 volts can be used. For instance, you can connect four "D" cells in series to get 6 volts, or you can use a standard 6- or 12-volt lantern battery. The battery voltage is not critical, although for best performance it should not be less than 6 nor more than 12 volts. The most noticeable difference in performance with the two different battery voltages is that you do get more sound power when you use the 12-volt battery. Even with daily use, the battery supply will last a surprisingly long time.

One of the first things you will notice in the wiring diagram of the stereophonic amplifier (Fig. 5-2) is that there are no transformers connecting the loudspeakers to the output transistors. This is not an oversight. The loudspeakers you connect to this amplifier are part of the circuit that makes it work. Should one of the loudspeakers become disconnected, there would not only be no sound (obviously), but the amplifier to which the loudspeaker normally connects would instantly stop working. It would stop drawing current at the moment of the disconnection, as though the power switch had been turned off!

How can the amplifier work without output transformers? Well, the purpose of the transformer in the output of a conventional tube-type amplifier is dual: (1) It isolates the loudspeaker voice coil from the high voltage usually found at the output of tube-type amplifiers: (2) It matches the low impedance of the voice coil to the relatively high impedance of the power amplifier tube so that there is a maximum transfer of useful energy into the loudspeaker. The power transistors in the amplifier you will build from these instructions are operated at low voltage, so the isolation is not needed, and the impedance of the power amplifier transistors is almost the same as that of the loudspeaker voice coils; thus, there is no requirement for an output transformer between the transistors and the loudspeakers.

Looking at the front view of the finished amplifier, Fig.

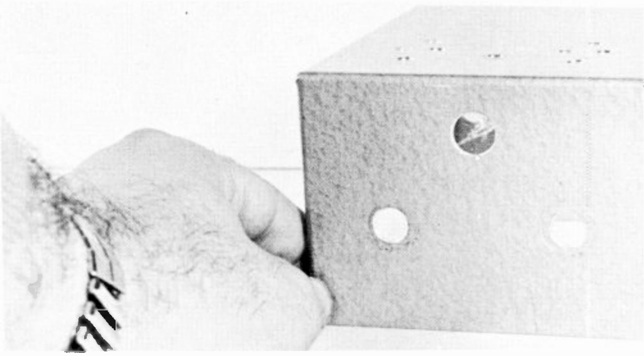


Fig. 5-3. Front view of the chassis section of the aluminum box shows relative positions of holes for S1, R1a-R1b, and R2a-R2b.

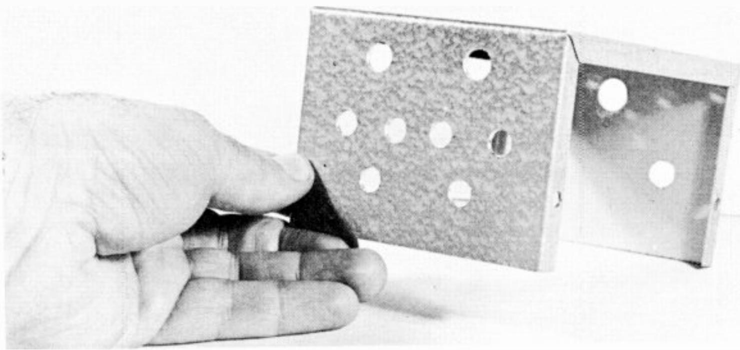


Fig. 5-4. Top of the chassis; four holes are needed for each of the two transistors, Q2a and Q2b. The single hole toward the center is for a solder lug that provides a common connection point for 5 wires.

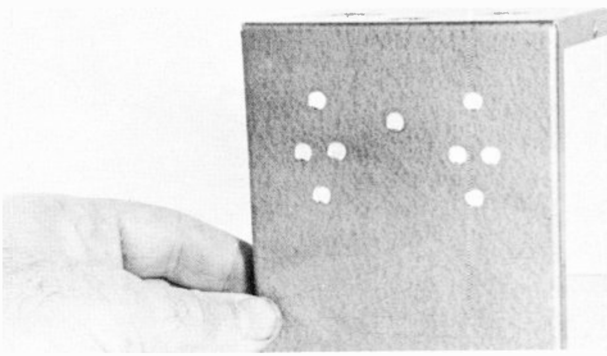


Fig. 5-5. Rear view of the chassis shows two holes near the top edge for P1 and P2; four in a horizontal row for J1a, J1b, J2a, and J2b; the two bottom holes are for battery connectors J3 and J4.

5-1, you can see three controls: (1) toggle switch S1 for turning battery power on and off; (2) a variable control to the right of the switch, R1a-R1b, for controlling volume; and (3) a control to the left of S1 which is the dual tone control, R2a-R2b. Fig. 5-5 is a rear view of the completed amplifier. Clearly shown are the metal-jacketed audio input jacks (P1a and P1b). The row of four connectors (J1a-J2a-J1b-J2b) provide the output connections for the loudspeakers. The bottom row of connectors (J3 and J4) are for the battery. When connecting the battery to the amplifier, polarity must be strictly observed. Different colored connectors for J3 and J4 aid in avoiding misconnections in polarity; red or orange is the usual color for the positive (+) terminal and black or white can be used for the negative (—) terminal.

The two oval or diamond-shaped devices on top of the box are the power output transistors (Q2a and Q2b). The metal case of each transistor is actually connected internally to

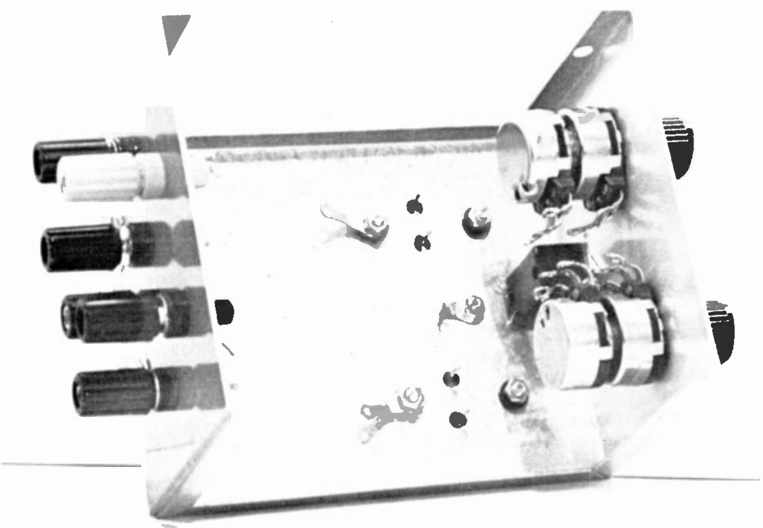


Fig. 5-6. Parts are mounted in the holes and tightly secured so that solder work and wiring can begin.

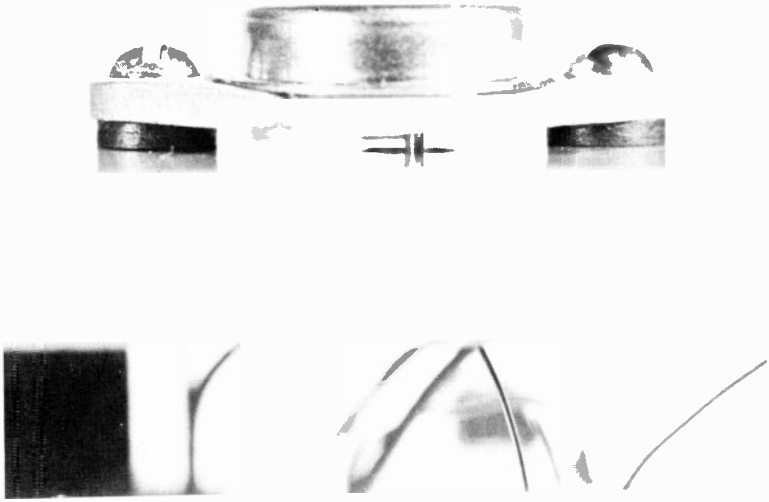


Fig. 5-7. Close-up view of Q2a shows how the transistor is insulated from the chassis by fiber washer mounting.

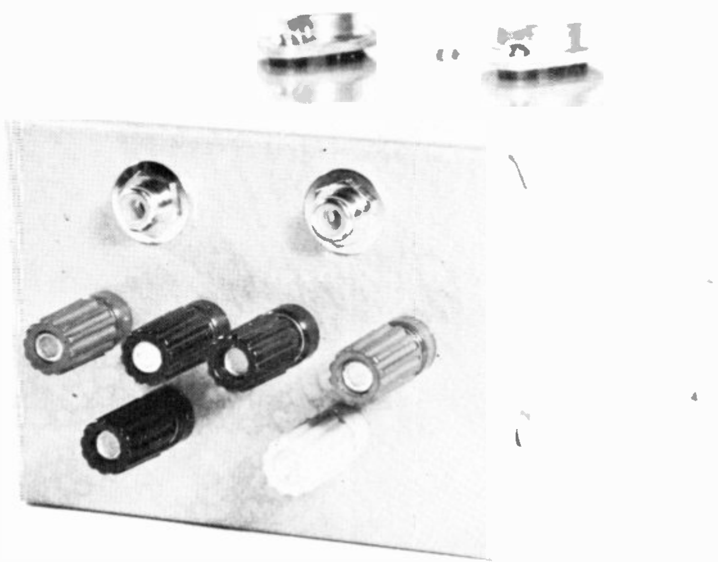


Fig. 5-8. Two top jack connectors, P1 and P2, are not insulated from the chassis; the other six connectors must be insulated.

the "collector" element. Since the transistor operates at low voltage, there is no need for high voltage protection. However, the metal case of the transistor is part of the operating circuit of the amplifier, so it must be insulated from the metal box. This is accomplished as shown in Fig. 5-7. Fiber washers serve as pillars on which the transistors are "seated" above the chassis. On the underside, more fiber washers likewise isolate the mounting nut from the chassis. A solder lug is inserted between the underside fiber washer and the nut of the mounting screw. This becomes the electrical connecting point between the transistor's collector and its associated circuitry.

Having followed the guidance of the photographs for laying out and drilling the metal box, the hardware can be installed as shown in Fig. 5-6. Care should be taken to make sure the connecting terminals do not touch the metal chassis or any of the other parts in the circuit not shown as a direct connection in the wiring diagram.

In Chapter 3 techniques of soldering fragile components were illustrated. These techniques come in very handy when you solder to the leads of the transistors. The two power transistors which mount on top of the chassis have two stiff wires protruding from their undersides; these must be soldered to circuit connecting wires. The use of a "heat sink" as described in Chapter 3 and illustrated in Fig. 3-8 is a must. The technique used in the construction of this amplifier is shown in Fig. 5-9. Note that the connecting wire is wrapped around the transistor lead, and long-nose pliers are being used to conduct the heat away from the body of the transistor. The same method must be used when soldering connections to transistors Q1a and Q1b, which have three leads each. When installing these transistors, do not cut their leads shorter than ½". In fact, they can be left full length without impairing the performance of the circuit; however, these leads must provide rigid support for the transistors. If they are allowed to remain full length, about 2½", the transistors might tend to flop around when the amplifier is moved or jostled. On the other hand,

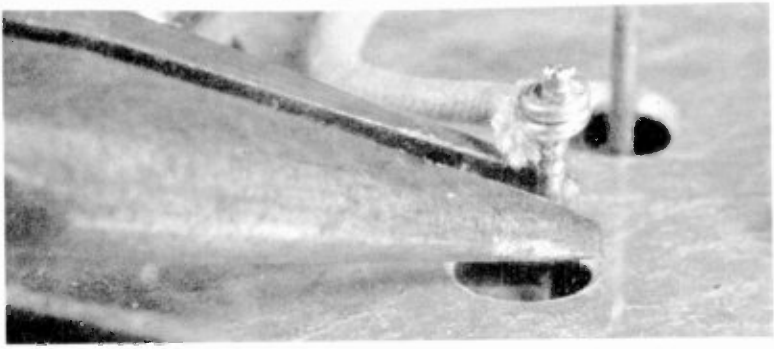


Fig. 5-9. The tips of long-nose pliers are used as a heat sink while soldering to heat sensitive components like Q2a.

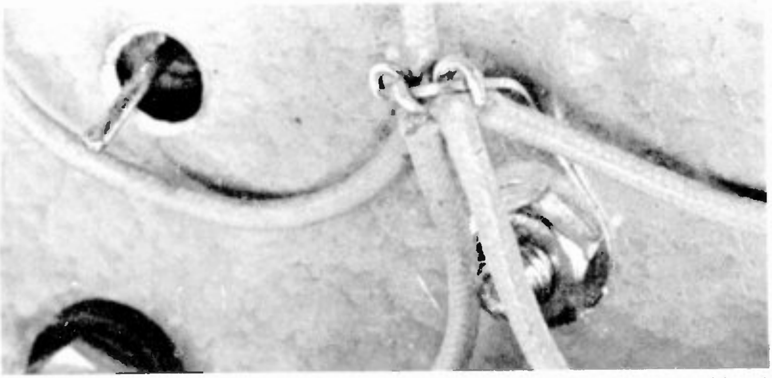
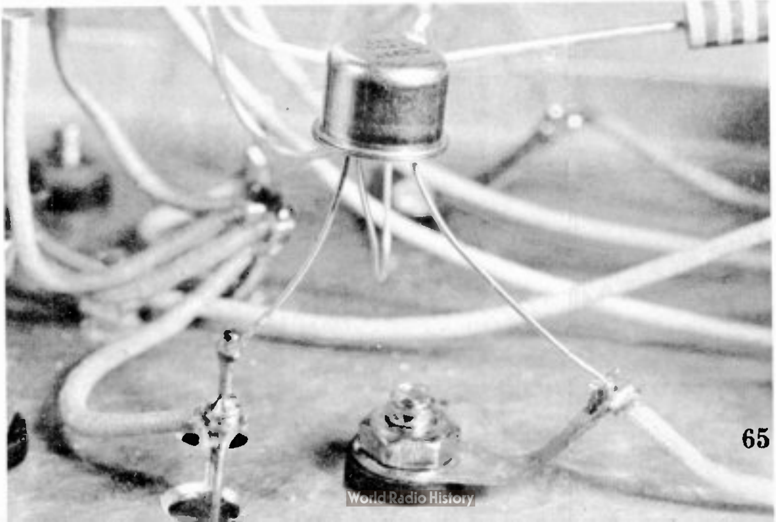


Fig. 5-10. Common connections are made to the terminal lug and all soldered at the same time.

Fig. 5-11. Close-up view shows how Q1a and Q2a are connected together. Do not cut Q1a leads shorter than 1/2".



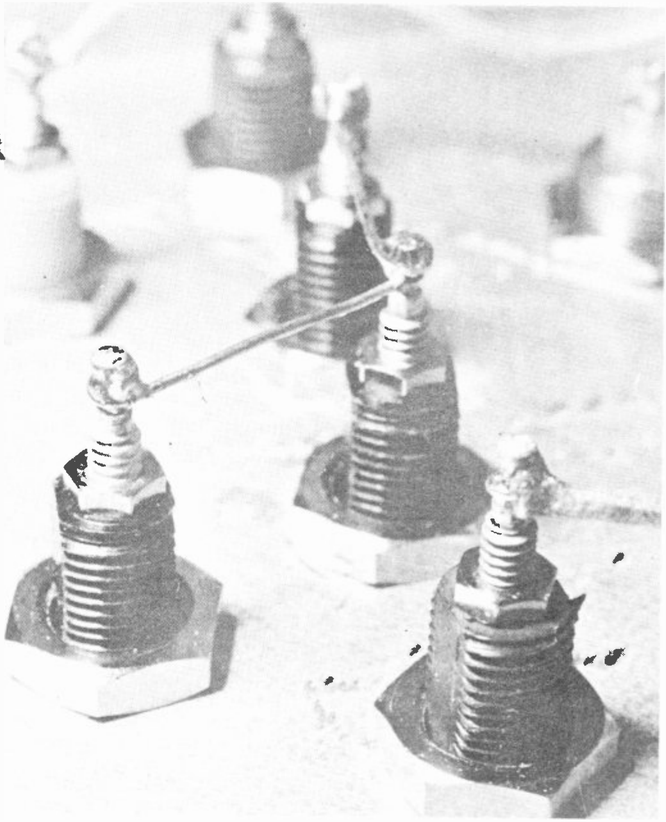


Fig. 5-12. Jack connectors have plastic bodies which automatically insulate them from the chassis. Solder connections are made to metal tail protruding through the back.

trimming the leads too close to the body of the transistor makes it more difficult to attach and solder the connections.

Fig. 5-10 shows how multiple connections are made to one common point, a solder lug bolted to the chassis in this instance. The ends of the wires connecting to the solder lug are first bared of insulation for approximately 3/16″ and are then inserted into the hole in the solder lug, twisted with the long-nose pliers to form a strong mechanical bond, and then soldered. All the mechanical connections, five in this case, are made before the soldering work is started. The five connections shown are from S1, R1a-R1b, and the

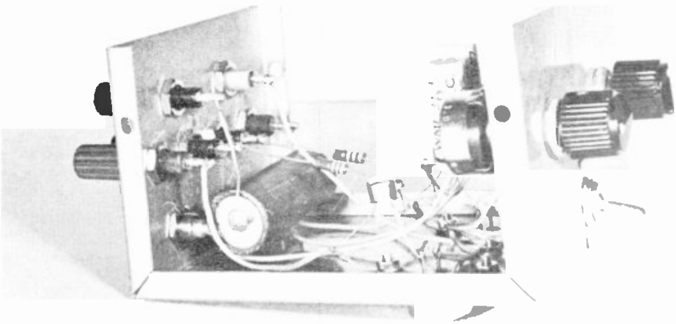
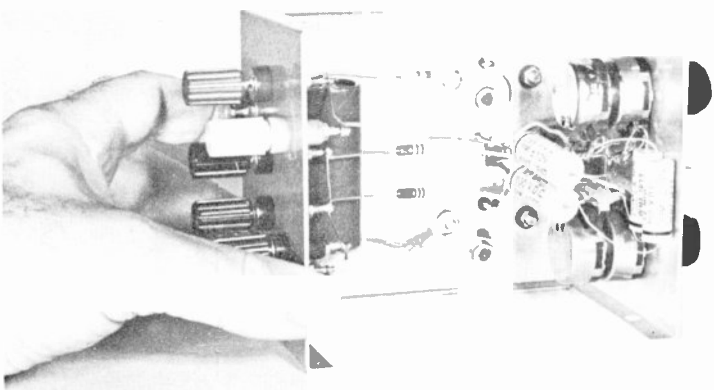
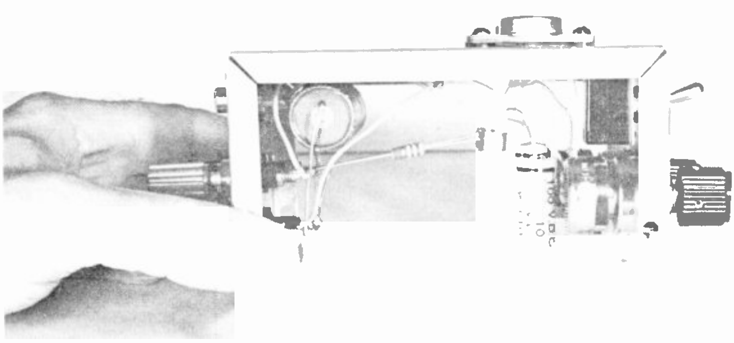


Fig. 5-13. The completed amplifier is compact, yet neat and uncrowded.





emitters of Q2a and Q2b.

Before connecting the battery and the loudspeakers, do two very important things: (1) Double check the wiring to make certain it matches the wiring diagram and that the transistor leads are properly connected; (2) Make a careful visual inspection to see that all joints are soldered and the excessive solder will not cause a short circuit between the chassis and other parts.

Ready for enjoyment now? Connect the stereo output of an FM tuner to the injut jacks (P1a and P1b) of the amplifier; attach the loudspeakers to J1a-J2a and J1b-J2b. Observe polarity and connect the positive terminal of the battery to J4 and the negative terminal to J3. Turn on toggle switch S1. Tune in a station and adjust the volume and tone controls for pleasant listening.

Parts List

QUANTITY	DESCRIPTION	ALLIED STOCK NO.	PRICE
1	Grey hammertone aluminum box 3" x 4" x 5"	42J7621	$1.40
2	R1a, R2a—Front sections of dual tone and volume controls, 100K ohms each	46J5527	1.71 ea.
2	R1b, R2b—rear sections of dual tone and volume controls, 100K ohms each	46J5580	1.62 ea.
2	R3a, R3b—330K ½-watt 10% resistors	45J5000C	.09 ea.
2	C1a, C1b—.22 mfd 100-volt tone control capacitors	43J6989	.39 ea.
2	C2a, C2b—.47 mfd 100-volt capacitors	43J6991	.47 ea.
2	P1a, P1b—front panel mount jacks	47J4902	.21 ea.
5	J1a, J1b, J2a, J2b, J3—black binding posts	47J6332	.30 ea.
1	J4—red binding post	47J6329	.30
1	C3—500-mfd 15-volt electrolytic capacitor	43J6238	1.05
1	S1—SPST on-off toggle switch	56J4527	.63
2	knobs for tone and volume controls	47J4170	.13 ea.
2	Q1a, Q1b—2N408 input transistors	49J12N408	.49 ea.
2	Q2a, Q2b—2N2869/2N301 output transistors	49J12N2869/ 2N301	1.52 ea.
1	Lantern battery—6 volt	18J5085	.92
	—12 volt	18J5088	1.96

CHAPTER SIX

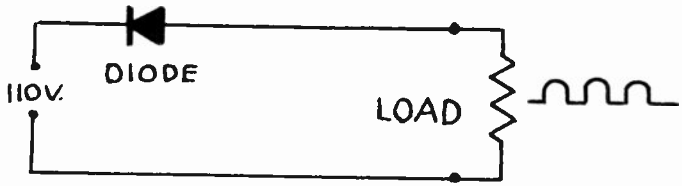
BUILDING A MOTOR SPEED LIGHT CONTROL

Here is an interesting project for the budding kit builder, a motor speed/light control kit. Not only does it afford an opportunity for you to become familiar with semiconductor devices such as the silicon-controlled rectifier (SCR) and the diode power rectifier, but is also serves as an exceptionally useful accessory in the home and workshop. The device permits you to control the speed of electric drills, food mixers, saber saws, vacuum cleaners, circular saws, sewing machines, and other electrically-powered equipment. In fact, with this unit you can control the speed of any universal wound AC/DC motor with a nameplate rating of up to 6.5 amperes. You also can control the brightness of incandescent lamps, or electric heating elements, including soldering irons, with ratings as high as 500 watts.

If you make much use of an electric drill, you will especially appreciate the benefits derived from being able to adjust the speed of the drill to the setting that is ideal for the job. What's more, the drill's torque will remain virtually constant at all speeds.

The ingenius component that makes this control unit possible is the *silicon controlled rectifier.* The SCR is a solid-state device resembling the diode power rectifier in its electrical symbol and performance, with one extremely important exception. As shown in Fig. 6-1, both the diode rectifier and the SCR will conduct electrical current in one direction only. When an AC voltage is applied to the diode rectifier, it conducts during the half cycle when the anode is positive with respect to the cathode. Thus, the diode rectifier converts the alternating current to a pulsating direct current. The usual frequency of the alternating current handled by the diode power rectifier is that of ordinary house power, 60 cycles per second.

The diode rectifier cannot be controlled; that is, it cannot turn the flow of current on or off. However, the controlled rectifier has an added element, a "gate" which can be used to make the diode rectifier fulfill the function of an elec-



Diode Rectifier

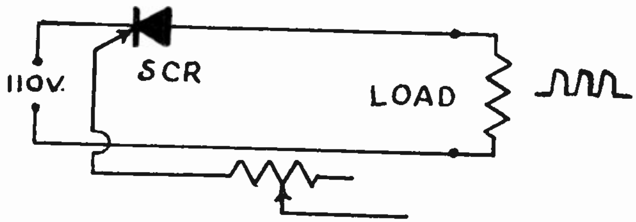


Fig. 6-1. Comparison of diode rectifier and SCR circuit outputs.

tronic switch.

Like any diode, the SCR cannot provide signal amplification. Without a gate voltage, the SCR blocks the flow of current. In this state it is nonconductive; the switch is off. Applying a suitable positive voltage to the gate turns the switch on and current flows immediately. The SCR can be turned off either by reducing the current flowing in the circuit to zero or by reversing the polarity of the voltage applied to the anode and cathode. Standard 110-130 volt house current reverses direction (polarity) 60 times a second. It starts at a zero level, rises to its maximum value, drops back to zero, then repeats the action in the opposite direction. One complete positive and negative period is called a cycle. House current has 60 surges of current during the period of one second.

If we were fast enough to apply a proper value of gate voltage to the SCR during one of these surges (120th of a second), the SCR would turn on and current would flow even after the gate voltage was removed. If we were able to observe the action, we would see current flow for 1/120 of a second and then stop. No further current would flow until the gate voltage was reapplied. If we were to apply the gate voltage at the middle of the half-cycle interval, the SCR would conduct only during the remaining half of that period. Thus, the control of the time at which the gate voltage is applied determines the conduction period. The effect is the same as repeatedly tapping an on-off switch connected to an electric lamp or motor. The longer the switch is held in its *on* position during each tap, the brighter the bulb will glow or the faster the motor will rotate.

This tapping or periodic control of the gate voltage for the SCR can be accomplished electronically. In the motor speed/light control unit, the adjustment is achieved with a simple potentiometer. When the potentiometer is in the full counter-clockwise position, the SCR is off. Clockwise rotation causes the SCR to begin to conduct when a lamp or suitable motor is plugged into the receptacle on the control box. The high position at the extreme clockwise rotation of the potentiometer actuates a mechanical switch that short-circuits the SCR and applies full AC voltage instead of pulsating DC.

Applications for the Controller

Many is the hobbyist who has put together, say a speaker cabinet requiring couple of dozen screws. But by the time

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the last screw was in, he would have given his numb right arm for a power screw driver. But there's no need to run out and buy one when you own a common electric drill. True, the speed of the drill is much too high to drive screws. But this Full-Range Speed Control can solve this problem easily. Plug the drill into the controller, turn the knob counterclockwise to get the speed way down, and the next cabinet will go together in half the time.

Speed controls are becoming both popular and plentiful, but they're not all alike. Most are half-wave jobs with limited control range and fading torque. This controller is a full-wave design that permits you to vary the speed of any universal motor from full speed to a virtual standstill—and the torque (or twisting power) remains constant throughout the range. As the work load increases, so does the power supplied to the tool to maintain torque.

There are many applications for the controller. When using a saber saw to cut metal or hard wood you must slow the motor to keep the blade from overheating. When cutting plastic, the speed of the saw also will have to be reduced to keep it from melting the plastic.

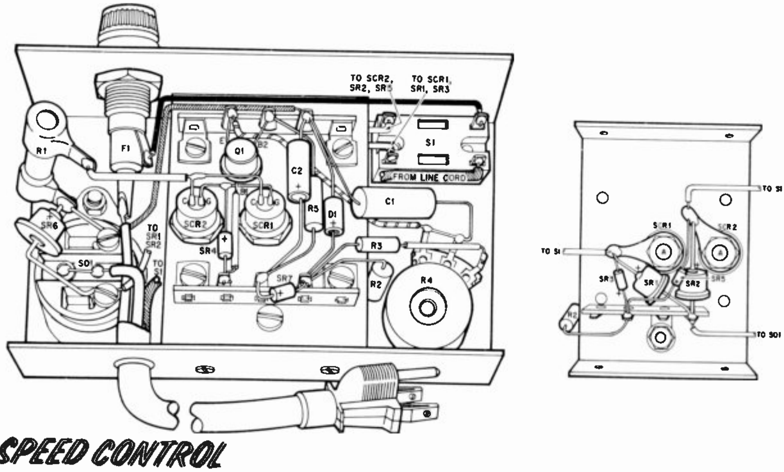

Fig. 6-2. Mount SO1, F1, S1, and R4 near the edges of the cabinet to allow room for the heat sink chassis in the center. Lead from B1 on Q1 goes only to anode of SR4. Mount SCR1 and SCR2 as shown. Be careful when installing the chassis that SR1 and SR2 do not touch the cabinet or get pushed against SCR1 and SCR2.

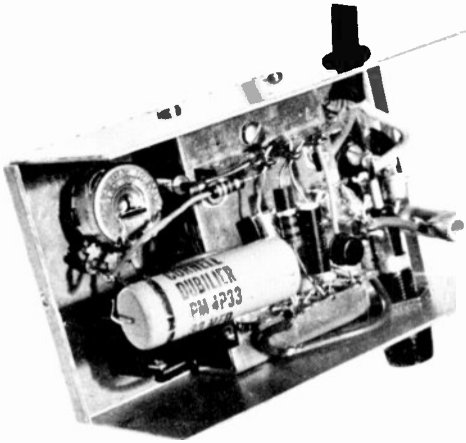

Fig. 6-3. Put tape on the inside of the other half of Minibox so that R1 (top) and C1 (bottom) leads do not short to the cabinet.

Or, suppose you have to drill a ½-inch diameter hole in a thick piece of steel. If you run the drill at full speed, the bit will burn up, lose its cutting efficiency and the hole will be filled with burrs. Not so at slow speed, though, and you'll be able to start the hole without a center punch because the bit won't creep.

Besides being able to reduce the speed of shop tools, the controller will work with fans, movie projectors, sewing machines, food blenders, sanders, lathes, vibrators, or almost any tool or appliance that has a series or universal (brush) motor that does not draw more than 6½ amps. Although some of these appliances have built-in speed controls, the speed range and torque characteristics will be improved greatly by this controller.

How does the controller achieve all this? Many speed-control devices have only one controlled rectifier. Hence, they are able to supply one half-wave power to the motor. This means that maximum speed is only about half the normal full speed. At less than full speed, many motors can't develop sufficient torque to handle the work load.

This controller overcomes these disadvantages because it provides full-wave power to the motor. It has a unique feedback circuit that furnishes extra power to maintain torque as the work load increases. To test this characteristic after you've built the controller, plug a drill into it and set potentiometer R4 for a speed of about 100 rpm. Then hold the chuck with your hand and turn the drill on. You'll be pleasantly surprised at the high starting and running torque.

Building Your Own Unit

Because many of the semiconductors used in the controller may be difficult to obtain locally, Allied Radio has made up a package of all parts except the fuse, resistor R1, the AC plug and other small hardware. However, the Parts List has sufficient information for you to purchase all parts

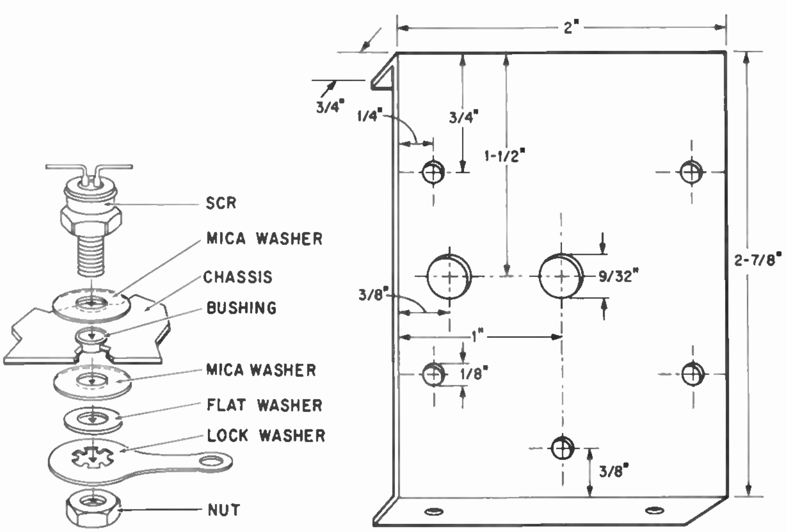

Fig. 6-4. Detail diagrams showing how SCRs are mounted and dimensions for heat-sink chassis.

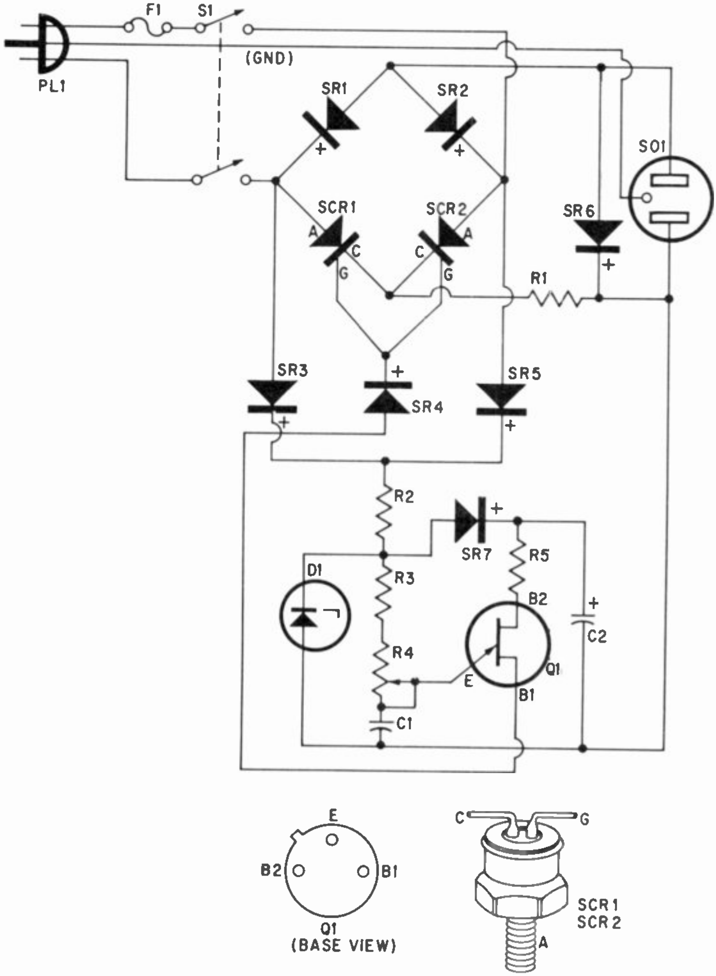

Fig. 6-5. Amount of power full-wave bridge (SR1, SR2, SRC1, SRC2) furnishes to motor (at SO1) is a function of the point in each half of the AC cycle at which the SCR begins to conduct. This is established by phase-control circuit (C1, R3, R4, D1, Q1).

on your own if you choose to do so. The Parts List includes Allied's special stock number and price for the parts package.

The model is built in a 3″ x 5″ x 2″ Minibox. Silicon-controlled rectifiers SCR1 and SCR2 must be mounted on a

Fig. 6-6. Knight-Kit motor speed/light control ready to operate.

1/16" thick aluminum (or copper) chassis. This thickness is important to permit the chassis to serve as a heat sink. A thinner piece of metal will not conduct the heat away quickly enough to prevent damage to the SCRs.

The SCRs also must be electrically insulated from the chassis, as shown in Fig. 6-4, with two mica washers, a bushing, and the hardware supplied with them. It is important that the holes for the SCRs be free of burrs or the mica washers may be punctured, resulting in a short circuit. This will create a shock hazard because the cabinet would have one side of the AC line connected to it. After the SCRs are mounted, install diodes SR1, SR2, SR3 and SR5 on the underside of the plate as shown in Fig. 6-2.

Drill the necessary mounting holes in the cabinet for mounting the SCR chassis, speed-control potentiometer R4, on-off switch S1, and the fuse holder. However, do not mount R4, S1, and the fuse holder in the cabinet until the SCR chassis has been installed. After all major parts are mounted, complete the interconnecting wiring. Where wiring must carry the load current, use heavy wire.

If the motor requires between 2 and 3 amps, R1 should be a 1-ohm, 5-watt wirewound resistor. For a 5- to 6-amp motor, R1 should be a ½-ohm, 10-watt wirewound resistor. If you want to be exact about it, compute R1 with this formula: R1=2/Im, where Im is the maximum rated current of the appliance's motor in amperes.

Operation

Plug the appliance into S01, and plug P11 into an AC outlet. Set switch S1 to "on." With the speed-control knob fully clockwise, the tool's motor will operate at full speed. Turning the knob counterclockwise will reduce speed until the motor runs at only a few rpm.

Most tools and kitchen appliances have a universal motor.

Parts List

QUANTITY	DESCRIPTION	ALLIED STOCK NO.	PRICE
1	C1—.33 mfd, 200v tubular capacitor	43J7917	$0.36
1	C2—1 mfd, 25v electrolytic capacitor	43J4121	.45
1	D1—Zener diode: 7v, 1 watt Sarkes Tarzian VR7	49D31 VR7	.62
1	F1—6A, 3AG fuse and Little-fuse Type 342014 holder	57J3003	.40
1	PL1—AC plug with ground lug		
1	Q1—2N2160 unijunction transistor (GE)	49D3 2N2160	1.49
1	R1—Resistor (see text)		
1	R2—15,000 ohm, 2 watt, 10% resistor	45J5070C	.18
1	R3—3,300 ohm, ½ watt, 10% resistor	45J5000C	.09
1	R4—25,000 ohm, linear taper potentiometer (Ma lory U-29 or equiv.)	46J3760	1.02
1	R5—220 ohm, ½ watt, 10% resistor	45J5000C	.09
1	S1—DPST toggle switch rated at 6A or higher	56J4647	.83
2	SCR1, SCR2-Motorola MCR2305-4 silicon-controlled rectifier: 8A, 200 PIV	49JD6-MCR2305-4	2.10
1	SO1—AC socket with ground lug	47J5524	2.16
3	SR1, SR2, SR6—3A 200 PIV Rectifier	49J26 IN4721	.82
2	SR3, SR5—IN4004 rectifier: 1A A, 400 PIV	49J26 IN4004	.67
1	SR4—IN4001 rectifier 1A, 50 PIV	49J26 IN4001	.45
1	SR7—IN4003 rectifier: 1A, 200 PIV	49J26 IN4003	.60
1	3x5¼x2⅛ Minibox, 1/30" thick aluminum	42J7622	1.20

Note: A package of parts including the fuse-holder (but not F1, PL1, R1, terminal strips, aluminum box, line cord, and small hardware) is available from Allied Radio Corp. Price is $14.95 plus postage. Specify special stock number 24JX9820.

However, if you are not sure of the type of motor, look for brush holders, or brushes, which are characteristic of this type of motor. Also, if the label on the appliance indicates that it can be operated on either AC or DC, you can assume that it has a universal motor.

Want a Ready-Made Kit?

If you're more interested in the finished product than in building it, the ready-made Knight-Kit KG201 should serve your needs very nicely. The unit, shown assembled and ready for use in Fig. 6-6, can be used to control motors with nameplate ratings up to 7.5 amps, incandescent lamps up to 500 watts, and electric heating elements up to 900 watts. It comes complete with instruction manual for assembly and operation, a heavy duty 3-wire power cable, a cabinet full of smaller parts and the front panel, two major components mounted on a card and the permanent mounting bracket.

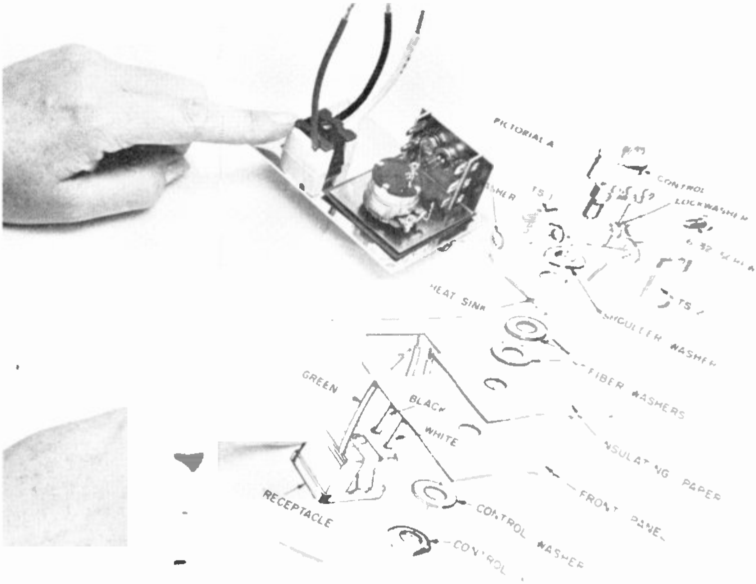

Fig. 6-9. Pictorial diagram shows how the parts are mounted.

As pictured in Fig. 6-7, the kit comes complete with the instruction manual for assembly and operation, a heavy duty 3-wire power cable, a cabinet full of smaller parts and the front panel, two major components mounted on a card, and the permanent mounting bracket.

Fig. 6-7. Components of the KG-201 Kit.

The SCR is capable of handling an extraordinary amount of current for a device so compact. The SCR in the KG-201 Kit can handle up to 7.5 amperes in this case. The main reason for its high current-carrying capability is the means used to dissipate the heat this current produces—a means of conducting the heat away from the internal elements of the SCR as quickly as possible. A radial fin provides an excellent and simple means for achieving this purpose, conducting heat away from the SCR by increasing the area from which heat may be allowed to escape.

The metal case of the SCR is also the electrical connection to the anode. In the case of the KG-201 Kit, the heat sink is supplied already secured to the SCR in the shape of large mounting bracket, which also serves as the terminal for the anode. In Fig. 6-8, the pencil points to the junction of the SCR case and the mounting bracket.

The anode and the heat-sink bracket are operated at the line voltage of the house current. Therefore, it is essential that the bracket and, in fact, all components of the circuit, be insulated to preclude the possibility of accidental electrical shock to the user.

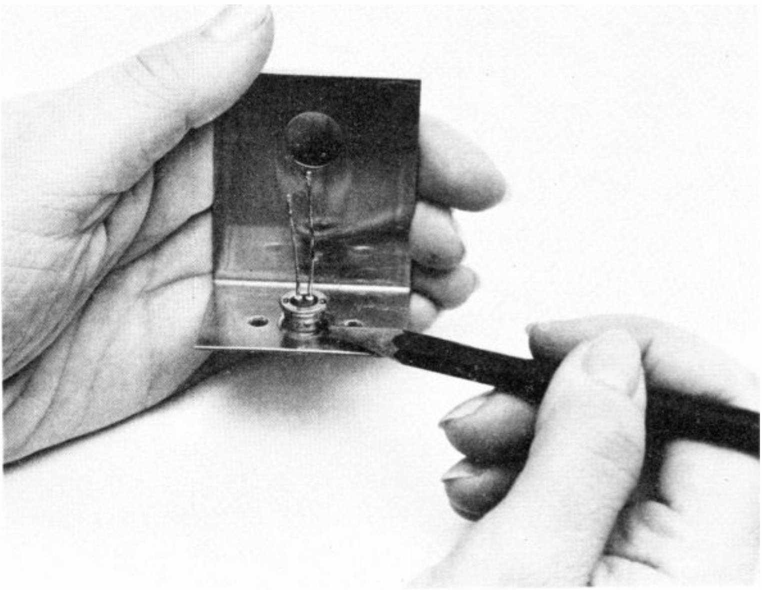

Fig. 6-8. Junction of the SCR case and the mounting bracket.

A large size pictorial diagram in the instruction manual supplied with the kit shows an exploded view of how the parts are mounted (see Fig. 6-9). The assembly procedure, which is extremely simple, also is described in the text of the manual.

Many of the points covered in the chapter on soldering will come in handy in the construction of this kit. For example, a tiny capacitor and resistor are connected in parallel by twisting the leads of the former around the latter (see Fig. 6-10). Long-nose pliers or a metal clamp should

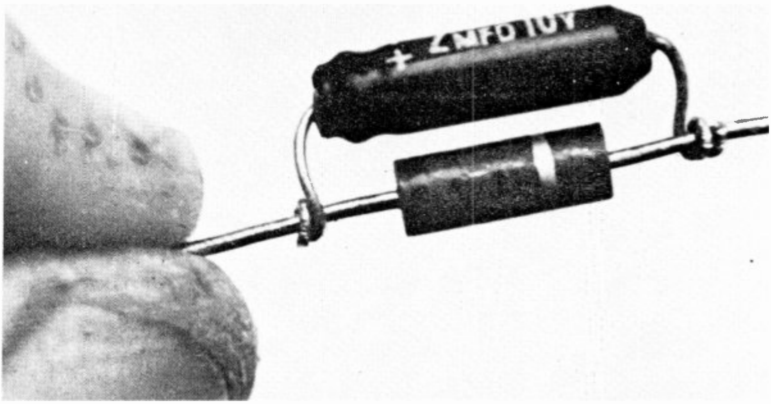

Fig. 6-10. Paralleling tiny capacitor and resistor.

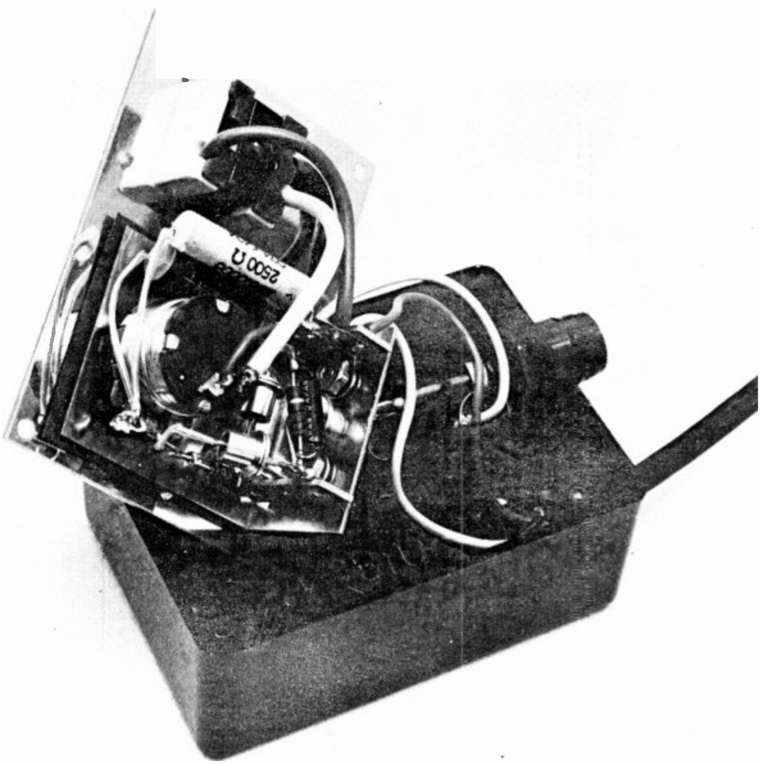

Fig. 6-11. How the chassis is installed in plastic case.

be used as a heat sink, clamped to the leads of the capacitor to conduct heat safely away while the soldering iron is applied to the junction.

After the wiring is completed, and the construction is double-checked against the instructions and the pictorial diagrams, the completed assembly is ready to be installed inside its enclosure, which is an insulated box (Fig. 6-11). The appliance or light to be controlled is plugged into the front panel of the control box. A power cord from the control box plugs directly into any wall outlet.

CHAPTER SEVEN

BUILDING A BCB BOOSTER

One of the most frustrating experiences for Broadcast Band DX'ers is to see all those rare stations logged by others and wonder how anyone ever heard them. Well, many people hear them—and you should, too! It might be that your receiver just won't receive them. Quite frankly, a budget receiver of the type most popular with BCB DX'ers can always use a little extra gain. In fact, even a high priced receiver can often use an extra "kick-in-the-pants" on the broadcast band.

Since only standard components are used, and the layout is clean, it's a simple project even for the beginner. Even

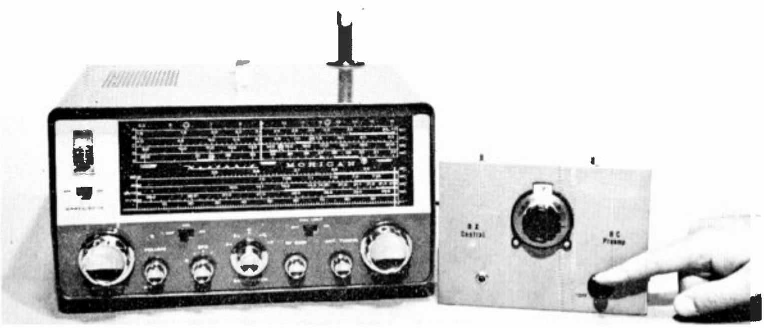

Fig. 7-1. Separating the "wheat from the chaff" is the job of this turnable broadcast-band preamp that connects to any receiver.

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the coils are prewound, and they require no modifications.

Construction

The booster has very high gain, and quite likely it will break into oscillation if layout and wiring is sloppy. We suggest you follow the layout shown, and wire in such a manner that, within reason, plate leads don't cross or run parallel to grid leads. Try to use maximum spacing between grid and plate connections. We suggest the use of specified components unless, of course, local conditions will make minor substitutions necessary. To insure stable operation the layout should follow the detail drawing.

The mounting centers for the major chassis components are given in Fig. 7-2. Holes for T1 and T2 should be large

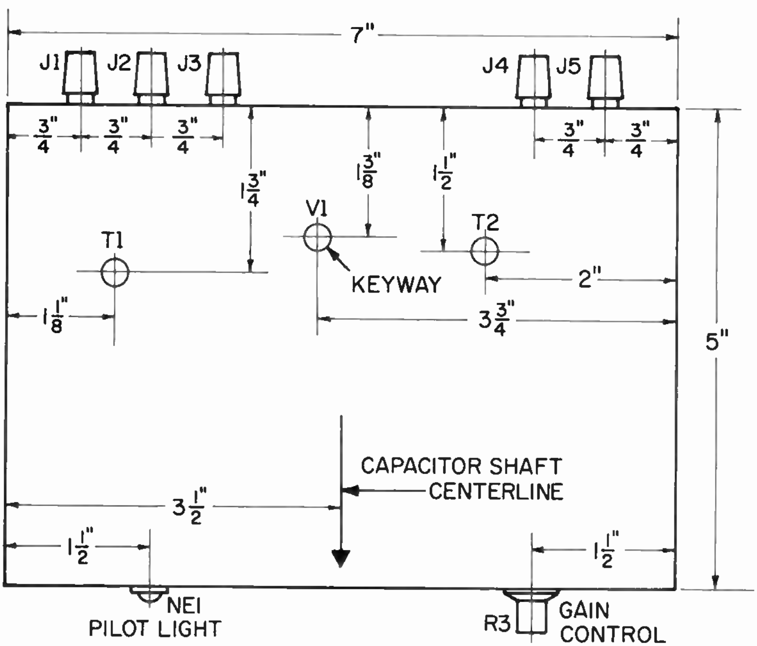


Fig. 7-2. Top view drawing showing parts placement on the BCB Booster chassis. Rubber cement white paper to the top, front, and back sides of the chassis and mark all hole centers as shown in the drawing. Mounting holes for the tuning capacitor are marked with the unit held in place and its shaft located along the centerline. Parts mounted on the front and back sides are located midway from top to bottom of chassis.

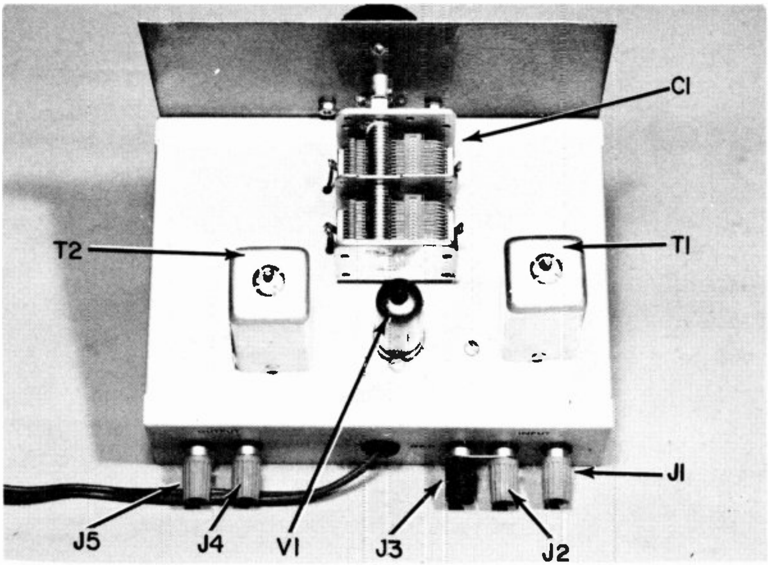


Fig. 7-3. Compare this photo with the top view drawing in Fig. 7-2. Parts placement is critical to satisfactory operation. Booster can be installed in a cabinet if desired.

enough to insure that the rough edges do not cut through the connecting lead insulation. We suggest at least a half-inch opening. If you don't make large holes, make sure the edges are burnished so no knife edges remain. Disregard all instructions which are supplied with T1 and T2 and make the connections exactly as shown in the schematic diagram. Do not reverse any of the color-coded wires.

V1's socket doesn't have to be shielded, but if you have a shielded socket handy it can be used. Whether or not a shield is used, the socket's center pin must be connected to ground. Failure to ground the center pin will most likely result in tuning instability and oscillations.

Tuning capacitor C1 is usually mounted by three screws passing through the bottom of the frame. If the screws are too long they will short circuit C1's stator plates; since one set of plates is connected to the B+ line, considerable damage can result. If possible, C1 should be mounted with 6-32 1/8" or 3/16" screws.

The front panel can be cut from scrap aluminum or a

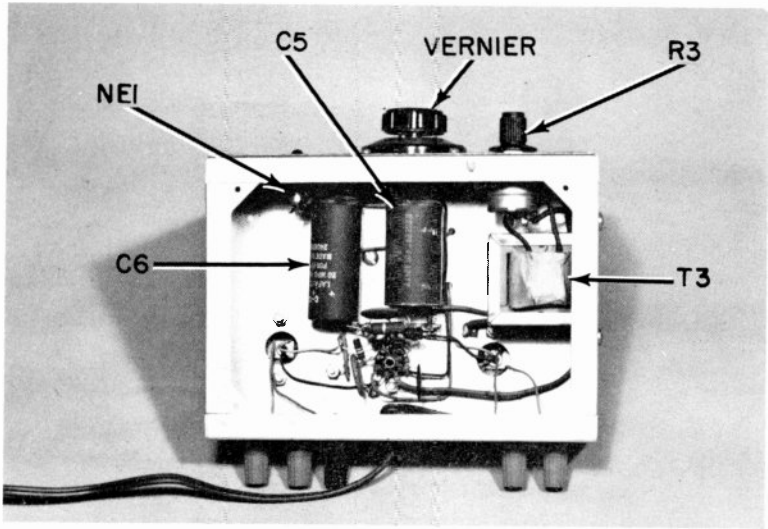


Fig. 7-4. Under chassis view of the booster showing parts placement. Note that power transformer T3 is mounted on a side flange. Filter capacitors C5 and C6 are mounted to terminal stips.

chassis bottom plate. Hole centers must match mounted parts. To avoid binding the vernier of the tuning shaft, cut the hole considerably larger than the shaft diameter—at least one-half inch is recommended.

Pilot lamp NE1 can be any neon lamp assembly. If the one you use has a built-in limiting resistor, R6 should be eliminated.

For maximum connection convenience J1-J5 are 5-way binding posts. Don't substitute phono jacks since both the input and output circuits are isolated from ground.

Alignment

For best results the booster should be aligned with an RF generator. Set C1 plates to full mesh and screw trimmers hand tight (the trimmers are the small brass screws mounted on one side of the frame). Using coaxial cable (any type), connect the booster to your receiver.

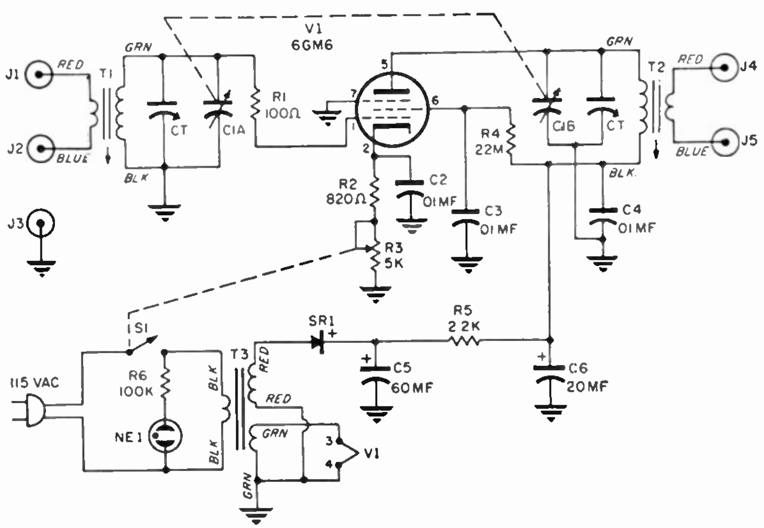
Connect a signal generator, set to 550 kc, to J1 and J2, and apply power to the generator, booster, and receiver.

Set gain control R3 to mid-position and allow a 15-minute warmup.

Set the generator to *unmodulated signal* and tune in the signal on the receiver. If the receiver is equipped with an S-meter, adjust the generator output for the lowest possible S-meter reading. If the receiver lacks an S-meter, use a *modulated* test signal, run the receiver's audio and RF gain wide open, and adjust the generator output for the absolute minimum signal you can hear. If the receiver has an AVC on-off switch, set it to *off*.

Using an insulated alignment screwdriver, adjust T1 and T2 for maximum preamp gain. Then, set the generator to the highest BC frequency the receiver can tune. Set C1 to full open and tune in the signal. Using an alignment screwdriver, adjust both C1 trimmers for maximum gain.

To insure optimum track adjustment, keep reducing the generator output so minimum usable level is maintained, and repeat the procedure several times (slug adjustment



Schematic diagram for the BCB Booster. Although the circuit may seem uncomplicated, considerable design and model-making effort was expended to insure maximum gain over the tuning range without oscillations.

Fig. 7-5. Schematic diagram for the BCB Booster. Although the circuit may seem uncomplicated, considerable design and model-making effort was expended to insure maximum gain over the tuning range without oscillations.

affects the trimmer adjustment and vice-versa).

It is important to remember to always set C1 to the low or high end before tuning the signal. The booster's selectivity is relatively sharp, and if C1 is set to full mesh you won't receive the high-end signal and you may waste time looking for a problem which doesn't exist.

Do It By Ear

If you don't have a signal generator, a reasonably good alignment can be made by ear. Set C1 to full mesh and tune in a very weak signal on the low end of the band. (If the signal is strong, disconnect the antenna.) Note how much the receiver's tuning capacitor is opened from full mesh and adjust C1 to a similar position. For example, if the receiver's capacitor is opened 10 degrees, open C1 10 degrees. Then, adjust T1 and T2 for maximum gain.

Next, set C1 full open and tune in a signal on the high end. Again note the position of the tuning capacitor and set C1 similarly. Adjust C1 trimmers for maximum gain. As with the generator alignment, the procedure must be performed several times to obtain optimum performance.

Using the Booster

For maximum convenience make a chart of what frequencies correspond to the vernier's 0-100 calibration. The easiest way to do this is to tune in a signal (station or generator) of known frequency, peak tune the booster, and note the vernier calibration.

Connect the booster to the receiver and the antenna to J1 and J2. If the antenna is just a length of wire, connect the antenna to J1 and a jumper from J2 to ground terminal J3. If you use an antenna coupler or tuner, connect to input terminals J1 and J2, but try grounding both J1 and J2—sometimes a ground will improve performance.

Set C1 to the part of the band you want to monitor (low, middle, or high end) and apply power by rotating R3 just past the point where you hear the power switch click. Tune in a signal and peak the signal with the booster. At minimum setting of R3 there will be considerable gain; if more gain is required, advance R3.

The booster's gain is very high, and depending on wiring and other conditions, the circuit may break into oscillation at full output—the oscillation is evidenced by receiver "blocking," or the ability to *tune* signals with the booster. If you get oscillations at full gain try changing the input ground, or connect the booster to an electrical ground such as a water pipe—this will usually eliminate oscillations. If the oscillation persists, reduce booster gain by backing off on R3. There's plenty of reserve gain and the little bit lost in eliminating instability won't be noticed.

Built as described, you'll find the BCB Booster a hot performer. Changes or modification to the BCB Booster circuit are not recommended.

Parts List

QUANTITY	DESCRIPTION	ALLIED STOCK NO.	PRICE
1	C1—Tuning capacitor, two gang TRF, dual 365 mfd	43J3521	$3.22
3	C2, C3, C4—.01-mfd, 1-kv ceramic disc capacitor	43J5674	.15 ea.
1	C5—60-mfd, 150-VDC electrolytic capacitor	43J5196	.72
1	C6—20-mfd, 150-VDC electroyltic capacitor	43J6243	.90
1	J1-J5—Five-way binding post	47J1327	.33 ea.
1	NE1—Neon pilot light assembly	60J8698	.73
1	R1—100-ohm, ½-watt resistor	45J5000C	.09
1	R2—820-ohm, ½-watt resistor	45J5000C	.09
1	R3—5000-ohm linear potentiometer with switch (IRC Q11-114/76-1 or equiv.)	46J5383 / 46J5359	1.23 / .75
1	R4—200,000-ohm, ½-watt resistor	45J5005C	.15
1	R5—2,200-ohm, ½-watt resistor	45J5000C	.09
1	R6—100,000-ohm, ½-watt resistor	45J5000C	.09
1	SR1—Silicon diode		
2	T1, T2—Midget RF coil	54J0867	1.35
1	T3—Power transformer; 125v at 15 ma, 6.3v at .6 amp.	54J1416	1.91
1	V1—6GM6 vacuum tube	25J286GM6	1.63
1	Vernier dial (type 390).	56J4600C	.12
1	Chassis, aluminum 5" x 7" x 2"		
	Misc.—7-pin socket, terminal strips, hardware, 5" x 7" aluminum plate, wire solder, etc.		

*specific value

CHAPTER EIGHT

INSTRUMENTS FOR KIT TESTING

Almost every electronic kit can be adjusted and tuned to deliver its finest performance without special test instruments. For some kits, you may need special types of screwdrivers and wrenches called *alignment tools*. Often these special tools are included with the kit. When such tools are included, instructions for their use are given in the manual. You can do an excellent job (if the instruction manual is properly prepared) without prior knowledge or experience in electronics.

However, you may want to make an electrical check of continuity from point to point as you make a final inspection of your kit wiring. You can assemble a continuity tester easily from conventional flashlight parts; a bulb, battery

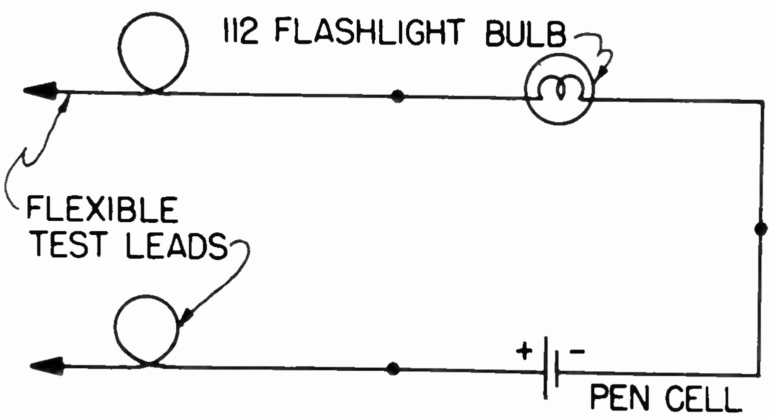


Fig. 8-1. A simple continuity tester.

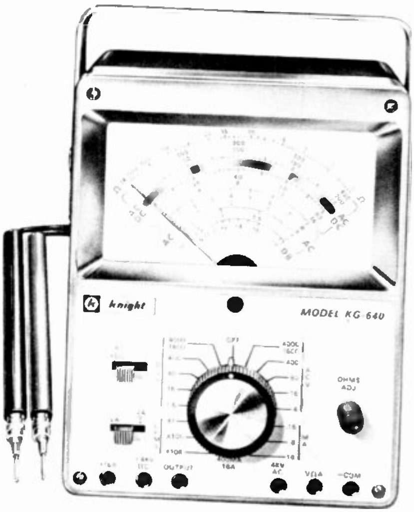
and 3 lengths of hookup wire. All parts are wired in series as shown in Fig. 8-1. If you want to determine whether you made a good electrical connection from one terminal to another, touching the bare ends of the test wires to the two terminals, for example, will give an immediate answer. If the light goes on there is electrical continuity.

The brilliance of the test light should be the same as that achieved simply by touching the bare ends of the two test wires together. If the test for circuit continuity produces lower brilliance, there is electrical resistance in the wiring or solder connections. If the instruction manual called for a direct connection without a resistor between the two terminals, inspect the work and locate the reason for the added resistance before you proceed further into the circuit. Perhaps a resistor has been installed inadvertently instead of the wire; or the wire has been connected to a wrong terminal; or the wire is broken under its insulation and should be replaced; or a solder joint is electrically imperfect.

Checking With a Test-Meter

If you are more technically inclined and want to make certain you are getting the best performance from your kit, you will want to check its operation against the specifications at the back of the instruction manual. These specifications are point-to-point voltage and resistance measurements. These measurements can be made with either one of two instruments, a VOM or a VTVM.

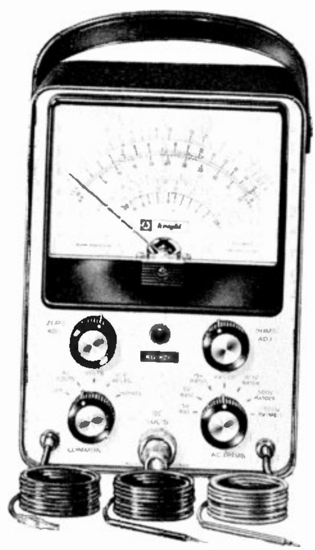
VOM is short for Volt-Ohm-Milliameter. It is used for measuring voltage, resistance and current. The VTVM is an abbreviation for Vacuum-Tube Volt Meter. It is similar to the VOM but uses vacuum tubes or transistors to provide more precise measuring circuits. The VOM is a self-contained instrument; it needs no external power source for operation. Its power is derived from the circuit to which it is connected and from self-contained batteries. On the other hand, a VTVM requires an external power source, usually 110-130 volt AC house current. Several kit models of VOM's and VTVM's are pictured in Fig. 8-2.



Knight-Kit 20,000 ohms/volt VOM

EICO Model 565 VOM

RCA WV 38-A VOM Kit



Knight-Kit KG-620 $4\frac{1}{2}$" VTVM

Fig. 8-2. Typical VOM and VTVM kits.

When to Use a VOM or VTVM

For many common measurements it makes little difference which of the two instruments are used; either will provide essentially the same voltage or resistance readings. However, there are certain instances when the ordinary VOM will give erroneous voltage readings. This is due to a characteristic of the VOM. Any instrument becomes part of the circuit to which it is connected and causes changes in electrical values. Because of its design, the effects of a VOM connection sometimes can be so pronounced as to affect the performance of the equipment, making the meter indications meaningless. This is known as *loading the circuit.*

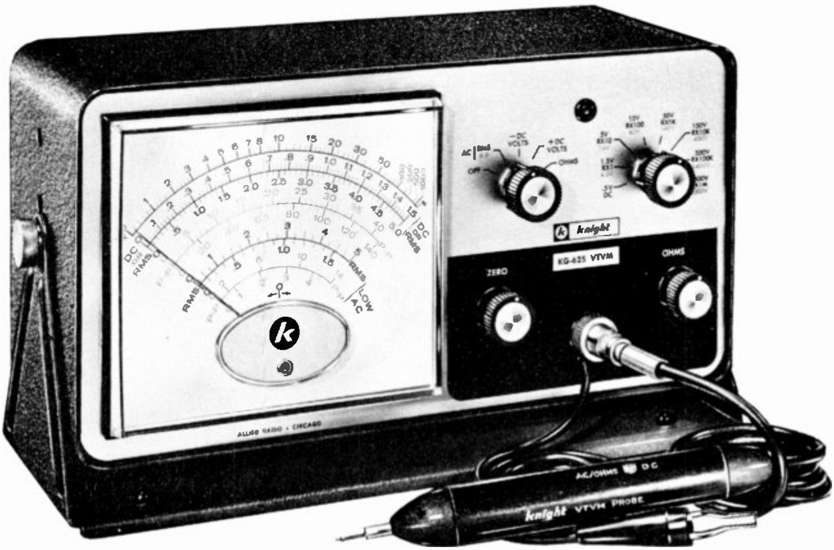
Connecting a VOM to a circuit is comparable to inserting a resistor of fairly high value between the two points where the test prods are placed. The resistance of the VOM varies with its range setting. Typically, the value is 20,000 ohms-per-volt; thus, on a 150-volt range, for example, the resistance is 3 megohms (3 million ohms). Some of the more expensive VOMs, designed for less circuit loading, are rated at 50,000 or 100,000 ohms-per-volt. Even so, on the low-range scale (5 volts, for example) meter resistance could be as low as 250,000 ohms (only 100,000 for a 20,000 ohms-per-volt meter). There are many circuits whose operation would be altered by the addition of such resistance values. And the voltage readings obtained would not be the same as those present with the meter disconnected. Thus, placing the test prods of a VOM across certain circuits loads them so they become inoperative or they change operation so that the meter indications are of no value.

A VTVM, on the other hand, is designed so its resistance is the same on all ranges, typically 11 megohms on all DC voltage settings. This high value usually has little effect on circuit operation so voltage readings are essentially the same as when the meter is disconnected.

A VOM is ideally suited to measuring voltages in low-resistance circuits. It also is useful for measuring direct current and resistance values. Actually, in these latter two functions, many consider it more versatile than a VTVM. Furthermore, most common VTVMs are not designed to measure current.

A well-built VOM will give many years of service. There is nothing to wear out other than the flashlight batteries it contains for resistance measurements. VOMs can be bought in kit or finished form. Some are quite compact, fitting in a jacket pocket. The smallest VOM is considerably more compact than the smallest VTVM and is lighter in weight, too.

A VTVM, as has been pointed out, is essential for making measurements in circuits that cannot tolerate loading.



Knight-Kit KG-625 6" VTVM.

A typical VTVM, the Knight-Kit KG-625, has an input resistance of 11 megohms. Such a VTVM can indicate resistance values that are considerably higher than those capable of being measured by a VOM. For example, the KG-625 can measure resistance as high as 1,000 megohms. A 20-megohm indication is considered an unusual capability for a VOM. Obviously, the VTVM is exceptionally valuable in indicating leakage resistances and in all tests involving the measurement of extraordinarily high resistance. Well-equipped kit builders and technicians often have both a VOM and a VTVM, using each where it is best suited to the measurement requirements.

Well-designed VOMs and VTVMs and all classes and types of test instruments can be purchased in either kit or factory-wired form. They are not essential to successful kit building, but if you plan to build a reasonable number of electronic kits for your home or hobby activities, a VOM and a VTVM should be given high priority. They can be extremely helpful in checking finished kits and in gaining maximum pleasure and utility from their performance capabilities.

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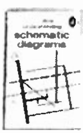

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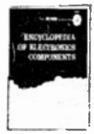

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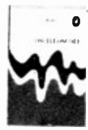

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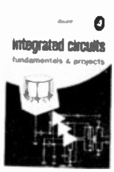

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