

TV-Radio & Hi-Fi HINTS & KINKS

By John J. Schultz

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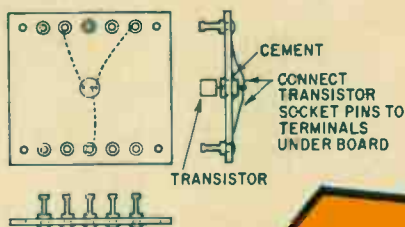
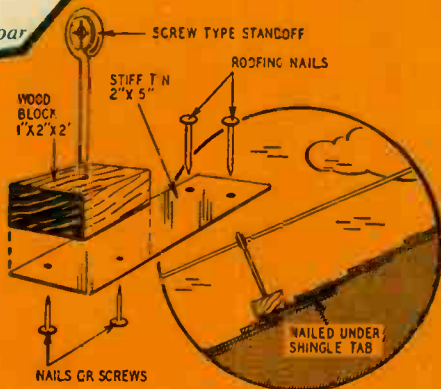
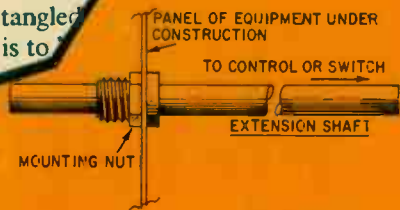


Fig. 502. Terminal board for transistor

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By John J. Schultz



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Preface

There is much that any TV, radio, or hi-fi equipment owner can economically do to improve and extend both the performance and usefulness of his equipment. This book offers a wide range of proven ideas, each intended for the average equipment owner who has, perhaps, only a limited knowledge of electronics. Included are over 150 ideas that encompass a wide spectrum, from a simple extension speaker installation, a multiple FM-TV antenna and receiver installation, to tips on the care of most equipment. In every case you'll find that we've used readily available commercial parts and accessories. Also, only the use of basic tools is required for the great majority of installation descriptions presented. And for those interested, we've included some information on basic soldering techniques and even basic breadboard circuit wiring.

It has been the author's observation that most people, once they learn how simple it is to add accessory features to their equipment, desire to do some experimenting of their own. Hopefully, this interest will develop into a further exploration of the fascinating hobby of electronics, in which case you'll probably purchase and study a basic book on electronics theory to learn a little bit of the "why" behind the functioning of electronic circuits.

As you thumb through this book, a certain idea may find appeal, or you may already have in mind certain equipment installation or modification ideas. In any case, unless you have worked with electronic equipment before, it is a good idea to relax and read Chapter 1 first; it discusses basic tools to use, simple techniques to enable you to check what you've connected, etc. Working on electronics equipment is no different from doing work on any specialized equipment, in that knowing the proper tools and basic procedures to use is usually more than half of the job.

A last—but big—word about safety. The great majority of the ideas presented do not require internal access to equipment and do not involve working with voltages that can be harmful. In a few instances, though, some internal connections have to be made. Common-sense safety precautions should be observed in these cases. **Unplug** the equipment before beginning and do not “explore” in equipment beyond those connection points which are described.

John J. Schultz

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Chapter 1

Tools, Test Equipment, and Wiring

Before starting on any sort of project related to electronics, it is a good idea to know where you can obtain the special parts that may be required. Of course, there are many parts stores in large communities. Although anyone can usually buy in any of these stores, some of them cater to professional electronics people and a hobbyist who cannot specify in technical language what he wants may not receive a friendly welcome. On the other hand, there are electronic parts stores that cater specifically to the hobbyists and they usually feature a wide assortment of parts in plastic "blister" displays. Many of the latter type stores do sell parts at reasonable prices, considering the extra packaging, display space needed, free advice offered, etc., but there are always a few who take advantage of the hobbyist. For instance, in one such small store in the middle of New York, the author was asked to pay \$2.40 for a component that he knew to be available from several mail order electronics parts houses for between 30 and 50 cents.

The best thing a hobbyist can do, until he develops some concept of what various parts should cost, is to obtain and use catalogs from various leading mail order electronics parts houses. These catalogs contain a wide range of parts, more than the average hobbyist needs. Even though you may understand nothing of the technical terms used to describe some components, all the simpler ones you need are there. And the accompanying illustrations will help to make the selection process easy. In essence, these firms are the Sears or Wards in the electronics parts field. Such catalogs are free; all you need to do is send a postcard. Following are some of the leading firms:

Allied Radio
100 N. Western Ave.
Chicago, Ill. 60680

Burstein-Applebee
3199 Mercier St.
Kansas City, Mo. 64111

Olson Electronics
260 S. Forge St.
Akron, Ohio 44308

Newark Electronics Corp.
500 N. Pulaski
Chicago, Ill. 60624

Lafayette Radio Electronics
111 Jericho Turnpike
Syosset, L.I., N.Y. 11791

Radio Shack
730 Commonwealth Ave.
Boston, Mass. 02215

Allied Radio publishes both an "Electronics for Everyone" catalog, as well as an industrial catalog. The latter may prove useful as you go into more advanced projects. Also, later on, you may become interested in exploring the various components and pieces of equipment still available from the military surplus field. A catalog on these items can be obtained from:

Fair Radio Sales
Box 1105
Lima, Ohio 45802

If you have very much European-made equipment which requires special connectors, or other accessories, it may be worthwhile to consider ordering such specialized parts directly. Many U.S. mail order houses do not carry these parts and the smaller stores that do, tend to charge premium prices. In this regard, a catalog from the following firm may be worthwhile, even though it costs \$1.00:

G. W. Smith and Co. (Radio)
147 Church Street
London W2, England

Ask for their "Catalog of Components and Equipment." If you can read a little bit of German and really want to find a bargain source for the specialized "DIN" parts used with many European-manufactured recorders, radios, etc., send \$1.00 for a catalog to:

Radio RIM
Bayer Strasse 25
8 Munich 15, W. Germany

BASIC TOOLS

Most of the projects described in this book require only the interconnection of wires, or the connection of wires to existing

screw terminals on pieces of equipment or on accessory items. Some accessories come with only wire leads, but even here simple connections can be made without soldering by means of “solderless” terminal blocks. So, as a basic minimum you need only a pair of 5-inch diagonal wire cutters, a pair of 5-inch long-nose pliers, a 1/8-inch screwdriver (to fit the screws on solderless connectors) and a 1/4-inch screwdriver (for screw terminals on equipment). These items can be purchased separately, or there are small toolkits available which contain most of them. The one shown in Fig. 1-1, for instance, also contains a small soldering iron.

Although soldering can be avoided in many cases by the use of solderless connectors, alligator clips, etc. (Fig. 1-2), it is a great help to be able to do basic soldering, as described later. For general electronic work, a small 30 to 50-watt soldering iron is sufficient, plus a coil of rosin core solder—never acid core solder. A final, simple item that may be purchased to complete a beginner’s tool set is a pair of wire strippers for up to no. 8 wire. Although diagonal pliers can be used for strip-

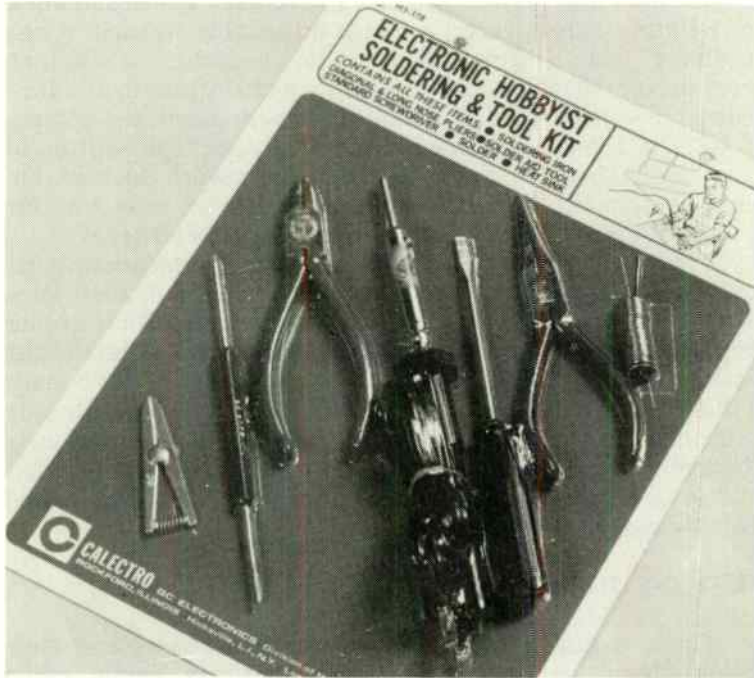


Fig. 1-1. One of several pre-packed tool kits for electronic hobbyists.

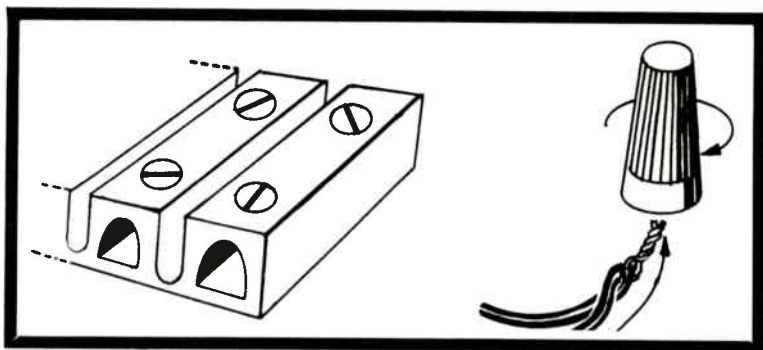


Fig. 1-2. Solderless wire connectors come in a variety of forms from multiple set-screw strip types to individual twist-on types.

ping insulation from (as well as cutting) wires, it requires some practice before you can strip the insulation from stranded wire without also removing some of the strands.

The next few simple tools that you might want to add are a no. 1 Philips screwdriver, a 6-inch adjustable wrench, a hex nutdriver set (three-sixteenth to 1/2-inch), a 3/8-inch screwdriver, 10-inch tongue-and-groove utility pliers, a 1/2-inch reamer, a 1/4-inch hand or electric drill with a drill assortment up to 1/4-inch and a ballpeen hammer. These tools will be of great assistance in doing slightly heavier work such as antenna system installations, internal house wire runs, and the installation of radio or hi-fi equipment in bookshelf areas.

If you become more interested in circuit-type accessories and start to home-build circuitry, you'll need finer tools such as jeweler's drills, various size screwdrivers, etc. On the other hand, if you engage mostly in antenna and heavier installation work, a variety of heavy-duty tools can make repetitive tasks of this nature far easier than it is with the simple tools already described. In any case, tools of both sorts are profusely illustrated in catalogs and one quickly learns for himself what he can use by comparing his requirements with the actual tools available.

TEST INSTRUMENTS

There is also a wide assortment of electrical and electronic "tools" or test instruments that are useful when working on electronic equipment. As with the mechanical tools, however, there are only a few very simple instruments that you can use to begin with. The simplest one, shown in Fig.

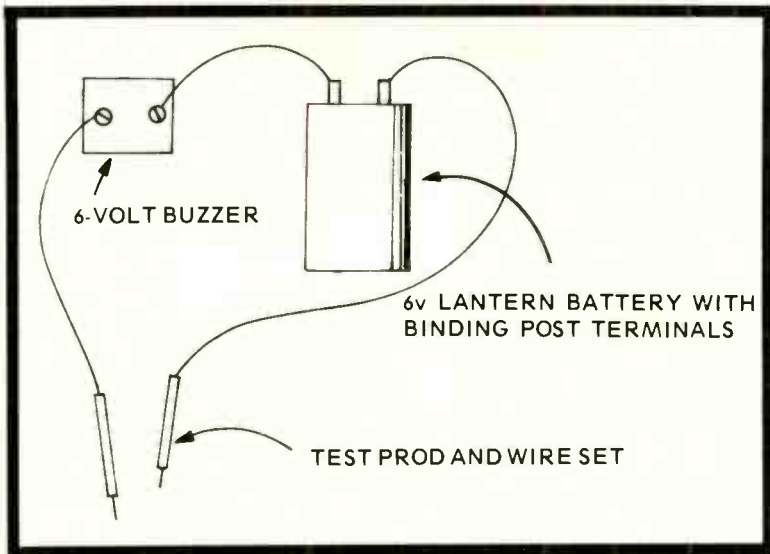


Fig. 1-3. Simple continuity tester circuit. If you can't find a 6-volt buzzer, any other suitable matching buzzer-battery combination will suffice; for example a 3-volt buzzer and a 3-volt battery.

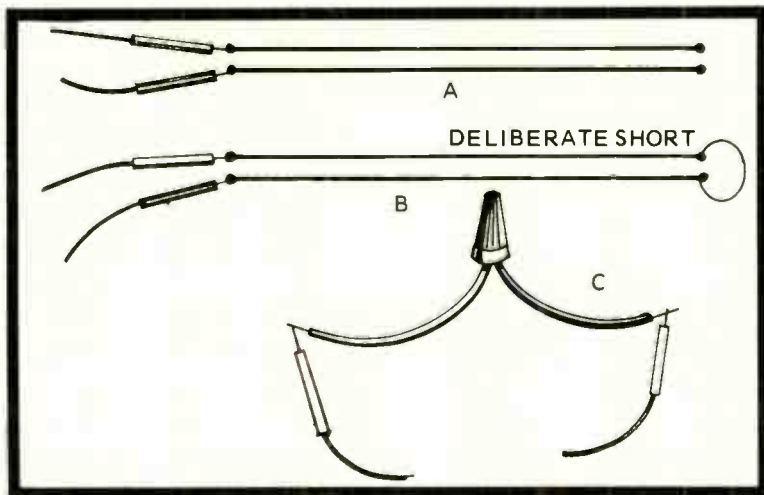


Fig. 1-4. A battery-buzzer continuity tester is useful for many simple checks—test for short circuits (A), to check the continuity of long lines by shorting one end (B), and for good connections (C).



Fig. 1-5. A typical, simple volt-ohmmeter, such as this one, costs from \$8 to \$10.

1-3, is a circuit continuity tester utilizing a buzzer and battery connected in series. Such a tester can be home-built, or similar units can be purchased. The tester is useful to check that a wire connection has been properly made. Fig. 1-4 illustrates a few uses for a continuity tester. The main disadvantage of such a tester is that it cannot be used on any circuit in which voltage is present. Also, it cannot be used to test most components—in fact, it can ruin certain components, such as transistors, if used to test them. Nonetheless, this simple tester can be very useful to check antenna lead-in connections, wiring for extension speaker connections, etc., where a simple wire connection is involved.

A relatively inexpensive instrument that offers a far wider range of tests is the volt-ohmmeter, or VOM. A typical type is shown in Fig. 1-5. Commercial types are available from as low

as \$8 to \$10. The range of uses to which this relatively simple instrument can be put is so great, however, that handbooks have been written on the subject. Consult any of them to appreciate the full versatility of this instrument. Generally, however, the hobbyist will first be concerned with using a VOM to check the condition of wire connections, that of simple components, and to check that operating voltage is being delivered to a piece of equipment or accessory unit. The latter may not always be obvious, since with transistorized, battery-operated equipment there is usually no pilot lamp, and if the unit should not operate properly, one of the first things to check is the battery condition.

A few simple tips on the use of a VOM are appropriate here. The easiest function to get used to is that of resistance measurements. With the unit on the lowest resistance range, the test prods are shorted together and the "ohms-adjust" control used to set the pointer at zero ohms on the scale. You can then experiment with various wire connections to see how the ohmmeter indicates opens, shorts, etc. Thus, an ohmmeter can do something during continuity checks that a simple battery-buzzer cannot do, and that is to indicate the quality of a connection. Assuming that the type and length of wire used has negligible resistance of its own, any resistance reading other than zero would indicate that the connection has not been properly made. Components such as resistors and potentiometers can be checked directly to see if their resistance value is as stated. Capacitors can be checked for shorts, too. Initially, when connecting the ohmmeter leads across a large capacitor, the meter will deflect towards zero ohms, then gradually move the other way. The final resistance reading is the one to note.

The voltage reading capabilities of the VOM can be checked first with a small 1½- or 9-volt battery, setting the VOM always on a scale with a higher value than that of the voltage source being measured. AC voltages, such as the line voltage, can be measured, using the proper AC setting on the VOM. When measuring any voltage which could possibly be dangerous, and that means roughly any voltage above 40 volts, it is a good idea to follow the safety precaution of keeping one hand in a pocket to insure that you cannot get both hands across a dangerous voltage via the VOM test leads. Insulated alligator clips which slide over the end of the test prods are very handy to have to fasten a prod to a voltage point and so avoid holding the prod.

Neon-light testers are generally useful only for checking that line voltage is present, since they require a minimum of

A - Ampere (also amp)
AC - Alternating current or voltage
AF - Audio frequency
AFC - Automatic frequency control
AGC - Automatic gain control
AM - Amplitude modulation
ANT - Antenna
AVC - Automatic volume control
BFO - Beat frequency oscillator
C - Capacitor or capacitance
CPS - Cycles per second
CW - Continuous wave (Morse)
DB - Decibels
DC - Direct current
F - Frequency (also freq.) or farad
FM - Frequency modulation
GND - Ground
H - Henry (also Hy)
HF - High frequency
Hz - Hertz (same as CPS)
I - Current
IF - Intermediate frequency
KC - Kilo (1,000) cycles
kHz - Kilo (1,000) Hertz
KV - Kilo (1,000) volt
KW - Kilo (1,000) watt
L - Inductance
LF - Low frequency (below 300 kHz)
MA - Milli (one-thousandth) ampere
MC - Mega (1,000,000) cycles

60 volts AC or 90 volts DC to light. Generally, unless you do a great deal of power line wiring, it is better to invest instead in the least expensive VOM available, rather than in such testers.

LUBRICANTS AND SPRAYS

One of the great conveniences when working on electronic equipment is to have available a few basic lubricants and sprays which you know how to properly use. There are literally hundreds of sprays and liquids available for specific applications, but a few basic types will suffice to start. A pen-type oiler, which disburses instrument oil in spray or liquid form, is useful to lubricate the small moving parts in tape players, phonographs, tuning mechanisms in radios, etc. The greatest danger is over-doing the lubrication of equipment. A good rule to follow is never to lubricate equipment unless some

MEG - Megohm (1,000,000 ohms)
 MFD - Micro (one-millionth) farads (also MF)
 MHz - same as MC
 MH - Millihenry
 MMF - Micromicrofarad (same as picofarad)
 MW - Milliwatt
 NC - No connection
 NF - Nanofarad (one-billionth MFD)
 PF - Picofarad
 P-P - Peak-to-peak voltage
 R - Resistor
 RF - Radio frequency
 RMS - Root mean square
 SW - Shortwave or switch
 Ω - Ohm
 UHF - Ultra high frequency (above 300 MHz)
 V - Volt
 VHF - Very high frequency (above 30 MHz)
 VOM - Volt-ohmmeter
 VTVM - Vacuum tube VOM
 VU - Volume unit
 W - watt
 Z - Impedance
 u or uu - Micro and micromicro (may appear before A, F, H, V, etc.)

Fig. 1-6. Common abbreviations used in electronics. Some frequently are used in lower case.

definite need for lubrication is indicated. Another basic spray to have on hand is a general-purpose cleaning spray, variously labeled as a tuner cleaner, volume control cleaner, tape-head cleaner, or contact cleaner. One spray can be used for all the purposes mentioned, unless you do a great deal of work in one specific area and then a specialized spray may be worthwhile. Whatever cleaning spray you buy, the label should specify that it leaves no residue and that it will not damage plastics.

Another very useful spray or liquid to have is one that provides a clear insulating coating. Such sprays are again labeled in various ways, such as lacquer sprays, clear acrylic spray, insulating sprays, liquid-tape spray, etc. In any case, the spray or liquid chosen should provide a rapid drying, weatherproof coating. Such sprays provide an insulating coating, particularly for connections made outdoors, and are particularly useful to exclude moisture from corroding such connections. When applying such a coating, it is best done by

applying several very light coatings, one after the other; be sure to take the time to allow each separate coating to dry completely before applying the next.

A small supply of cotton-tipped swabs, such as the type sold in drugstores, is also useful to have on hand. The close quarters in some equipment may not permit the use of a spray without also spraying undesired areas. In this case, the spray can first be used to saturate the swab and the swab used to apply the spray material.

CIRCUIT DIAGRAMS AND ABBREVIATIONS

Although most of the diagrams in this book are presented in pictorial form, standard circuit symbols are used to represent common components. You will also encounter these symbols, as well as many more, of course, in the wiring diagrams for pieces of electronic equipment. Therefore, it is a good idea to become well acquainted both with the symbols and with the abbreviations commonly used with them. Even if you don't understand the complete technical meaning of the terms used, it is still necessary to specify correctly the components that you want to order for replacement or construction purposes.

Fig. 1-6 is a listing of the common abbreviations used in electronics work. Fig. 1-7 is a presentation of the most commonly used symbols for components. It is necessary to also carefully notice the qualifying statements appearing on most circuit diagrams regarding component values. For instance, a common statement is that all resistors shown are $\frac{1}{2}$ watt, unless otherwise specified. So, if you see a resistor symbol with just 1K written next to it, a 1,000-ohm resistor of $\frac{1}{2}$ watt size is meant. If next to the symbol 1K-2w is written, the resistor has a value of 1,000 ohms but is a 2-watt unit. The same is true of capacitors. Frequently, the statement is made that capacitor values are shown in pf, except for electrolytic capacitors where the value is shown in mfd. So, you have to be sure that the symbol used is read correctly.

For instance, if 5 appeared next to the symbol for an ordinary capacitor (see Fig. 1-7), a value of 5 pf is indicated; 5 appearing next to the electrolytic capacitor symbol would indicate 5 mfd. The voltage rating of a capacitor is sometimes also indicated next to the symbol, particularly for electrolytic capacitors, such as 5/16v, which in the case of an electrolytic capacitor means a 5-mfd unit with a 16-volt DC voltage rating. If the voltage rating is not shown, the rating should be assumed to be that of the highest voltage potential

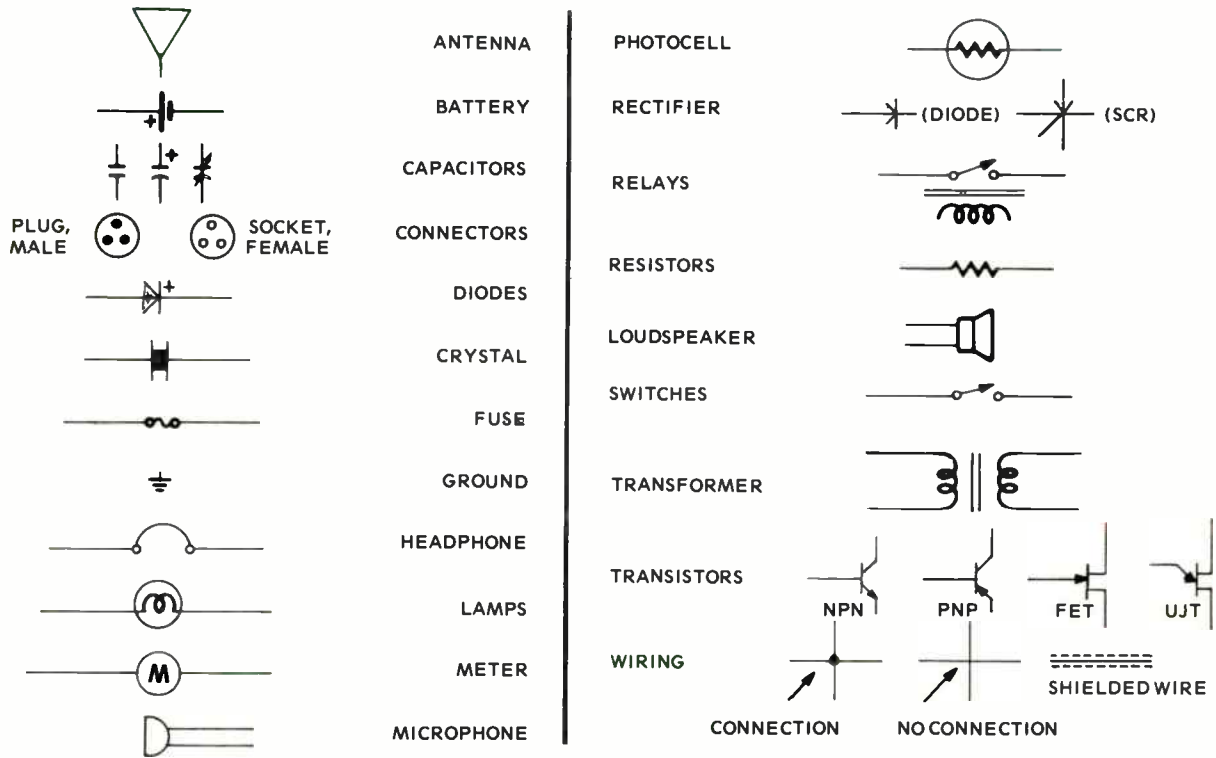


Fig. 1-7. Most commonly used electronic symbols.

used. Since capacitors come in groups with different voltage ratings, the safest course is to choose one from the next highest voltage rating group. Thus, if a capacitor rated at 18 volts is indicated, you would normally purchase a capacitor in the 25-volt group.

PARTS SUBSTITUTION

More often than not, components which are locally available do not exactly meet the specifications called for; therefore, you have to judge how far you can go in substituting parts. Unfortunately, there are no guidelines that can be used in every situation. For instance, in a timing or flasher-type circuit the use of a 100-mfd capacitor instead of a 50-mfd unit would probably completely change the flashing rate. The use of the larger type capacitor in a filtering or coupling application would probably produce no difference in performance. Certainly, the safest thing to do is use capacitors and resistors whose voltage and wattage ratings, respectively, are equal to or higher than that of the original part. As to capacitance and resistance values, try to stay within 20 percent of the specified value. In most cases, this will suffice since the manufacturing tolerance of commonly used components is 10 to 20 percent of their marked value, and good manufacturers make allowance for this variation when designing circuits.

Transformers can also be treated in the same manner as resistors and capacitors. For instance, if a transformer with a 1K centertapped primary is required and only an 800-ohm centertapped primary unit is available, it should work as well. A 250 ohm centertapped primary would probably not work because the impedance mismatch would either produce distortion or a great deal of signal loss. Do not be confused by the names used for various transformers such as input, output, line, etc. The important consideration for low-power applications is whether the transformer has the desired primary and secondary impedances and, if necessary, centertaps on one or both windings.

The power rating of an audio transformer is significant only when the transformer is to be used at the output of an amplifier or in a speaker system. The power rating of a power-supply type transformer is dependent upon the voltage and the current rating. Substitution for such transformers is often more critical than for audio transformers, since the voltage output rating is the voltage present at the rated output current. If the current drawn from a substitute transformer is less than that for which it is rated, the output voltage will be

higher, and in some marginally designed power supplies the higher voltage may place intolerable stress on the power supply filter components. Such a transformer can, of course, be loaded down with resistance across its secondary to reduce the voltage. But the total current drawn from the transformer secondary must not exceed its rating.

American-made transformers use a color coding scheme for their leads to identify the secondary and primary windings, etc. This color code is shown in the Appendix. It may not be used by foreign manufacturers.

BASIC WIRING PRACTICES

Good wiring techniques not only make equipment look good but contribute to reliable operation. Who has not seen a "rat's nest" of wiring behind hi-fi equipment and gone away wondering how anything could operate properly? The situation is not confined to home installations, however. It is surprising how many commercial installations are in the same condition when you really look behind the front panels of equipment racks.

Good wiring probably starts with good planning as to where and how interconnecting wires are to be run. Even if you do not immediately have all the equipment you intend to purchase, plans should be made for the necessary interconnecting wiring to accommodate future equipment. Preassembled audio interconnecting cables are available in a variety of lengths, or you can make your own cables by placing connectors on appropriate wire. The latter course is usually much less expensive than buying preassembled cables.

The next step in good wiring is good connections. When using preassembled cables, this step is usually avoided, of course, since the cables just plug into equipment. If you make your own, the connectors usually have to be soldered (the procedure is covered later). There are, however, various circumstances where simple connectors have only screw terminals for connection to a cable or where a solderless screw or twist connector can be used. When using such connectors, the wire to be used must be stripped of insulation. This can be done with a stripping tool, a small knife, or with diagonal cutters. The objective is to remove the insulation without nicking the wire or, as frequently happens with stranded wire, without removing some of the wire strands also. Once the insulation is removed, stranded wire should be twisted together and inserted in a screw type connector. When tightening a screw connector, the objective is not to crush the wire by tightening with undue force. The screw needs to be

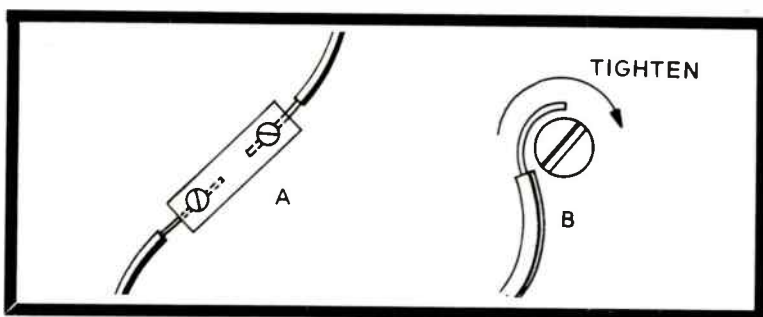


Fig. 1-8. When wires are connected by a solderless connector (A), only enough insulation should be removed to allow the wires to reach slightly beyond the screens. Here, too much insulation has been removed. The drawing on the right shows the correct way to wrap a wire around a screw-type terminal.

tightened only to the point where a slight tug on the cable will not dislodge it from the connector. Fig. 1-8A shows two wires connected by a solderless connector, but too much insulation has been removed from each wire; the insulation should continue to each side of the block. Fig. 1-8B shows the correct way to place a wire on a screw-type terminal. A general rule to follow in any wiring is to avoid using connector terminals to provide the mechanical support for a cable. Mechanical support should be provided to the complete insulated cable, as illustrated in Fig. 1-9.

The final step in good wiring is the neat assembly of a number of cables. Various techniques are available for this purpose, ranging from the placement of cables in plastic tubing to the taping of cables together at short intervals. For longer cable runs, and where you do not expect to add future cables, the use of flexible tubing, plastic conduit, plastic wire ducts, etc., offers many advantages. Tubing in a color that blends into the room decor can make a most inconspicuous and quite neat installation. Taping is the least expensive way to bundle cable but unhandy if a cable has to be removed or another one added. A good middle-of-the-road solution is the use of plastic spiral cable wrap. This is simply a short piece of flat plastic formed in a spiral which can be used along a bunch of cables at intervals like tape. Plastic cable wraps can, however, be readily removed and reused to facilitate cable changes.

SOLDERING TIPS

Good clean surfaces, both on the soldering iron and the surface to be soldered, plus the proper application of soldering

iron heat, are the keys to good soldering. As was mentioned earlier, a 30- to 50-watt iron and rosin core solder are all that is needed for most electronic work. Soldering guns, heavy-duty irons, etc., have their uses but are not necessary for normal tasks.

The wires to be soldered should first be cleaned and then twisted together, or wire to be soldered to a terminal should be wrapped around the terminal. Soldering is a means of providing an electrical connection—not a means of providing mechanical strength to a connection. To clean wires, terminals, etc., scrape with a knife or a file. In any case, the surface should be shiny. The heat from the tip of the soldering iron should be applied to the joint to be soldered and then solder applied (not to the soldering iron!) to the joint which the soldering iron is heating. It is the joint which must be warm enough to melt the solder, not just the soldering iron. If this procedure is followed, the solder will flow around the joint in a liquid manner.

Some practice is necessary to master the technique; therefore, it is a good idea to practice on some scrap wire. The quality of a soldered joint is not dependent on the quantity of solder used; it depends on whether the solder has flowed around the joint properly. Excess solder can be shaken off while a joint is still hot, or removed with the tip of the soldering iron by wiping off the excess solder, which the iron

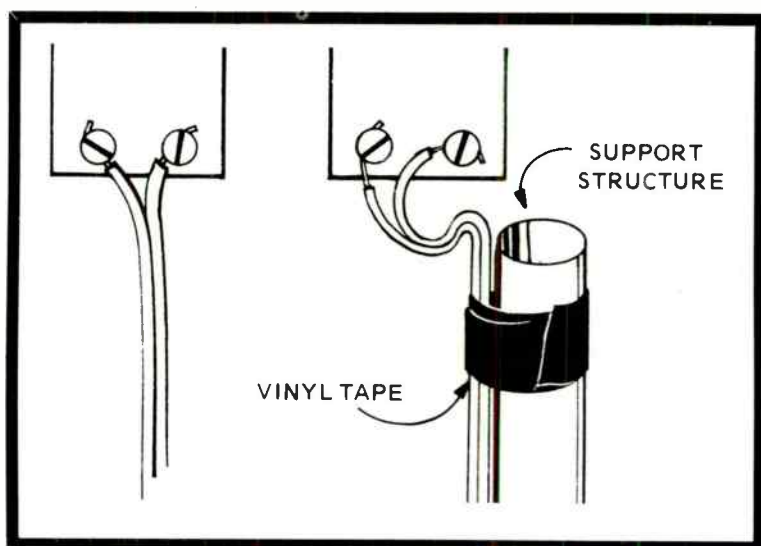


Fig. 1-9. Connecting wires should be supported as illustrated, not allowed to hang from terminals.

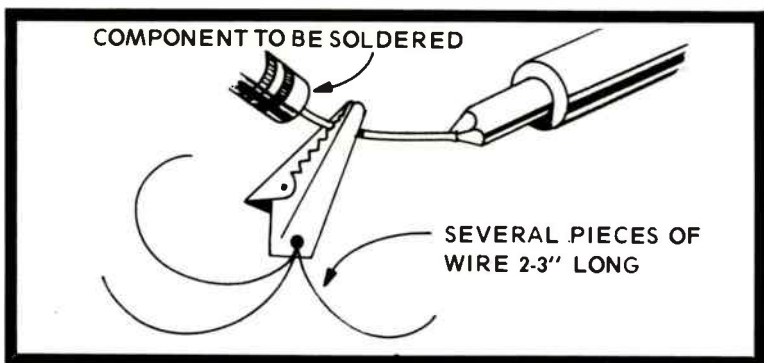


Fig. 1-10. To prevent heat damage to transistors, diodes, and other components, a heat sink (dissipator) should be used during soldering. An ordinary alligator clip with wires attached is adequate.

tip takes away, with a sponge. If you move a joint before it has cooled to the point where the solder has solidified, just reheat the joint again to produce liquid solder flow.

The soldering iron tip should be kept clean by wiping it with a damp sponge. When the tip becomes excessively black, file it clean and apply just enough solder to coat the tip; wipe off the excess.

A "finishing touch" that is not necessary, but which does enhance the appearance of a soldered joint, is to wipe it immediately after the solder has solidified with an old toothbrush dipped in denatured alcohol. This removes excess rosin deposits, brightens the joint, and facilitates inspection of the joint quality.

If you apply just enough heat long enough to accomplish the soldering operation, you can solder in almost any component, including transistors, without damaging any component. However, until you develop facility in this operation, when soldering in transistors, diodes, photocells, and other components subject to damage by excessive heat, a heat sink should be used. This is simply a heat-dissipation device connected to the solder joint. Such devices can be purchased or simply devised using an alligator clip. Fig. 1-10 illustrates the use of such a device.

When soldering shielded cables to connectors, it is usually best to cut away the outer insulating jacket with a safety razor blade, then unbraid the braided shield with any pointed tool. The loose braid is then twisted together to form a wire lead and soldered as any ordinary wire. Audio connections can be

greatly simplified by using shielded cable with an aluminum wrap for shielding. This type of cable has an internal ground wire which you can solder to directly as the shield connection.

WIRE SIZE SELECTION AND INSULATION

To avoid excessive power loss, as well as from the viewpoint of safety, it is necessary to choose the proper size wire for use in electrical circuits which handle significant amounts of power. Usually, this means power- and extension-cord runs and speaker connections. The Appendix contains a table which lists the characteristics of various wire sizes. However, you normally only want to know which gauge or size of wire to purchase. This information is shown in Fig. 1-11, which contains tables for the selection of speaker extension wire and power-cord extension cable. The table for speaker wire is valid for RMS amplifier outputs rated up to 50 watts

SPEAKER WIRING OR EXTENSION WIRE SIZE TABLE

Distance (feet)	Smallest Gauge Wire to Use	
	4-Ohm Speaker	8-Ohm Speaker
10	22 AWG	22 AWG
20	20 AWG	22 AWG
30	20 AWG	20 AWG
40	18 AWG	20 AWG
50	18 AWG	18 AWG
100	16 AWG	18 AWG

POWER EXTENSION CORD SELECTION TABLE (100 VOLTS)

Distance (feet)	Load in Watts	
	500	1000
20	18 AWG	18 AWG
40	18 AWG	16 AWG
80	16 AWG	14 AWG
120	16 AWG	12 AWG
250	14 AWG	10 AWG

Fig. 1-11. Tables for speaker and power extension cables.

per channel. For higher output levels, use one wire size larger (lower gauge number) for each additional 50 watts of output power.

To connect small circuit components and for general experimental wiring in low-power circuits, solid hookup wire of 22 gauge is both adequate and easy to handle. The problem of insulating wire both for electrical purposes and to prevent abrasion of the existing insulation on wire, where the wire enters a connector, fixture, etc., can be handled in four general ways, with small-size plastic or fabric tubing (so-called "spaghetti"), heat shrinkable plastic sleeves, vinyl electrical tape, and liquid "tapes." Each has advantages for specific applications. Rugged plastic tubing is probably best for abrasion resistance where a wire run outdoors must constantly abrade against a hard surface. Small size "spaghetti," slipped over the ends of wires, provides a neat way to extend insulation right up to the point where it enters a connector. Vinyl electrical tape, which has some stretch to it, serves as a general purpose insulating and bonding means for wire runs. It can also be used fairly well wrapped around most connectors designed for outdoor use, to exclude moisture from the connector at the point where a wire or cable enters the connector. Heat-shrinkable tubing, however, can do an even better and neater job in the latter application. The only difficulty with such tubing is that to really use it properly, you should have a heat gun specifically designed to heat-shrink such tubing. You can do a fair job with practice by using a small gas torch or even the flame from a cigarette lighter.

"BREADBOARDING" CIRCUITS AND ETCHING

Invariably, as you get involved with electronic components, there arises the desire to construct various experimental circuits to try out the effects of using different value components. Also, you may want to try out, in the simplest possible manner, some of the accessory units described in this book. "Breadboarding" is the way to accomplish this. Breadboarding itself does not have any specific meaning any longer, unlike the times when radio circuits were experimentally constructed on pieces of wood with staples used to hold down wires, etc. It just refers to the provisional connection of components in a circuit to test its performance.

There are many ways to "breadboard," but the easiest way is probably to use perforated board stock, a phenolic board with a network of holes in it. Board with about ¼-inch spacing between holes is a good general type to use. Solderless

breadboard terminals (also called push-in terminals) can be inserted in the board wherever desired. These are spring-loaded terminals into which the ends of four or five wires can be inserted. Thus, you can connect a circuit using these solderless terminals without having to cut the leads on any components. Batteries can be fastened also to the board, if desired, either directly or in battery holders, by looping a piece of hookup wire around the battery and twisting it tight. Metal brackets are available, too, so you can also mount potentiometers, variable capacitors, etc., on these boards.

One advantage of breadboarding, besides seeing whether a circuit works, is that you can easily rearrange the parts used to find the most compact and logical arrangement possible. This would be done, of course, in preparation for the final construction of an accessory. The final construction can be done in several ways. One is to change the board connectors from solderless to solder types, clip component lead lengths as necessary, and simply solder all the connection points. Another method is to simply bend the wire leads through the holes in the board and directly solder them together. Still a third approach, and one that provides the neatest appearance, is to construct a printed-circuit board.

Construction of a printed-circuit board is relatively easy if you purchase an inexpensive printed-circuit kit and some perforated printed-circuit boards. These boards are the same as regular perforated boards, except they have a layer of copper on one side. Etch-resistant lacquer or etch-resistant pressure-sensitive strips are used to cover those portions of the copper surface which are to remain on the board to serve as interconnecting "wires" between components. The board is then dipped in a ferric chloride solution (etch solution) which removes all the unprotected copper. After washing and drying, components are placed in their position on the non-copper board surface, their leads bent through the holes, then clipped and soldered to the copper interconnecting surfaces on the bottom of the board. Components should be laid out to avoid "wiring" crossover points. If such points cannot be avoided, a hookup wire connection is used on the surface of the board to provide the crossover connection.

Chapter 2

Remote Speakers and Headphones

Many radio and TV sets have only very small internal speakers, although the quality of their audio circuits is usually capable of operating larger, better quality speakers. Some sets have terminals for the connection of external speakers, while many do not. So, many times it is desirable to install additional speakers and headphones. We also consider in this chapter the installation of speakers for hi-fi systems.

The selection and arrangement of external speakers in homes, outdoors, automobiles, etc., provide, perhaps, one of the simplest but most effective ways to enhance the sound of music program material. The meaning of good "sound," however, does not lend itself to any objective definition. The quality of sound seems to be a very subjective thing; therefore, it is wise, if possible, to first temporarily wire in any elaborate type of multiple speaker arrangement in order to test its suitability.

SPEAKER BASICS

Almost all speakers in use today are the dynamic type and function essentially the same as a dynamic microphone, ex-

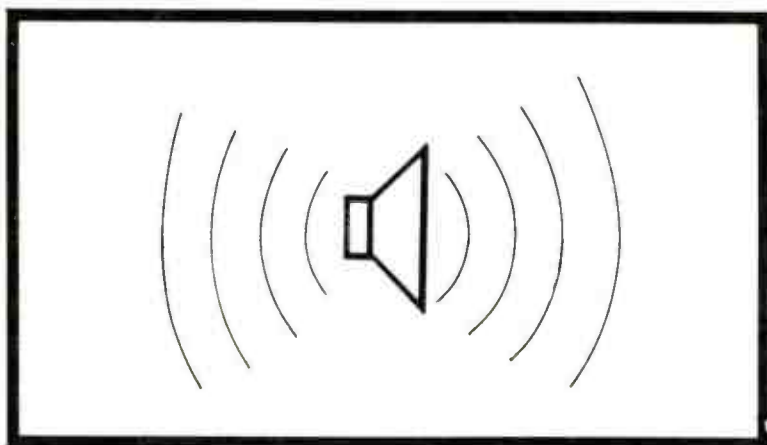


Fig. 2-1. A speaker cone moving freely in space radiates almost equal sound energy from the front and rear.

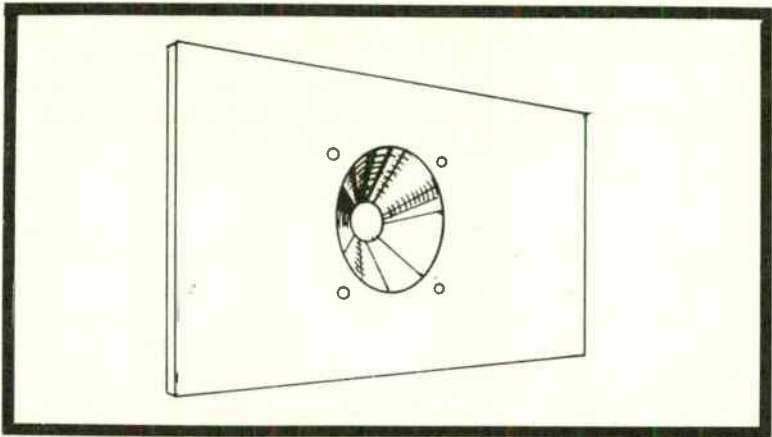


Fig. 2-2. As a minimum, a speaker should be mounted on a stiff, flat baffle having several times the area of the speaker cone.

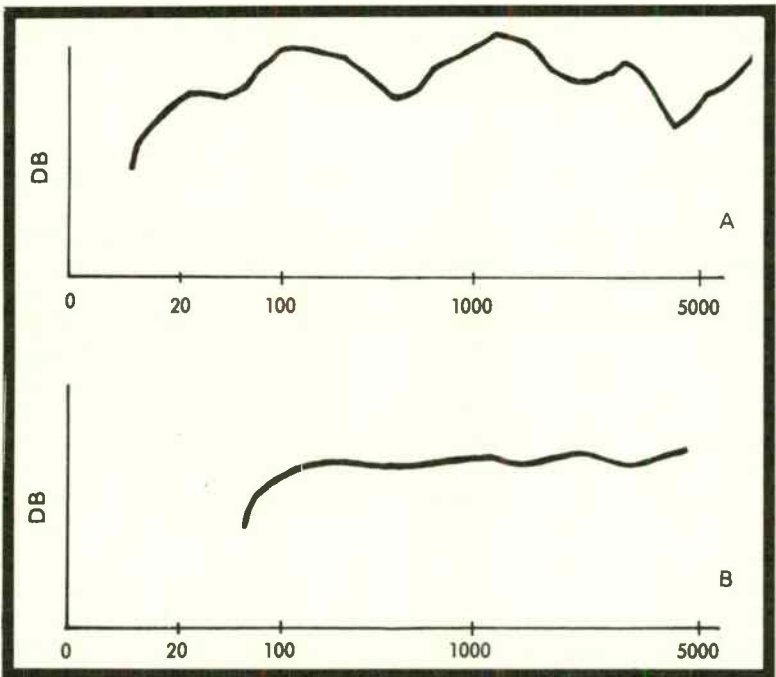


Fig. 2-3. Frequency response and quality of reproduction are not the same. The response indicated by Curve A may not sound nearly as good as the response at B, because Curve B is smoother.

cept that they convert an electrical signal to an acoustic signal, instead of vice versa, and at a higher power level. Sound radiates both from the front and rear of the speaker cone, as shown in Fig. 2-1. The distance in back of the speaker is usually not infinite, however, and so some of the sound is deflected by some object behind the speaker and is returned to combine with the sound radiating from the front of the speaker. The manner in which these sounds combine causes some frequencies to appear lower in volume, other frequencies higher in volume, etc. Speaker enclosures attempt to control this combination of sounds so they do not interfere with each other or, in more elaborate designs, to control the combination of sounds in such a way that the performance of the speakers is enhanced in the lower frequency range. A speaker can rarely be utilized without some form of enclosure if reasonable sound quality is expected. As a very minimum, the speaker should be mounted in a flat board which has several times the area of the speaker cone, as shown in Fig. 2-2.

There are a few things you'll encounter in descriptive literature for almost any speaker which should be understood. Power rating simply refers to the maximum power input the speaker can handle and still faithfully reproduce sound over a given frequency range. The power rating should match the RMS power rating of the amplifier with which it will be used, if the full output capability of the amplifier will be utilized. If multiple speakers are connected so they equally share the output power, their individual power ratings can be added together. Frequency response usually refers to the speaker operating unenclosed. Proper enclosures can enhance the response, particularly for the low frequencies. Generally, the larger the speaker, the better the response, although response is not only a question of frequency range but also of evenness, or flatness, as illustrated in Fig. 2-3. Impedance refers to that of the wire coil in the speaker at some standard audio frequency. For maximum power transfer, the speaker impedance should be the same as the output impedance of the amplifier, radio, etc., being used. The usual impedances are 3 to 4 ohms and 8 ohms. Some hi-fi speakers utilize 16 ohms and some small transistor radios may use speakers up to 100 ohms. You can sometimes tolerate a small mismatch, such as operating 8-ohm speakers on a 4-ohm system, but rarely anything more than this. In a multiple speaker installation, speakers of varying impedance can be connected in parallel, or series, to produce a desired final impedance for an amplifier to work into. This is illustrated by some specific examples later.

CONNECTING SINGLE AND MULTIPLE ACCESSORY SPEAKERS

If the set being used already has terminals for an accessory speaker, a single extension speaker of the correct impedance can be connected directly. The use of 2-conductor "zip" or power cord of the correct gauge is particularly convenient to use. When the set has no such terminals, connection can be made to the speaker within the set as shown in Fig. 2-4, using either soldered connections or solderless connectors. Usually, the series connection, as shown, will give the best results, but you can experiment by simply connecting the extension speaker in parallel with the existing speaker. By adding one additional wire, however, as shown in Fig. 2-5, it is possible to add a few extra features at the remote speaker location. The switch wired as shown allows the selection of the remote speaker only, the set speaker only, or both speakers together. A simpler on-off switch could be substituted for the 3-position switch shown if you wanted to provide only one remote function such as cutting off the set speaker when the remote speaker is used (switch wired to short the set speaker) or to cut off the remote speaker when it is not desired (switch wired to short the remote speaker; notice, also, that only a 2-conductor cable is required for the latter installation). The wiring can be made particularly neat and attractive by using small-size 3-conductor round cable or the flat 3-conductor cable sold for antenna rotator connections. Remote volume control for both the set speaker and-or the remote speaker can be inserted in any speaker lead. The general forms of volume controls, any of which can be used, are discussed in a later section.

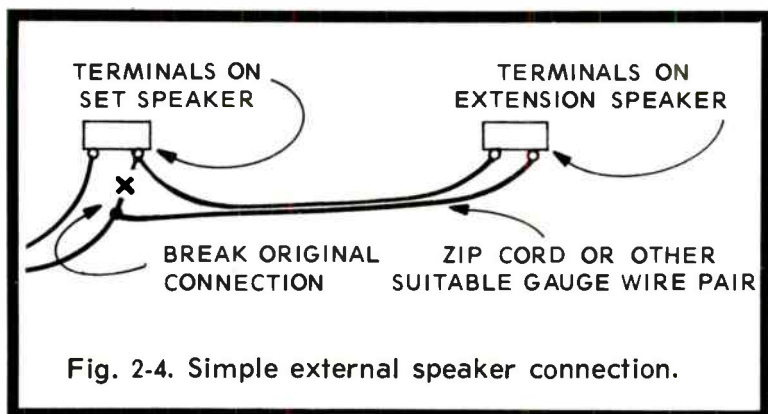


Fig. 2-4. Simple external speaker connection.

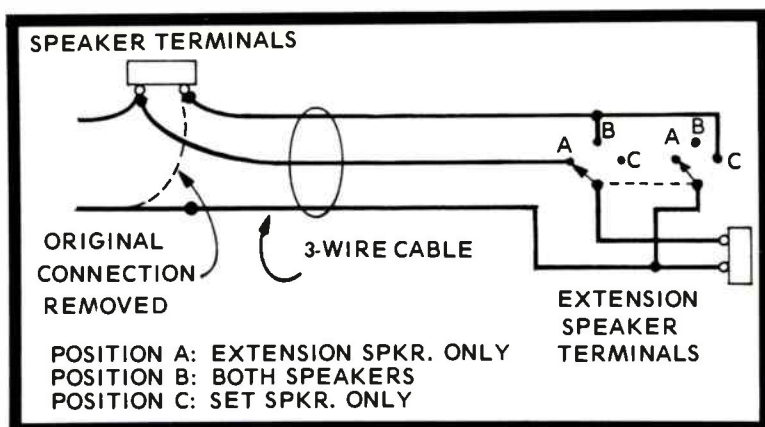


Fig. 2-5. Extension speaker connection providing on-off control of either speaker or the use of both.

Multiple extension speaker arrangements, such as when you want to create an all-around sound effect in a playroom, a small meeting hall, etc., have to be wired differently than a single extension speaker. Connecting a number of speakers in series alone or in parallel alone will rapidly alter the total impedance to a value which an amplifier cannot accommodate. The series-parallel arrangement shown in Fig. 2-6 overcomes this problem. The arrangement shown has only six speakers but the idea shown can be extended up to as many speakers as desired. The three 4-ohm speakers in series in each leg provide a total of 12 ohms. The two 12-ohm legs in parallel provide a final total of 6 ohms, which will nicely match any nominal 4- to 8-ohm amplifier output. The Appendix provides the equations used to determine the combined value of resistance in series and parallel and they can be used to figure out the final impedance for any number of speakers in any desired arrangement. By selecting speakers with different frequency response characteristics for each series leg or by the use of frequency splitting (described later), each leg can be tailored to provide a different range of sounds. Also, the volume level in each leg can be controlled separately if desired. The range of combinations and effects that can be generated by this means is practically limited only by your imagination and pocketbook.

Notice the plus and minus signs on each speaker shown in Fig. 2-6. This refers to the "phasing" of each speaker, a particularly important consideration in any multiple speaker system.

SPEAKER PHASING AND STEREO CONSIDERATIONS

As shown in Fig. 2-1, a speaker radiates a sound wave both in front and in back of the speaker. Considering only the front wave, if two speakers, excited by the same source and located close to each other, do not work in synchronization, one could provide a sound wave which interferes with that produced by the other speaker. This would occur when the electrical signal causes one speaker cone to deflect inward at the same time the other deflects outward. To avoid this, speakers used together must be phased so that the cones in all speakers move in the same direction simultaneously—in phase.

More expensive speaker systems come marked with terminal polarity markings, but most individual speakers are not marked. To mark a speaker, proceed as follows: use the lowest resistance range on a VOM, or a simple 1.5-volt flashlight battery, and connect it briefly to the speaker terminals. The speaker cone will deflect. When it moves outward, mark the terminal connected to the positive side of the voltage source as plus and the other terminal as minus. The movement of the speaker cone should be very clearly visible. Do this with all the speakers to be used in a multiple speaker installation.

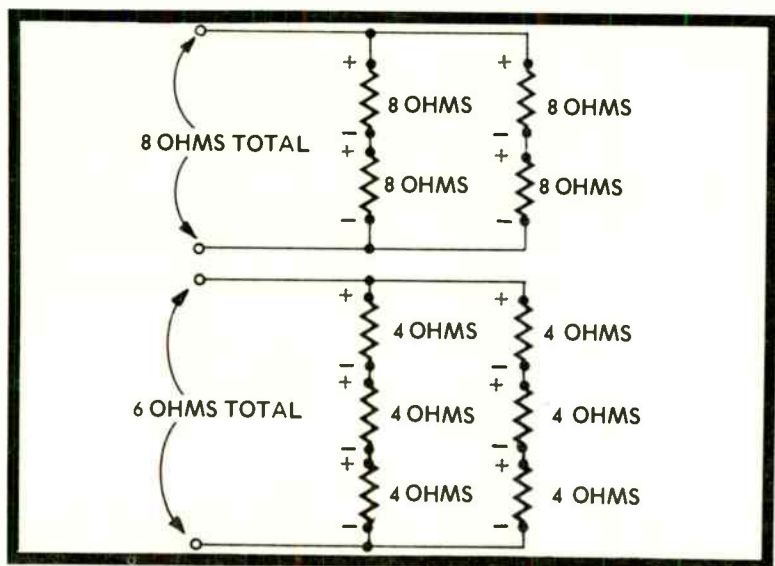


Fig. 2-6. In multiple installations, speakers can be connected in series-parallel legs. (Speakers are represented in the drawing by 4- and 8-ohm resistors.) The polarity signs (+ and -) indicate phasing.

When using speakers already mounted in an enclosure, the above test may be difficult to perform. However, if it is possible to remove a back panel from the enclosure so you can see the movement of the speaker cone, it should be done, since this test is positive and foolproof. If a view of the speaker cone cannot be attained, Fig. 2-7 shows another phasing method. Use one speaker as a reference and place the speaker to be phased next to it. Move away 10 feet or so from both speakers and listen to them with the unknown speaker connected each way (Fig. 2-7). When the speakers are in phase, the sound from one will reinforce the other, and when they are out of phase the sound level will appear to drop. When phased, mark the speaker terminal connected to the plus lead of the sound source as plus.

With a stereo setup, extension speakers can be connected to either channel in the same manner as previously described. The speakers used in each channel must be properly phased, as well as the two channels themselves. The phasing of the channels is usually simplified because one output terminal is marked ground. Therefore, if consistent wiring polarity is followed with the ground terminal of each channel output connected to the minus terminal of each speaker, there should be no problem. This can be checked by placing the two stereo speakers next to each other and then listening to some monaural sound material. If the channels are properly phased, when the connections to one channel output are reversed, the total sound output should drop. Perform this test at low volume levels, since the ear's sensitivity to sound level changes is then at its greatest.

Besides the usual addition of extra speakers to each stereo channel, some other interesting effects can be obtained by

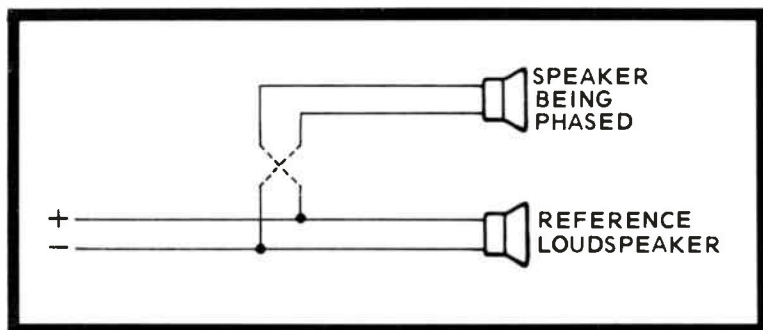


Fig. 2-7. Setup for phasing an unknown speaker with one of known polarity. Speakers should be side by side.

connecting a speaker or speakers between the channels to provide a third-channel effect. The possible connections are shown in Fig. 2-8. In one case, when the additional speaker is connected between the plus lead to one channel and the negative lead to the other channel, it provides a summed signal output. In the other case, when connected to the plus lead on both channels, it provides a difference signal output. The latter is usually the more interesting effect, and if the third-channel speaker can be placed somewhat behind the two regular stereo speakers, it provides the feeling of added depth to the total sound output. It should be emphasized that the third speaker will provide only interesting additional sound if the two main stereo speakers are properly phased.

OUTDOOR SPEAKER INSTALLATIONS

The basic electrical connections for outdoor speakers do not differ from those for any extension speaker, except that particular care should be given to the wire size used because of the longer wire runs usually involved. Also, cable suitable for outdoor installation should be used. Again, multiconductor antenna rotator cable can prove to be very useful. The cable comes with up to eight conductors and individual conductors

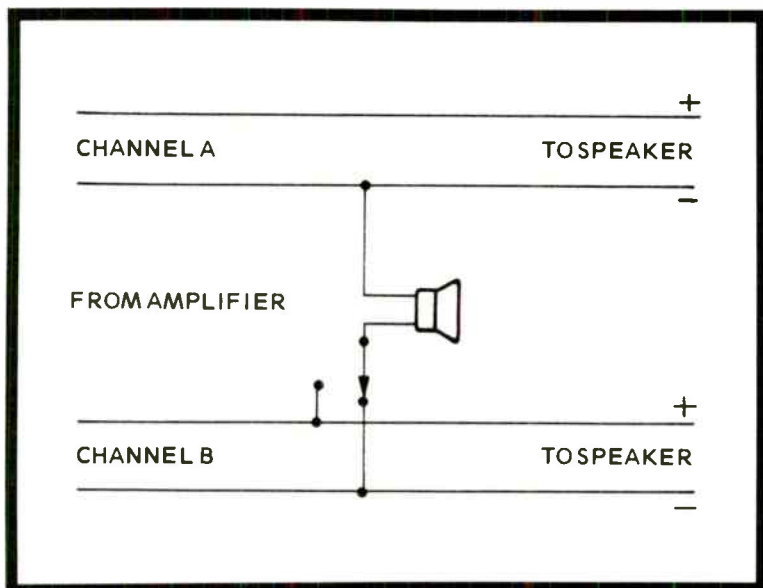


Fig. 2-8. An extra speaker connected between stereo channels can add additional depth to the stereo sound.

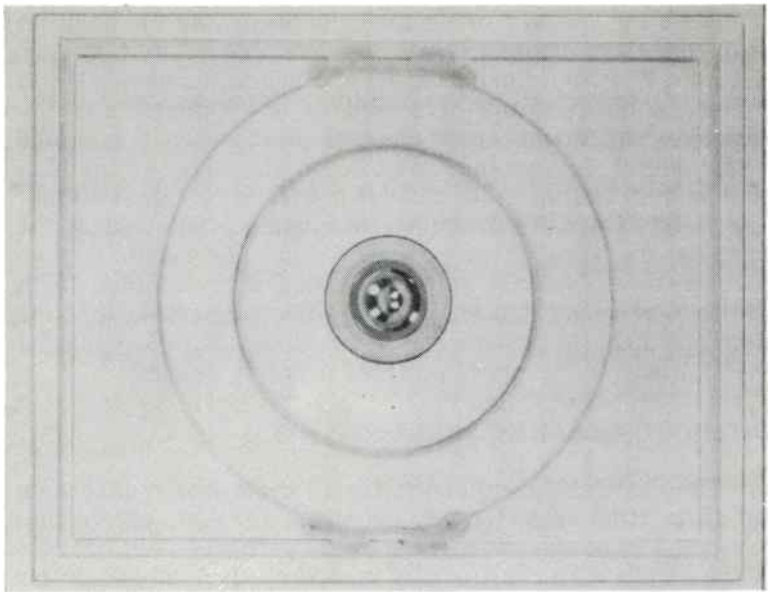


Fig. 2-9. Special poly-planar speakers offer "flat" speakers which are about 1-inch deep.

can be paralleled, if necessary (use the wire table in the Appendix) to produce the total wire cross-sectional area equivalent to a larger size conductor.

If only speech reproduction or a minimal music service outdoors is required, the bull-horn type of speakers with fiberglass or other non-rusting horns are particularly recommended. They should be mounted in an elevated position so the horns can be deflected slightly downward to cover the desired area. If a number of such speakers are used, phasing is required as previously described for multiple speaker installations.

If good fidelity music reproduction is desired, it is usually best to use a conventional type dynamic loudspeaker mounted in a weatherproof outdoor enclosure. Speakers can be purchased already mounted in suitable enclosures or an enclosure can be home-constructed. The enclosure should be completely sealed, except for the front which is covered by a very fine mesh plastic grill cloth. The speaker should be mounted so that it is recessed an inch or so from the front grill rather than flush with it as is usual. The enclosure itself should be mounted with the front deflecting slightly downward to provide drainage. This sort of home-made enclosure will work nicely for simple patio installations, etc., but in any installation

where the speaker is subject to windblown sand, snow, etc., a commercial type of outdoor speaker is the best solution. The flat polystyrene dynamic speakers shown in Fig. 2-9 offer particular advantages for installations in difficult outdoor locations because of their sturdy resistance to extremes of temperature, humidity, shock, and vibration.

AUTOMOBILE SPEAKERS FOR CB AND HI-FI

The same basic considerations applicable to speaker system installations for home use also apply to automobile installations. The relatively small area inside an automobile, and the fact that the listener is enclosed in this area, allow some unusual sound effects to be achieved which are much more difficult to accomplish in large room spaces.

The first consideration of an automobile speaker system installation is the purpose for which it is going to be used. For use with a CB rig that does not have a built-in speaker, or as an extension speaker for a CB rig, it is usually advantageous to use one specially designed for voice frequency communications. A definite advantage in speech crispness and clarity will result. Such speakers can be purchased in enclosures which tailor the response from 300 to 3000 Hz. You can also purchase the appropriate speaker alone, choosing one which has a low-frequency cutoff of from 100 to 300 Hz. If you have been using a dashboard-mounted speaker for CB, a definite improvement in communications speech clarity can usually be obtained by coupling the speaker to the CB rig via a capacitor, as shown in Fig. 2-10. This will reduce the low-frequency response of the speaker installation, which is necessary for speech purposes.

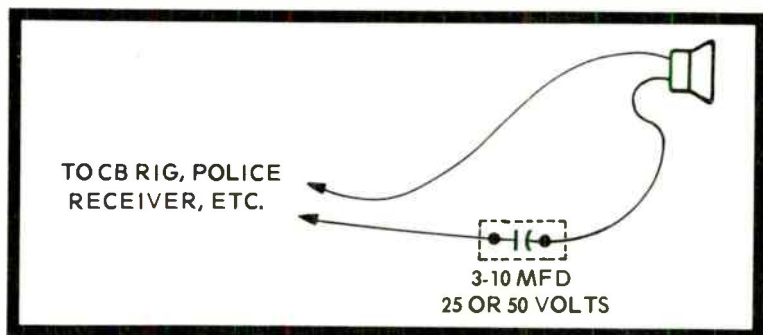


Fig. 2-10. If a regularly installed auto speaker is used with a CB rig or similar receiver, sharper audio will result by connecting the speaker through a 3 to 10-mfd capacitor.

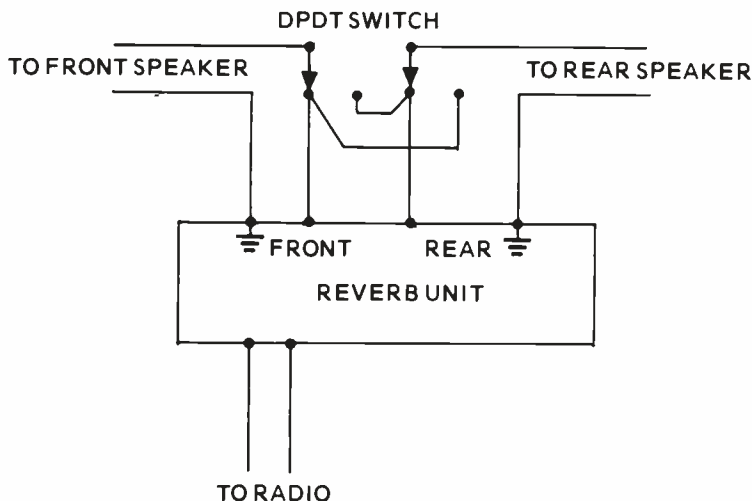


Fig. 2-11. Wiring for a reverb changeover switch. The switch can be installed in the reverb unit if desired.

If the speaker system is to be used for radio or tape playing applications, you should try to take advantage of the baffling effect produced by mounting a speaker in the dashboard area or rear deck area, rather than just placing speaker enclosures on the sidewalls or laying one on top of the rear deck. A considerable improvement in low-frequency response will usually result. If this is not possible, use a closed speaker enclosure rather than one of the plastic shell enclosures. If a shell enclosure is used, however, mount it tightly against a flat surface to prevent both vibration and air coupling around the edges of the enclosure.

A simple extension speaker can be mounted on the rear deck and coupled to the existing dashboard speaker in the same manner as shown in Fig. 2-4. Level controls, balance controls, selector switches, etc., can also be wired in the same manner as for a home installation. A latter paragraph covers these items in detail. Also, frequency splitters can be used so the rear speaker responds to only the higher or lower frequencies and the front speaker to the opposite frequency range to produce a pseudo-stereo effect on monaural sound material. Reverberation units can also be coupled into such a system. A reverb unit usually provides a balance control to vary the level of sound distributed between the front and rear

speakers. Although the reverberation effect is usually applied to the rear-mounted speaker, it is interesting for variety to feed it to the front-mounted speaker. A simple changeover switch, either externally mounted or mounted in the reverberation unit and wired as shown in Fig. 2-11, can accomplish this.

Stereo installations are usually made with a speaker mounted on each of the front sidewalls or on each side of the dashboard. One speaker mounted up front and one in the rear do not produce the best stereo effect. The only exception to this is the stereo unit which comes with four speakers, where two speakers for each channel are mounted on one side of the car with a pair forward and back. Two additional speakers can be added to an existing front-mounted 2-speaker stereo system, the same as adding any extension speaker, but all speakers must be properly phased. A balance control is particularly important to stereo adjustment in an automobile, and if one is not included in the FM stereo set or tape player, one should be added to provide control of both channel outputs simultaneously.

SPEAKER SELECTOR SWITCHES

Selector switches can be used to switch between speakers in different locations or between different types of speakers for either effect or comparison purposes. For the simple extension speaker shown in Fig. 2-5, which has been added to a TV or household radio, etc., simple toggle switches used for power line switching will suffice. However, when dealing with higher powered hi-fi amplifiers, greater care must be taken, especially if the switching is done while the speakers are being used. Many high-power amplifiers can be damaged if switching is attempted while the amplifier is being used and if for even an instant there is no load (speaker) connected to the amplifier.

Rotary selector switches are usually used for speaker switching. Such switches come with two general types of switching contacts—shorting and nonshorting. In the nonshorting type, when the contact arm shown in Fig. 2-12A moves from contact A to contact B, there is an instant when the switch arm neither makes contact with terminal A nor terminal B. In the shorting type, the contact arm makes contact with terminal B before it completely leaves terminal A, so for an instant both terminals are connected together. The latter type is desired when switching between speakers. There may be instances where you'll want to switch in additional speakers, leaving the original speakers on, rather than

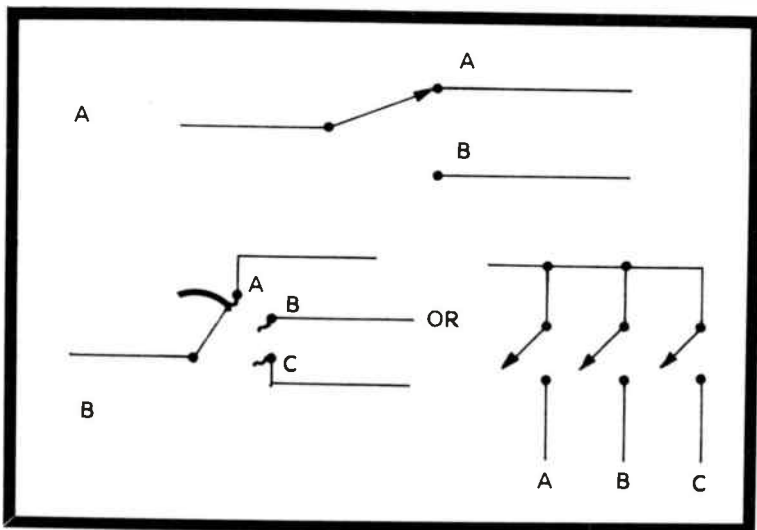


Fig. 2-12. Simple rotary switch connections. Continuously shorting rotary switches (B) can be replaced by three SPST toggle switches.

switching between speakers. This action can be accomplished by a continuously shorting switch, as shown in Fig. 2-12B, which, when rotated consecutively, connects terminals A, B and C together. Selector switches of both the shorting and continuously shorting type can be purchased in completed assemblies for various speaker switching functions, or you can design your own switching arrangements by purchasing just the basic switches. The usual rotating switches, rated to switch 5 amperes at low voltages, can be used for speaker switching at amplifier output levels of 50 to 60 watts.

Fig. 2-13 shows a few switching arrangements that can be used with both monaural and stereo systems. The switch type designations are those normally found in a parts catalog. Notice that the simple additive speaker scheme shown in Fig. 2-13C will switch up to three speakers per channel with most amplifiers. Beyond that, the total paralleled impedance usually becomes too low for the amplifier.

If you want to distribute sound to a really large number of speakers, such as in a hi-fi distribution system throughout a building, a different wiring approach is necessary. Speakers are supplied by a line distribution system using line transformers, as shown in Fig. 2-14. Any number of speakers can be accommodated by this system, dependent only upon

available amplifier power. With this system each speaker can be switched on and off, at the speaker itself, without affecting the sound level on any other speaker. Or a central switch can be used to connect each transformer across the main line. To develop the "line," an 8-ohm to 70.7-volt line transformer is connected to the amplifier. Some public address system amplifiers already have a 70.7-volt line output, and in this case, an external transformer is not necessary.

If an amplifier-to-line transformer is used, it must have a wattage rating equal to the total amplifier output. For instance, say a 10-watt amplifier is to supply five speakers. The line transformer must be rated at 10 watts, and the transformer at each speaker need be rated only at 10 divided by 5

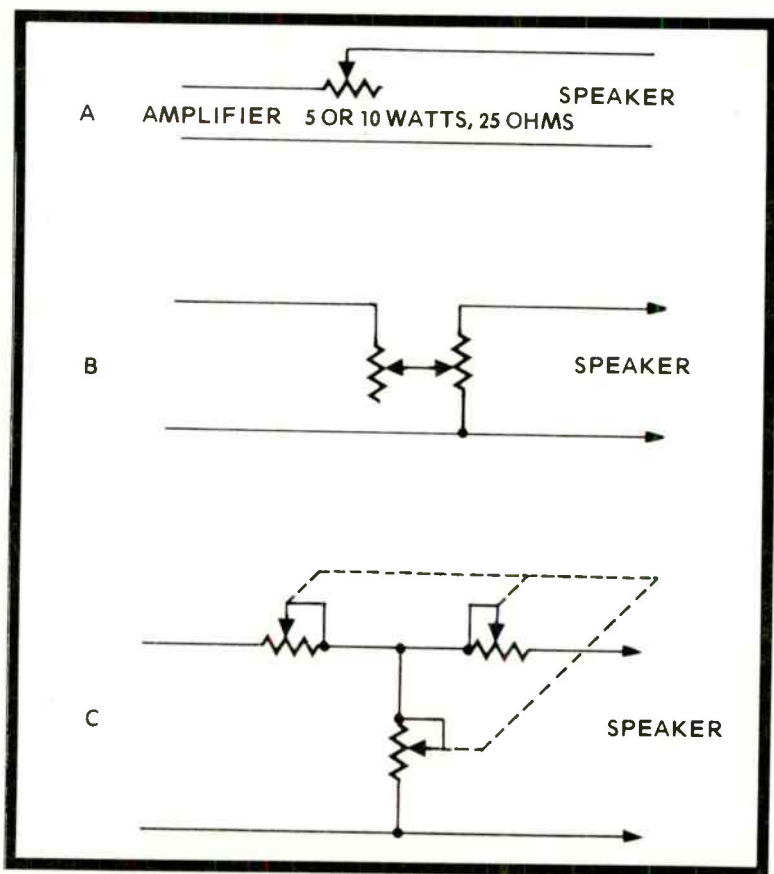


Fig. 2-13. Various speaker switching circuits. The ground leg is not switched. The switch at D is often replaced by a special type of continuously shorting switch.

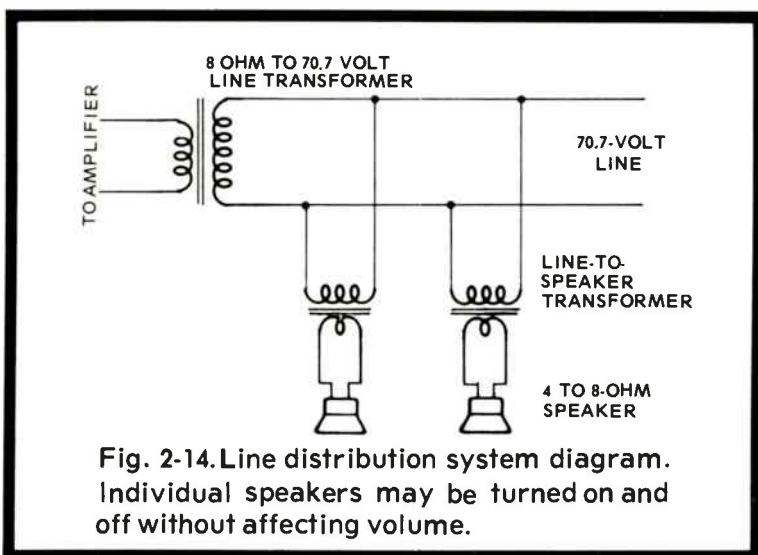
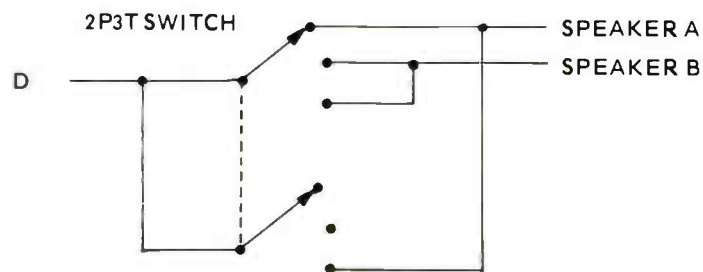
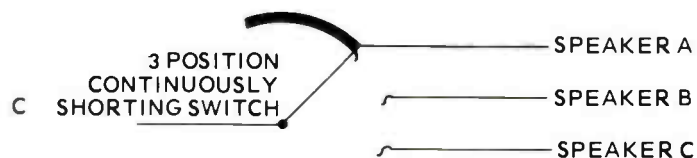
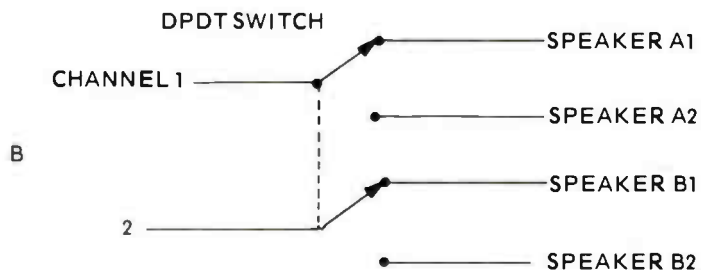
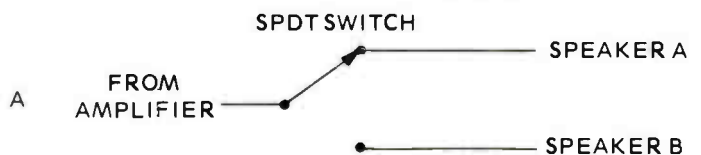


Fig. 2-14. Line distribution system diagram. Individual speakers may be turned on and off without affecting volume.

or 2 watts. If the same total power (10 watts) were distributed to ten speakers, each speaker transformer would have to be rated at only 1 watt, etc. If a central selector switch is used, either all the loudspeakers can be connected simultaneously, or only selected ones. Because a 70.7-volt line operates at a higher impedance level, the distances given for various wire sizes for speaker extensions in Chapter 1 do not apply. The farthest speaker can be at least four times the distance shown in the table and still utilize the same wire size. Individual volume controls, if used for each speaker, are connected on the speaker side of the line transformer.

LEVEL AND BALANCE CONTROLS

In a multiple speaker setup, level (or volume) controls can be used to vary the output of a group of speakers simultaneously, or just that of an individual speaker. Three general techniques are used to control volume, as shown in Fig. 2-15. The simple series variable resistor method is suitable for a simple extension speaker on a TV set, car radio, etc. Its main disadvantage is that the impedance it presents to an amplifier varies as the resistance setting is changed. With a high-power amplifier this situation is not satisfactory and damage to the amplifier may result. In such a case, you should use either an "L" pad or a "T" pad control. The "T" pad type is not necessary in most applications, unless very accurate impedance control is necessary. It does provide somewhat smoother level control, but an "L" pad is less expensive and



SWITCH SELECTS SPEAKER A ONLY,
SPEAKER B ONLY OR BOTH A AND B

Fig. 2-15. Typical volume or level controls: the common series resistance (A), "L" pad (B) and "T" pad (C).

perfectly satisfactory for most hobbyist applications. Such level controls (also called attenuators and pads) are available commercially at reasonable prices and it is not worthwhile to try to construct them by gauging individual potentiometers. That is why no resistance values are given for the controls in Fig. 2-15. They are available in both monaural and stereo models for the control of up to two channels simultaneously. The stereo version of an "L" pad is sometimes referred to as a "LL" pad.

The level controls in Fig. 2-15 can be used to balance the feed to multiple speaker systems (in a stereo system or multiple speakers on one audio channel) in either of two ways. Separate level controls can be placed in each channel or a stereo "LL" pad can be used, but with one of the pads wired in reverse, so that the control is turned, the sound level of one channel decreases while the other channel sound level increases. This reverse wiring is shown in Fig. 2-16A. Since separate controls are no more costly than gauged stereo controls, they are preferable, if space is available. With separate controls and the amplifier's built-in volume control, you can set up any possible level situation. A much simpler balance or fader type control is shown in Fig. 2-16B; it can be used with simple extension speakers from a TV set, in an automobile, etc., where only a few watts of audio power is involved.

FREQUENCY SPLITTING AND SPECIAL LOUDSPEAKERS

Besides the usual general purpose single-cone speakers, there are a number of specially built types available that cover, with the flattest possible response, only specific portions of the audio spectrum. Woofers are low-frequency speakers with a response that may go from 20 Hz up to a few thousand Hz. Mid-range tweeters cover the range from 2 or 3 thousand Hz to about 10,000 Hz, and high-range tweeters operate within a range of 5,000 or more Hz to as much as 40,000 Hz. The actual dividing point between various speakers varies considerably among manufacturers. Two- or 3-way speakers are also available, where multiple cones are used in one speaker assembly to provide the same performance as having a separate woofer and tweeter. Some multiple-cone speakers come with built-in level controls for the woofer and tweeter elements. So-called "brilliance" is achieved by adjusting the level of the tweeter element while "presence" is achieved by adjusting the level of the mid-range tweeter or woofer.

Many interesting effects can be achieved by using separate speakers, such as having the high- and low-frequency sounds come from different sides or ends of a room. Also, tweeter elements can be added to an existing loudspeaker to extend its frequency range.

Except in the case of 2- or 3-way speakers where the speaker assembly has only two terminals for connection to an amplifier, individual woofers and tweeters are not normally simply connected in series or in parallel to a sound source. So-called frequency-splitting or dividing networks are used to channel sound power in different frequency bands to the appropriate loudspeaker. This is done to prevent a loudspeaker from being driven by frequencies which it cannot adequately reproduce, as well as to try to maintain a constant impedance load on an amplifier over the entire audio frequency range.

Two types of frequency-splitting or dividing networks are shown in Fig. 2-17. The network at 2-17A consists of nothing more than a simple capacitor. Nonetheless, it will divide the frequency spectrum broadly at the 2 to 3 thousand Hz point so you can use a tweeter effectively with an existing full coverage speaker or with a woofer in a 4- or 8-ohm system. A separate level control for the tweeter, as discussed in the preceding section, is very useful. More complicated

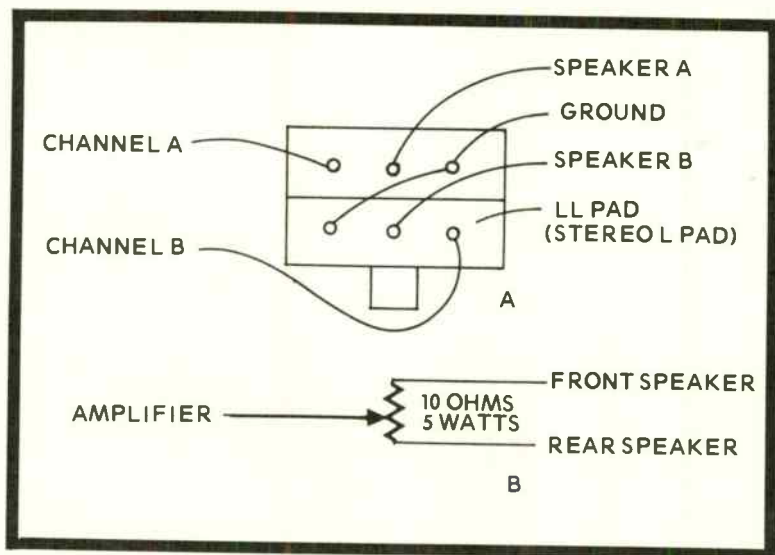


Fig. 2-16. Stereo balance control (A) using reversed wiring of one section of an "LL" pad. B is a simple balance system for auto, TV, etc., extension speakers.

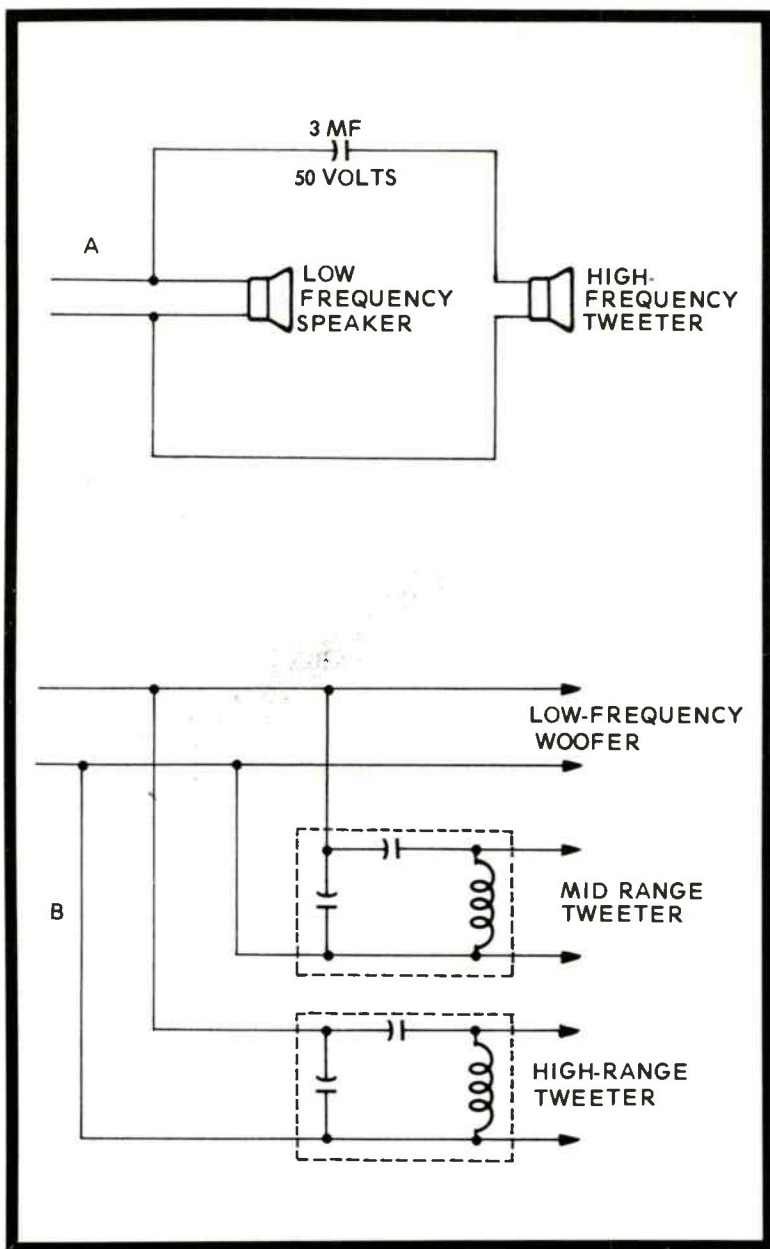


Fig. 2-17. Simple capacitor frequency splitter (A) and special networks (B).

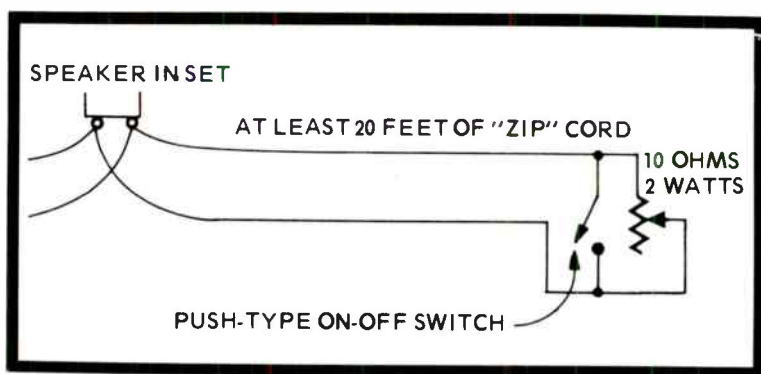


Fig. 2-18. Commercial killer and remote volume control circuit.

frequency-splitting networks illustrated in Fig. 2-17B are available. Such networks provide a much sharper division of the audio frequency spectrum than the simple capacitor network, and they can be used to provide a pronounced frequency separation between speaker emplacements. Frequency splitters are useful in controlling system frequency response characteristics when speakers are used for dual purposes such as music distribution and public address announcements. By switching in a network which cuts off the system frequency response below 300 Hz or so, the useful power of an amplifier for speech reproduction is greatly enhanced. Level controls, when used, are connected between the frequency splitter and the loudspeaker being driven.

COMMERCIAL KILLERS

Such devices are designed to remotely cut off the audio output from a radio or TV set so you aren't annoyed by commercials and, in general, to simply avoid having to get up every time it is desired to turn off the audio. The simplest form of remote killer is a 2-conductor cable with one end connected directly across the speaker terminals in the set and the other end connected to a push-on push-off switch. When the switch is on, it simply shorts the speaker terminals. There is some resistance in the two cable conductors (zip cord will do); therefore, this sort of operation will not damage most small radio or TV sets. The push-on push-off switches are available in attractive housings so you do not have to mount the switch in a separate enclosure. In fact, you can use the in-line rocker type on-off switch found on some electrical appliances, especially heating pads.

If you go to the trouble of connecting such a device, however, it might be also worthwhile at the same time to provide for remote volume control of the set. Then you'll have the means to completely cut off the sound as well as a way to remotely change volume during normal listening. The diagram of such a unit is shown in Fig. 2-18. The parts used can be mounted in a small plastic utility box.

HEADPHONE CONNECTIONS

Headphones provide probably the most realistic way to listen to stereo, since they divide the sound into two truly distinct channels, one for each ear. Headphones also are a boon to private listening.

In general, low-impedance headphones (8 ohms or more) can be treated like an extension speaker, and all of the foregoing circuits relating to small extension speakers can be applied to them. It is not likely that you would want to use them as shown in Fig. 2-4, however, although this could be done, since some sound will still come from the loudspeaker in the set. The switching arrangement shown in Fig. 2-5 is preferred; you can select between the loudspeaker in the set or the remote headphones. For remote volume control purposes, simply add a 25- to 50-ohm potentiometer rated at 2 watts in series with one of the headphones leads (see Fig. 2-15A). For stereo listening, separate volume controls can be used for each channel or a ganged potentiometer (two sections) can be purchased.

The headphone connections themselves, in the case of stereo headphones, usually are terminated in a 3-circuit plug. If you look at the plug end carefully, you will notice three separate insulated metal sections. The shank is the common connection and the headphone for each channel is connected to one of the two smaller metal sections at the tip of the plug. A check with an ohmmeter or buzzer will quickly verify the connections. Jacks which accept this plug can be readily purchased, so you can wire to the headphones as desired.

A special note of caution is necessary if you are connecting headphones to a powerful hi-fi amplifier which does not have a built-in headphone jack; that is, if you are connecting the headphones directly to the main speaker or the amplifier speaker terminals (in the latter case, so you can use the speaker selector switch in the amplifier to switch between loudspeaker and headphone operation). The power available can easily damage the headphone units if the volume is accidentally turned up too high. This can easily happen if you are

listening to the speakers and then suddenly switch to headphone operation. As a protective measure, when connecting headphones to speaker terminals, they should never be connected directly but rather through a 220-ohm 2-watt fixed resistor. In a stereo installation, this would mean two such resistors, one in each channel lead. These resistors in themselves will not insure protection for the headphones if the full volume from a 150-watt per channel amplifier is suddenly switched to a pair of headphones. If headphones are used with an amplifier, you should either develop the habit of turning the volume control completely off before switching on the amplifier or of disconnecting the headphones whenever the amplifier is turned off.

Chapter 3

Sound-Activated Light Displays

Light displays, color organs, and psychedelic sound-light accessories have become a popular adjunct to many hi-fi systems. Such accessories are even available in types suitable for use with an automobile radio, although their use in such an installation should be carefully weighed against the safety considerations involved.

Almost all such accessories connect simply across the loudspeaker leads of either an external speaker or the internal speaker in a set, as shown in Fig. 3-1. A typical unit is shown in Fig. 3-2. Some types are also available which are not really sound-activated, but simply turn on when the hi-fi equipment is turned on and provide a continually changing pattern of light. They use flasher bulbs (similar to the Christmas tree

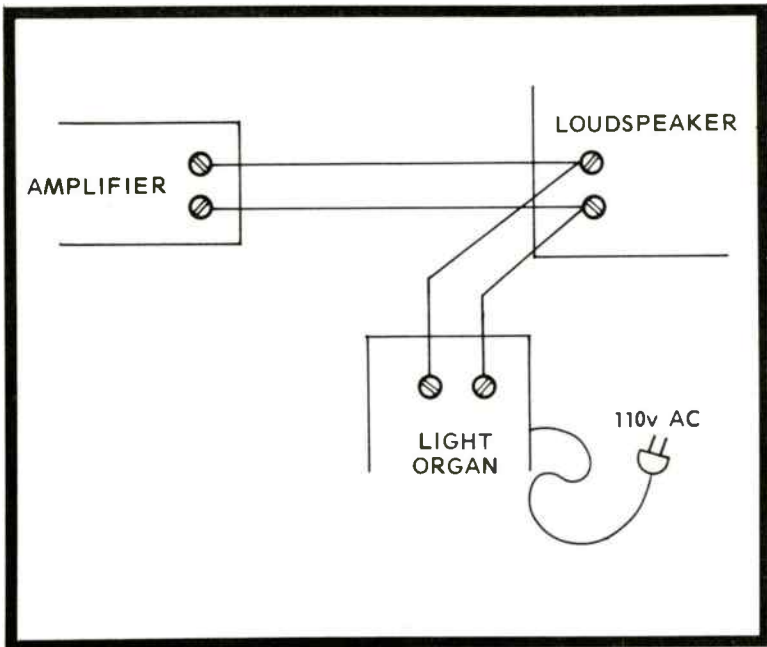


Fig. 3-1. Sound-activated light displays connect directly to the speaker terminals.

type) which are mounted behind a multi-colored translucent panel. You can build such a display, using a flashing light bulb chain suitably mounted.

SOUND-ACTIVATED FLASHERS

Of the sound-activated types, some flash a display only as long as sound of some level is present, while others vary the intensity of the light either according to the amplitude of the sound or according to the sound frequency. Some combine both effects. The lamps used may be of the incandescent type or strobe flash lamps. The latter provide extremely bright short-duration bursts of light; the burst frequency is usually preset or controlled by the number of times the sound exceeds a preset level, so the light appears to flash in synchronization with music. The circuits used for these displays range over a wide span from simple to very sophisticated. The purpose here is not to cover all of these circuits but to present a few simple ideas for circuits that you can construct and also to present a few possibilities for interconnecting commercial displays of different types for combined effects.

It was mentioned that one of the simplest displays that could be developed is one which turns on with the hi-fi



Fig. 3-2. Typical color organ. The controls provide an overall sensitivity adjustment, plus independent control of the red and green light effects. (Courtesy Allied Radio)

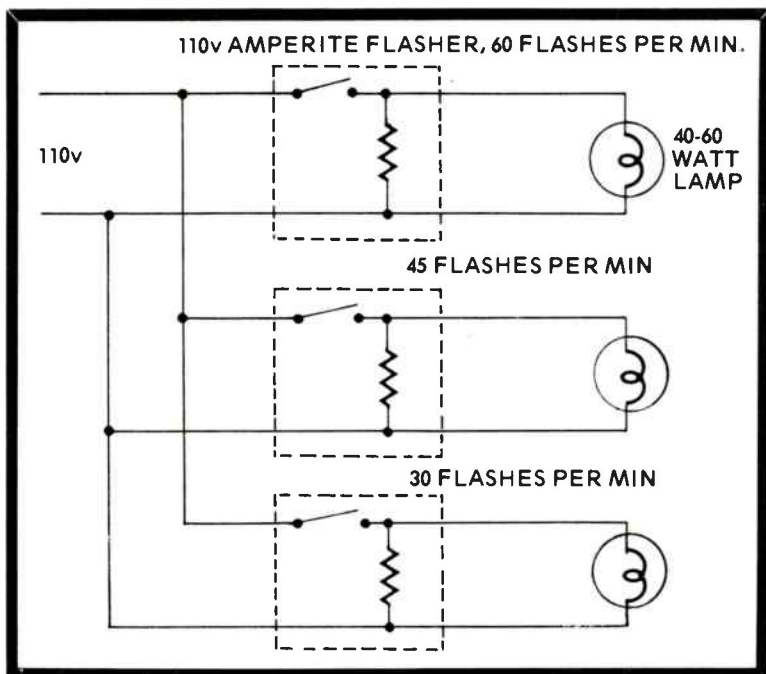


Fig. 3-3. This simple circuit provides a changing light display.

equipment and provides a changing display. A circuit for this type is shown in Fig. 3-3. Here, three flashers are used to control simple 40- or 60-watt light bulbs which can be colored or placed behind colored panels. The flashers are chosen to operate at different on-off rates for a more interesting display. Any number of flashers can be used to extend the size of such a display. To make such a system sound-activated, or, indeed, any simple on-off display, a relay is added across the loud-speaker terminals. The relay senses the presence of audio and turns on the display. The circuit for such a relay is shown in Fig. 3-4A. The relay contacts must be rated to handle the total load being switched.

For those who like to do things with electronics, the circuit of Fig. 3-4B performs the same function with an SCR (silicon controlled rectifier) acting as a relay. In this case, sound peaks gate the SCR into conduction and the lamp lights. Since the sound peaks do not occur in synchronization with the power line frequency, the lamp lights bright sometimes and then dimmer at other times. You can extend this idea to control lamps activated either by different levels of sound or different frequency bands of sound.

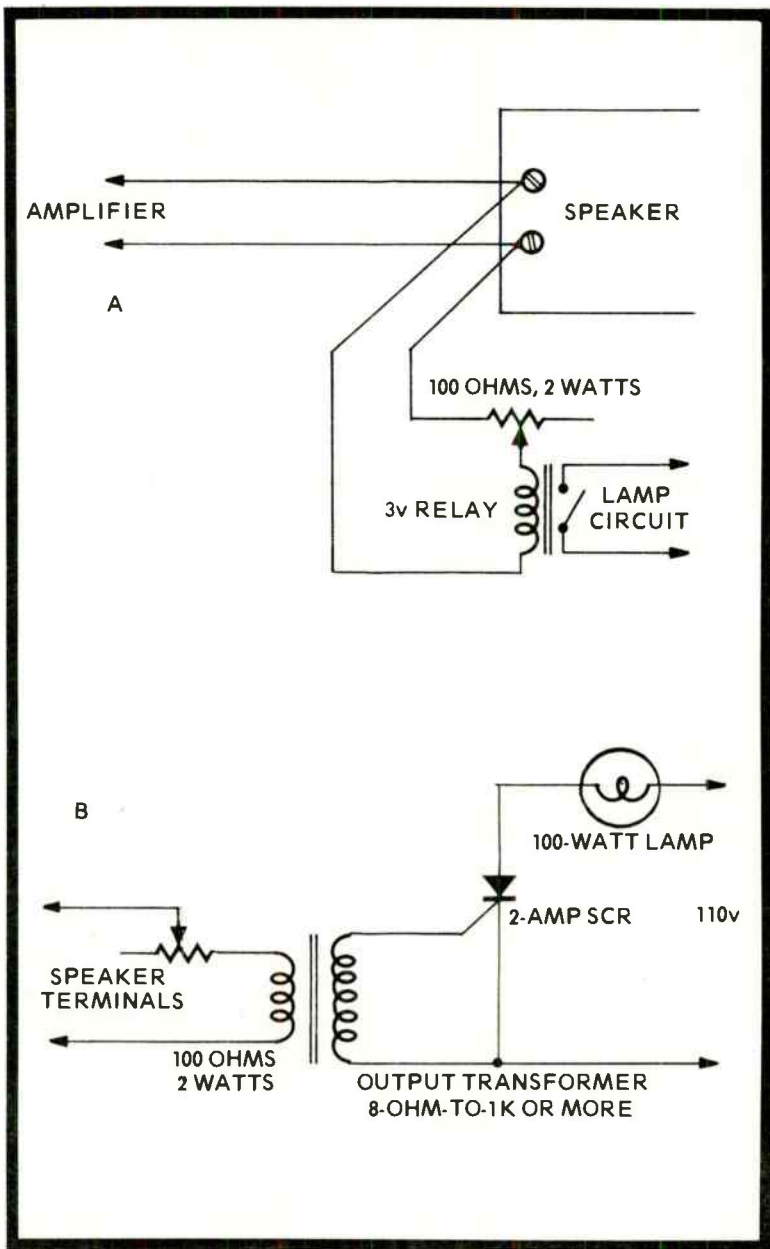


Fig. 3-4. Sound-activated control circuits: relay control (A) and a solid-state relay using an SCR (B).

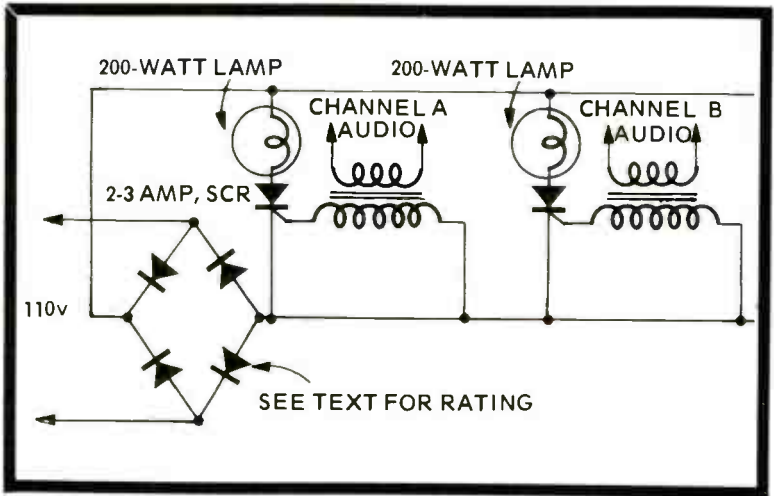


Fig. 3-5. High-power audio-activated lamp display. The transformers are the same as those used in Fig. 3-4.

Line- And Low-Voltage Flashers

Fig. 3-5 shows a higher-powered circuit, using 200-watt lamps, which provides more consistent full lamp brightness. You can add as many SCRs and lamps as desired to make a display of any size. The total lamp load must, however, be such that it can be accommodated by the rectifier circuit. The rectifier rating must be increased by 2 amperes for each lamp used. For ten lamps, for instance, a 20-ampere rectifier is needed. Such rectifiers are readily available and not very expensive. Only two lamps are shown in Fig. 2-5 to simplify the diagram. One lamp can be driven by each channel of a stereo system, or each lamp driven by the same channel but the potentiometer used to adjust the level at which different lamps are turned on. The lamps can be colored, or placed behind different displays to create any desired lighting effect.

Caution is necessary when constructing and interconnecting such a unit because you are dealing with line voltage potential. The lamps must be placed in heat-resistant sockets and all wiring properly insulated. The SCRs and rectifier diodes should be placed in a plastic enclosure for protection.

If each bulb is a different color or placed in a widely different position in relation to other bulbs behind a colored translucent panel, a varying display will be obtained. The

bulbs could also be connected to form a circle which will appear to turn. Another more complicated way to obtain a spinning light effect is to use a small DC motor to operate a rotary switch, such as a 1-pole, 10- or 12-position switch. The snap-action mechanism is removed and the switch is used to distribute power in turn to a number of lamps. The motor speed varies according to the applied DC voltage, which can be obtained by connecting a bridge rectifier across the amplifier output terminals. Small hobbyist's 3- to 6-volt DC motors designed for radio control are very handy for this purpose.

Frequency-Selective Flashers

If you already have two or more light display units, it might be interesting to vary the means by which they are activated. The frequency-splitting networks described in Chapter 2 can be used to trigger a light display on only certain frequency sounds. A changeover switch to put a light display alternately on different channels of a stereo setup can add variety. Such a switch can be manually operated or it can even be a relay which is controlled by the sound level (see Fig. 3-4). Level controls can be placed before each device in a monaural setup, so that each device comes on in turn to correspond to the overall sound level.

The lamps shown in these circuits can be the so-called "black" lamps if desired. Glow sprays, which are currently available, can be used to form decorative patterns which are then illuminated when a black lamp directed at the pattern is switched on.

Chapter 4

Remote Controls and Timers

Remote operation of at least the most often used controls on a radio, TV or amplifier can add a great deal of convenience to the operation of such equipment. In some cases, remote controls are almost a necessity if the equipment is mounted in a concealed location. Independently or combined with remote control, automatic timing of the turn on and off of entire pieces of equipment or of certain functions may be desired. For instance, you may want to turn a radio and recording equipment on and off to record a special program that takes place when no one is at home. Also, it may be desirable to turn on a TV set or radio at a certain time automatically in anticipation of catching a specific program. This chapter details a variety of ways that can be used to achieve both remote control and automatic time control functions.

TV REMOTE CONTROLS

The degree of remote control for a TV set may range from only a simple on-off power function to complete control of picture and sound levels and channel selection. The remote

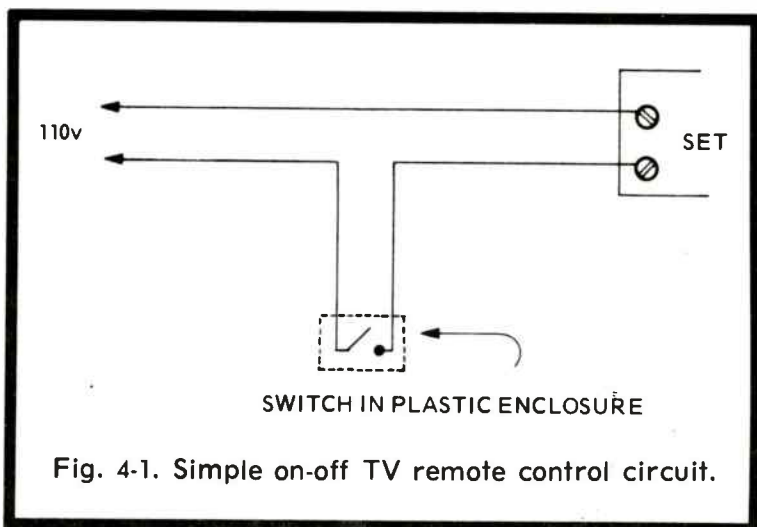


Fig. 4-1. Simple on-off TV remote control circuit.

controls described in this section are cable types, where some sort of wire connection has to be used between the set and the remote control point. But almost any cable type remote control function can be replaced by a wireless control unit, if desired. Wireless units are described in a later section. However, a cable type system remains the least expensive and most reliable form of remote control and should be used unless long cable runs are involved or you desire wireless control for the novelty aspect.

The simplest type of remote control, if a set usually remains on one channel, is a power line on-off function. This can be wired as shown in Fig. 4-1. The switch itself can be a simple rocker type on-off switch in which a zip cord is terminated. Simple remote volume control can be provided as shown in Fig. 2-18 (Chapter 2) by using only the potentiometer (without the switch). The volume control on the receiver is set at a high level, initially, and then the remote volume control used to decrease the volume as desired.

The remote control of other picture functions such as brightness, contrast, tint, etc., as well as a more elaborate method of remote volume control, can be accomplished in a number of ways, depending upon how the set itself is wired. Some sets are purposely designed for the addition of remote controls by cable. These controls can be wired to simply parallel the controls within the set, as shown in Fig. 4-2. In such a case, the control circuit usually varies a DC voltage level only, so the addition of an external cable will not introduce problems of impedance mismatch and hum pickup.

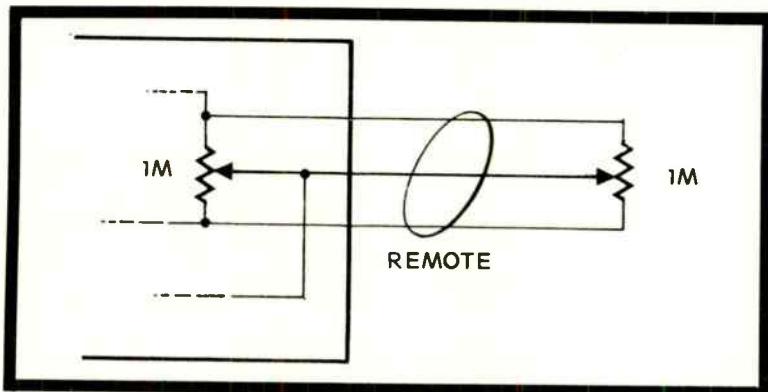


Fig. 4-2. If a receiver control handles only low-level DC voltages, it usually can be remotely controlled by paralleling the control with a potentiometer of the same value. Inexpensive intercom cable is adequate for the connections.



Fig. 4-3. Typical lamp-photocell module suitable for remoting a potentiometer. The module is about $1\frac{1}{4}$ inches long and $\frac{3}{8}$ -inch in diameter.

If the TV set has a remote control connector on the back panel it most certainly is designed for DC voltage control. In any case, the receiver schematic diagram has to be studied to determine how the remote controls should be wired. As a general rule, the value of the remote control potentiometer will be the same as that of the potentiometer it parallels. In operation, the receiver control is set at the fullest value (maximum contrast, etc.) and the remote control then used to set the desired level. The remote potentiometers can be housed in any small plastic or metal enclosure.

A more difficult situation occurs when the set is not specifically designed for remote control, although this in itself does not prevent the installation of remote controls. You should first study the schematic of the set to determine in which manner the built-in controls are being used. If you can clearly determine that certain controls are only used to change DC bias levels or deal with very low impedance levels, a remote control can simply be wired to parallel the built-in receiver control. If the receiver controls handle other than DC levels, as is usually the case, a simple parallel remote control will not generally work satisfactorily. In this case, the use of a lamp-photocell module, as pictured in Fig. 4-3, can be used.

The module consists of a small 6- or 12-volt lamp mounted next to a photocell in a sealed enclosure. As the lamp

brightness varies, the resistance of the photocell unit can change from about 50 ohms to over a megohm. The main feature of the unit is that there is no electrical connection between the lamp and the photocell. The circuit of such a module wired to provide remote control of a potentiometer function is shown in Fig. 4-4. The photocell resistor is connected between the contact arm on the potentiometer and ground. The remote control potentiometer then varies only the current passing through the lamp portion of the module.

The current source for the module lamp is shown in Fig. 4-4 as being a battery located at the remote control position. The lamp voltage could also be obtained from a suitable source within the set, since it is not important whether the voltage source be positive or negative with respect to ground. Caution should be observed if the TV set is of the type where the chassis is "hot"; that is, connected to one side of the AC line. The type of remote control described can still be used in such receivers, but be very sure that the remote control cable and control unit are properly insulated.

The remote control of channel selection, at least for the VHF channels, is best done with one of the commercial kits available for this purpose. These kits, designed for certain tuner types, consist of a small AC motor which attaches to the back of the tuner. The motor is pulsed by a remote control switch every time a change of channel is desired.

If you have a tuner for which no adapter kit is available, there is little choice left, except to try to fabricate a suitable mechanism by placing a cam on the tuner shaft, which is notched for each channel setting, and turn the cam by a solenoid plunger activated from a remote position. Another

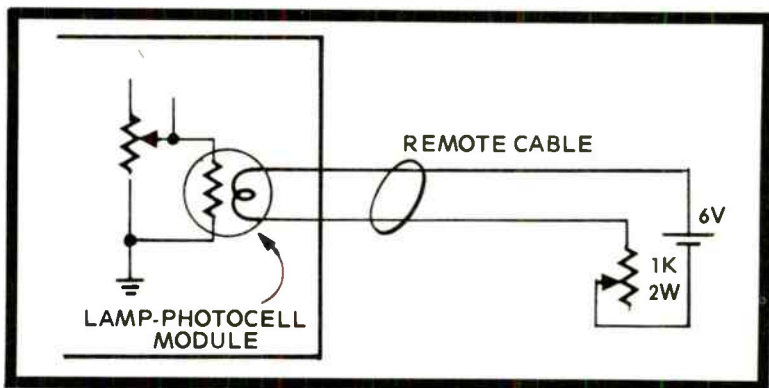


Fig. 4-5. Varactor diode circuit designed to remote control a variable capacitor.

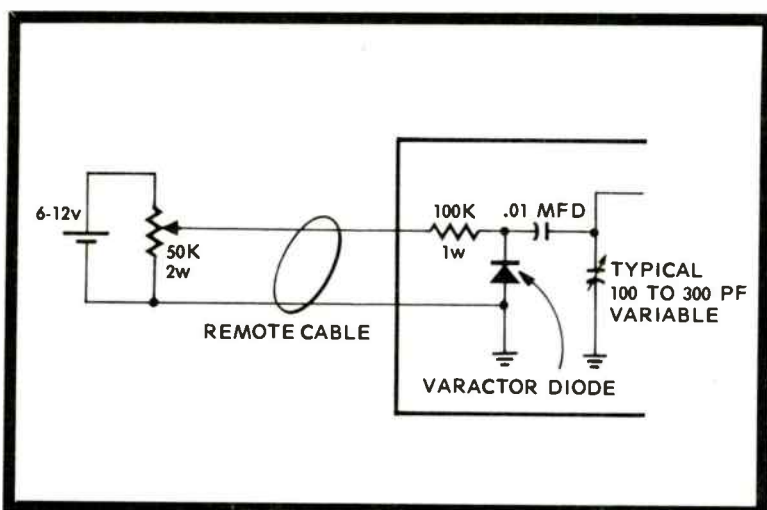


Fig. 4-4. Remote circuit using a lamp-photocell module to control a potentiometer function.

approach is a chain drive loop with a tooth ring placed over the tuner shaft (at the rear of the tuner so as not to interfere with the fine tuning shaft which is usually concentric to the channel selector shaft) and a small chain drive to a motor. The latter sort of approach, using also a friction drive mechanism, is about all that can be done to remotely control the usual continuous-tuning type UHF tuner. The drive motor, however, should be a DC type so you can reverse the direction of rotation as desired to provide for fine tuning.

RADIO RECEIVER REMOTE CONTROLS

Providing remote control for a communications, amateur, SW receiver, hi-fi, etc., requires techniques very similar to those suggested for a TV set. The volume control function can be remotely controlled in a similar manner. Those controls which regulate only a DC bias level, such as the usual RF gain control, can be remoted by paralleling the receiver control. Other potentiometer functions can be remoted with a lamp-photocell module as shown in Fig. 4-4.

To remote variable capacitors or switch functions requires a different approach. A variable capacitor function can, of course, be controlled by some form of a motor which drives the capacitor shaft. A better and usually less expensive approach, when only a single-section capacitor must be

remoted, such as for fine tuning or for BFO pitch, is to use a varactor diode as shown in Fig. 4-5. These diodes provide a continuously variable capacitance, the same as an air variable capacitor. However, the capacitance is varied by a change in the bias voltage applied to the varactor. Notice that the varactor diode (or voltage variable capacitance diode) is backward biased rather than forward biased. This is done purposely so that an increase in backward bias also increases the so-called depletion region in the diode, thus reducing its terminal capacitance. When using such a diode, the variable capacitor in a receiver is set at its minimum capacitance value, the varactor diode connected in parallel with it, and the latter then used to regulate the circuit capacitance to a desired maximum.

The installation of such a diode in a receiver is usually quite simple. By listening to the receiver you can determine how much diode bias voltage is necessary to duplicate the capacitance range of the air variable capacitor. Such diodes should be used with great caution, however, in a transceiver where the transmitter output frequency may be affected. Usually, only an FCC-licensed technician can make alterations which affect a transmitter's output frequency.

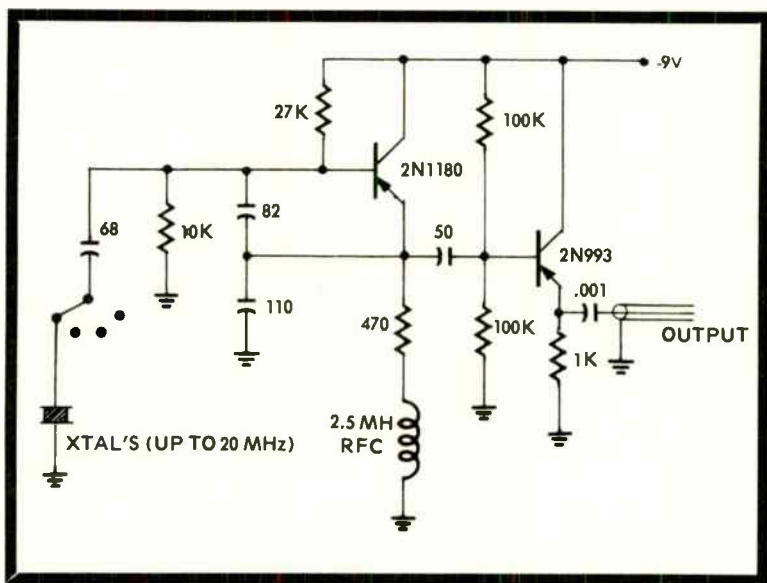


Fig. 4-6. Remote oscillator circuit with buffer stage, designed for operation using long lines. Similar kits are available.

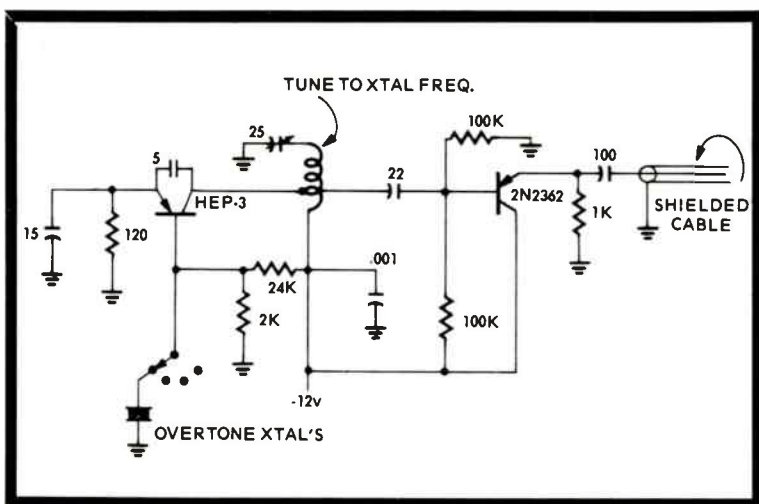


Fig. 4-7. Remote oscillator and buffer circuit for remote operation with overtone crystals (usually those above 20 MHz.).

Remote switch functions, in the case of simple on-off switches for squelch, BFO on-off, etc., may be controlled with a relay. Choose a relay with contacts equivalent to the circuits to be switched, a DPDT paralleling those of a similar DPDT switch, etc., for example. Remoting a multiposition switch is somewhat more complicated. It can be done in relay-like fashion using stepping relays or sequential switching relays, but this is an expensive means.

Usually, the multiposition switch functions in CB receivers, fixed-frequency police or emergency receivers, etc., really only choose the necessary oscillator crystal for reception on a certain channel. In this case, it may be easier to remote control this function by building a separate remote local oscillator circuit which uses crystals the same as those in the set. The RF oscillator output is fed back to the set via a shielded cable and applied at the same point where the local oscillator was connected within the set. A suitable remote oscillator circuit for this purpose is shown in Fig. 4-6. The oscillator requires no tuning whatsoever and will oscillate at frequencies up to about 20 MHz with appropriate crystals. The buffer amplifier stage provides an excellent degree of isolation between the actual oscillator and the RF cable to the remote receiver so that changes in the length or characteristics of the cable will not affect the actual oscillator

frequency. If the crystals used are of the overtone type (usually any crystal stamped with a frequency above 20 MHz is of this type), a different oscillator circuit must be used. A suitable oscillator is shown in Fig. 4-7. Again, the buffer stage provides isolation between the oscillator and the cable connecting it to a receiver.

Although not really a remote function, an extremely useful accessory item that can be used with almost any receiver is a crystal calibrator. Such an accessory can be located at a remote control position or it can even be built into the receiver itself and then remotely controlled for on-off functions.

Crystal calibrators come in a variety of forms and can be purchased ready to operate, as kits, or you can construct such a unit from scratch. The usual type is a 100-kHz oscillator which provides signals at accurate 100-kHz intervals on a receiver, ranging all the way from the fundamental 100-kHz frequency to over 30 MHz. Extended range units, such as that shown in Fig. 4-8, provide 50-kHz interval signals which extend all the way up to 400 MHz. Such units can, in fact, be used as a form of signal generator to align a receiver, as well as to provide calibration points on a tunable receiver. Such a calibrator is almost a necessity if you are trying to find a



Fig. 4-8. This wide-range calibrator provides markers at 50-kHz intervals up to and including the high VHF band. (Courtesy R. L. Drake Co.)

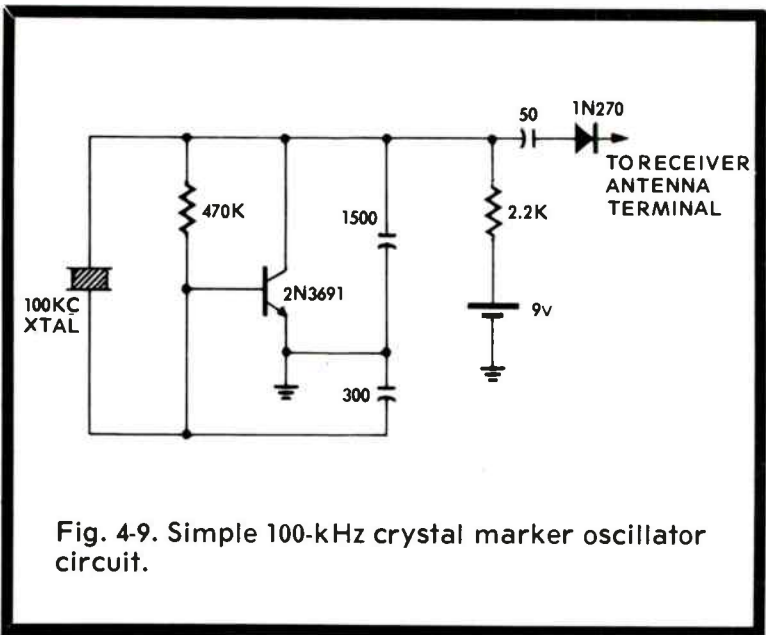


Fig. 4-9. Simple 100-kHz crystal marker oscillator circuit.

transmission on a known frequency while using a tunable receiver which does not have exact frequency readings. This is particularly true of many portable types of 30- to 50-MHz or 152- to 174-MHz monitor receivers.

An extremely simple type of calibrator circuit which can be constructed is shown in Fig. 4-9. It can be used with 100, 500 or 1,000-kHz crystals so you can have markers at any of these frequency intervals. The output of the calibrator must be connected directly to the antenna input of the receiver with which it is being used. It can be powered by a standard 9v transistor radio battery and, in fact, can be constructed so compactly as to fit into the case of most monitor receivers.

Remote antenna switching for a receiver can be done with a standard power type relay at frequencies below about 15 MHz. Above these frequencies, however, the relay should have a type of insulation which will prevent the loss of the RF signal. For strictly receiving purposes, the relays described in Chapter 6 are very suitable for any receiving application extending up into the UHF range.

For a transceiver installation where a transmitter is also involved, the TV type relays can be used only at a power level of up to about 5 watts. For greater power levels, a coaxial type relay should be used to prevent unnecessary power losses.

WIRELESS REMOTE CONTROLS

Wireless or radio type remote controls may be desired when a long distance is involved between the remote control point and a receiver, or when the remote control point must be moved frequently, thus making a cable type remote control awkward to use. The basic units in such an installation are a small RF transmitter and a receiver located at the device to be controlled.

The types of units available range from relatively simple single-channel units, where the transmitter is turned on and off. The transmitter signal is picked up and detected by the receiver which activates a power relay. There are also multi-channel units of the type used for model airplane control. The latter units also have only one transmitter which can be

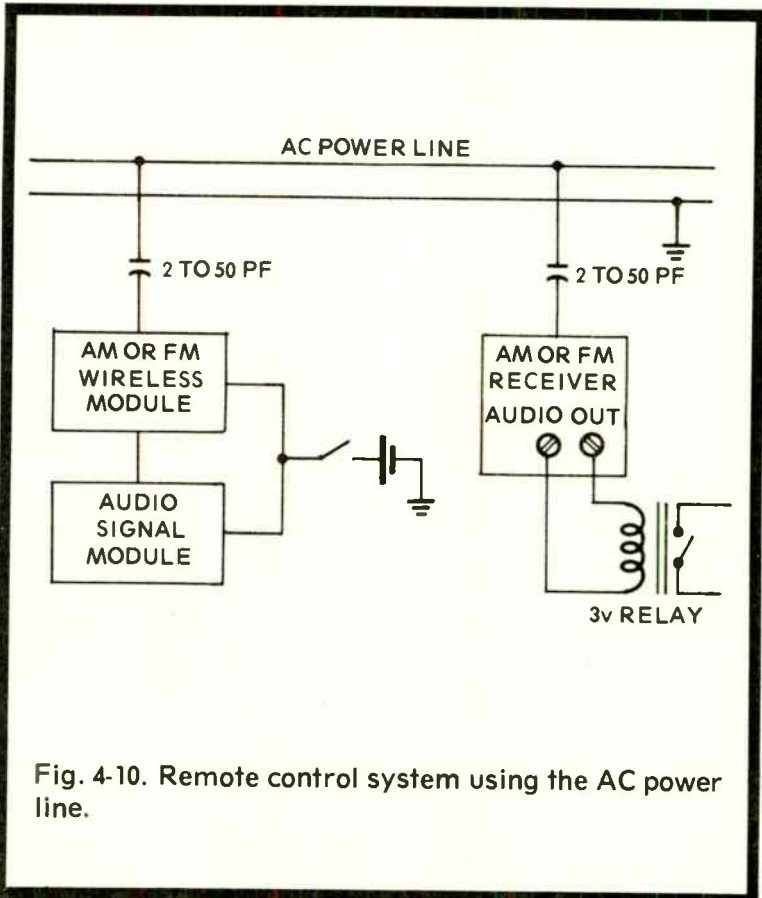


Fig. 4-10. Remote control system using the AC power line.

modulated with different tone frequencies. Each tone has a separate output at the receiver which is used to activate a relay or other device for the independent control of several functions simultaneously. A useful accessory to extend the range of such units is a better form of antenna system, such as those described for emergency and monitor type receivers.

Some wireless control systems simply apply an RF signal to the AC power line. The power line carries the control signals to a remote connected at another outlet. A typical system is shown in Fig. 4-10. In this system, a small AM transmitter module is modulated by a tone injector module. At the remotely controlled point, a sensitive relay is connected to the audio output of a standard AM receiver which is tuned to the frequency of the transmitter module. Turning on the transmitter module causes the relay to be activated. The same functions can be realized with an FM transmitter module. But with an FM transmitter you can operate in a true wireless sense without using the power line as a connection medium. The FM transmitter module must, however, be enclosed in a metal case if hand capacity is not to affect its output frequency and the receiver should have automatic frequency control (AFC) for reliable operation.

The simple single-channel control provided by the above systems can be expanded easily into a 5-channel control providing independent operation of fine on-off functions at the remotely controlled position. All that is necessary is a 5-channel frequency-selective relay. Such a relay has a resonant reed arrangement so that a contact is closed only when a specific frequency is received. Thus, you simply modulate the transmitter with a specific frequency for the desired control function. The modulator can be a tone oscillator which generates the required tone frequencies.

A suitable circuit is shown in Fig. 4-11. Each oscillator frequency is first tested and adjusted so that it activates just one channel of the 5-channel relay by coupling the oscillator directly to the relay. The relay is then connected to the audio output of a receiver and the tone oscillator to the microphone input of a suitable AM or FM transmitter module. Each channel of the relay remains closed so long as its tone is being transmitted. If you want each channel output to remain closed whenever a tone is transmitted, a latching relay can be used. The latching relay changes position each time it receives an impulse. The channel relay contact is used to supply the necessary operating voltage to a latching relay; one pulse closes the latching relay contacts, the next pulse opens the contacts, etc.

SOUND-ACTIVATED REMOTE CONTROLS

Sound-operated controls are very similar to wireless controls, except that sonic or ultrasonic audio frequencies are used instead of RF frequencies. Sonic frequencies are usually avoided because normal sounds may activate the remote control device. However, you can make an interesting test to prove that such devices do work by connecting a sensitive relay to the output of an amplifier which has a microphone on its input; the amplifier controls are adjusted to favor only the highest frequencies. A special high-pitched dog whistle can be used, with the pitch adjusted so that only the highest sound possible will activate the relay. With a good hi-fi amplifier, the frequency used can be almost inaudible, but it will still activate the relay from 20 to 30 feet away.

One case in which audio frequency tones can be used to advantage is in a system where the tones are transmitted on a wire circuit such as the AC power line in a building. The oscillator shown in Fig. 4-11 can be coupled to the input of a normal audio amplifier with several watts output. The amplifier is coupled to the power distribution system. At the

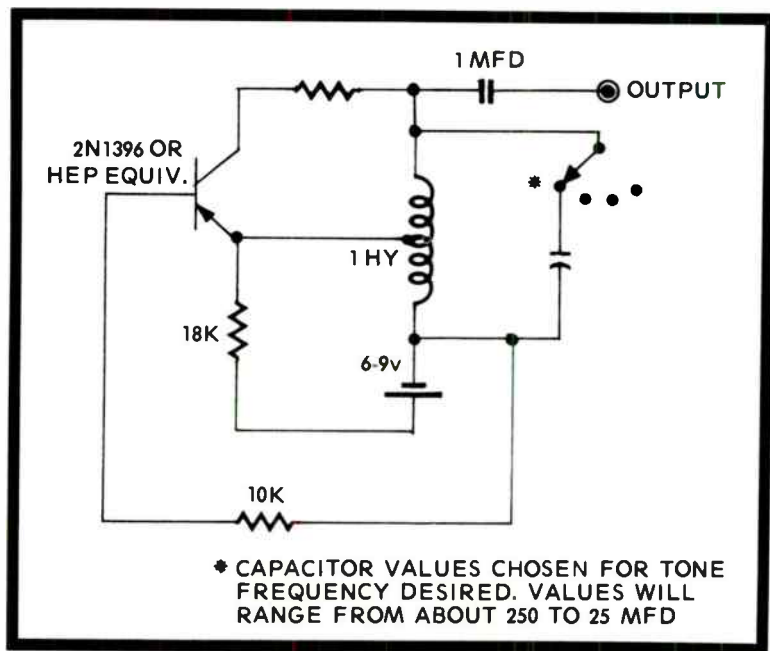


Fig. 4-11. Tone oscillator circuit designed to produce discrete tone outputs in the 200- to 1,000-Hz range.

remotely controlled point, another amplifier is coupled to the power distribution system and its output coupled to a 5-channel resonant reed relay. By transferring the audio power directly over the power distribution system, it is possible to achieve up to a 5-channel remote control capability.

The capacitors used to couple the tone generator and amplifier to the power line should be the smallest value that will allow proper operation of the system over the distance desired. Be sure to measure the AC line leak-through voltage at the oscillator and amplifier ends of the coupling capacitors—particularly at the amplifier input—to be sure that it does not exceed the amplifier's input level restrictions.

A self-contained sound-activated remote control device that you can build (similar commercial units are available) is diagrammed in Fig. 4-12. It uses a special microphone and audio amplifier circuit. The time constants and frequency response of the circuits were designed so that some sharp, sudden sound such as that produced by clapping hands sharply or a short yelp will activate the relay. The circuit features adjustable sensitivity so that it can be set to respond to sounds within a room. The circuit also features an SCR to control the relay, allowing the use of a simple relay. The relay in this case stays activated, once it has been turned on, until the manual reset button is depressed.

Supersonic frequency control units operate in a manner similar to those previously described, except that the frequencies used (usually from 30,000 to 50,000 Hz) are far beyond normal audibility. The circuitry is basically the same as Fig. 4-12, except, of course, components which respond to the higher frequency ranges are used. You can use the circuit shown at much higher frequencies by experimentally reducing the size of the input coupling capacitors connecting the microphone to the gate of the HEP 801 and the HEP 50 so that a dog whistle activates the set at a frequency practically inaudible to humans. The output of an audio oscillator suitably increased in frequency and connected to a miniature, expensive tweeter speaker having a response up to 15,000 or 20,000 Hz, will also function as an activating device.

LIGHT-OPERATED REMOTE CONTROL

Light-operated devices offer the general advantage that the activating device can be a simple hand-held lamp, usually a simple form of flashlight. Also, they are not so subject to stray activation. Light-operated devices are available commercially and they make interesting projects for home con-

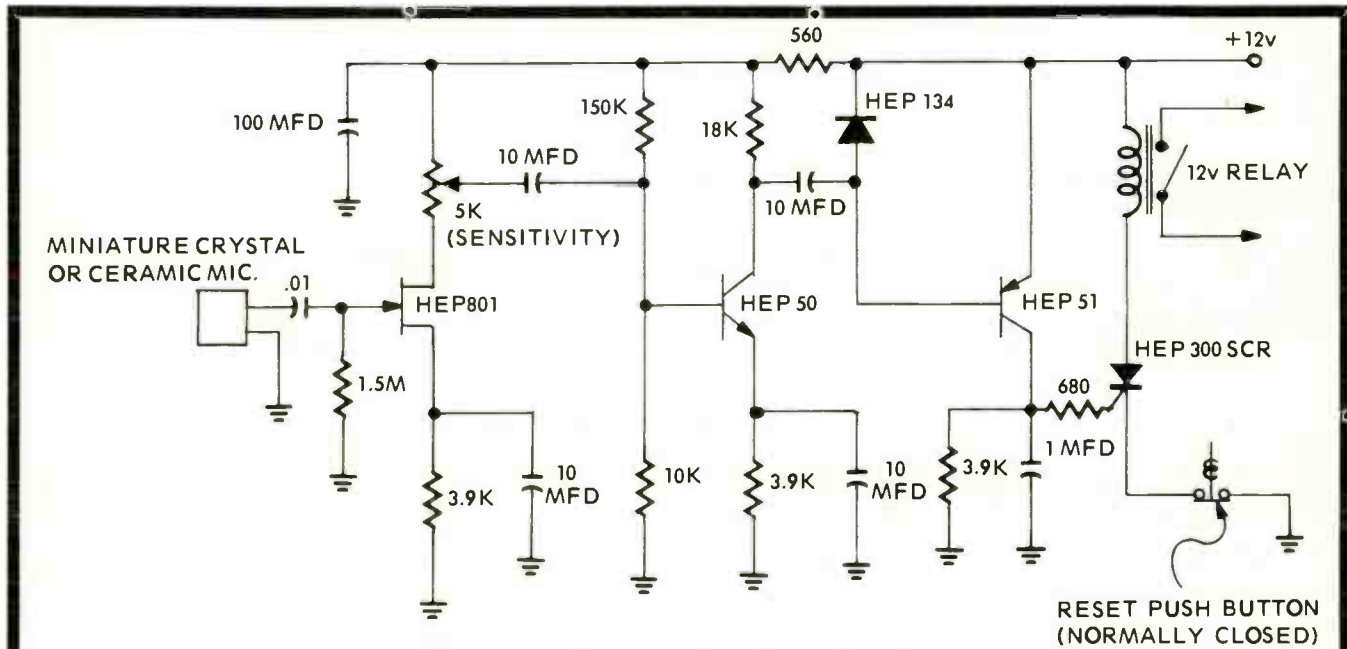


Fig. 4-12. This sensitive sound-activated switch circuit will respond to normal room sounds, particularly sharp, high-pitched sounds.

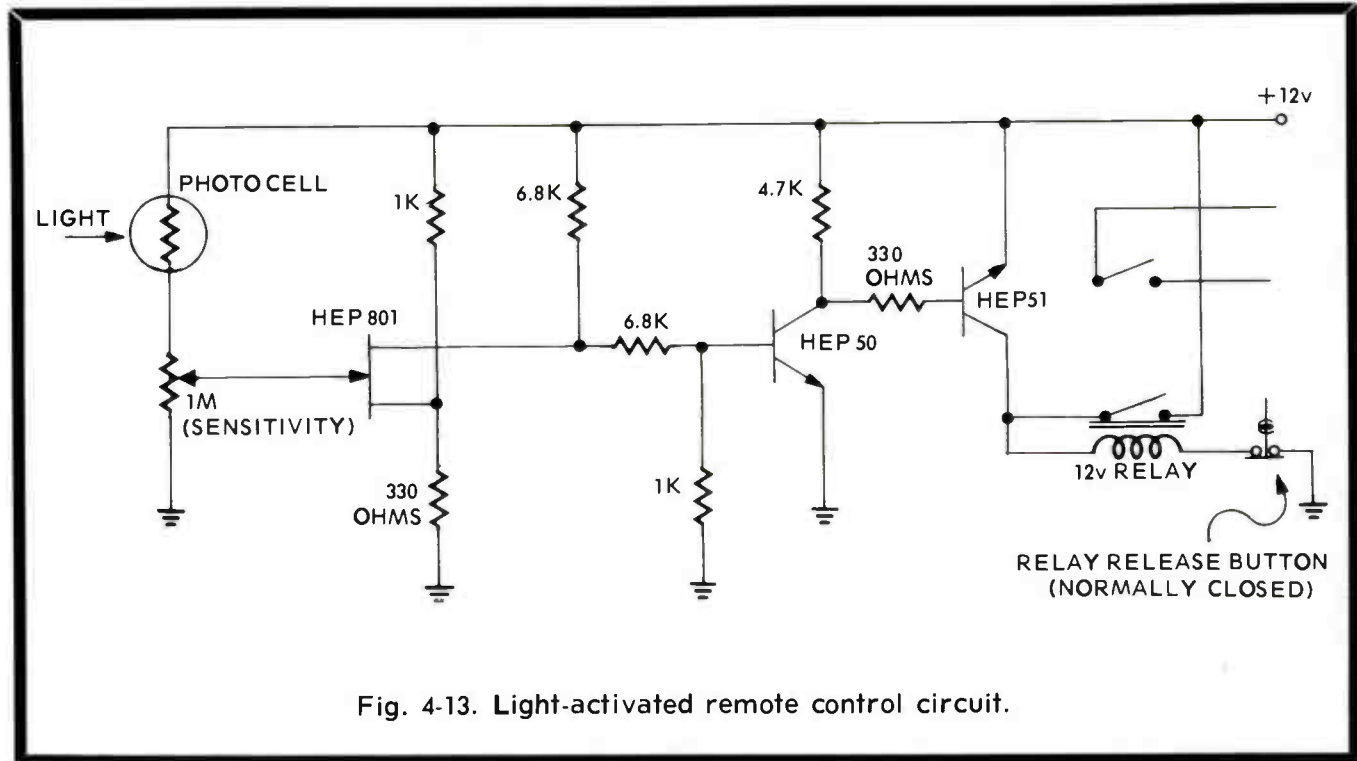


Fig. 4-13. Light-activated remote control circuit.

struction. The main limitations are that they usually cannot be used over distances greater than 10 to 20 feet and usually only a simple on-off control action is possible.

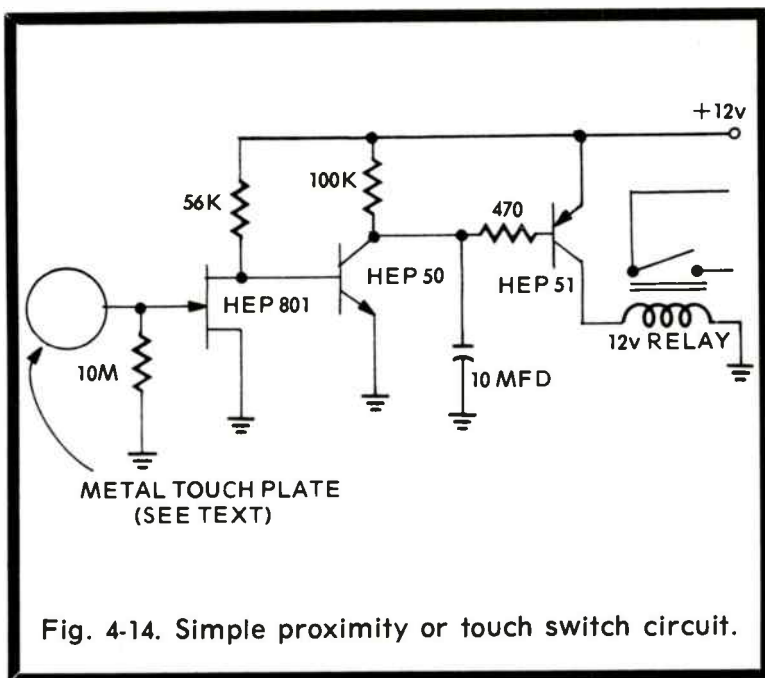
An interesting light-operated circuit is shown in Fig. 4-13. The sensitivity of the circuit is adjustable and it can be activated by a flashlight. The pointer type flashlight, designed to point out details on a movie screen, is particularly suitable. The photocell entrance should be covered by a short tube to shield it from stray light. The relay used in this circuit is a latching type so that only one pulse of light is necessary to activate the relay to either the alternate on or off position. The device lends itself particularly well to a simple remote on-off switch for a receiver or a light-controlled "commercial killer." Photocell and phototransistor relay kits are also available in a wide assortment of types; therefore, you can build these devices to suit almost any specific remote control function.

PROXIMITY TYPE REMOTE CONTROLS

Proximity, touch, or capacitance switches are not really remote controls in the sense that they can be used to control variable functions such as sound volume. Also, a capacitance switch can be replaced by a toggle switch in the sense that a wire connection is still required between the switch and the device to be controlled. However, proximity switches, where you only have to touch a metal plate which may be concealed in a wall, floor, etc., do provide an intriguing means of mystery control to turn equipment on or off. In some cases, of course, particularly where a person may be handicapped, they provide the only practical means of controlling equipment if such a person is not able to turn switches, etc.

Proximity switches usually operate when you touch a small metal plate, changing the capacitance existing between the plate and ground. The capacitance change, in turn, can be used to gate a transistor circuit into operation, which controls a relay or SCR. Capacitance switch kits are available, or a unit of the type shown in Fig. 4-14 can be constructed. In the circuit shown, the touch plate can be any small piece of metal about the size of a quarter. The touch plate should be wired to be as close as possible to the gate of the input FET.

Although not usually necessary, the sensitivity of the unit can be improved if a larger metal plate (concealed under a rug, for instance) is used as a ground plate and connected to the ground side of the circuit. For the control of several functions, several touch plates can be mounted next to each other,



keeping them about 1 inch apart. The relay shown is a simple one that only operates when the plate is touched. It can be replaced by a latching relay so alternate touches will turn a device on and off, or with a stepping relay in the circuit each touch will advance the relay one position.

TIME INTERVAL SWITCHES

Time interval switches are timers which keep a circuit completed for a preset interval. (They should not be confused with the clock-type time switches described next.) Interval timers usually come with a minimum time setting of one minute and a maximum time setting of from one to five hours. Many are designed so the device to be controlled is simply plugged into the timer and the timer itself plugged into the AC power line. You set the timer (which turns on the controlled device) for the time period desired and the device will be shut off after this time period has expired. Such timers are useful to shut off TV, hi-fi equipment, etc., after a preset time, or to allow a tape recording to be completed, enabling you to leave the equipment unattended. A typical timer of this sort is shown in Fig. 4-15.

CLOCK TIMERS

Clock timers contain an electric clock motor and can be used to preset the hour of day when a device will be turned on and the hour when it will be turned off. The timers available vary widely in their capabilities; therefore, it is wise to read the catalog descriptions for such timers very carefully to be sure that the one chosen is suitable. For instance, the simplest timers allow only one on-off operation per 24-hour period, with a minimum period between on and off of two hours. More elaborate timers allow a controlled circuit to be turned on and off many times during a 24-hour period and the minimum time duration of any on-off cycle may be as short as 15 minutes. Still more elaborate timers have a skip function so that the preset on-off cycles will not function during certain days of the week. A typical clock timer is shown in Fig. 4-16.

The variety of applications of such timers to TV and radio equipment is almost as broad as your imagination. A timer can be used to turn on equipment only for the duration of



Fig. 4-15. A typical small interval timer. (Courtesy Lafayette Radio)



Fig. 4-16. This clock timer allows multiple on-off settings and provides for the skipping of selected days. (Courtesy Intermatic Div., International Register Co.)

certain programs, starting at certain times of the day, etc. One of the most interesting uses of such a timer, however, allows the recording of program material while equipment must be left unattended.

Unattended Timed Recordings

A clock timer allows program material to be recorded at one or more periods during the day when the equipment must be left unattended. The clock timer itself can be used to control any circuit function, but with most modern transistorized equipment, it usually has only to switch on and off the power to a receiver and tape recorder, once the equipment has been preset.

First, check that the receiver can be suddenly switched on and quickly stabilized on the desired station. With most

transistorized receivers, particularly FM types having AFC, this should be no problem. Older receivers may require several minutes to stabilize, a fact that must be taken into consideration when the clock timer is set. Initially, the receiver and recorder should be set up to make a recording from the desired station with the recording levels adjusted to accommodate the peak audio input. Make several test tries to be sure the level settings are correct. With the receiver properly tuned in, level controls set, and the recorder in the record mode, the common AC power line for both units is disconnected and plugged into the clock timer. Depending upon how the clock timer is set and the time length of recording tape available, one or more programs may be recorded while the equipment is left unattended.

Chapter 5

Microphones

A good microphone, one designed for the purpose, is the heart of a good recording or communications system. It also can be one of the least overall expensive investments that you can make toward improving the quality of a recording or communications system. Fortunately, microphone prices, even for the specialized types, have gone down considerably in the past few years due to the competition from imported types, so you should no longer regard a good microphone as something that only a broadcast station can afford. Also, as is discussed later in this chapter, it is the proper use and placement of any given microphone, as well as its basic characteristics, which finally determine the quality of its output.

GENERAL TYPES

A microphone is a device for converting sound pressure waves into a fluctuating electric current. It is just the opposite of a loudspeaker which converts electric current changes into sound pressure waves. Some devices, notably the dynamic loudspeaker, can function both ways—as a loudspeaker and as a microphone. Most devices are, however, single purpose. A great number of different microphone types have been developed over the years, but only the most popular and currently available types are discussed here.

The dynamic microphone, like the dynamic loudspeaker, is the most common types of microphone in general use today. It consists of a lightweight voice coil which is rigidly attached to a thin diaphragm (the equivalent of the paper cone in a loudspeaker). The wire coil itself is placed between the poles of a permanent magnet. (See Fig. 5-1). Sound waves cause the diaphragm-coil assembly to move, and the coil moving within the magnet field develops an alternating voltage across its terminals. The level of this voltage is not very high—on the order of millivolts—but it is adequate for further amplification.

The frequency response and the smoothness of the response vary widely with the microphone type. Studio types

have a response ranging from below 60 Hz to well over 15,000 Hz. Even less expensive types come close to duplicating this range. Besides its wide response, however, the main advantage of the dynamic microphone for general purpose applications is its ruggedness. It will withstand relatively rough treatment, such as normally encountered in a mobile installation, and also function well over wide extremes of temperature and humidity.

Similar to the dynamic loudspeaker, most dynamic microphones are basically low-impedance devices, even though various types may be advertised as being high impedance. Usually, a small stepup transformer is used, either within the microphone housing or externally, to raise the impedance to a higher level when required. There is a distinct advantage to using the microphone at a low impedance (600 ohms or less) when a long microphone cable is used. Hum and other stray signal pickup problems are far less troublesome at the low-impedance level. If an amplifier requires a high-impedance input, a match is attained by using a stepup transformer at the amplifier. The use of such devices is described in more detail later.

The crystal microphone, until not too many years ago, was the most common type general purpose microphone. That has

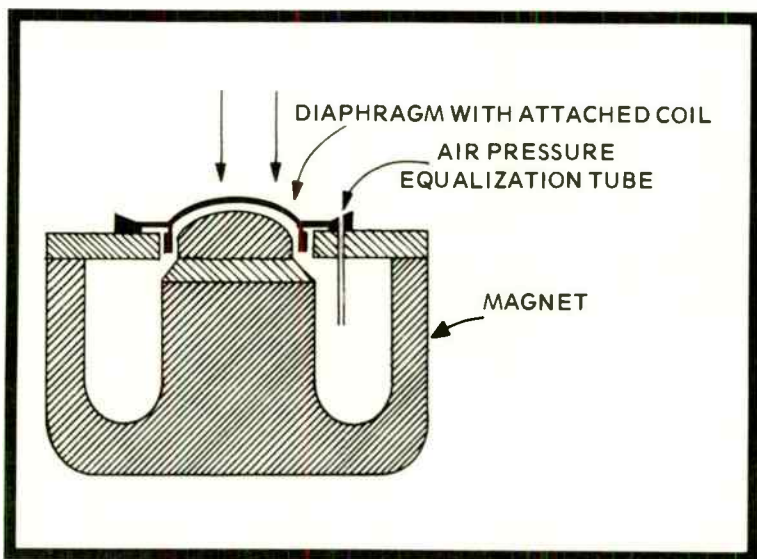


Fig. 5-1. In a dynamic microphone the diaphragm moves a coil within a magnetic field to produce an electrical equivalent of the sound waves striking the diaphragm.

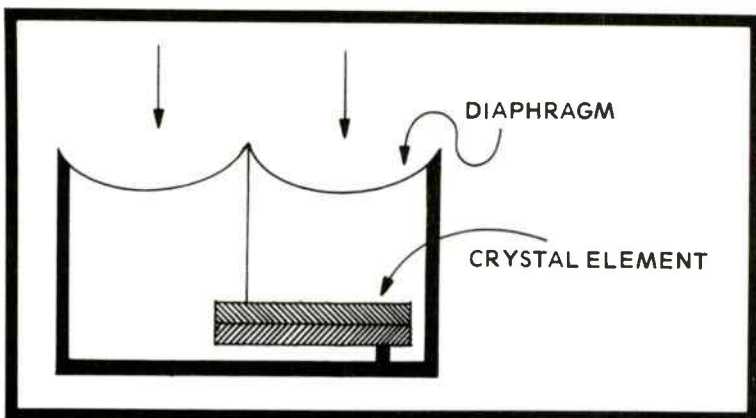


Fig. 5-2. Crystal microphones employ the piezoelectric properties of a crystal block to produce a voltage.

changed greatly now since inexpensive dynamic microphones are available, but crystal microphones still remain useful when a really inexpensive microphone will suffice. In some cases, subminiature types, for example, crystal microphones are the only type available.

The crystal microphone (see Fig. 5-2) makes use of the electric current generating properties of a rochelle-salt crystal (so-called piezoelectric effect) under pressure. When the diaphragm places pressure, due to sound-wave pressure, on the salt crystal, the latter generates an electric current. This current, when considered flowing in a high-impedance circuit of about 1 megohm or more, can amount to 20 or more millivolts. So the output is better than that of a dynamic microphone; therefore, the output of a crystal microphone seems less noisy, when used with some equipment which has a poorly designed microphone amplifier input stage, simply because the overall gain of the system need not be as great.

A distinct disadvantage of the crystal microphone is that it will not work well with a long cable because the output level drops and problems with cable noise and hum pickup increase with cable length. The response of a crystal microphone is not as good as a dynamic type, although it can still extend up to 9,000 or 10,000 Hz for a wide-range type. Probably the main disadvantage of the crystal microphone has to do with the crystal element itself, since it will not work properly under wide humidity or temperature ranges. A crystal microphone left in a closed car on a hot summer day, for instance, can easily be ruined. A variation of the crystal microphone, known as the ceramic microphone, since it utilizes the piezoelectric

effect produced by certain ceramic materials, overcomes the temperature sensitivity problem of the crystal microphone. Its output is almost as great as the crystal type but its high-impedance output is subject to the same cable problems as with the crystal type.

In general, it is better to use a dynamic microphone instead of a crystal type. If the existing microphone preamplifier does not do as good a job with the dynamic type as it does with a crystal type, a low-noise preamplifier (as described later) can be added to the system. The extreme low cost of simple crystal microphones (less than \$1), however, still make them suitable for a variety of test and experimental purposes.

The last common type of microphone we'll discuss, although it was one of the earliest types developed, is the carbon microphone. Some enthusiasts still regard it as the best type for speech communications. A carbon microphone is basically different from the dynamic or crystal types in that it does not provide any direct voltage generation. The diaphragm in a carbon microphone compresses a quantity of carbon granules in direct relationship with the sound pressure waves striking it. The resistance of the carbon is thus varied in accordance with the sound pressure input. The resistance change produces a change in the current flowing through the microphone.

A simple carbon microphone circuit is shown in Fig. 5-3. The battery supplies the microphone current and the transformer steps up the output voltage. This voltage can be fairly high—up to several volts; therefore, the microphone can be

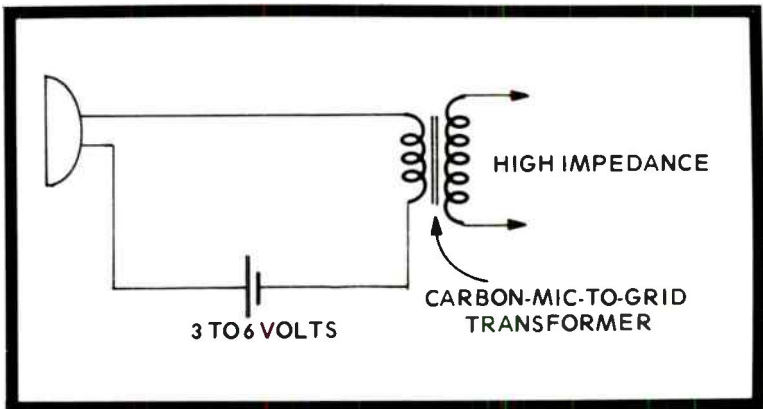


Fig. 5-3. Unlike dynamic and crystal microphones, carbon mics require a power supply.

used without the usual preamplifier stage. The carbon microphone is extremely rugged. Its frequency range is limited to a few thousand Hertz and a problem that occurs with time is that the carbon granules become packed together resulting in increased noise in the output. Nonetheless, for speech communication purposes, where a very rugged microphone is required, the carbon type still maintains its hold.

A number of other microphone types exist, such as the velocity or ribbon microphone, but their use is not common for general purpose pickup applications. Many such microphones work on principles similar to the dynamic microphone. Do not become confused between the basic type of a microphone and its characteristics. For instance, a cardioid microphone is not a basic type but rather could be any type with a certain pickup characteristic.

GENERAL CHARACTERISTICS

Some of the characteristics of certain types of microphones have already been mentioned, but it should be useful to define more completely what is meant by various characteristics to assist in the selection of a microphone.

Frequency Response

The frequency response of a microphone is determined not only by the basic characteristics of the microphone type but by the quality of the microphone element and the microphone housing. For instance, even though a basic, typical dynamic microphone can have a wide frequency range, the response of such a microphone intended for speech communications may be deliberately restricted to 300 to 3000 Hz or a similar range. The frequency response of some microphones varies, depending upon whether they are used close up to a speaker or far away. So, the response of a so-called "close speaking" microphone should be understood to be effective only when the microphone is used in a specific way.

The frequency response of a microphone is determined in an acoustic chamber where reflections do not exist. In an actual room environment, the response can change considerably. Also, as with loudspeakers, the total frequency response is meaningful only when you also know how smooth the response is over the frequency range desired. Certainly, before investing in any expensive studio type microphone, obtain the response curves published by the manufacturers.

A typical response curve is shown in Fig. 5-4. Notice how it also shows the variation in response when the microphone is used close to a speaker. Finally, the frequency response of most microphones, particularly crystal types, can vary with the load impedance to which they are connected. For the crystal type, the lower frequency response gets poorer as the load resistance is lowered.

Output Level

The output level is generally expressed as the open-circuit or unloaded output voltage produced when some standard sound pressure (such as 10 dynes per square centimeter) is impressed on the microphone diaphragm. The output level,

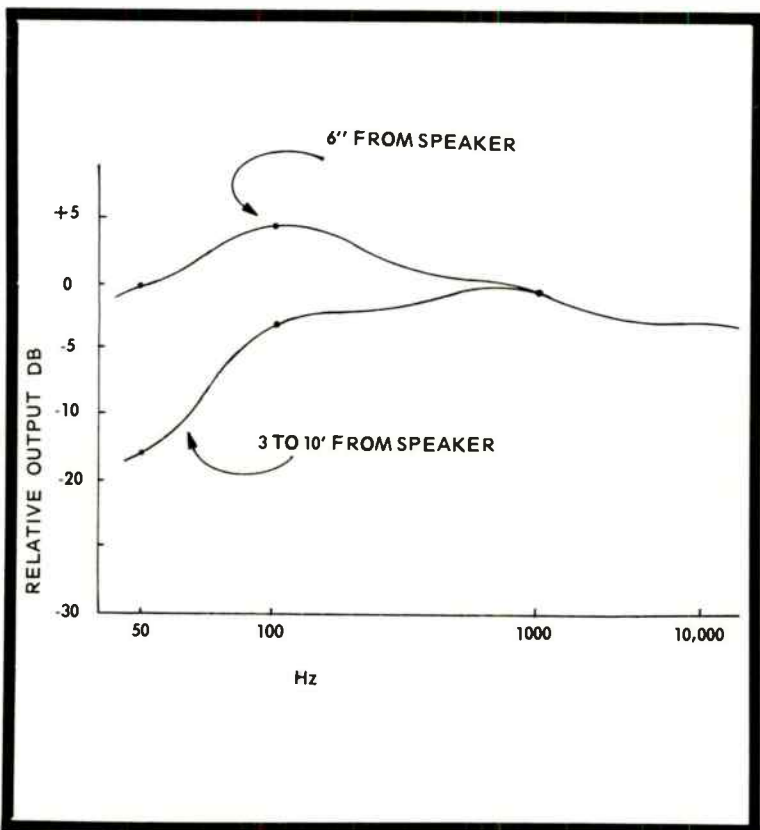


Fig. 5-4. Curves illustrating how microphone response is affected by the distance from the speaker.

since it is generally very low, is expressed in db below 1 volt. The stated output levels for typical dynamic and crystal microphones vary from -52 to -60 db. The lower (-60 db) output levels are typical of the wide frequency response microphones, while microphones with a response "shaped" for just speech tend to have a slightly higher output.

The output level is mainly important in regard to whether or not the amplifier with which it is to be used has sufficient sensitivity to accommodate the microphone. This is usually clear from the amplifier specifications. As long as the amplifier has a gain of anything more than the microphone output in db, the two can be matched together (notice also the output impedance discussion which follows). If at all possible, the amplifier gain should also provide a reserve for times when the microphone output is very low, as when picking up faint sounds. A reserve range of 30 db is desirable. A small preamplifier can be used with a microphone to easily provide a 30 to 40 db boost in output, so the exact output level of a microphone is rarely a problem. Some microphones come with built-in preamplifiers, but their value is questionable unless it has already been determined that the amplifier with which the microphone is to be used does not have sufficient gain in the microphone input channel.

Output Impedance

The output impedance rating of a microphone represents the input impedance into which it is designed to work to produce the stated frequency response and often the stated output. The reserve gain of most amplifiers is such that you can get by with a degree of mismatch and still obtain adequate output. But, if examined carefully, it usually will be found that the frequency response has been changed, with an accompanying increase in distortion. It is certainly poor economy to buy a good microphone and then compromise its performance by improper impedance matching. A later section shows how microphones of almost any impedance can be connected to an amplifier input of fixed impedance, using simple matching transformers.

Response Characteristic

This feature refers to the pickup characteristic of a microphone in various directions; that is, the sensitivity to sounds arriving from various points around the microphone. Such characteristics would be relatively simple to state if it

were not for the fact that the pickup pattern of many microphones changes completely with a change in the frequency of the sound arriving at the microphone. Again, for expensive microphones you can obtain diagrams showing the pickup pattern and how it changes at various frequencies. For inexpensive microphones the manufacturer usually states only the response in broad terms as being omnidirectional or unidirectional; these pickup patterns are illustrated in Fig. 5-5. The unidirectional pattern is also commonly called a cardioid response. The latter pattern can be made much sharper—particularly at the higher frequencies—in the forward direction by the use of parabolic reflectors. A few microphones are available where it is possible to select the response characteristic with a switch. Almost all of the sub-miniature microphones available have only an omnidirectional response.

Matching

It is rarely necessary to match microphones according to exact frequency response, etc., for stereo recording, except for the highest quality studio recordings. In general, it is suffice to use two microphones of the same type. The use of very different microphones will produce a very uneven and annoying characteristic. The microphones must be correctly phased, however, before using them for stereo recordings as described under multiple microphone usage.

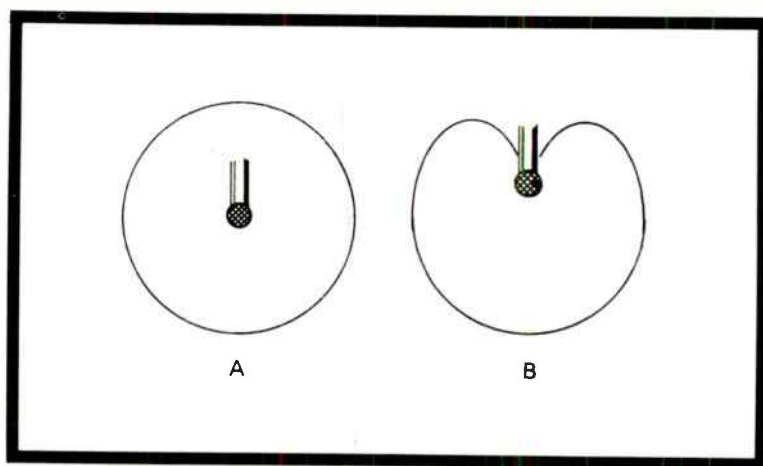


Fig. 5-5. Omnidirectional (A) and unidirectional or cardioid microphone pickup patterns.

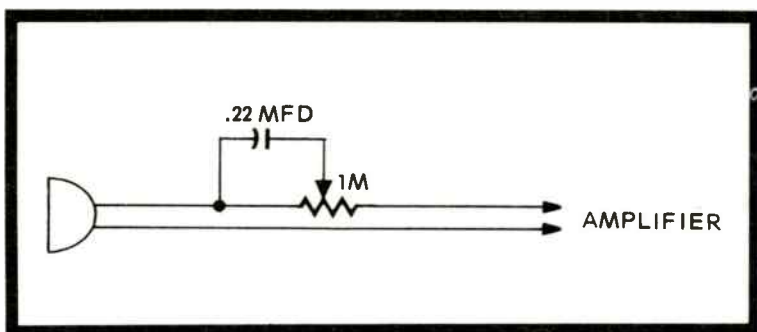


Fig. 5-6. Simple RC network designed to reduce the low-frequency response of a high-impedance microphone.

CHOOSING A MICROPHONE

Considering the foregoing characteristics, it should be clear which microphone to choose in most situations. The frequency response should be based on the service to which the microphone is being placed. For public address, paging, radio communications purposes, etc., a microphone with a shaped response of from 300 to 3000 Hz, 400 to 4,000 Hz, or something similar, is advantageous in that it will produce crisp speech. For general voice and musical recordings, a wider range microphone of from 60 to 12,000 or from 50 to 15,000 Hz is desirable.

If one microphone is used for both purposes, it is desirable to provide some arrangement (tone controls on an amplifier, for example) to change the overall frequency response to suit the application. Wide-range microphones with extended low-frequency response are particularly poor to use for voice announcements over loudspeaker systems initially set up for music distribution. A small network can be inserted in the microphone lead, if the amplifier used has a bit of reserve gain, to roll off the low frequencies when the microphone is used for speech announcements. A suitable network is shown in Fig. 5-6.

The response characteristic needed depends on the intended use. For a roundtable discussion a circular pattern is desirable. A directive characteristic is best for an interview so only one person will be heard at a time, and when there is a noisy background, etc. Also, a very directive characteristic is usually essential if the loudspeaker system is located near the microphone to prevent coupling (feedback) from the loudspeaker back into the microphone.

The response characteristic cannot be determined by the appearance of a microphone. For instance, the circular looking microphone of Fig. 5-7 actually has a directive response characteristic. The response can be determined only from the microphone specifications or by testing the microphone. If the latter can be done, a good approximation of the microphone pickup characteristic can be obtained by moving a small battery operated audio oscillator-miniature loudspeaker combination about the microphone and noting how the output of the microphone amplifier varies. If the audio oscillator is a sine-wave type, the test can be done at different frequencies. This is not a very exact test but it does provide some general indication of the microphone's directional pickup characteristics.

The impedance level should usually match that of the amplifier input. This is always true in the case of a low-impedance input. In the case of a high-impedance input, a high-impedance microphone should also be used as long as its cable length is less than 8 to 10 feet. When the cable length is greater, a low-impedance microphone should be used, along with an impedance stepup transformer at the amplifier input



Fig. 5-7. The pickup characteristic of a microphone are not apparent from the appearance. This microphone, a Shure 558SA, actually has a sharp directional pattern.

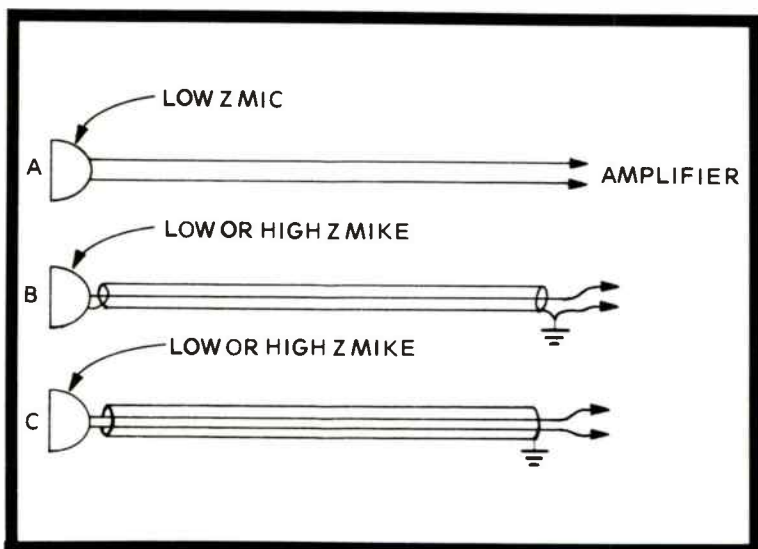


Fig. 5-8. Three ways of connecting low-impedance microphones. The shielded pair (C) provides the best protection against external noise pickup.

to provide the correct match. In this manner, cable lengths of 20 to 40 feet can easily be accommodated. You may find that the output level in such a setup, due to the inherently lower output level of some dynamic microphones (not because of the cable length), is not sufficient. In this case, a small preamplifier can be used at the amplifier input. Such a preamplifier usually provides the necessary impedance matching so a transformer is not required in addition.

CONNECTING THE MICROPHONE

Various microphone connections are possible, depending upon the type of microphone used, the distance to the amplifier, and its input impedance. The simplest type of connection is shown in Fig. 5-8A where a very basic 2-wire unshielded line is used between a low-impedance microphone and the input of a low-impedance amplifier. At a low-impedance level (600 ohms or less) cable shielding and loss is relatively unimportant and a very long cable can be used without difficulty. Cable shielding, however, even at a low-impedance level, provides an extra measure of protection against stray external fields and should be used whenever feasible.

The basic forms for cable shielding are shown in Figs. 5-8B and 5-8C. The unbalanced shielding of Fig. 5-8B is usually sufficient. When strong RF fields are encountered, such as in a broadcasting station; the balanced shield system of Fig. 5-8C will prove to be particularly advantageous. This sort of system is, in fact, used by most broadcasting stations, and even in nonbroadcast applications it provides an extra degree of protection against the pickup of stray interference fields. Microphone connections over distances of more than 100 feet have, in fact, been accomplished very easily with this type of connection and provided full response without harmful noise pickup or attenuation.

The situation with high-impedance microphones, however, is drastically different, as shown in Fig. 5-9. Even moderate cable lengths of 20 to 40 feet affect the response by 2,000 Hz, and particularly long cable lengths can render a high-impedance microphone almost useless for anything but the poorest voice reproduction.

In reality, the situation is far worse than that portrayed by Fig. 5-9, since a cable operating at a high-impedance level will pick up considerable hum and noise. If a high-impedance microphone is the only type available and if it must be used with a high input impedance amplifier over a considerable

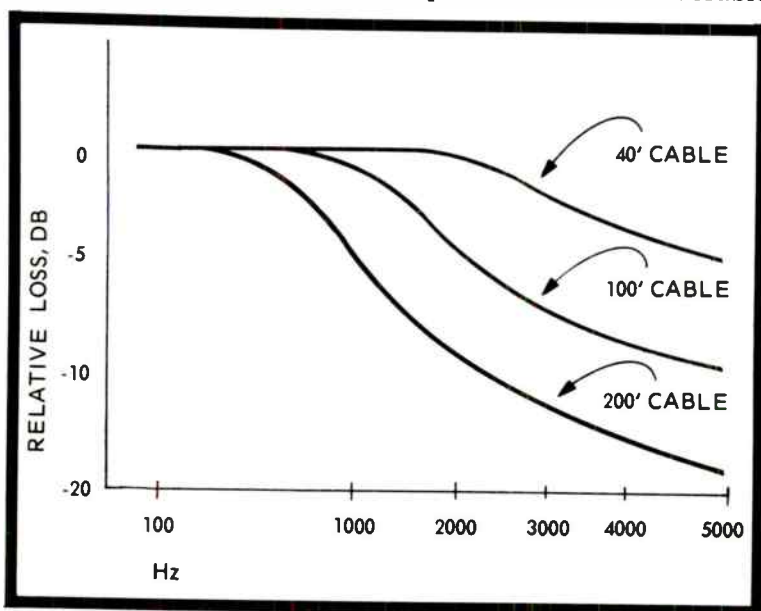


Fig. 5-9. The curves illustrate the loss caused by various cable lengths in high-impedance microphone circuits.

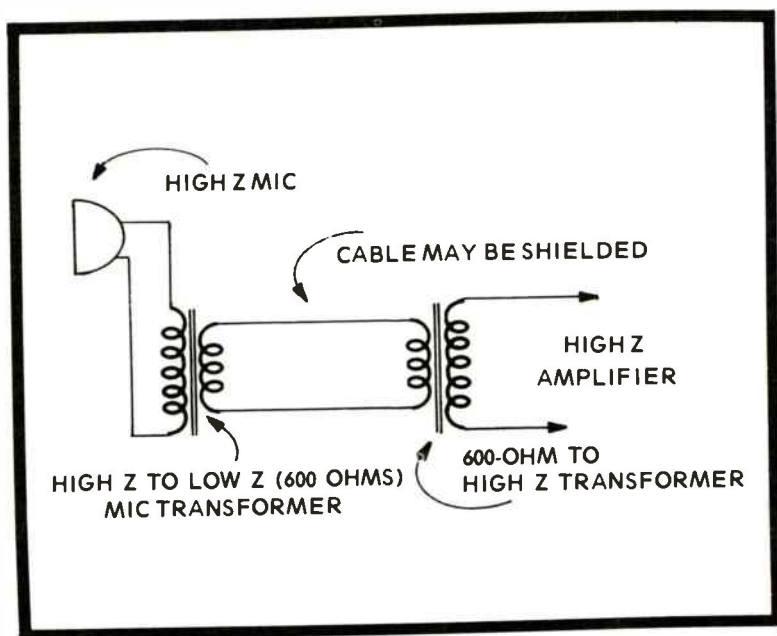


Fig. 5-10. With impedance matching transformers, it is possible to use a high Z microphone on long cables without the losses accompanying high-impedance cable runs.

distance, a transformer should be inserted at the microphone to convert its output to a low impedance and another transformer at the amplifier input to go back again to a high impedance. These connections are illustrated in Fig. 5-10. If a low-impedance microphone is already available, it can be directly connected to the cable and a transformer used only at the amplifier input. A low-impedance microphone used with a low-impedance amplifier input, of course, requires no transformer.

The transformers themselves can be subminiature units and built into the microphone enclosure, the amplifier enclosure, or in an external metal enclosure. Another possibility is to purchase an in-line transformer, as shown in Fig. 5-11, which is simply "wired in" the microphone cable with standard microphone connectors.

In a rare case, you may have a microphone with a built-in amplifier which provides too much output. If the microphone amplifier itself cannot be adjusted, an in-line attenuator, similar to the in-line transformer, can be purchased to reduce the gain. It should be used at the input to the main amplifier.

PREAMPLIFIERS

Preamplifiers are mainly intended to provide additional amplification for a microphone, either where the microphone output itself is inadequate to drive a main amplifier or to boost the microphone output when a particularly long microphone cable is used so that the ratio of signal level to noise level along the microphone cable always remains high. Thus, even if the microphone cable should pick up some noise, it will not affect the final quality. Preamplifiers, in addition, can usually provide an impedance-matching function so that transformers are not necessary.

For communications purposes, such as with a CB transceiver, preamplifiers are often combined with speech compressors. The latter type of device is designed to increase the amplification level when faint sounds are delivered to a microphone and to decrease the amplification level when particularly loud sounds reach the microphone. The result is that the average speech level input to the transceiver is kept high and the average modulation level is likewise high. A compressor is not useful for normal music pickup because it would greatly distort the natural ratio between soft and loud passages. However, for public address systems and for roundtable speech discussions, the addition of such a device is very useful. In the former case, it can add considerably to the power of an announcement and in the latter case, it compensates for the different levels of individual speakers.

A wide variety of commercial preamplifiers and preamplifier-compressor units are available. Some come in the form of basic printed-circuit boards, semicomplete units



Fig. 5-11. Typical "in-line" microphone matching transformer.



Fig. 5-12. A typical commercial-type compressor-preamp. The switch places the unit in or out of the microphone circuit.

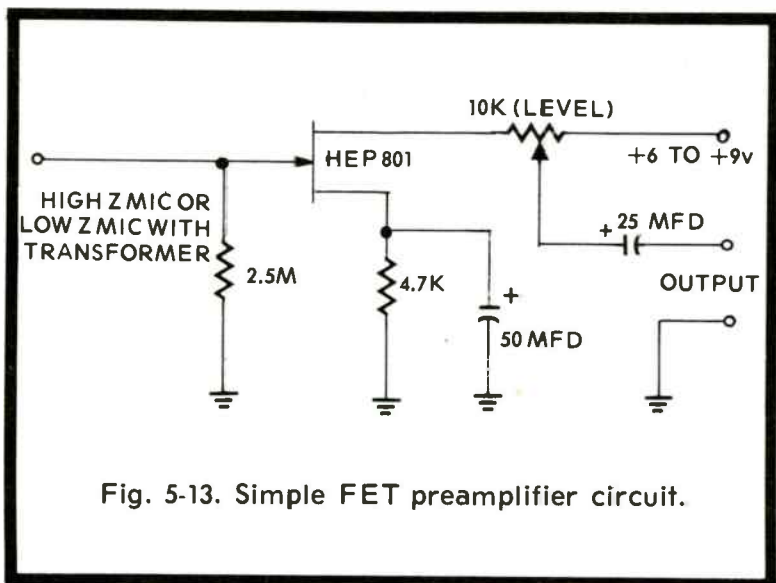


Fig. 5-13. Simple FET preamplifier circuit.

requiring external batteries and connections, and completely enclosed units with a meter to indicate the level of amplification or compression. A typical unit is shown in Fig. 5-12. These units should be connected according to the directions supplied with the unit.

Suitable preamplifier or compressor units can be constructed, if desired. Fig. 5-13 shows the circuit of a very simple but high quality preamplifier which utilizes an FET (field-effect transistor). The unit has a particularly wide frequency response, combined with high gain and a very low internal noise figure. It can also be operated from a wide range of battery supply voltages, starting with a simple 6- to 9-volt transistor radio battery supply. The input impedance to the circuit is high, across the 2.5-megohm resistor, to the gate of the FET. The output impedance is suitable for connection to either a low- or high-impedance amplifier. The 10K potentiometer in the output permits adjustment of the output level.

A low-impedance microphone input can also be accommodated in either of the two ways. The best response must be determined by experimenting. One method is to "lift" the ground end of the 50-mfd capacitor going from the source terminal of the FET to ground and connect the ground terminal to the microphone input, still leaving the gate terminal connected to ground via the 2.5-megohm resistor. The other method is to replace the 2.5-megohm resistor going from the gate lead to ground with a 10K to 100K potentiometer; the outer terminals of the potentiometer are connected between the gate terminal and ground and the contact arm of the potentiometer forms the input lead. The circuit will provide a voltage gain of from 100 to 200 times, which should suffice to raise the output of any low-level microphone to that required for normal amplifier operation.

The circuit of a very simple but effective preamplifier-compressor is shown in Fig. 5-14. This compressor circuit was developed by the author as a simple, single-stage unit for amateur radio use. The collector load resistance of the single-stage audio amplifier varies according to the degree of signal level (input). With increasingly strong input signals, the diodes begin conducting and reduce the collector load resistance and output in reverse proportion to the input signal increase. The circuit works best when the output is connected to a high-impedance load so the diodes can conduct in sequence with an increasing output voltage swing from the transistor. The circuit is designed for use with high-output microphones. Low-output microphones require the use of a preamplifier ahead of the compressor unit.

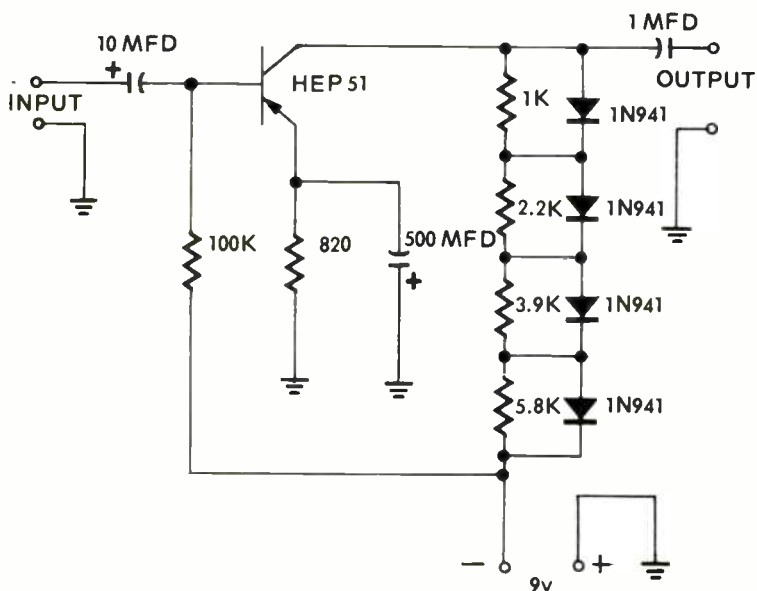


Fig. 5-14. This simple circuit provides gain as well as signal compression.

MULTIPLE MICROPHONES AND STEREO

It is often necessary to use several microphones to adequately pick up the sounds from a musical group or from individual speakers when they are widely separated. Microphones can be simply connected in parallel and phased, but usually it is desirable to control the output level from each microphone independently. If this is done, it is necessary that each microphone output be well isolated from the others or truly independent output level control is not possible.

A circuit usually known as a mixer is used to combine the output from several microphones. Such units are available in a wide variety of commercial forms. They can also be easily constructed. A circuit for a 3-microphone mixer is shown in Fig. 5-15. Additional channels can be added if desired. Each channel has an FET preamplifier which provides some gain at a very low noise level. If you don't want to construct the FET amplifier, a module type preamplifier can be used instead for each microphone and the external potentiometers added. A potentiometer is used to control the output level of each microphone channel and another potentiometer functions as a master volume control.

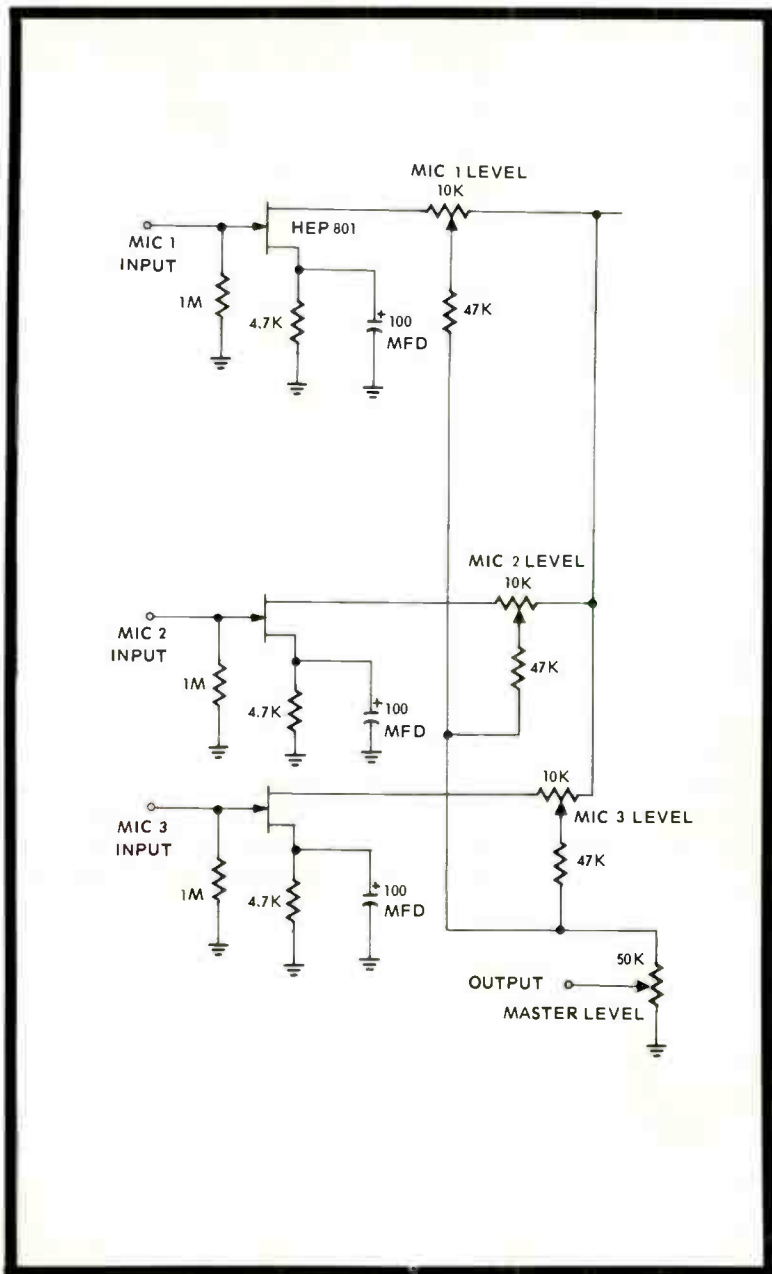


Fig. 5-15. High-quality 3-channel FET mixer-preamplifier.

Before several microphones are permanently wired in for use together, they have to be perfectly phased. This can be done by selecting one microphone as a reference. The microphone to be phased with the chosen "standard" is placed next to it and both are connected to the same amplifier. When both microphones are spoken into simultaneously, the overall sound output level should slightly increase. If it decreases, the second microphone is working out of phase with the reference microphone. The situation is corrected by reversing the lead connections to the second microphone.

If the microphone has a single-conductor shielded cable, the leads at the terminals inside the microphone capsule should be reversed. If the microphone has a 2-wire balanced output, the leads can be reversed at the microphone connector or even at the mixer input connection. The same phasing process is followed for each microphone used.

Microphones used for stereo pickup also have to be phased in the same manner as described above. The job is just made a bit easier, however, by placing the stereo-mono switch on the amplifier to monaural and determining whether or not the total volume output increases or decreases as one mike is moved next to the other. As before, both are exited by the same sound source, of course.

The above phasing process, once carried through, does not have to be repeated unless microphones are changed or different preamplifiers used, etc. If you are involved in a situation where a great deal of microphone cabling is used and interconnections are changed frequently for different microphone setups, the only way to preserve phasing is to carefully mark the polarity of each connector so that they are always connected in the same manner.

VOICE TECHNIQUES AND ROOM EFFECTS

As you gain experience with the use and placement of microphones, many special effects can be obtained. However, at the start it is best to follow a few simple ground rules and then experiment as desired.

Place the microphones as close as practical to the sound source. For instance, an amplifier may have sufficient gain to allow a microphone to be placed 10 feet away from a musical instrument, but placing it closer will reduce the pickup of stray background noise. During a voice recording, don't get so close to the microphone as to touch it. The result will be scratching noises and an overexaggeration of breathing sounds. If a microphone must be used very close to a speaker,

as may be the case outdoors on a windy day, cover the microphone grill with a wind filter. Such filters can be purchased, but they are also inexpensively made. They consist of $\frac{1}{4}$ to $\frac{1}{2}$ -inch thick layers of the foam plastic material used for cushioning in packages.

Don't shout into a microphone; it will usually only create distortion. Let the amplifier do the work of raising the level of a soft passage. With practice, you can provide emphasis to various spoken or sound passages simply by moving slightly towards or away from the microphone, with hardly any need for great changes in voice level. Remember, with most microphones the bass response increases as the microphone is placed closer to the sound source.

Books have been written on the subject of room acoustics for recording, microphones placement, etc.; therefore, only the main principles need be covered here. No single best arrangement can be defined, and microphone placement and sound effect treatment still remain both a matter of taste and experimentation, even in professional recording studios.

There are two main areas to consider when trying to set up a room for recording purposes. One is to have the room isolated as far as possible from external sounds, both those conducted through the air and those conducted by structural members of the building. In a studio this means air-tight doors and a "floating" type of construction for the room so that you have, in effect, a room within a room. In the usual situation where one has to make do with the space available, there is not much that can be done, except to keep doors and windows tightly sealed and to be sure that the microphone itself, or the table it sits on, is not conducting structure-borne noises.

The other main point to consider is the acoustic quality of the room. A microphone receives direct sound from the speaker and indirect sound reflected from the walls and other objects in the room. If the room reflects sounds very well, or really too well, it causes the pickup to sound distorted and high-pitched. If the room reflects hardly any sound, the pickup sounds dry and lifeless.

In many recording studios the ceilings and two side walls are covered with sound absorbing material. The other two walls are equipped with adjustable panels which have sound absorbing material on one side and a hardwood surface on the other side. The panels are turned to provide the necessary balance between a "live" sound with some reflection and a "dry" sound with no reflection. The usual problem with home recordings, however, is that of too much reflection. Make a recording outdoors on a quiet day without any obstructions

around and then indoors in a recreation room; the difference in sound quality will be immediately apparent.

To improve indoor recordings, sound absorbing material can be added to the ceilings and walls. If a speech recording home studio is desired and some small room is available, try placing on the ceiling and walls the paper separators used to ship eggs. These square-shaped forms with their multiple cone shapes make a remarkably good sound absorbing material. In fact, some radio stations during times of economic hardship have used these trays to line a simple studio with very effective results. As a minimum, try building a single wood-frame panel, as large as possible, and cover it with sound-absorbing material or tiles; place the panel several feet behind the microphone which the speaker uses (the speaker faces the panel). Even this simple device can considerably improve the sound quality of a recording made in an otherwise untreated room. Make several test recordings and vary the distance between the speaker and the panel for the best sounding result.

The placement of a microphone or microphones when trying to record a group performance depends upon the type of room used and the type of group being recorded. For a roundtable discussion group, an omnidirectional microphone in the middle of the table or, better yet, suspended in the center at about head level will suffice. For a choral or music group in a hall, a common practice is to use a single microphone suspended somewhat above the place where the conductor stands. The theory is that the conductor's position provides the best balanced sound point, since he directs the group for the sound effect he can hear.

For dance bands, rock groups, etc., a multiple microphone arrangement is more common, with a microphone placed before each major instrument or singer. The theory here is that only direct sound from the instruments is important because of the fact changing sounds; the "liveness" missed by not picking up reflected sound mixed with the direct sound is not important. The effect of "liveness" can be artificially injected by using some sort of reverberation amplifier.

Microphone placement for stereo recording follows two general forms. Both methods are used professionally, along with several others which require very specialized equipment. The first of the two methods is the side-by-side microphone placement shown in Fig. 5-16A. The technique is suitable for microphones with an omnidirectional response pattern, although microphones with a cardioid pattern provide a more pronounced stereo effect. Even though both microphones are

at the same point, the sound intensity arriving from each side will vary and this provides the stereo effect.

The other setup method uses separated microphones as shown in Fig. 5-16B. Again, either omnidirectional or cardioid response microphones can be used. If only omnidirectional microphones are available, this method is preferred over the side-by-side type of microphone placement. If cardioid response microphones are used, improved results will be realized if each microphone is slightly turned towards the center so there is a slight overlap of pickup from both microphones in the center area.

The disadvantages of both techniques, except when cardioid microphones are oriented as last described, is that a dead spot appears in the center of the pickup area. One method used to correct this defect is to place a third microphone in the middle. The output of the center microphone is fed in equal amounts through an attenuator to the other two microphone channels. The level adjustment used to fill in the center sound is determined by trial and error so the stereo effect is not destroyed.

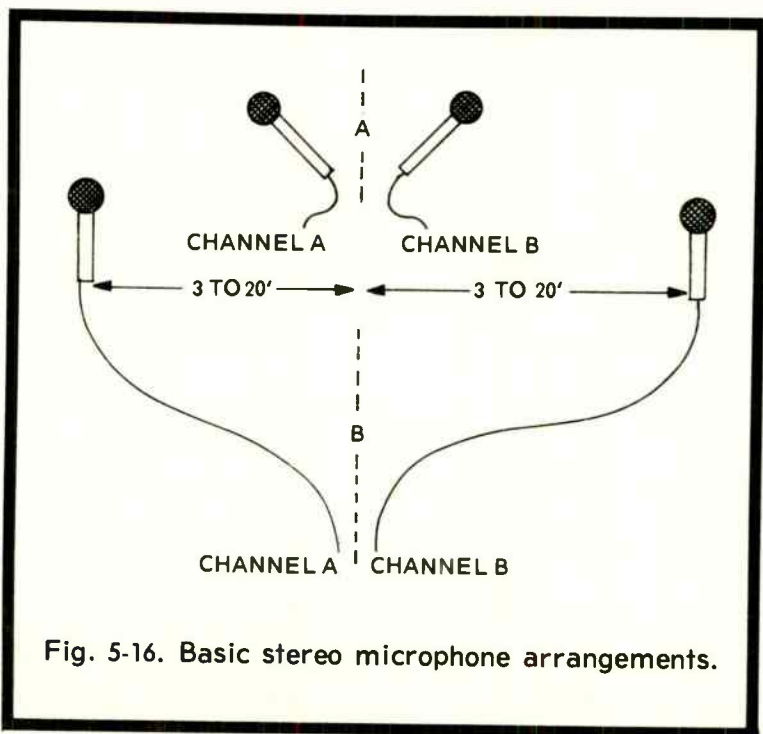


Fig. 5-16. Basic stereo microphone arrangements.

MUSICAL INSTRUMENT MICROPHONES

Musical instrument microphones differ somewhat from the usual type in that they are "contact" microphones. Otherwise, they are connected and used in the same manner as any microphones. As the name suggests, contact microphones attach directly to a musical instrument and pick up the sound by contact with the body of the musical instrument. For example, a guitar microphone attaches below the bridge in the instrument. The output from such a microphone slightly alters the musical sound of the instrument but rarely to a degree that proves objectionable. For a soloist performance, however, a conventional acoustic microphone pickup will provide a truer sound. A good way to experiment with the sounds available from a musical instrument is to feed the contact microphone into an amplifier and listen on a pair of headphones.

CB EXTENSION MICROPHONES

Many CB transceivers, as well as commercial transceivers designed for hand-held use, utilize the loudspeaker as the microphone in the transmit mode. This requires that the unit be held very close to the mouth for effective modulation. When using a hand-held transceiver in a fixed location, it is very handy to be able to set the transceiver down and utilize an extension microphone for transmitting. The built-in speaker then functions only as a loudspeaker during receive.

There are many ways to connect such an extension microphone, depending upon whether or not you want to modify the internal wiring in the transceiver. For instance, as shown in Fig. 5-17, a switch inside the transceiver usually transfers the speaker between the receive and transmit circuits. The switch could be rewired so that only the speaker is connected during receive and during transmit a connection is made to an external microphone with a preamplifier.

The complete circuit (shown in Fig. 5-17) requires no modification to the internal switch. Connection has to be made only to the speaker terminals within the transceiver. A standard microphone, preferably of the communications type, and a module type preamplifier and matching transformer are used. The module should be a type which allows a gain control to be used. The matching transformer couples the output of the module to the impedance of the speaker, which may vary between 8 to 100 ohms, depending on the transceiver. The transceiver schematic in the instruction book

usually indicates the speaker impedance value. In the transmit mode, the extension microphone, through its preamplifier, modulates the transceiver. The preamplifier gain control should be set to the best sounding level in a test with another station. The internal transceiver speaker is still in the circuit, but its sensitivity is so low that if you speak several feet away from it, it will not be effective. In the receive mode, signals are supplied to the loudspeaker as usual.

To prevent damage to the preamplifier module, two power type silicon diodes are connected across the matching transformer as shown. The diodes place a short across the transformer winding if the voltage becomes too high so no damage results to the internal components of the preamplifier.

HIDDEN AND WIRELESS MICROPHONES

Hidden microphones of the miniature and subminiature variety are available from all major mail order parts houses. Such microphones can be fixed in place or worn by a person, and connected to an amplifier, recorder, or small wireless transmitter. Being so small, the frequency response of such

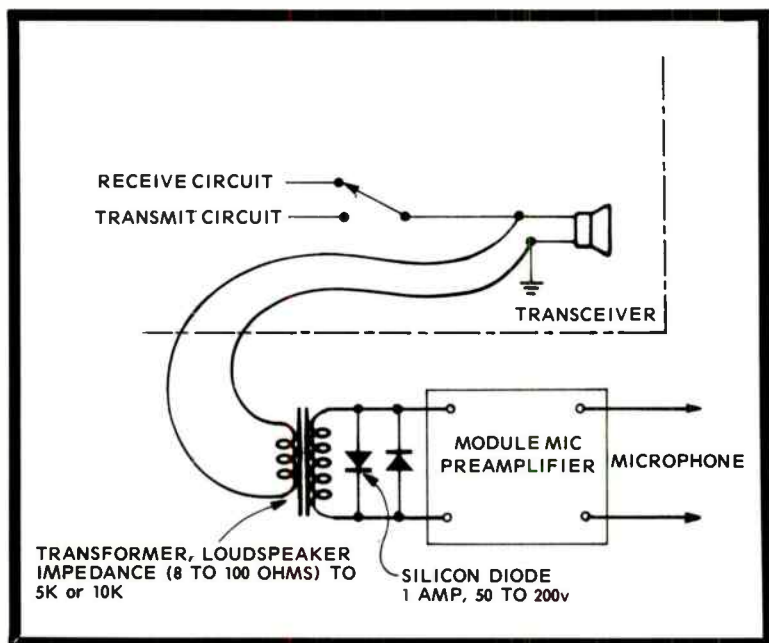
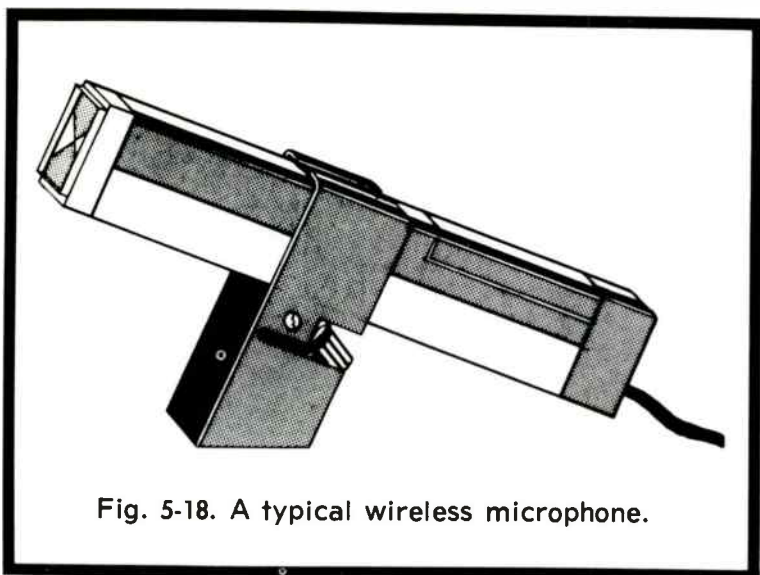


Fig. 5-17. An extension microphone can be added to a CB or other communications transceiver with this circuit.



microphones is poor, particularly for low frequencies. But, they provide adequate response for voice reproduction. The magnetic type, if available, is generally preferable because of its more rugged construction.

The placement of such microphones is more a matter of imagination than anything else. If possible, they should be placed as high as possible so they are on a level with the sound source. Also, a porous grill or foam plastic can be used in front of such a microphone, but not any solid surface.

A very high degree of amplification is necessary with hidden microphones if sounds are to be picked up over any great distance. Generally, a preamplifier should be used as soon as practical after the microphone, especially if there is a long cable connection to the final amplifier location. Contact-type microphones are also useful as hidden microphones, especially if they can be fastened to the hidden side of some device that can act as a sounding board in a room. A plastic tube connected over the end of a miniature button-hole microphone can also be used to extend the corners or places into which it can reach. Specialized microphones, such as spike microphones for driving into a wall, are available but they are expensive.

Wireless AM and FM transmitter modules are available at a reasonable cost and can be purchased as complete assemblies, such as the unit shown in Fig. 5-18, or assembled from the necessary modules. The output in either case can be

picked up on any standard AM or FM receiver. If a miniature microphone is used, the unit will be suitable only for voice reproduction. However, with a better grade microphone, the fidelity is good enough for such purposes as recording bird calls, etc.

The main disadvantage of the basic units or modules is their lack of sensitivity as far as sound pickup is concerned. Additional audio amplification is needed if you want to pick up sounds 10 to 20 feet away from the microphone. A simple audio amplifier, built by the author, which considerably improved the sensitivity of an FM transmitter module is shown in Fig. 5-19. The preamplifier is powered from the same 1½-volt battery which powers the FM transmitter module. The power drain proved to be so low that even with an AA size flashlight battery, the unit remained in continuous operation for several months.

FM transmitter modules are particularly good if you have a good quality FM receiver. The sensitivity of most FM receivers is far better than AM receivers and it is a simple matter to construct a small antenna which extends the range of the transmitter module, FM receiver, or of both.

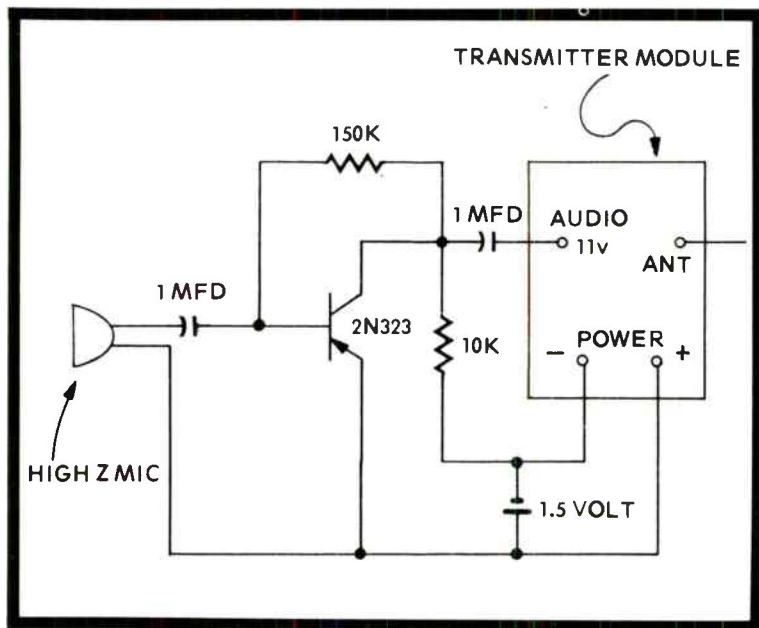


Fig. 5-19. Simple amplifier circuit designed to the range of a wireless microphone.

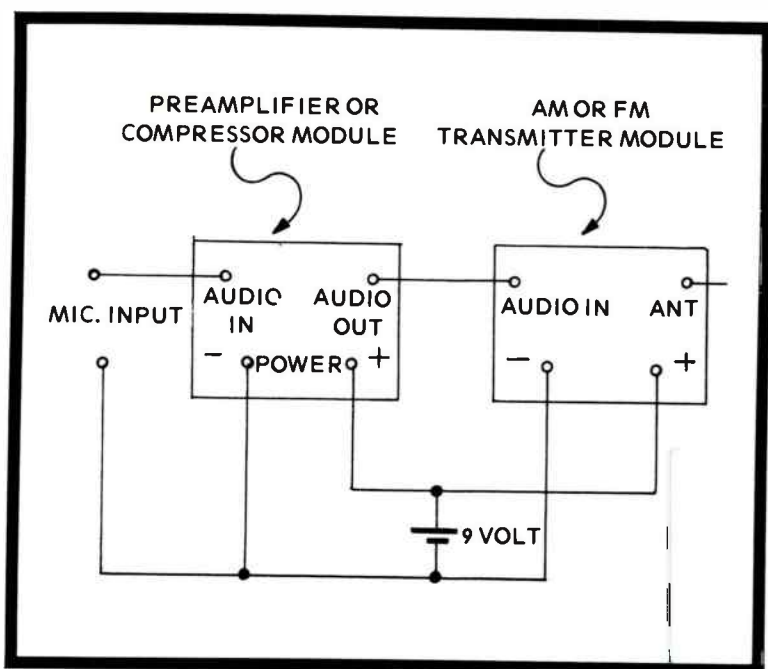


Fig. 5-20. The addition of a preamp or compressor module will increase the sensitivity of a wireless microphone.

The sensitivity of a wireless microphone can also be increased with an audio preamplifier-compressor module as shown in Fig. 5-20. A compressor type module is particularly useful when it is not important to preserve the dynamic range of the sound that is picked up, since it will prevent overmodulation of the wireless module. Overmodulation often causes the little modules to shift the output frequency.

Imagination is again the key to the use of such modules if you are trying to make hidden recordings. The power line can often be used as the antenna for such modules, but not by making a direct connection to the line. Instead, the wire from the antenna terminal of the transmitter module is wrapped around the power line for several inches in the form of a coil. If a speaker is available in the room being used, such as the speaker in a radio, it can be used as the microphone pickup.

FEEDBACK PROBLEMS

Feedback refers to situations where some of the sound energy reproduced by a loudspeaker is coupled back into the

microphone. When this happens, the amplifier acts as an oscillator and squeals and howls result. The only way to cure this problem is to somehow terminate the feedback path. Often, this can be done only by experimenting with loudspeaker and microphone placement. The substitution of a directional microphone for an omnidirectional type may also help. Adjusting the tone controls on an amplifier may minimize the effect, too, since feedback is usually frequency selective. If none of the preceding suggestions work, try reducing the amplification level, assuming this can be done and still provide adequate service. When using a very selective wireless microphone, the only cure for feedback is often the use of headphones at the receiver. Even the mere output of the speaker at distances of 50 to 100 feet, when a high degree of amplification is used, can cause the system to go into oscillation.

This acoustical type of feedback should not be confused with electrical feedback. The latter is often deliberately built into circuit design to improve the frequency response and the stability of an amplifier.

Chapter 6

FM and TV Antennas

A good antenna system is one of the main elements in achieving good FM or TV reception. On one hand, a really good antenna system can almost make a poor receiver perform well. But a good antenna system improperly installed or poorly thought out can result in worse reception than the indoor or built-in antennas on many sets. This is particularly true for UHF television reception. Many people have tried installing their own outdoor UHF antennas, only to find that the receiver performs worse than with a simpler antenna mounted right next to the TV set.

COMMERCIAL ANTENNA TYPES

The appearance of various antennas may lead you to believe that there is almost an infinite variety of types. Actually, there are only a few basic antenna types and by understanding their basic characteristics it is possible to plan for the installation of almost any commercially made antenna.

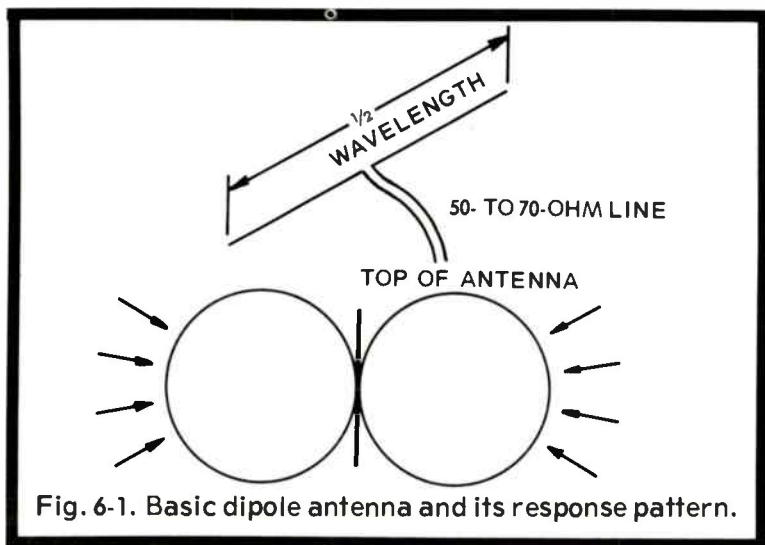


Fig. 6-1. Basic dipole antenna and its response pattern.

The simplest form of antenna, a dipole, is shown in Fig. 6-1. Indoor antenna types of the "rabbit ears" variety are dipoles. Theoretically, the antenna's total length should be a half wavelength at the operating frequency. In fact, this length is roughly equal to 460 divided by the desired frequency expressed in MHz. For instance, for an FM station operating on 92 MHz, you would make the overall length of such an antenna five feet.

The response or pickup pattern of the antenna shown in Fig. 6-1 is bidirectional; that is, it receives equally well in both directions at right angles to the line of the antenna and has very poor pickup from the ends of the antenna. The terminal impedance of the antenna is 50 to 75 ohms and so can be directly connected to a transmission line of this impedance. Normally, it should not be connected directly to such lines as 300-ohm twinlead.

Basically, a dipole is a single-frequency antenna. That is, it can be used for reception of only one channel for the best results. In practice, such antennas are often used as indoor antennas, connected with short pieces of 300-ohm twinlead to a set, for general purpose all-channel reception. They still can provide pickup in such a case, although their performance is hardly much better than if you simply connected an equivalent length of simple hookup wire to the set. Often by taking the time, when such an antenna has telescoping elements, to set those elements to the correct length for a specific channel, an improvement in performance will be obtained.

A simple variation on the basic dipole is shown in Fig. 6-2. The folded dipole antenna has basically the same pickup pattern as a simple dipole antenna. However, its terminal impedance is about 300 ohms, so it can be connected directly

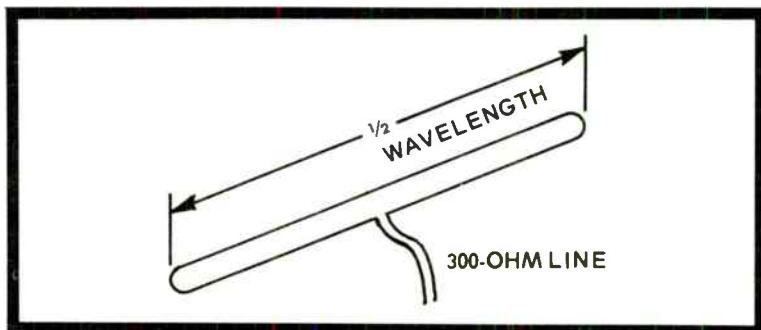


Fig. 6-2. A folded dipole has the same response as a dipole but its bandwidth is greater and it can be connected directly to a 300-ohm line.

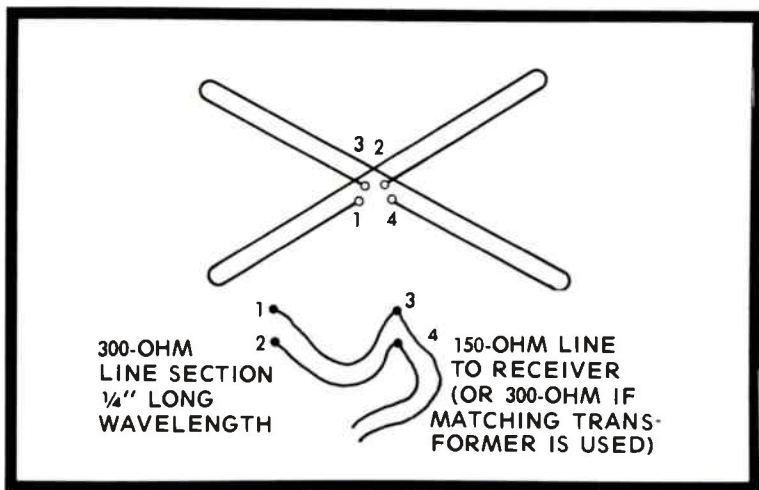


Fig. 6-3. A "turnstile" antenna consists of two folded dipoles mounted at right angles to each other.

without signal loss to any type of standard 300-ohm transmission line. A greater advantage of this antenna form is its increased bandwidth. Such an antenna, when cut to a half wavelength at a frequency about at the center of the FM band, for instance, will provide satisfactory performance over the entire FM band. Similarly, a folded dipole element is often used as the main element in more elaborate multielement antennas designed for the VHF or UHF TV channels.

Folded dipoles are often combined to form a non-directional "turnstile" antenna, as shown in Fig. 6-3. Such an antenna is often used for FM reception when it is desired to receive stations from different directions and where you don't want to go to the expense of using a unidirectional antenna and rotator. Notice that the two folded dipole elements cannot be simply connected together. Their terminals must be joined by a phasing line of the correct dimensions. If this is not done, the antenna's response pattern will exhibit deep nulls in certain directions. Such an antenna is rarely used for TV reception since it will pick up not only the direct signal from a TV station but also equally well the same signal after it has been reflected from a building or other structure. Two such signals arriving at a TV set will result in "ghosts" in the picture.

More elaborate unidirectional antennas are often desired for both FM and TV reception. Such antennas can have very sharp directional pickup patterns and usually have to be rotated if it is desired to pick up stations from different

directions. The sharp pattern means that there is less chance of picking up signals arriving from other than the desired direction. Therefore, TV reception is cleaner and without "ghosts," and FM signals are bothered less by interference caused by a number of FM stations operating near the same frequency. You've probably read of special color TV or FM stereo ratings, but in reality there is no such thing. It is true, however, that good color reception does require a higher input signal level at the receiver than black-and-white reception, so a more elaborate antenna will usually give better results. But, you should examine an existing antenna installation first to see if some single change, such as a better transmission line, addition of a booster, etc., would not upgrade the system sufficiently for good service without changing the antenna.

Another confusing term associated with a directive antenna is gain. The impression given is that the antenna amplifies a signal, but this cannot be true since the antenna is a passive structure without tubes, transistors, etc., and no form of energy conversion can take place. A better way to think of receiving antenna "gain" is that the directive pattern means the less noise and undesired signals will be accepted. So, the desired signal is cleaner or has a higher signal-to-noise ratio than the same signal from an antenna having less directivity. Still another way to visualize the situation is to remember that

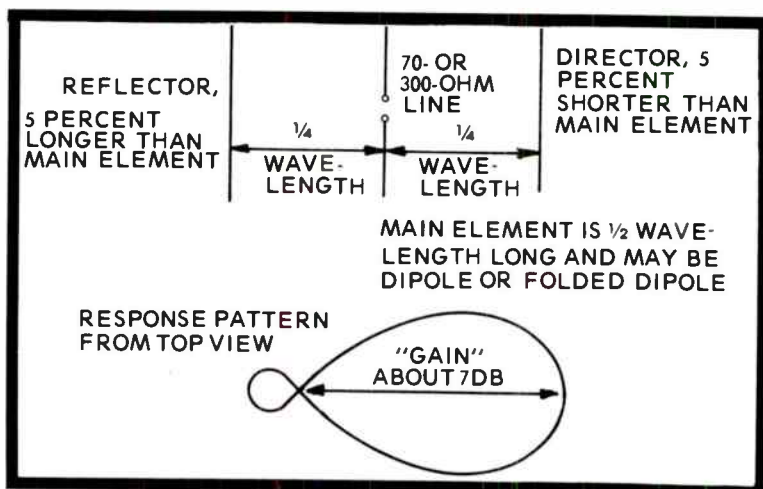


Fig. 6-4. Basic yagi antenna specifications. Yagis come in a wide variety of element spacings. These shown are convenient since a feedline can be connected directly without matching difficulties.

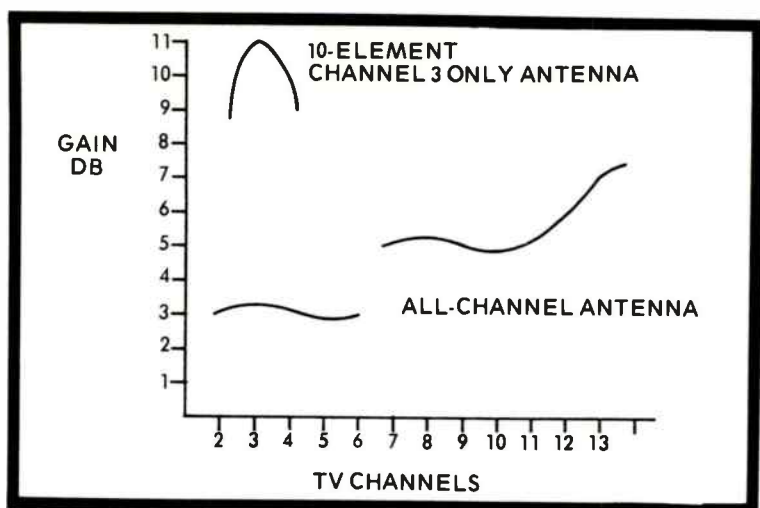


Fig. 6-5. Graph showing the relative gain of an all-channel antenna and a single-channel antenna.

a larger antenna structure, because of its area, is able to extract a higher signal level from a passing electromagnetic wave.

Unidirectional antennas come in a wide variety of forms. One of the most basic is the yagi beam shown in Fig. 6-4. The response pattern is essentially unidirectional. As more elements are added, the pattern becomes sharper and sharper and the signal "gain" increases.

Multiple channel reception with a yagi antenna is achieved in a variety of ways. Usually, a folded dipole serves as the main element, and multiple elements functioning as reflectors and-or directors at certain frequencies are interwoven along the antenna boom (horizontal support member). Such all-channel antennas for VHF reception are necessarily compromise designs, although they can provide good service in many areas.

The compromises involved should be realized, however, so it is possible to properly evaluate which antenna to use. The differences between an all-channel and a single-channel antenna are shown very clearly in Fig. 6-5. The graph shows the amount of signal gain to be expected from antennas of each type using about the same amount of metal. Notice the much lower average gain produced by the all-channel antenna, particularly on the lower frequency channels. If reception on these lower channels is a problem, it may be traceable to the

poor performance of all-channel antennas. Rarely will antenna manufacturers specify the exact gain on each channel and-or make easily available the type of graph shown in Fig. 6-5 for a specific antenna. Nonetheless, you should try to obtain this type of information because it is the only accurate way to compare antennas.

Another type of common unidirectional antenna, particularly for the UHF channels, is the flat screen or corner reflector type shown in Fig. 6-6. This type of antenna has an inherently much better broadcast response than a modified yagi type. Such an antenna can produce a relatively constant gain of 6 to 10 db or more across all of the UHF TV channels. If such an antenna were to be built for the VHF channels, it would have to be of an unreasonable size to realize any useful gain. The antenna also has the advantage of a fairly constant terminal impedance, unlike an all-channel yagi. The yagi may have a "nominal" 300-ohm impedance but, in fact, the terminal impedance on a specific channel could vary from twice to half of this value.

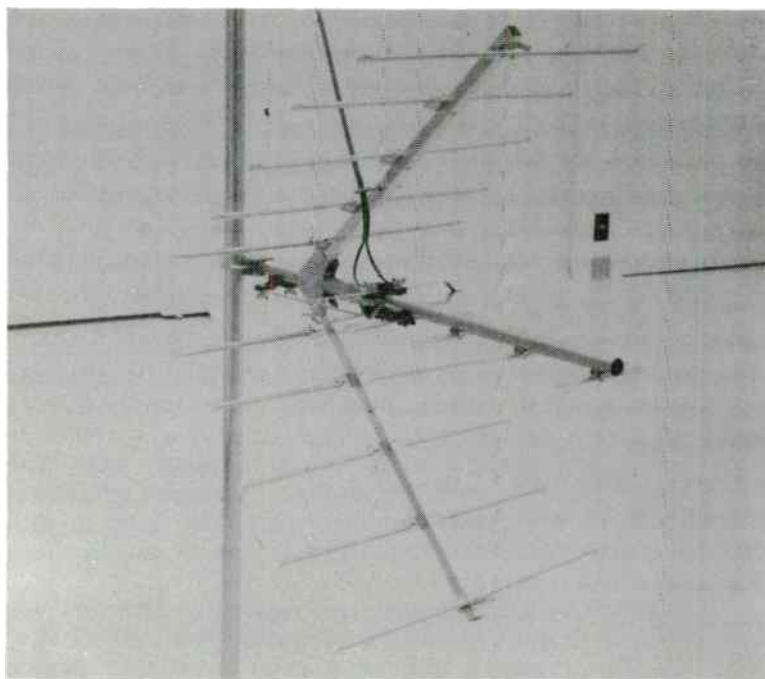


Fig. 6-6. Typical UHF corner reflector. (Courtesy Winegard Co.)

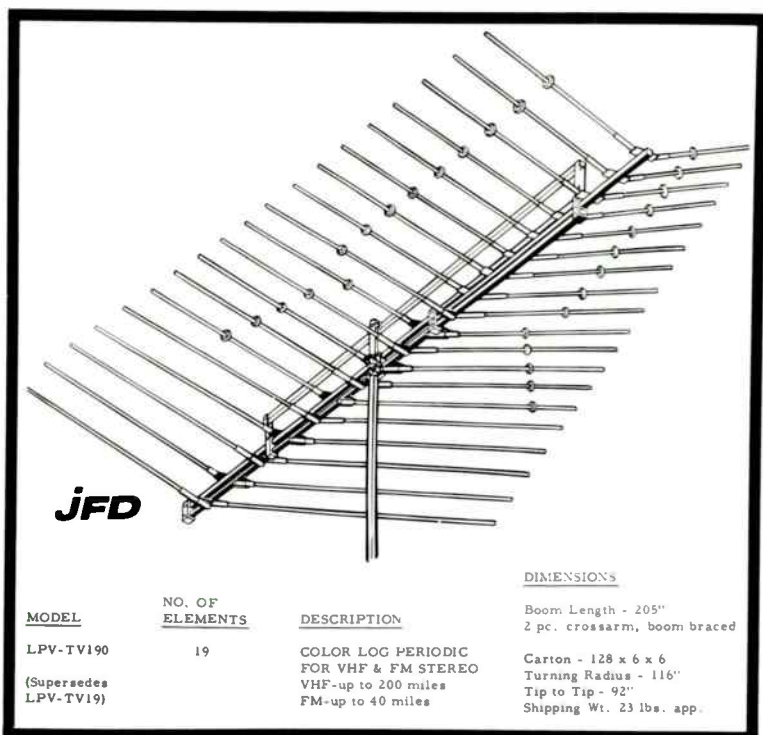


Fig. 6-7. A typical log-periodic antenna for VHF TV and FM reception. (Courtesy JFD)

Still another basic form of a multichannel unidirectional antenna is the log-periodic type, as shown in Fig. 6-7. This relatively new form of antenna is derived from types developed for broadband military communications systems. The main feature of the log-periodic is that all of the elements are electrically connected. Depending upon the frequency being received, certain groups of elements are active to provide antenna action similar to a single-band yagi. The main advantage of the antenna is that it provides somewhat better gain on the lower frequency channels than an all-channel yagi design and its terminal impedance is more constant.

Antennas of a similar type are frequently "stacked" as illustrated in Fig. 6-8, to provide additional directivity. Stacking also provides additional gain of about 3 db. Notice that the gain of the two antennas does not add. Thus, if an antenna alone has a gain of 10 db and it is stacked with another similar antenna, the total gain is 13 db, not 20 db.

Stacking is useful because beyond a certain size of antenna, usually one having 10 elements in the case of a single-channel TV or FM antenna, it becomes very difficult to get additional gain by merely adding more elements. Stacking is usually limited to only two antennas, one on top of the other. However, it can be continued with additional antennas placed on top of each other and even side by side. Tremendously sharp directive patterns can be developed in this manner, but other problems start to develop quite rapidly. For instance, the pattern becomes so sharp that aiming the antenna becomes a major problem. Normal TV rotators do not provide sufficiently accurate resetability once the antenna has been rotated, and even normal flexing of the antenna structure in windy weather causes considerable flutter in the received signal.

HOME-BUILT ANTENNAS

The variety of home-built antennas which can be constructed is limited unless you have good metal working shop facilities, so only a few simple types are presented here. One of the simplest but most useful antennas for FM or VHF TV reception is the folded dipole type. Fig. 6-9 shows dimensions for FM or any specific VHF TV channel. The antenna can be used for two adjacent TV channels by simply making it the dimension halfway between those given for two adjacent channels.

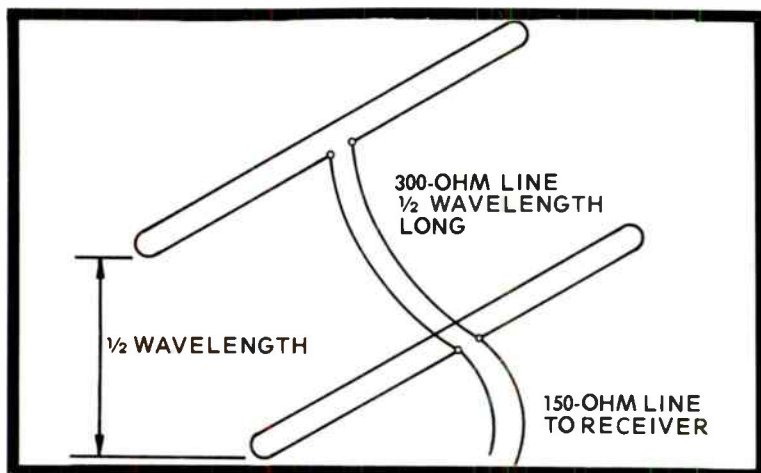


Fig. 6-8. Stacking one antenna a half wavelength above another similar type increases gain by about 3 db.

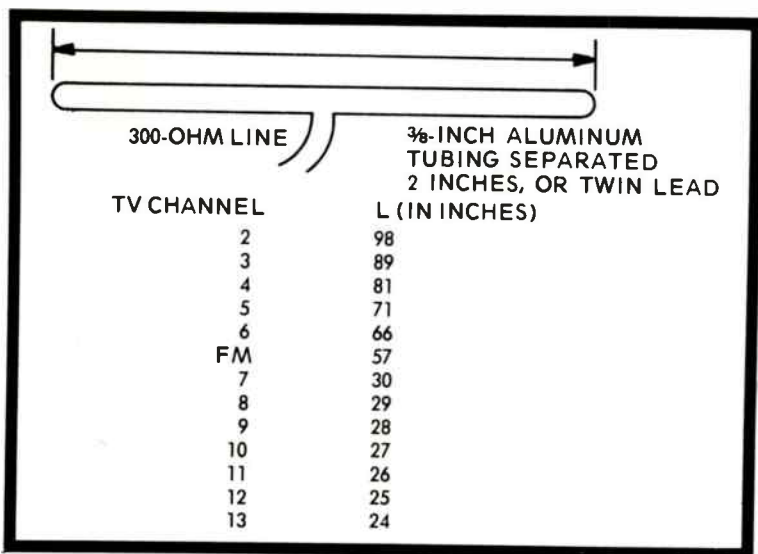


Fig. 6-9. Antenna dimensions for a dipole or folded dipole for FM and VHF TV.

A single folded dipole will usually prove broad enough to cover three of the so-called "high-band" VHF TV channels. For instance, an antenna cut for Channel 12 will receive Channels 11 and 13 equally well. The antenna can be constructed entirely from 300-ohm twinlead, as indicated in Fig. 6-9, or from aluminum do-it-yourself tubing. The latter is, of course, more rigid and it can be supported by some non-metallic arm at its center and rotated for best reception.

A similar type of antenna but one meant specifically for use on the UHF TV channels (14 to 83) is the triangular dipole shown in Fig. 6-10. This antenna's response is very broad, so there is only one dimension for all of the UHF TV channels. The two triangular sections should be made from sheet metal, sheet copper of any thickness being particularly excellent. The two triangular sections can be held together by fastening them to a backing sheet of thin bakelite or phenolic board stock. The antenna is quite directional in its pickup pattern; therefore, it has to be rotated carefully for the best reception of a specific UHF channel.

Building more directive indoor antennas for the VHF TV channels is quite difficult. The situation is usually such that if an indoor folded dipole will not suffice for good reception, a considerable increase in the signal level is necessary. The addition of one or more elements to the basic folded dipole will

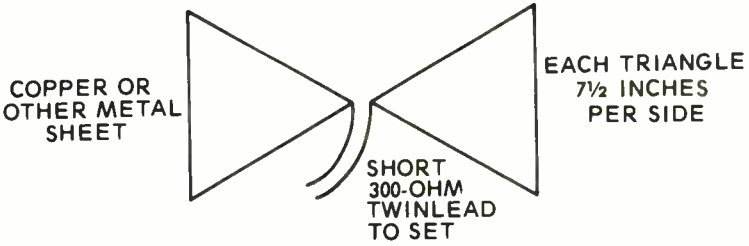


Fig. 6-10. Simple UHF-TV triangular dipole.

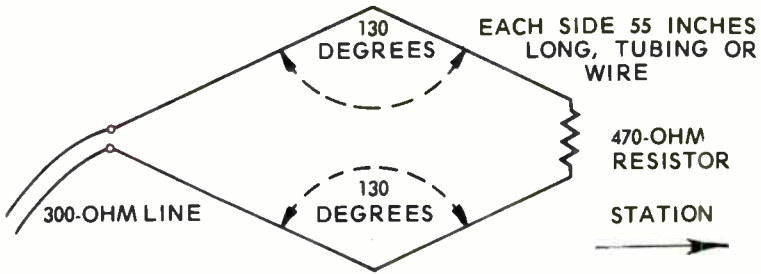


Fig. 6-11. All-channel (14 to 83) UHF rhombic antenna.

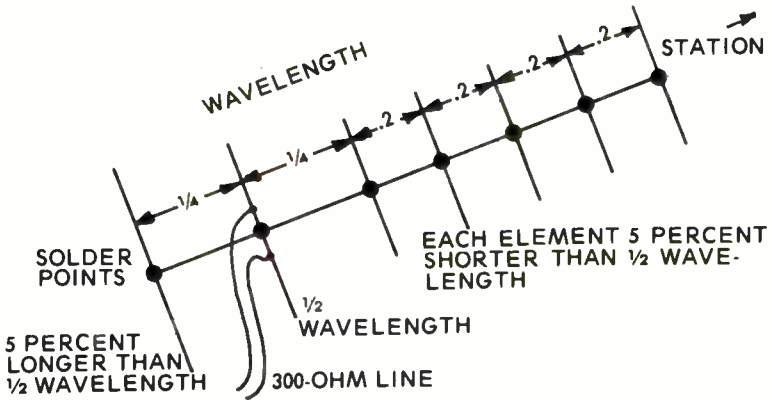


Fig. 6-12. The author's "coat hanger" UHF antenna. Dimensions for any channel can be determined from the table in the Appendix.

rarely increase the signal level to the point where the reception can be changed from poor to good. An outdoor antenna, booster, etc., are required to do this.

UHF reception, however, can be improved by building a better indoor antenna, since the small dimensions of UHF antennas allows the necessary "gain step" from a simple dipole to a simple high gain array. The rhombic antenna shown in Fig. 6-11 will provide about 10 db gain across the UHF channels. It is particularly inexpensive to construct; the side legs can either be copper wire or aluminum tubing. The antenna is especially useful when all desired UHF signals come from about the same direction. The antenna can be mounted in the attic or even at other outdoor locations. Although the antenna could be rotated, it is a somewhat large structure for this purpose. A commercial UHF antenna of more compact design would be easier to use.

An inexpensive but highly efficient antenna for single-channel UHF reception is shown in Fig. 6-12. Termed the "coat hanger antenna" by the author (since that is that basic material used) it is actually a 5 or more element yagi antenna dimensioned for a specific channel. Metal coat hangers or large size copper wire is the only material needed to construct the antenna. No insulators are required. The antenna elements are all simply clamped and soldered or welded to the main metal support element (boom). The 300-ohm transmission line is spaced out on the main dipole element for best reception, but there is nothing critical about the dimensions used. The 300-ohm line to the set's UHF terminals should, however, be kept as short as possible consistent with having enough room to rotate the antenna for the best reception.

MOUNTING AND INSTALLATION

The first rule, usually, is to get the antenna as high as possible, utilizing some convenient mounting feature on a house such as a chimney, plumbing vent, side wall, or even the roof surface itself. Although not commonly done in the U.S., the European system of putting the antenna mast directly through a small hole in the roof and clamping it to one of the main building members in the attic can also be considered. Specially designed mast mounts are available for almost any surface. Fig. 6-13 shows one type of chimney mount. Don't "make-do" with a type of mount not designed for the intended installation. The correct mount can always be obtained by mail order.

The selection of a mounting site should be decided on the basis of height and the shortest possible lead-in run to a

receiver. Stay away from utility wires, electric signs, or other sources of possible interference. If a rotatable antenna is used, be sure there is sufficient clearance in all directions. Usually, in a suburban location there is no great difficulty in deciding upon the location of an antenna. The situation in metropolitan areas is generally much more difficult. It often becomes necessary to temporarily mount an antenna by the crudest means possible in different locations just to see which location should be finally chosen.

The length of the antenna mast depends on the mounting location and the height necessary to clear obstacles. Short 5-foot masts provide far better stability; therefore, it is better to utilize a higher location with a shorter mast than a lower location with a 10 or 20 foot mast.

Whether a mast should be guyed or not depends upon the location. At a coastal location, even a 5-foot mast might be guyed for stability. The cost of the extra material is in-

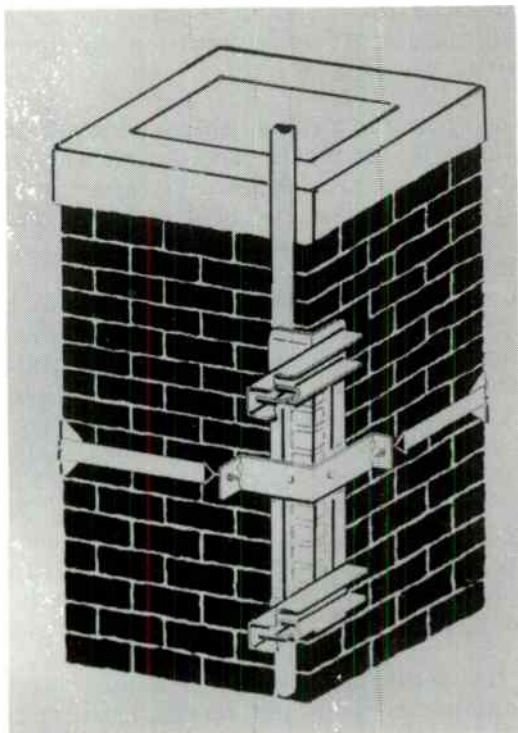


Fig. 6-13. Typical one-strap chimney mount for light TV antennas. Two-strap types should be used for large VHF antennas.

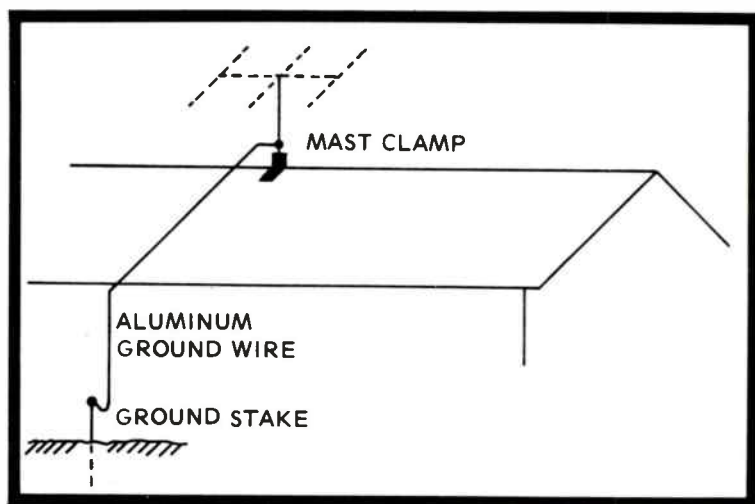


Fig. 6-14. Antenna masts should be grounded directly with a heavy aluminum wire—in addition to the lightning arrester wire.

significant compared to a ruined antenna installation. In less windy locations, 10-foot masts can be used without guys. In any case, when a taller mast is used, guy wires are necessary. The general guidelines for guying a mast are the same as those for tower installations and are discussed in the following section of this chapter.

Often, on suburban lots where there are many trees, it is simply not practical to raise an antenna above the tree level without going to a tower installation. Mast installations are possible up to about 50 feet, but the number of guys involved, plus the fact that the guys have to be re-tensioned yearly if the mast is not to assume a lop-sided appearance, argue against any mast installation above about 20 feet. For FM and TV reception, extreme heights are seldom necessary. Tests made by military communications people have shown that in a temperate climate wooded area, vertically polarized signals are much more severely attenuated than horizontally polarized signals. Fortunately, FM and TV signals are horizontally polarized.

During the actual installation of a mast and antenna system, a number of bolts and screws usually have to be secured. Although these parts appear bright and shiny at the time of installation, a glance at them a year or two later usually reveals a mass of rust. Part of it is the manufacturers' fault, because of a too thin plating, but the greater fault

usually lies with the installer who nicks the plated surfaces. Such nicks are rarely seen, of course, but the nicks eventually allow access to elements that destroy the plating over a large area. It would take a remarkable person to handle tools so carefully as to never nick a plated surface during installation, so it generally pays to coat all bolt and nut surfaces, terminals, etc., after installation with either a clear acrylic spray or a heavy duty automotive grease. Bolt screws, particularly when exposed, should be covered with grease.

Grounding of the antenna mast is sometimes ignored if the lead-in wire is connected to a lightning arrester. However, some local codes specifically require that the mast be grounded separately; it is a good safety measure to follow in any case. A typical ground installation is shown in Fig. 6-14. The material involved is inexpensive in cost and simple to install. In many suburban homes, a ground rod has already been installed somewhere around the house by the telephone company. In installations where a connection to an existing ground rod is not feasible, the most direct connection to a cold water pipe is used. Special pipe clamps are available to facilitate a wire connection to any size pipe.

TOWER INSTALLATIONS

Towers are either self-supporting or guyed. High mast-type installations are always guyed, of course. Unguyed towers are either supported by wall brackets or by stakes which are placed in a concrete base. The strength of the concrete base support is wholly dependent upon the proper pouring and setting of the concrete base. If you are going to do this type of job alone and have had no previous experience in concrete work, a strength test should be made with the concrete mixture. The directions on an 80 lb. sack may appear simple, but many persons, the author included, have found that the strong concrete expected turned out to be a brittle mass, which would be a very dangerous base for a self-supporting tower.

Guyed towers or masts are generally secured by three or four guy wires going from the tower or mast to a ground anchor in the case of a tower or a screw-eye in the case of a roof-top mast installation. Turnbuckles are often inserted in each guy wire to provide a means of tension adjustment.

Three guy wires are most commonly used, although four provide a slight extra degree of safety. The spacing from the mast to the guy wire anchor points varies from half of the tower height when "possible" to about a third when

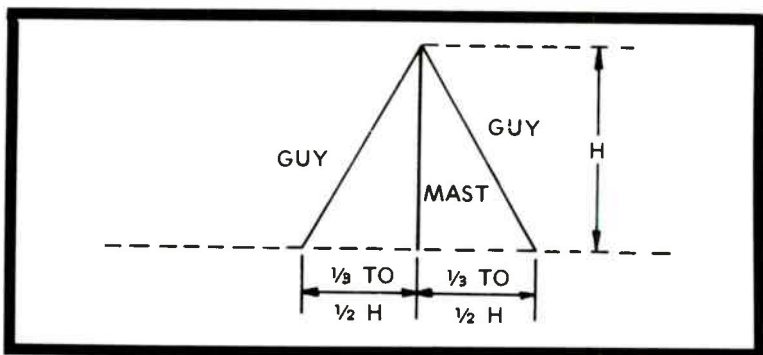


Fig. 6-15. Proper guying dimensions for a tower or mast are indicated in the drawing. If intermediate guys are used, they should anchor at the same points as the top wires.

“necessary.” Fig. 6-15 illustrates a typical installation. Metal guy wires are by far the most inexpensive and reliable. Polyglass wires are sometimes used on high-frequency installations, but they provide no advantage on the usual FM or TV installation. The guy wires themselves are usually simply twined around the hook-eye in a turn-buckle or in a ground anchor. A guy wire or cable U clamp can also be used to secure the guy wire. Such clamps are often used in sets of three with each succeeding clamp reversed. For instance, if the U bolt on one clamp is facing upward, that on the next will face downward, etc.

Tensioning of the guys on huge broadcast towers is determined by strain gauges and becomes a very professional affair. The purpose of tensioning, by the adjustment of turn-buckles, is not to produce the very maximum equal tension on each guy. The purpose is just to provide enough tension on each guy so the mast or tower can flex a bit during severe windy conditions but still not break apart. Unfortunately, without the use of instruments, there is no simple way to specify how tight a guy wire should be. A good rule of thumb is, when flexed, each guy should still be able to vibrate for a few seconds rather than being so tight as to be completely rigid. In other words, there should still be some “give” in the guy.

A tower installation, particularly if it is on top of a building or if it rests on an insulating surface such as stone, should be grounded. A ground rod, driven into the ground as near to the base of the mast as possible and connected to the mast by aluminum grounding wire, is the best means. Special clamps are available for connecting the wire to the ground rod and

tower and they should be used to be sure of good electrical connection.

LEAD-IN TYPES AND INSTALLATION

There are two main factors to be considered when choosing a lead-in type: impedance and signal loss. The impedance is usually the simplest factor, since almost every FM or TV antenna is designed to connect to a 300-ohm cable. There are some instances where you might want to use a different impedance cable; one is a multiple-set installation, and this subject is covered later. There are several different types of 300-ohm cable available, as shown in Fig. 6-16, and you should understand their basic characteristics and the signal loss details as shown in Fig. 6-17.

Flat 300-ohm twin-lead is the most economical type available and its loss for runs of up to 50 feet or so from antenna to set are acceptable for VHF-TV and FM reception in suburban areas next to a metropolitan area. Even in a close-in suburban area, however, its loss becomes too great for UHF reception. Another disadvantage is that in wet weather its impedance characteristics change and the loss increases still further. The disadvantages listed may seem to leave no possibility for the use of such cable. This is not really true. If you are within 30 to 40 miles of a central TV transmitting

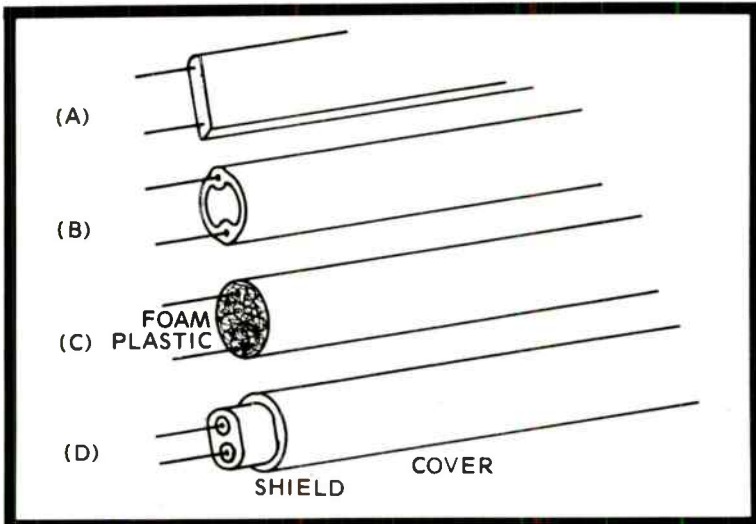


Fig. 6-16. Basic types of 300-ohm cable: flat (A), hollow (B), foam-filled (C) and shielded (D).

CABLE TYPE	LOW VHF AND FM	HIGH VHF CHANNELS	LOW UHF CHANNELS	HIGH UHF CHANNELS
Flat	4.5	7	16	19.5
Hollow	4.5	7	16	19.5
Foam	1	2	3	4.5
Shielded	4	6	10	14

Fig. 6-17. Table of typical 300-ohm cable losses in db per 100 feet. The loss sometimes varies widely for the same cable type. If possible, check the manufacturer's data.

facility, such as the Empire State Building in New York, plain 300-ohm flatlead is perfectly suitable for VHF TV and FM reception.

A slight variation on the flat 300-ohm twin-lead is the hollow tubular type. Its main advantage is that it is less sensitive to the effects of wet weather and is useful in salt-water areas where the cable accumulates a salt deposit which would effect the performance of flat 300-ohm cable.

The most efficient 300-ohm cable is the foam-filled type. It is almost the only common lead-in with a loss factor low enough to allow good UHF reception. Whenever possible, this type of cable should be used. Its slight extra initial cost will go a long way towards providing years of efficient signal transfer.

Shielded 300-ohm twin-lead should be used only in special circumstances. In normal installations, it introduces a higher signal loss than unshielded foam type lead-in. The shielding on the cable does, however, provide isolation from the effects of electrical interference from motors, electrical signs, etc.

The effect that lead-in loss has on antenna system performance can be evaluated by directly subtracting the lead-in loss (in db) for a particular channel or frequency from the antenna gain (in db) at the same channel or frequency. For

instance, assume that a UHF antenna has a gain of 10 db. Let's compare plain 300-ohm twin-lead and foam 300-ohm twin-lead with this antenna. From Fig. 6-17, it should be clear that the signal loss provided by the plain 300-ohm twin-lead for a 50- or 100-foot lead-in run would render the antenna useless.

If the best type of lead-in available has been used and it is not possible to shorten the length of the lead-in, the only way you can compensate for the lead-in loss is to use a booster amplifier. The gain of the booster compensates for the db loss in the lead-in. Since you should compensate for the lead-in loss before it starts to accumulate, the preferred location for the booster amplifier in every case is right at the antenna. The reason a booster placed at the set rather than at the antenna does not do as well is not told by the db loss figures. The reason is that the lead-in wire picks up noise in proportion to its length. The booster placed at the set, therefore, amplifies the accumulated noise along signal.

The installation of unshielded twin-lead of any sort requires that it be held a few inches away from metal and other objects. This is easily done with standoff insulators which are available in a very wide variety of forms; some clamp to the mast, others are nailed into wooden members, etc. Standoffs should be used every 4 to 6 feet so the lead-in, as it flexes, does not touch any surface. Standoffs come with insulators formed to fit standard lead-in sizes. The lead-in is placed in the standoff and then the metal ring around the insulator pinched closed with pliers. The lead-in should not be able to slide back and forth in the insulator.

Don't forget to use a standoff at the antenna terminals if the antenna connection point does not provide a means to hold the twin-lead body. The lead-in cannot be left hanging by its wire leads alone from the antenna. A drip loop at the antenna and where the lead-in enters a building provides for rain drainage so water does not flow down the lead-in and into your home. A lightning arrester, inserted in the twin-lead at the point where it is nearest a ground connection point, is always good insurance even if the mast itself is grounded. With most antennas, some elements connected to the lead-in are insulated from the mast. The ground lead from the lightning arrester may connect to the same point as that used for grounding the mast.

It would be desirable to keep lead-in isolated from surrounding structures right up to a receiver. Unfortunately, this is not always practical where lead-in enters a building or is run across a room. The best you can do in this case is to keep

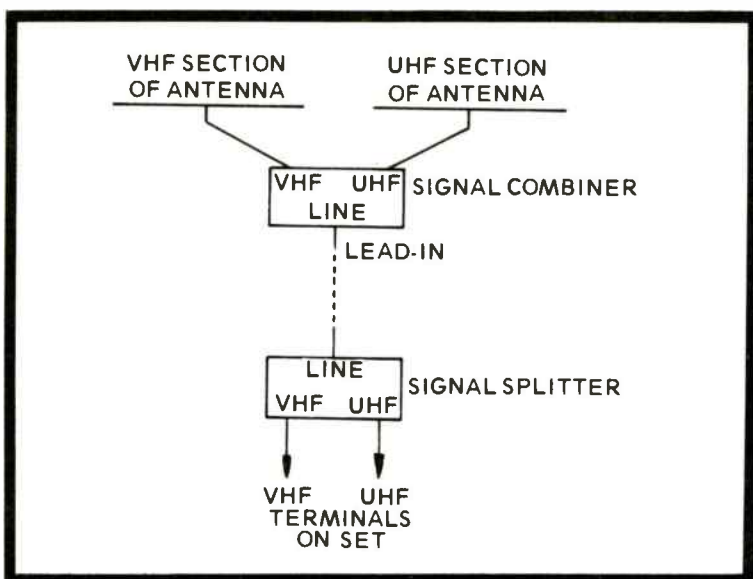


Fig. 6-18. Signal combiners and splitters allow one lead-in to be used for two or more signals.

unshielded lead-in away from metal objects. Avoid, for instance, running such lead-in right next to metal heating ducts.

Shielded lead-in, as mentioned before, really requires no standoffs, although they are still used for a neat appearance in some cases. The cable can be taped directly to a mast, if desired. The shield should be connected securely to the mast and to ground at the receiver or where the cable enters the building. In a difficult situation where a bad interference problem exists, some experimentation as to where to ground the shield may be necessary. For instance, it may prove better to ground the shield only at the receiver and not at the antenna. One thing that must be carefully done when installing shielded cable is to seal the end at the antenna so moisture cannot enter; use tape or a sealing compound (auto gasket sealer).

SIGNAL COMBINERS AND SPLITTERS

Many all-channel antennas have separate VHF and UHF (plus, possibly, FM) sections. Depending upon the design of the antenna, you can simply connect a single lead-in to the antenna, or provision has been made for the connection of separate lead-ins to the various sections of the antenna. It is

then left to the person using the antenna as to whether or not he wants to install separate lead-in for VHF and UHF or employ a combiner at the antenna to allow for the use of a single lead-in. A combiner connected for this purpose is shown in Fig. 6-18.

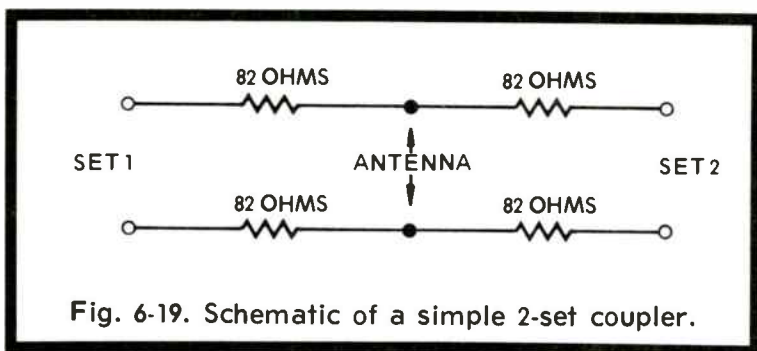
Combiners are available for a variety of functions: some combine VHF and UHF outputs; others combine VHF, UHF and separate FM outputs, or a TV output (VHF and UHF already combined) with an FM antenna, and others provide a single output from separate VHF low-channel (2-6) and a VHF high channel (7-13) antenna. The disadvantage with any combiner is that it introduces some signal loss. Good combiners may introduce no more than about a 3 db loss, but some, which are nothing more than resistive networks, can introduce a much higher loss. Try to obtain some technical data on any combiner which you plan to use. One combiner at an antenna will generally pose no problem, but the two or more can lead to a severe signal loss which is equivalent to the effect of an extremely poor lead-in.

Most combiners function in reverse as signal splitters at the set to separate the UHF, VHF and FM signals. This is also illustrated in Fig. 6-18. Unfortunately, the splitter at the set introduces still another loss of several db in each signal path. Again, a booster placed at the antenna can compensate for the losses encountered in the combiner and splitter. If, however, you are dealing with a fringe area installation and trying to avoid the cost of a booster, combiners and splitters should not be used. It should be noted that the cost of a 100 feet of low-loss foam type lead-in is hardly more than that of a UHF-VHF signal combiner and matching splitter.

MULTI-SET COUPLERS

It is often desired to operate several TV sets or FM sets from a single master antenna system. However, it usually is not practical to simply connect receivers in parallel across the same antenna lead-in, because of interaction between sets; that is, when one set is tuned in and the other is used on certain channels, interference will be experienced on one or both sets. This is not absolutely always the case, however, and there is no reason why you cannot try a simple parallel connection of sets.

Multiset couplers vary all the way from simple 2-set units having only a resistive network to distribution couplers designed for hotel installations. The simple 2-set coupler, which provides no signal amplification, can be used in strong



signal areas. You can easily construct such a coupler, as shown in Fig. 6-19, since only a few resistors are needed. Such couplers introduce several db of signal loss and so cannot be used if the reception on one receiver is just on the fringe of being acceptable. In such a case, an amplifying multiset coupler should be used to account for the extra signal needed for each set.

Coupler-amplifiers come in two basic systems, as shown in Fig. 6-20. For most home installations, the fan-out type multicoupler will suffice where two to four leads are run separately from each set to the centrally located coupler. The power requirement of most such transistorized couplers is so low that they can be left connected to the power line at all times. For commercial or elaborate home installations, a central distribution amplifier is used and a single master cable run throughout the building. A set can be coupled at any point on to this master cable, but a resistive isolating pad (half of that shown in Fig. 6-19) must be used at each set.

BOOSTERS

Boosters have been mentioned somewhat casually in preceding sections. However, before installing a booster, you should be aware of the general types available and their different functions. Generally, boosters fall into either the all-channel category or are designed for specific purposes such as VHF (low or high channels or both), UHF, or FM. For a given price, you obtain more gain in a special purpose booster than in an all-channel booster. For instance, a VHF low-channel booster may provide 20 db gain, while an all-channel booster of about the same price produces an average of 10 db gain on both VHF and UHF. If you are having a specific reception problem with only certain channels, a booster designed for

these channels is obviously a better solution than an all-channel booster.

Boosters should, whenever possible, be mounted directly at the antenna terminals. Most modern boosters are designed for antenna mounting with the power supply for the booster (often also containing a resistive type 2-set coupler) located at the set. The operating voltage for the booster is transferred over the lead-in. Some boosters have separate inputs for VHF and UHF antennas, while on others there is one combined input. Whenever the connection possibilities on the antenna and booster allow, a signal combiner, if used, should be connected after the booster. Except in the case of old sets, a booster used with an indoor antenna at the set will rarely provide any worthwhile increase in signal quality.

ROTATORS

Antenna rotators are usually the only practical means to provide reception from stations in different directions with a single antenna. If reception from only two distinct directions is required, two separate antennas and lead-ins, switch selected at the set, provide an economical and a more reliable solution.

The use of a rotator on top of a mast usually means that the mast must be guyed. You must also be careful to leave enough lead-in slack around the antenna to provide for full rotation of the antenna. The control cable for the rotator need not be placed on standoffs; it can be taped to the antenna mast

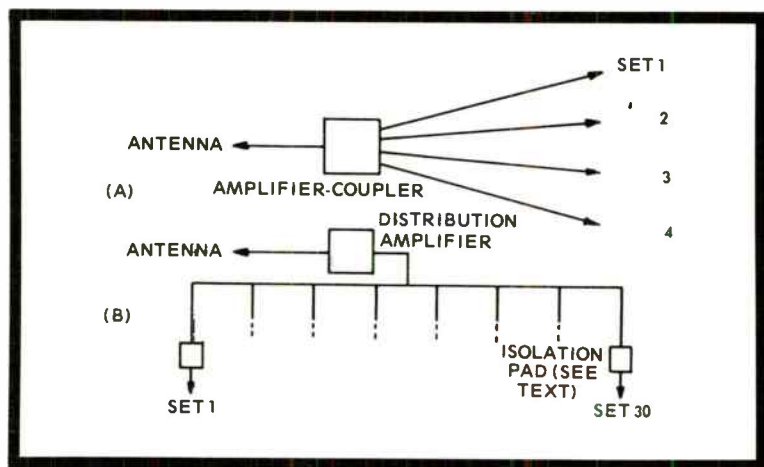


Fig. 6-20. Diagram of a simple multiset coupling system (A) and a large-scale distribution setup (B).

and then to the stem of the standoffs used for the lead-in. Alternatively, it can be stapled to the building with suitable weatherproof staples.

The weight that any rotator can handle is specified by the manufacturer and should be carefully followed, especially with multiple antennas on a single mast. Thrust bearings to relieve the rotator bearings of the weight load are relatively inexpensive and should be used in most multiple antenna installations.

The method of setting up the rotator for the proper directional reading at the control box varies from system to system. Usually, the antenna is rotated to one extreme position, the antenna mast freed at the rotator and turned to the North, then retightened. A "set" button in the bottom of the rotator control box housing is used to set the control box indicator at North. A simple child's play compass is usually adequate to use to set the antenna to the North.

In rare cases, you may find an odd effect taking place with elaborate antenna systems and the rotator type which "steps" around in response to a control box setting. Each step represents 6 degrees and it is possible that the resting position may not place the antenna squarely on a desired station. This will be obvious if reception quality improves during a "step" of the antenna. The only solution is to reposition the antenna in the rotator.

SELECTOR SWITCHES

In multiantenna installations with separate lead-in wires, there must be some provision to connect the desired lead-in to the receiver. Signal splitters can be used to do this, but if you don't mind the slight inconvenience involved, manual switching is perfectly satisfactory. The easiest manual switch to use, and one that causes a very low loss in spite of its old-fashioned appearance, is a power line knife switch. Miniature switches of this sort are available at low cost. With 300-ohm twin-lead, both sides of the line must be switched from set to set. Toggle switches are less useful, particularly on the higher frequencies, because the close spacing of the contacts still allows a great deal of signal coupling to exist between "open" contacts. Relays can also be used for signal switching, but good types with the proper type of insulation for UHF frequencies are expensive. For a simple installation, a good relay can almost be as expensive as a simple booster amplifier and signal splitter combined.

Chapter 7

Long-Distance AM and Short-Wave Antennas

A little bit of antenna can mean a big difference in reception. The sentence sounds a bit too much like a cliché, but, nonetheless, it is usually true that the effort expended in constructing a good antenna system will make even a relatively poor receiver pick up stations that could not be received otherwise. This is especially true where a receiver has no RF amplifier stage. Even a good receiver will provide a cleaner signal output in a relatively strong signal area with the use of a good antenna. The difference in signal quality output in such a case may not always be apparent while listening to a program, but it becomes quite obvious when you make an off-the-air recording where background noise of any amplitude soon becomes very noticeable.

One thing that an improved antenna system cannot do, however, is to improve the signal selectivity of a receiver; that is, its ability to separate closely spaced stations. In fact, the problem of inadequate selectivity usually becomes more apparent when a good antenna is used because of the greater number of stations present at the input. Antenna tuners, as described later, do afford some minor improvement in signal selectivity, but the only real way to obtain useful improvement in this area is to modify the IF section of the receiver. This means the addition of some accessory such as a Q multiplier, adding a sharper IF filter of the quartz or mechanical kind in the IF section, etc.

ANTENNAS FOR IMPROVED LOCAL AM RECEPTION

One of the simplest ways to improve local AM reception is to put up a single-wire antenna, made as long as possible and placed as high as possible. The effectiveness of such an antenna, indoors or outdoors, can be considerably improved by the addition of a simple antenna tuner. A suitable circuit is shown in Fig. 7-1. Simple commercial types, often comprised of only an adjustable inductor element, are also available. The size of the coil needed depends upon the length of the antenna wire and may be less than that shown in Fig. 7-1.

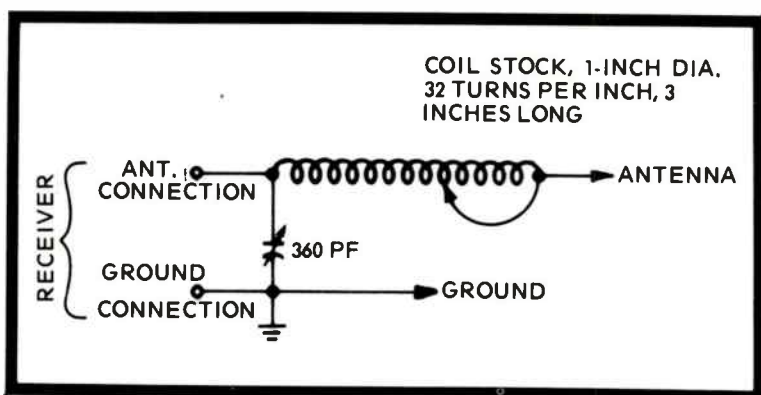


Fig. 7-1. Circuit of a random length wire antenna tuner. If the receiver does not have a ground terminal, do not connect the ground wire to the receiver.

The adjustment procedure is quite simple. The capacitor is set at about the center of its rotation and the coil tap tuned until a broad peak in signal level is heard in the receiver. If the receiver AVC can be shut off, it should be done. Then the variable capacitor is tuned for a peak in signal. Repeat the coil and capacitor adjustments alternately until the best results are obtained. If the AVC cannot be disabled, perform these adjustments using the lowest volume level possible and preferably with earphones. This procedure takes advantage of the fact that the ear is most sensitive to changes in volume level at very low levels, just on the threshold of audibility.

A long horizontal wire antenna may exhibit some directivity. Usually the best reception is realized from signals arriving at a right angle to the antenna. This effect is advantageous if you are interested in reception from a particular station. Vertical or zig-zag antennas do not have any predictable directivity.

Nondirectional antennas are useful if your goal is to provide stronger signal levels to a receiver for general purpose reception. Another problem that often arises, however, in addition to improving the signal level, is that of providing an antenna with directive qualities in a reasonably compact form so that individual stations can be favored. The ability to use an antenna for directive pickup is particularly useful when the stations are operating on nearly the same frequency.

Two antenna forms are particularly useful for directional pickup: a ferrite rod antenna and a wire loop antenna. Ferrite rod antennas are, of course, built into many sets and the directional effect of the antenna is evident when you turn the

set. A few imported models have a front panel control that rotates the ferrite rod antenna within the set. With most receivers, though, the only alternative is rotating the entire set, which is hardly a practical approach.

A more convenient method is an external ferrite antenna modified as shown in Fig. 7-2. Such antennas can be purchased commercially. The primary or larger winding is tuned by means of a miniature 365-pf paper type variable capacitor (transistor type). The secondary or smaller winding is connected to the external antenna terminals on a receiver. Such antennas are available in lengths up to about 7 inches and are frequently called ferrite "loop" antennas because their pickup response is like that of the loop.

The use of such an antenna depends upon whether you are simply trying to improve reception of a desired station or are trying to reject an unwanted station while favoring another. In the former case, the capacitor is tuned for the loudest reception of a desired station and the rod rotated for the best pickup. In the latter case, the capacitor is tuned for the best reception, but the rod is rotated for the greatest rejection of the undesired signal. The rod pickup pattern is very broad in the maximum signal direction, but there are two very sharp nulls in its pattern. One of the nulls is directed toward an offending signal. The rod itself should be supported by some nonmetallic material and placed away from any metal surfaces.

The loop antenna, Fig. 7-3, is a more classic type of simple directive antenna. It is used in the same manner as the ferrite rod antenna. Such loops are easily constructed from available

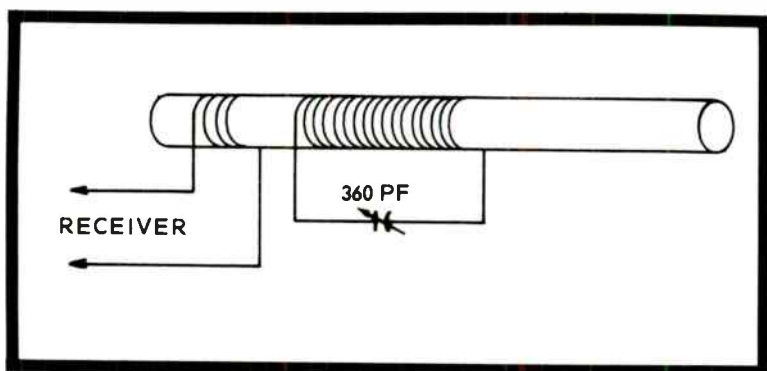


Fig. 7-2. Ferrite rod directional AM antenna. Prewound types are available at low prices.

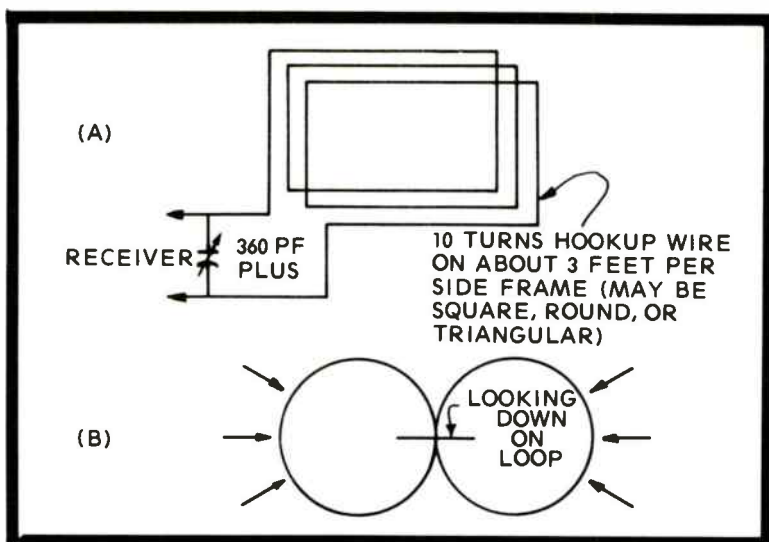


Fig. 7-3. Sketch of a basic loop antenna (A) and its pickup pattern.

materials or are available at many military surplus equipment outlets. For medium-wave reception, there is nothing critical about the size of the loop or even the number of turns used, over a broad range of values. The dimensions shown in Fig. 7-3 can be varied from half to twice those shown without difficulty. The advantage of the larger loop is its greater signal pickup capability. Any size loop has the same response pattern as shown in Fig. 7-3. The capacitor at the base of the loop is used to peak the loop at the desired reception frequency. Depending upon the size of the loop, a bit of experimentation may be necessary to find the correct capacitor value; two or more capacitors may have to be connected in parallel.

Regardless of the antenna used, a preamplifier will effect a considerable improvement in the performance of any AM receiver which does not have an RF amplifier stage. The unit described later under shortwave antennas will also function very well on the AM band.

SIMPLE SHORTWAVE ANTENNAS

One of the main features that distinguishes a shortwave receiving antenna from an AM type is that any reasonable size

antenna starts to show a pronounced directivity at higher frequencies, which favors stations in specific directions. Also, shortwave signals are received via reflection from the ionosphere and the placement of more elaborate shortwave antennas must take this into consideration for the best results.

One of the simplest general purpose shortwave receiving antennas is a simple wire antenna arranged in an L form as shown in Fig. 7-4. In contrast to horizontal wire AM antenna installations, some care should be taken that the wire used is run straight in the directions shown. The antenna is generally omnidirectional in response, so it doesn't matter in which direction the antenna is oriented. The dimensions shown are not extremely critical, but the vertical section of the antenna should be kept at least half the length or more of the horizontal section, or the antenna will exhibit too much directivity at higher frequencies. The antenna is basically useful for reception over the entire shortwave range up to 30 MHz.

A considerable improvement in the performance of the simple "L" antenna will result if, instead of connecting the antenna directly to a receiver, it is first tuned via a so-called antenna coupler or tuner. There are many types of such tuners or couplers and they can be purchased or constructed. A simple coupler circuit is shown in Fig. 7-5. You can use

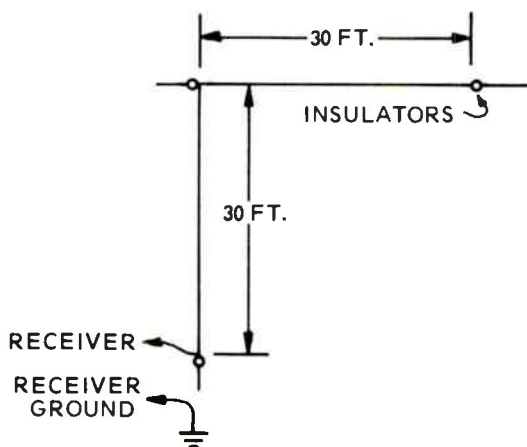


Fig. 7-4. Simple "L" type shortwave antenna.

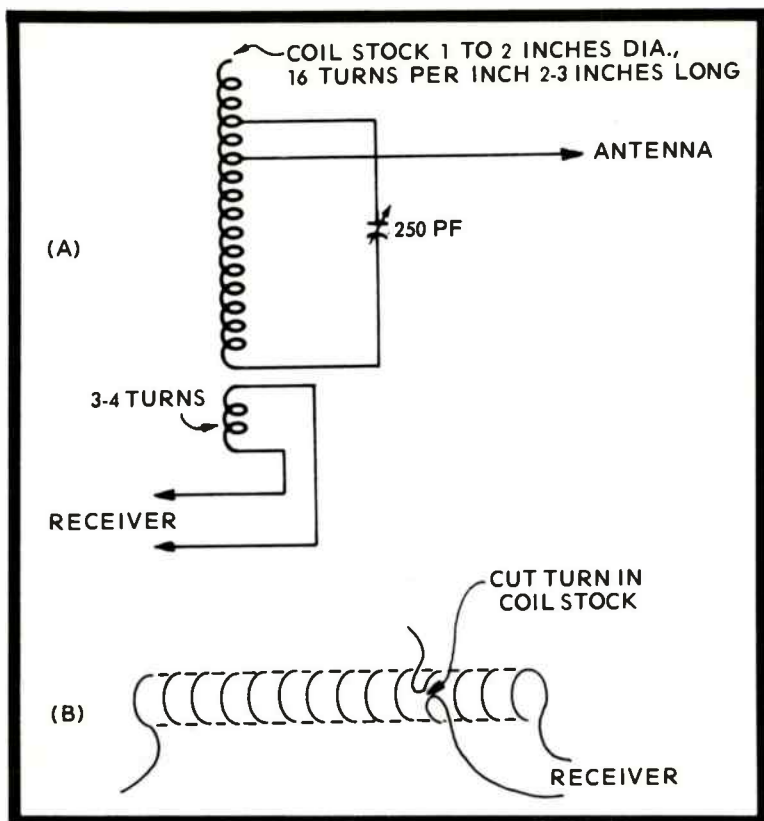


Fig. 7-5. A simple shortwave antenna tuner constructed from standard coil stock.

commercial coil stock and an air dielectric 250-pf variable capacitor. The link portion of the coil is formed by simply cutting the coil winding a few turns from one end and connecting 3- to 4-turn portion to the receiver antenna terminals. Miniature alligator clips, or better yet, special coil stock clips if they can be obtained, are used to attach the capacitor and the antenna to the main portion of the coil. Once the receiver is tuned to a desired shortwave frequency, the capacitor and antenna clips are jointed together, the capacitor set at about $\frac{1}{2}$ to $\frac{3}{4}$ meshed, and the combined clip assembly moved up and down the coil until some peak in the received signal results. The capacitor is then adjusted to refine the signal peak. The clips are separated and the antenna clip moved down on the coil for improved reception, repeaking the capacitor every time.

The tuning process sounds complicated, but it is easily done after a few tries. Once the best connection points are found for various shortwave bands, they can be marked on the coil or a rotary switch can be used to "bandswitch" the coupler. When done properly, a sharp peak in response should occur at every frequency as the capacitor is tuned. If difficulty is encountered in attaching the clips to the coil, alternate turns can be pressed inward on opposite sides of the coil to allow better access to the coil turns.

Another simple wire antenna which can be used for general purpose shortwave reception, or even tailored for high performance reception on a particular shortwave band, is the "bobtail" antenna shown in Fig. 7-6. It should be used with the coupler just described. The dimensions can be tailored for any specific shortwave band with the dimensions shown. A half wavelength in feet is equal to 468 divided by the frequency in MHz. So, if you were primarily interested in the 11-MHz shortwave band, the length of each horizontal section would be about 43 feet and each vertical section about 21½ feet. When constructed in this manner, the antenna shows high directivity broadside; that is, into and out of the page of this book; therefore, reception will be best in those directions. The antenna must be oriented to receive stations in the direction

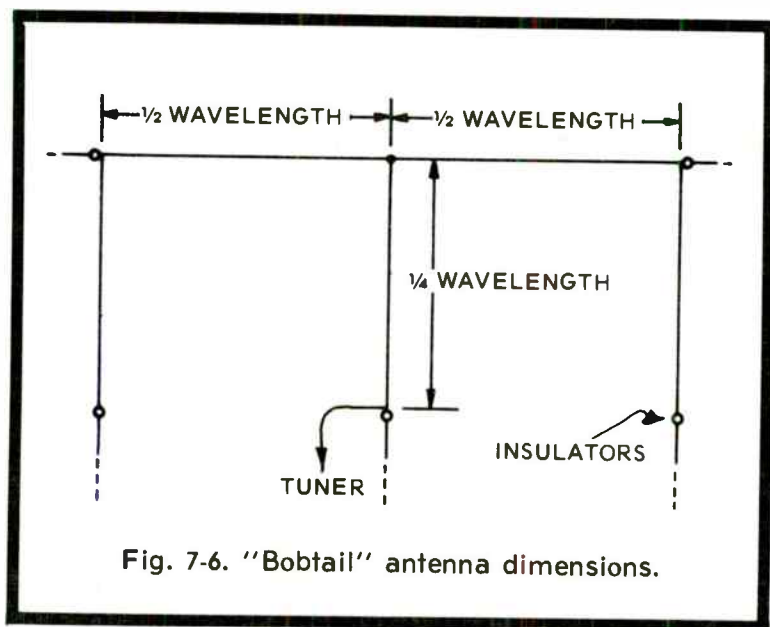


Fig. 7-6. "Bobtail" antenna dimensions.

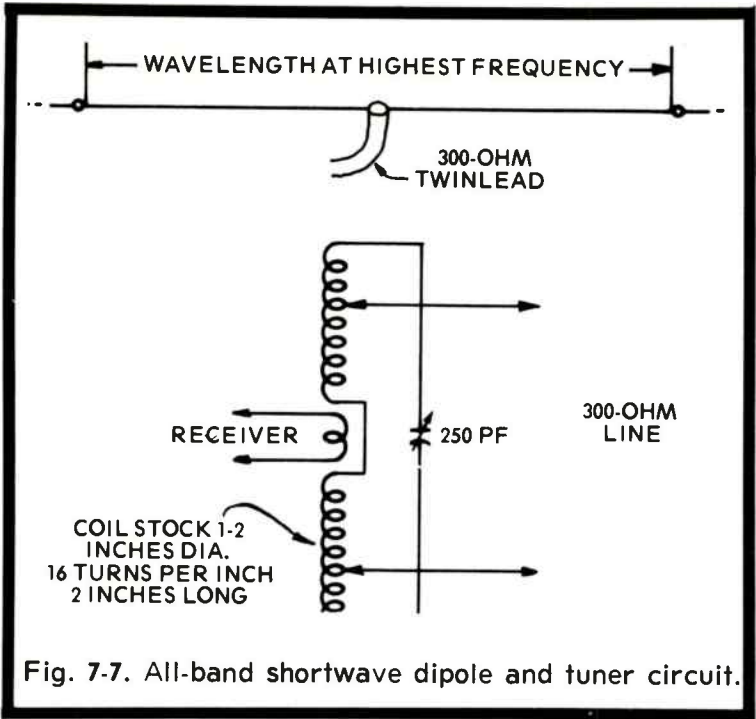


Fig. 7-7. All-band shortwave dipole and tuner circuit.

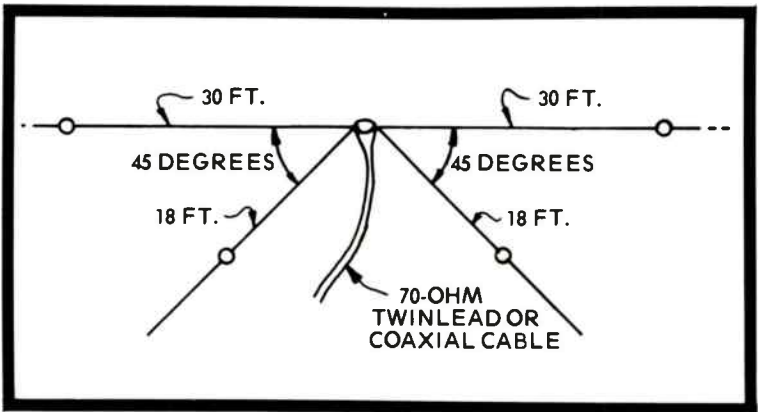


Fig. 7-8. Diagram of a broadband shortwave receiving antenna, based on a military design.

desired. If the antenna is tailored for a single shortwave band, it will still function very well as a general purpose receiving antenna on all other shortwave frequencies.

A simple dipole antenna, elevated as high as possible, is an excellent receiving antenna for a single shortwave band. The antenna and its dimensions are discussed in some detail in Chapter 6 and so won't be repeated here. For shortwave, it would, of course, be constructed from wire and any low-impedance (50 or 72 ohm) coaxial transmission line, or even 72-ohm twin-lead, attached at the center. The antenna should be oriented towards the desired direction of reception.

A dipole-type antenna will function as a general purpose shortwave receiving antenna, but it should be no longer than one wavelength at the highest frequency to be received. You can use a 300-ohm twin-lead to couple it to an appropriate antenna tuner. Sketches of such an antenna and tuner are shown in Fig. 7-7. Reception will generally be best broadside to the antenna (into and out of the page). The tuner is adjusted in the same way as the single-wire antenna tuner just described.

Another basic form of dipole, but one that will provide good reception without the use of an antenna coupler, is shown in Fig. 7-8. It is useful over the frequency range from 4 to 18 MHz but, although the directivity is not sharp, reception is slightly better broadside to the antenna. The antenna was developed as a general purpose shortwave receiving antenna for military communications and it provides excellent results when used with a sensitive receiver.

An antistatic antenna is shown in Fig. 7-9. This antenna can be used either as the main receiving antenna, if it is made

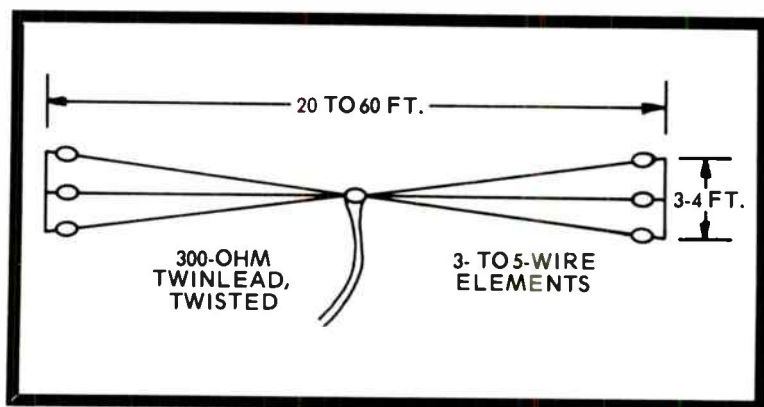


Fig. 7-9. Antistatic receiving antenna. To be effective it must not be more than 10 feet above ground level.

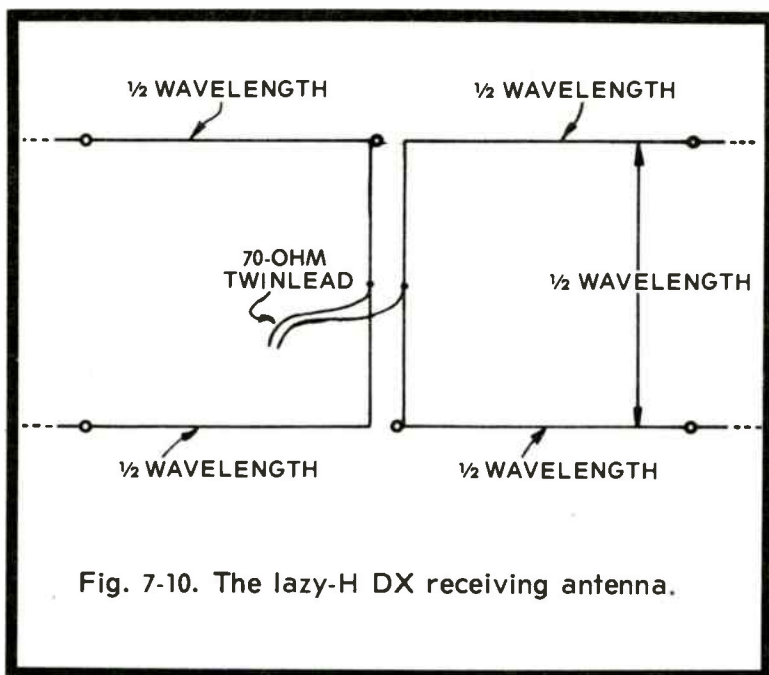


Fig. 7-10. The lazy-H DX receiving antenna.

over 20 feet long, or as a special antenna to be used when atmospheric static is a problem. To be effective, though, the antenna must not be elevated more than 10 feet. The antistatic antenna has several special characteristics. It is oriented only in an east-west direction, as shown in the diagram, for general purpose reception, and the twin-lead feedline to the antenna should be twisted once every foot or so. An antenna coupler is not necessary, although it can prove useful.

DX SHORTWAVE ANTENNAS

“DX” refers to distant stations and the antennas described in this section are especially meant to provide optimum reception of stations on a single shortwave broadcast or amateur band and from a specific direction. Such antennas tend to be large in size and are frequently based on transmitting antenna designs. An important feature of all such antennas is that they must be adequately elevated from the ground—at least a half wavelength at the frequency for which they are designed. Useful results will be obtained at lower elevations, but the major advantages of the antenna will be lost.

One of the best directive antennas, which requires only simple wire construction, is the Lazy-H, shown in Fig. 7-10. It is a "broadside" array, with the main directions of response into and out of the page. The gain of the antenna is about 6 to 7 db in both directions. The gain can be raised several db in one direction if a wire mesh screen of some sort is placed behind the antenna to act as a reflector. On a single band, the antenna can be connected to a transmission line as shown without a coupler. The antenna will still exhibit good performance for receiving purposes at frequencies ranging from half to twice those for which the antenna is "cut." An antenna coupler is needed, however, for this extended usage.

Another relatively simple but extremely effective single-band antenna can be constructed as shown in Fig. 7-11. The antenna is unidirectional, as indicated, with a cardioid-shaped response pattern and a gain of 5-6 db. Since the cardioid response pattern is quite broad, such an antenna can easily provide coverage of all of South America from a northeast location or all of Europe and most of Africa, when oriented midway between the two areas, without a tuner. The antenna will provide pickup on other bands as well, but usually without any gain advantage.

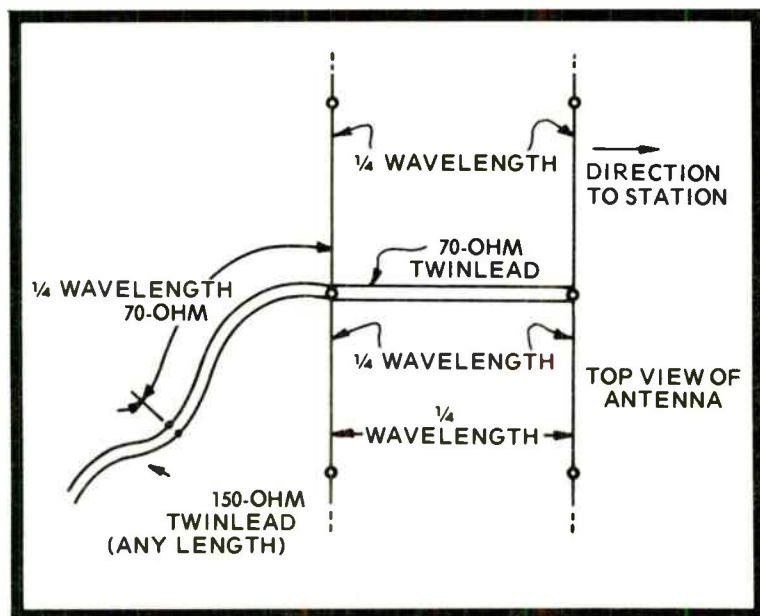


Fig. 7-11. This unidirectional shortwave antenna has a cardioid-shaped pickup pattern.

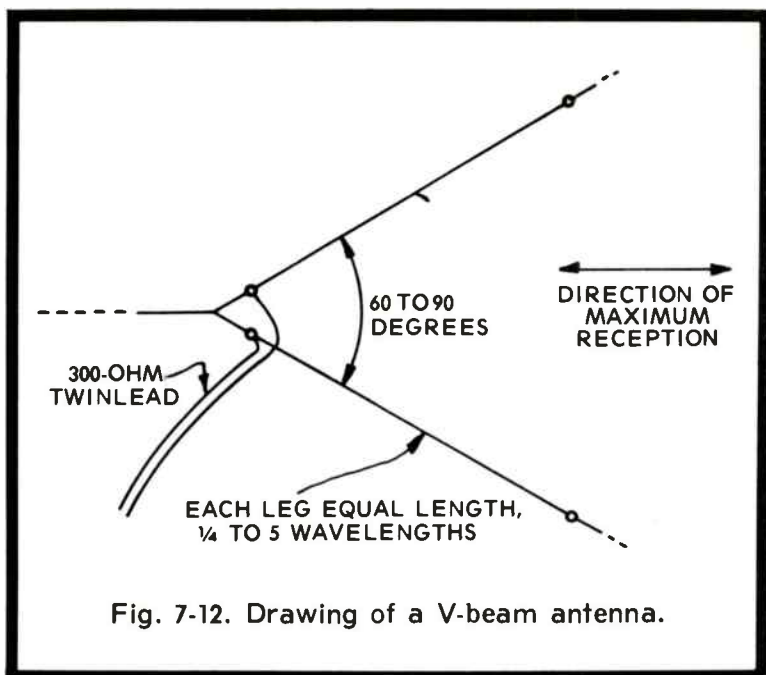


Fig. 7-12. Drawing of a V-beam antenna.

The V antenna shown in Fig. 7-12 receives signals in two directions through the intersection of the V. There are many minor response lobes, however, so the antenna is not really dead in any direction. With the aid of an antenna coupler, it can function as a very good all-band antenna that retains its general directional characteristics over a broad range of frequencies. The antenna can be constructed with almost any length wire for the side legs; the longer lengths provide sharper directivity. Exact dimensions are necessary for peak single-band performance and can be found in various antenna manuals. For general purpose reception, the dimensions shown in Fig. 7-12 are adequate.

For someone who has the necessary space, there is perhaps no better receiving antenna than the rhombic, as years of military and commercial antenna experience have proved. Books have been written on the design of such antennas, and that shown in Fig. 7-13 is a general purpose design useful over the frequency range from 6 to 18 MHz. With the terminating resistor installed as shown, the antenna is unidirectional over its frequency range. If the resistor is removed, the response becomes bidirectional. Signal rejection from the rear can be made quite sharp if the terminating

resistor value is tailored experimentally. When used with a terminating resistor, no antenna tuner is required over the entire frequency range of the antenna. When no resistor is used to provide bidirectional response, an antenna tuner is required for the best performance. Like the V antenna, the rhombic has so many minor response lobes that there is no direction for which the antenna does not provide some pickup, except to the rear when the terminating resistor is properly tailored.

The yagi beam antenna, discussed in Chapter 6, is extremely effective also as a single-band antenna. Although some amateur radio designs provide for 2- or 3-band coverage by special designs, the yagi is basically a single-band affair. Unlike some of the antennas described here, which will offer reasonable performance over many bands with peak performance on one band, the response of a yagi on other than its designed band is no better than the antenna of Fig. 7-7. So, you have to be convinced that the peak performance this type of antenna provides on a single shortwave band is worth the expense involved.

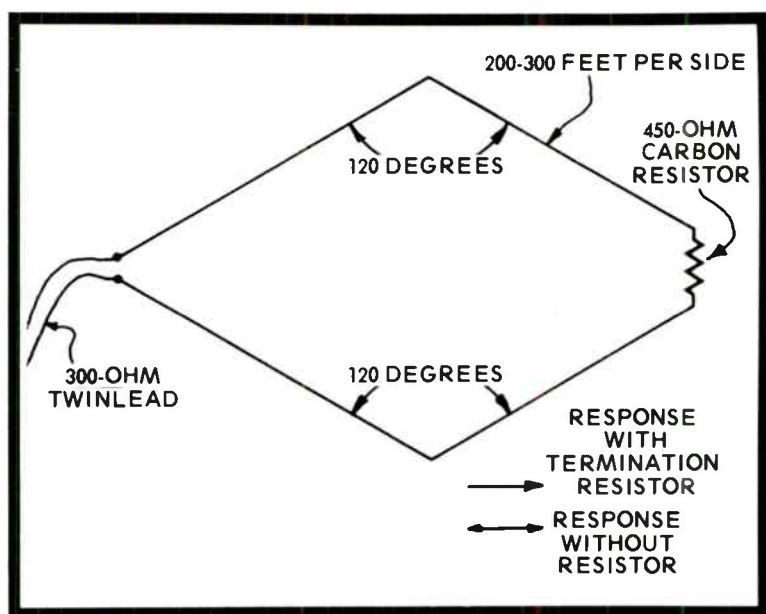


Fig. 7-13. The rhombic is the king of DX antennas. For best results, the entire antenna should be level above ground and elevated 40 to 60 feet at all points.

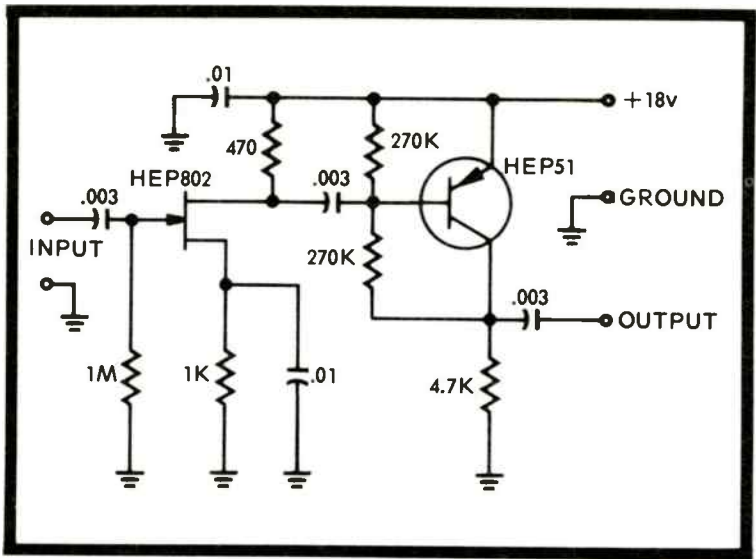


Fig. 7-14. Untuned preamplifier circuit usable up to 40 MHz.

ACCESSORIES

The list of accessories that you can apply to shortwave receiving installations is far longer than can be covered here. Once you become really interested in this phase of electronics, specialized books on communications receivers and short-wave reception should be consulted.

There are, however, two accessories that, in addition to a good antenna, will immediately improve the operation of almost any shortwave receiving setup. One is a good, low-noise preamplifier, such as that shown in Fig. 7-14. The preamplifier itself does not have any tuned circuits and it will provide good amplification from AM medium-wave frequencies to over 40 MHz. It is particularly effective when used between an antenna tuner and a receiver. However, it can also be used alone, with its input simply connected to a random length of wire for an antenna. When constructing the unit, component lead lengths used should be kept as short as possible; otherwise, the performance will be degraded. The unit lends itself particularly well to printed-circuit board construction, if you would like to experiment with this technique, since the parts can be laid out just as shown in the diagram.

Another accessory item, which will not directly improve reception but which is so simple to construct and so useful for shortwave reception, is a crystal calibrator. The circuit, shown in Fig. 7-15, provides calibration signals every 100 kHz. If the receiver has a BFO, it can be turned on to identify the calibrator signal, but the signal will be apparent even without a BFO. The main value of the calibrator is to provide reference points on the receiver dial to which you can always return when tuning the receiver. The "markers" at various points enable you to find desired stations more quickly. Also, since it generates a small RF signal, the calibrator provides a means to verify that the receiver is functioning. Often, when a shortwave band is dead, you don't know whether the receiver itself is defective or whether propagation conditions have changed so that no signals are present.

ANTENNA INSTALLATION PROCEDURES

Since outdoor shortwave antennas must be elevated to be effective, they invite lightning. Either the feedline from the antenna should be grounded directly, using a knife switch when the antenna is not being used, or a lightning arrester (a TV lead-in type) should be used on the feedline.

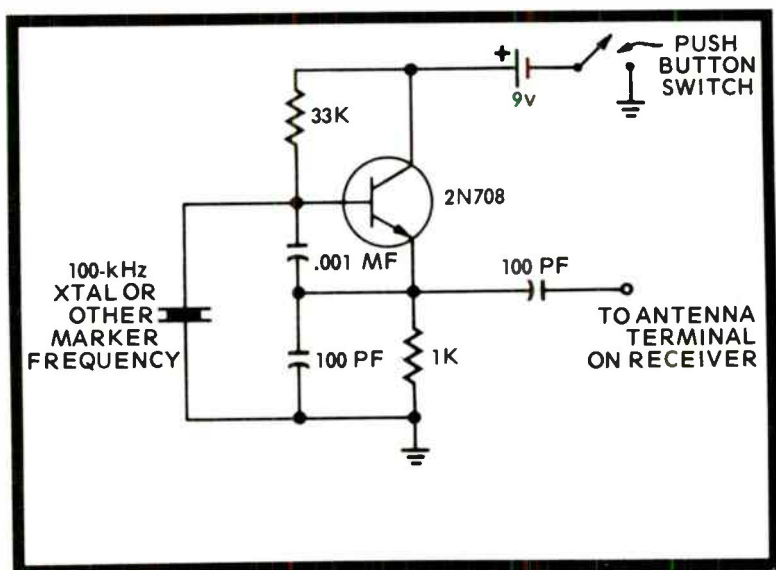


Fig. 7-15. Schematic of a crystal calibrator oscillator which provides "markers" every 100 kHz.

The wire used for an antenna should be a type specifically designed for the purpose, not just large size hookup wire. Copperweld wire is particularly good for larger antennas, such as the Lazy-H, V beams, rhombics, etc. In a salt water environment, bronze-copper antenna wire should be used.

The insulators used at the ends and middle of an antenna deserve special consideration. If you are going to just string a slack piece of wire to the top of a tree, almost any inexpensive insulator will suffice. But, if the wire elements will be taut, quality insulators should be used. The usual 10-cent insulators will simply break apart under any sort of strain. So-called "egg" insulators (egg-shaped) are particularly good (and relatively inexpensive), since the wire coming from each side loops through the other in the insulator, while still insulated from each other. Thus, even if the insulator breaks, the two wires do not separate and the antenna structure won't fall to the ground.

Where guy wires are used to support metal or wood towers or masts, egg-type insulators should be inserted every 20 feet or so (the distance between insulators should not be a quarter wavelength, or any multiple thereof, on a desired frequency). For small towers or masts, nylon or plastic rope guys are suitable and they do not have to be broken up with insulators.

One of the most common end supports for shortwave antennas is a handy tree, and the most common failure when using such a support is to provide for the flexing action of the tree. The result is that a windstorm comes along, the flexing action stresses and eventually breaks the wire. There are several ways to prevent this trouble. With a very light single-wire antenna, a simple screen door spring, inserted after the antenna insulators, will provide the necessary "give." Inexpensive boat-type compression springs, meant for steering systems on outboards, are also very good and shouldn't rust. For very large antenna installations, a rhombic type, for example, it is common practice to attach a pulley at the top of the antenna mast or tree support. The antenna is held by a rope, which goes through the pulley. Near ground level a free-moving weight is attached to the rope. As the tree or mast flexes in the wind, the weight rises and falls in unison.

Transmission lines should be supported at the antenna and at the building entrance so that flexing does not directly strain the points at which the line conductors are fastened. In the case of long lines, it is far better to drop the line straight down near the ground and then horizontally run it to a building, rather than have a long slanting line which will "whip" during windy conditions.

SWITCHING BETWEEN ANTENNAS

Anyone really interested in shortwave reception invariably ends up with an assortment of antennas and the need to switch from one to the other. For the simple arrays, inexpensive components are adequate. For manual switching, a rotary switch with ceramic or "steatite" insulation is preferred. If possible, you should obtain a 2-section switch; one section is used to tie unused antennas to ground. In other words, as the switch is rotated, all unused antenna lead-ins are connected together and grounded. Otherwise, a simple one- or two-pole switch (depending upon whether a single line or two-wire feedline is used) should be installed, with as many positions as antennas to be switched. A simple TV knife switch is ideal for switching between only two antennas.

Chapter 8

Two-Way Radio Systems

Two-way radio systems of interest to the hobbyist involve Citizens Band equipment, VHF monitor receivers, or unlicensed low-power equipment. All such equipment presents an interesting challenge to establish good communications, often using relatively simple equipment and a fixed power level. There are usually a number of improvements that can be made in such equipment if you can modify the internal circuitry, but few hobbyists are equipped to do this kind of work and, indeed, many modifications can be made only by a licensed technician. However, the hobbyist is generally free to make external modifications which do not affect the output characteristics of the equipment. These types of modifications are discussed in this chapter, along with operating information that should prove of value.

RECEIVER IMPROVEMENTS

CB equipment owners sometimes get so fascinated with the power output aspect of their equipment that they tend to forget that improvements in receiver sensitivity will also extend their possible communications range. If the receiving sensitivity of two transceivers used together are both improved, the increase in range can be far greater than that obtained by minor increases in transceiver power output of 20 to 30 percent. The receiving range of VHF monitor receivers is, of course, also extended by increased receiver sensitivity.

The easiest way to increase receiver sensitivity is to add a good quality low-noise preamplifier. Many commercial designs are available, such as that shown in Fig. 8-1. The unit connects between the antenna and a CB transceiver. You can also build a preamplifier, using the untuned circuit in Chapter 7. The circuit must be modified, however, to incorporate a bypass relay when the transceiver is in the transmit mode, as shown in Fig. 8-2. The relay coil should be connected to some point on the transceiver accessory connector which supplies 12 volts when the transceiver is in the transmit mode so the relay is energized. Placing still another tuned circuit between the



Fig. 8-1. Solid-state CB receiver preamplifier. This unit also provides an on-the-air light when transmitting. (Courtesy Ameco Co.)

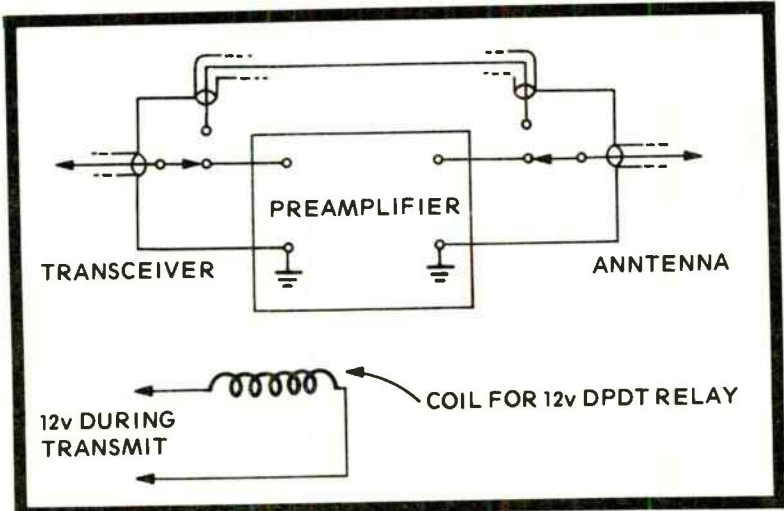


Fig. 8-2. Circuit connections for the installation of a CB receiver RF amplifier. During transmit the amplifier is bypassed.

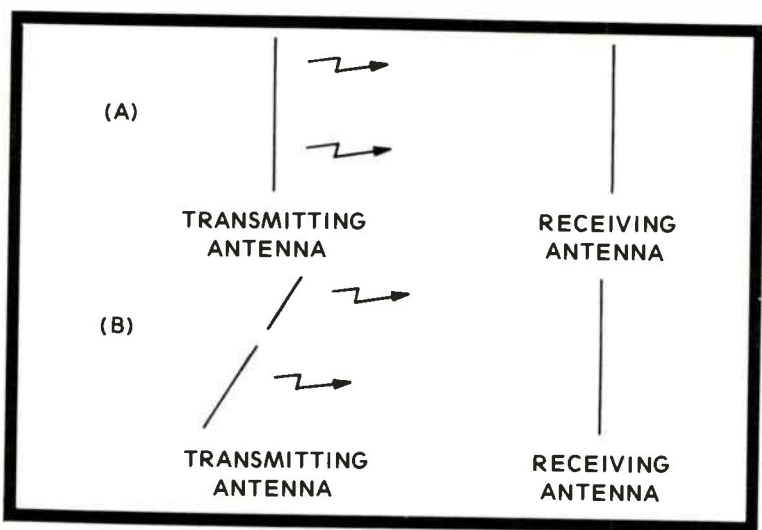


Fig. 8-3. The polarization of transmitting and receiving antennas must be the same for maximum effectiveness. A mismatched system (B) can be the cause of signal loss.

antenna and preamplifier (such as the pi-network circuit shown later) can further increase the sensitivity of the preamplifier. The smaller types of preamplifiers can usually be fitted inside the case of most transceivers.

When a VHF monitor is used alone, there is no need to provide a bypass relay for the preamplifier. The untuned circuit just mentioned will function well over the low-VHF band (30 to 50 MHz), particularly with a pi-network circuit used between it and the antenna. The low-VHF band preamp will not be effective on the high-VHF band (150 to 174 MHz). Commercial preamplifiers for this band are not so readily available, either, and it would probably be too advanced a project for the hobbyist to build a good preamplifier for this band, not because the circuits used are complex but because the higher frequencies demand very careful wire and component placements if the circuit is to function properly. For someone who has a bit of experience in tuning circuits, however, excellent preamplifiers for the high-VHF band can be obtained by just retuning an amateur 2 meter preamplifier for the high-VHF band frequencies.

ANTENNA REQUIREMENTS

There is probably no single element more important in 2-way communications setups, where you must work with a

given power level, than the proper choice of an antenna and its placement. Unfortunately, the problem is made even more difficult in the CB field because antenna descriptions and the claims of performance vary so widely from manufacturer to manufacturer. CB antennas, because of the frequencies used, are somewhat a cross between TV antennas and shortwave antennas.

You should read the foregoing chapters on TV and shortwave antennas, if you haven't already, since all of the comments applicable to these antennas for good reception apply to the CB situation also. In general, all of the types of antennas previously described, when properly dimensioned, can be used on CB frequencies. One area in which far greater care must be exercised, however, is that of power transfer. CB power is low enough without somehow wasting major parts of it before it is effectively radiated by an antenna or transferred to the input terminals of a receiver.

The first requirement that should be considered is antenna polarization, as illustrated in Fig. 8-3. For maximum signal transfer between transmitting and receiving sites, the polarization of each antenna should match as shown at (A). If they do not match (B), a drastic loss in the received signal will result and reduce the effectiveness of a 5-watt transmitter to far less than that of a 100 milliwatt transmitter. The polarization of most antenna types is obvious from their physical appearance, with vertical polarization being the most common, particularly for mobile installations. However, there are types such as the Quad where the polarization is not immediately apparent and can vary, depending upon how the antenna is wired.

Vertical polarization is the most commonly used mode, mainly because vertically-polarized whip antennas are the most easily installed on automobiles. For maximum effectiveness, the base station antenna must also be vertically polarized. There are, however, situations where horizontal polarization does offer distinct advantages. Usually, horizontal polarization is used only between fixed stations because of the difficulty of erecting a horizontally-polarized antenna for a mobile station. One situation where horizontal polarization is particularly advantageous is in a wooded area. Since trees are vertically polarized, they cause more loss to a vertically-polarized signal than a horizontally-polarized one. This effect is particularly true if the antenna cannot be elevated above the top of the surrounding trees. Horizontal polarization is quite useful, too, if other stations are using a desired channel with vertical polarization. Changing to horizontal polarization many times will permit co-channel operation with another pair of stations oppositely polarized.

	10	4.5	
	20	6.5	
ANTENNA	30	8	RADIO
ELEVATION	40	9	DISTANCE
(FEET)	50	10	(MILES)
	60	11	
	70	12	
	80	13	
	90	14	
	100	15	
	200	20	
	300	25	

Fig. 8-4. Table showing the effect of antenna elevation on communications range. The distances are line-of-sight.

The elevation and siting of an antenna should be carefully considered in terms of how far you want to communicate. Of course, if the requirement is simply to communicate as far as possible, the answer is to place the antenna absolutely as high as possible. Usually, however, the question revolves about the worth of elevating an antenna 20 to 25 feet on a roof top versus the expense of a 40-foot tower, etc. You can evaluate this type of situation with the help of Fig. 8-4, plus examining the landscape contour over which a signal must travel from transmitter to receiver.

In Fig. 8-4 it is assumed that the signal travels line-of-sight from transmitter to receiver and over a ground path. Over a sea water path, the distance covered may be greatly extended. Fig. 8-4 shows how far out from a base station a mobile unit may be reached over level ground as a function of antenna height. Notice that relatively small changes in height can increase the range by a number of miles. The chart can be used to determine communication between two base stations by imagining that a mobile unit exists between the stations. If they both reach the mobile unit, they should also reach each other. The chart assumes level ground. When this is not the case, as shown in Fig. 8-5, you must compensate for obstacles by additional antenna height. If the transmitting site is already located on a hill top, it enjoys a natural elevation advantage. Maps having elevation contour lines allow you to quickly survey the natural obstacles present over a desired transmission path. These maps are available from many state offices and for the entire U.S. from the U.S. Geodetic Survey. Road maps which do not contain detailed terrain elevation data are not usable.

The question of how much gain or directivity is desired for a transmitting antenna depends upon the service to which the antenna is being put. Gain cannot be achieved without somehow making the radiation pattern of the antenna more selective. To state it another way, antenna gain does not increase transmitter power output but concentrates that output in a given direction so that a 5-watt transmitter can become the equivalent of a 50-watt transmitter in a specific direction as compared to the situation when both transmitters use omnidirectional antennas which radiate equally well in all directions.

A simple example of this effect is a flashlight bulb burning alone as compared to a flashlight bulb used in a holder with a reflector. The main point to be made, however, is that a directive antenna must be oriented towards the receiving point, whereas an omnidirectional antenna covers the radius around its location equally well. The evaluation of how much increased range a directive antenna provides over that of an omnidirectional antenna is basically easy to calculate in an ideal situation (level ground), but it is wholly dependent upon local conditions in any real situation. An extremely rough rule-of-thumb is that the gain of an antenna (in db) provides an increase in coverage equal to the square root of the antenna gain.

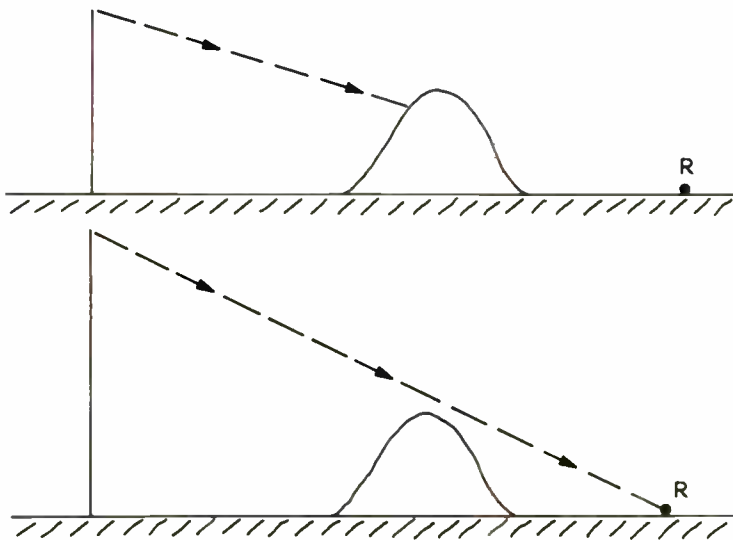


Fig. 8-5. Although exaggerated in this drawing, the height of a transmitting antenna must be sufficient to clear obstacles in the desired path.

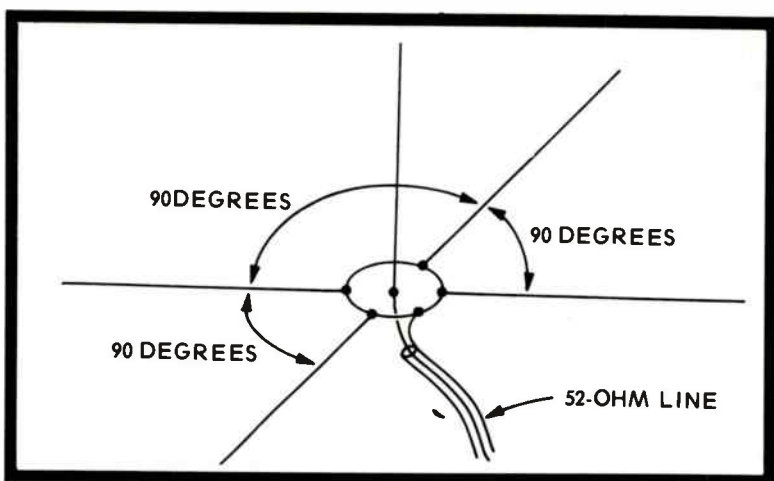


Fig. 8-6. Basic ground plane antenna. All five elements are 9 feet long.

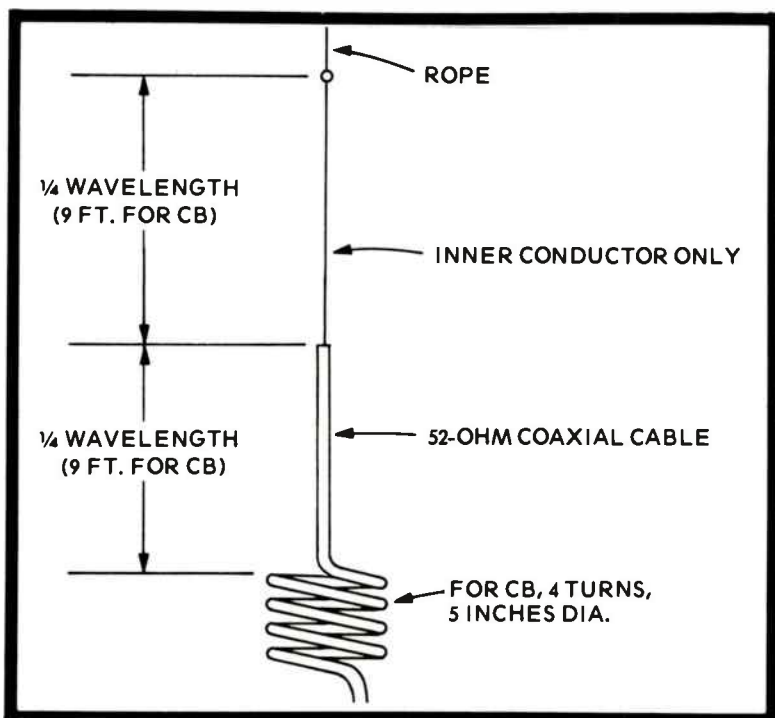


Fig. 8-7. CB antenna designed for portable CB transmitting and receiving.

For example, suppose you have a ground plane antenna with omnidirectional coverage capable of working a mobile station at 5 miles. If the antenna were changed to a Quad with 8 db gain, the distance to the mobile station is increased almost to 15 miles. Naturally, the Quad antenna has to be oriented exactly in the direction of the mobile station and elevated sufficiently for the distance involved according to Fig. 8-4. The gain will increase the level at and beyond the point where the signal was just weak enough not to be usable before.

Since the antenna gain has concentrated the signal in one direction, the signal radiated in other directions will be weaker than before with the nondirective antenna. To work other areas, then, the directive antenna either has to be rotated to the desired communications direction, or you can switch back and forth between a directive antenna, when extra communications range is desired in only one direction, and a nondirectional antenna for general area coverage.

ANTENNA TYPES

As was mentioned before, almost any previously described FM or TV antenna can also be used for transmitting purposes. The polarization of most antennas can be changed by proper physical orientation. For instance, the simple dipole and yagi antenna, shown horizontally for TV use, is simply turned vertically to achieve vertical polarization. One antenna previously described where this cannot be done, or at best would not provide the desired result, is the turnstile antenna. Instead, for omnidirectional coverage with vertical polarization, either a single vertical dipole or a ground plane antenna (Fig. 8-6) can be used.

The ground plane antenna is generally preferable to the single vertical dipole, since its performance is more consistent regardless of its elevation above ground. It may be constructed with the ground plane elements perfectly horizontal or with them sloping down about 30 to 45 degrees from the horizontal. The latter type construction is preferable since it acts to raise the antenna's terminal impedance a bit and provide a more exact match to a 52-ohm coaxial cable.

A particularly useful and excellent antenna that can be quickly fabricated for emergency or portable use is shown in Fig. 8-7. The entire antenna is constructed from 52-ohm coaxial cable. As shown in the diagram, the upper portion is formed by stripping away the shield. Otherwise, no alteration to the cable is required. Do not omit the small coil in the cable at the bottom or performance will be decidedly degraded. The coil itself can be wound over a cardboard or wooden form. The

CABLE TYPE	LOSS (DB) ON CB PER 100 FT.
300-ohm twin-lead	0.6
Coaxial, RG58	3
RG59	1.9
RG8	1.0
RG17 *	0.4

* Very large, 1-inch cable.
Included for comparison only.

Fig. 8-8. Typical transmission line losses for a CB system. Every 3 db loss halves the transmitter output power.

top end can be supported via a plastic clothes line rope from a support such as a tree branch, building fixture, etc.

One great difference between receiving antennas and those used for low-power transmitting service is that much more care must be taken to correctly match the transmission line to the antenna. If a mismatch exists, there will be an inefficient transfer of transmitter power between the line and antenna. So unlike a receiving antenna, where you may put up an antenna "according to the book" and expect good results, you should actually measure what is taking place with a transmitting antenna before the antenna is finally considered to be operating properly.

ANTENNA AND TRANSMISSION LINE TESTING

In the ideal situation, the output of a transceiver designed for 52 ohms is connected to a 52-ohm transmission line and the line, in turn, is connected to a 52-ohm antenna. Impedances are matched and all the transmitter output power, except for the inherent loss in the line, reaches the antenna. In reality, impedances rarely match exactly and transmission lines may have more loss than is imagined. Transmission line losses alone are shown in Fig. 8-8. The length of transmission line used should be kept as short as possible when it is considered that a 3 db loss means that the power appearing at the end of the line is half of that put into the line—even when impedances are perfectly matched throughout!

If the impedances are not matched, the situation becomes even worse. The term SWR (Standing Wave Ratio) is a

reflection of how badly a line is mismatched at either end. For instance, when impedances are matched, the SWR is said to be 1:1. If a 52-ohm line is connected to what is thought to be a 52-ohm antenna, but really the antenna impedance is 26 ohms, the SWR at the line-antenna junction is 2:1. If the antenna-line connection is not matched, an additional loss is generated over and above that caused by the line loss alone. This is illustrated in Fig. 8-9. Even if you can't follow the db figures very well, just remember that every 3 db of loss represents the loss of half the transmitter output power. So, with a 6 db total loss, the power delivered to the antenna is only one fourth that available at the transmitter output. Obviously, it doesn't take very much for transmission line losses to reduce the real power output of a transmitter to a small fraction of its value under ideal conditions.

The SWR bridge (Fig. 8-10) is one of the most useful instruments available to check the degree to which a transmission line is matched to either an antenna or transceiver. It is also useful even after an antenna system is properly adjusted to check that the system continues to function properly. For this purpose, the SWR meter is often left permanently connected in a transmission line by the transceiver. When initially testing a transmission line, however, placing the SWR meter only at the transceiver can often lead to false indications. Because of the loss factor in transmission lines, it is possible that although an SWR meter placed at the output of a transceiver registers a reading of 1:1, the SWR at the transmission line-antenna junction is actually 2:1 or even higher. Therefore, the initial adjustment of an antenna system should be done more carefully.

NORMAL LINE LOSS, DB	IF SWR IS:	ADDITIONAL LOSS IS:
1	1.5:1	NIL
1	3.0:1	0.5 db
2	1.5:1	NIL
2	3.0:1	0.8 db
3	1.5:1	0.1 db
3	3.0:1	1 db
3	10.0:1	4 db

Fig. 8-9. Table of loss caused by SWR.

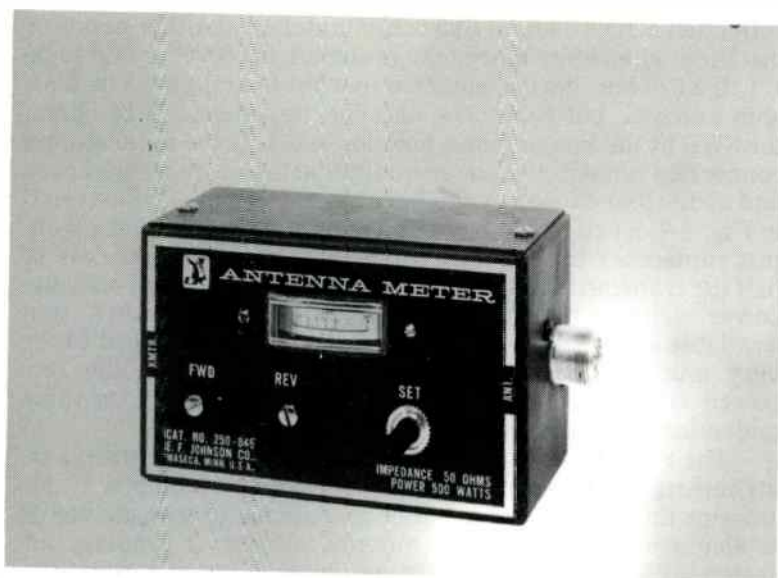


Fig. 8-10. An SWR meter should be used to properly match a CB antenna system. (Courtesy E. F. Johnson Co.)

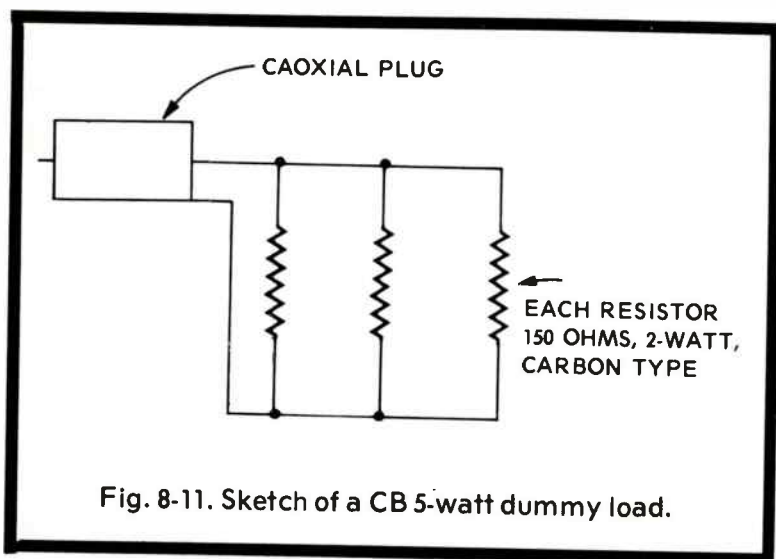


Fig. 8-11. Sketch of a CB 5-watt dummy load.

First, you should estimate the actual length of coaxial line to be used in an installation and connect it to the transceiver with a "dummy load" on the other end of the line. The dummy load is nothing more than a carbon resistor (see Fig. 8-11) with a resistance value equal to the impedance of the coaxial line being used. An SWR meter, placed either at the transceiver or dummy load end of the line, should register the same SWR ratio. If any great difference is noted, it indicates an incorrect transmission line impedance or some output adjustment fault in the transceiver.

Assuming identical readings are obtained, the transmission line should be connected to the antenna system with the SWR meter again inserted at both the line-antenna and line-transceiver junctions. If the reading at the line-antenna junction is high, obviously the antenna terminal impedance is incorrect and should be adjusted to bring the SWR ratio as close to 1:1 as possible. As a practical matter, an SWR ratio of 1.5:1 is commonly regarded as acceptable and no adjustment is necessary to achieve a lower ratio. The power loss at this ratio is insignificant, although you must not become too confused by the smaller numbers involved. A 3:1 SWR ratio represents a loss of almost all the transmitter power and is not acceptable.

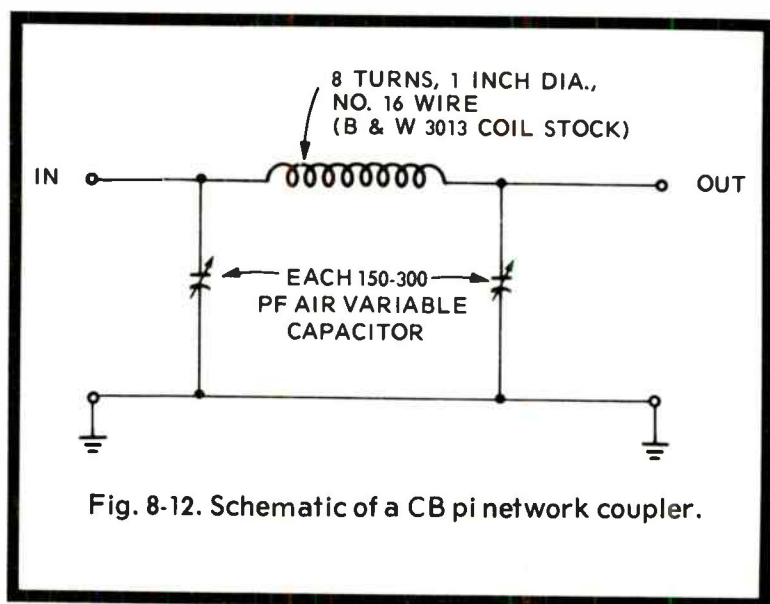
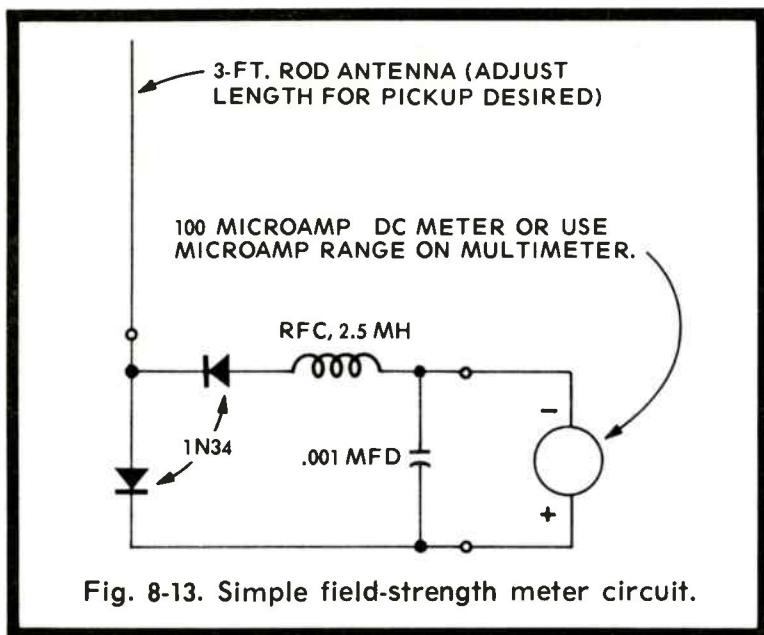


Fig. 8-12. Schematic of a CB pi network coupler.



When the transmission line does not match the impedance of either the transceiver or the antenna, a matching network, consisting of inductive and capacitive elements, is often used to provide an impedance transformation or match. The most useful of such networks is the pi network, as shown in Fig. 8-12. It can be placed at either the junction of the transmission line and antenna or the transceiver and transmission line, as required. It is adjusted in conjunction with an SWR meter and/or a field strength meter (the latter is described later). The variable capacitors are adjusted so that the SWR reads 1:1.

Usually, the SWR meter has a forward-reflected power switch and a "set" control. The meter is set to forward and the variable capacitor in the pi network on the transceiver side tuned for a maximum meter reading. With the "set" control adjust the meter to full scale. Switch the meter to read reflected power and adjust the other variable capacitor in the pi network for minimum SWR. Return the meter to read forward power, readjust the set control to full scale, then set the meter to read reflected power while the variable capacitors are again adjusted. This sequence may have to be repeated a few times until a proper adjustment is achieved. Just remember to reset the SWR meter to its reference position, using the "set" control, every time an adjustment is

made to obtain correct SWR readings. The SWR meter, if it is of the in-line type, can be left in the transmission line during operation to continuously monitor for any significant change in line condition.

Field-strength meters are not basically as useful an instrument as an SWR meter, but they can provide a useful double check on whether antenna and transmission line adjustments have been correctly made. The field-strength meter measures the intensity of the radio frequency field radiated and, of course, this field should be a maximum when the antenna and transmission line have been matched.

A basic field-strength meter circuit is shown in Fig. 8-13. It is tuned to the frequency being transmitted and the meter set for some relative reading. As adjustments are made to an antenna or matching network, the meter indicates whether the field strength increases or not. One useful application of a field-strength meter is a rough check of the directivity of an antenna. The field-strength meter can be set in place and the antenna rotated or the field-strength meter carefully "walked" around an antenna, without changing its meter setting. You should be able to roughly see how the field strength varies as a function of the horizontal angle to a directive antenna. Such tests should be made in a clear space

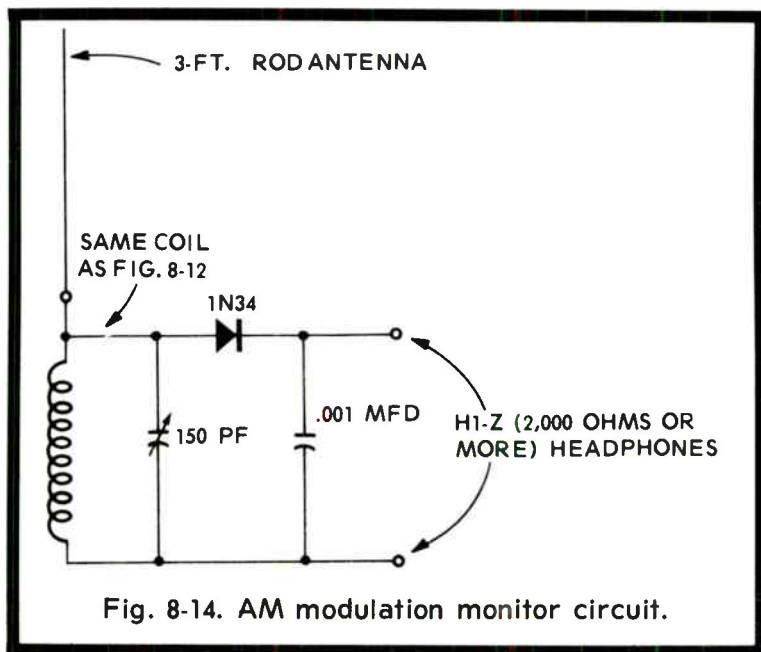


Fig. 8-14. AM modulation monitor circuit.

free from obstacles and with the field-strength meter at least 50 to 100 feet away from the antenna. Field-strength meters are often left on permanently as a double check that a transmitter continues to radiate every time it is used.

A simple AM modulation monitor (Fig. 8-14) is extremely useful if you don't have a second receiver and if you intend to do some experimenting with the audio modulation characteristics of a transceiver. Basically, it is nothing more than a crystal or diode radio receiver tuned to the transmitter frequency. Its range is extremely short, but, nonetheless, it will allow you to hear immediately the effect of modulation system changes rather than having to wait for reports from other stations.

MICROPHONES FOR TRANSMITTER USAGE AND ACCESSORIES

The usual type hi-fi microphone will usually provide poor service in communications, since it is designed for a broad, flat frequency response. Instead, a microphone tailored for voice communications intelligibility is needed. Many microphones are available of the latter type and they are the ones which should be used with 2-way radio equipment. Dynamic microphones are especially recommended because of their rugged construction. Good microphones can even be built by obtaining a replacement capsule for the receiver element in a telephone handset. These receiver elements are essentially small dynamic loudspeakers, but they will function in reverse as a low-impedance dynamic microphone. They are particularly good because their frequency response has been carefully tailored for voice frequency communications.

When trying to marry a microphone to a transmitter, problems with output and impedance levels often arise. A microphone may not have a sufficient output level to fully modulate a transmitter. Since CB transceivers are built so they cannot be overmodulated, there is not much danger of the microphone level being too great (if it can be adjusted to the level required), but too low a microphone level will mean that the full output capability of a transmitter is not utilized. A microphone preamplifier of the type discussed in Chapter 5 is useful for communications applications, too. The speech compressor circuit also discussed in that chapter is particularly useful to ensure that the transmitter is fully modulated for a wide range of sound level inputs.

Impedance matching between low-impedance microphones and high-impedance transmitter inputs, or high

impedance to low impedance, can be done either with transformers or simple transistorized impedance converters. The transistor circuits are advantageous because they also provide some gain and thus act as a preamplifier. The two circuits shown in Fig. 8-15 should match almost any type of microphone to any transmitter. Similar circuits are also used in ready-made microphone preamplifier modules which can be purchased ready for use.

CONVERSION OF CB TRANSCEIVERS (BASE-MOBILE)

A transceiver originally purchased for either base or mobile use can be "converted" to its opposite application. That is, the base unit can be used as a mobile and the mobile as a base unit. The base-to-mobile conversion is usually the more difficult of the two. In order to use the base unit as a mobile

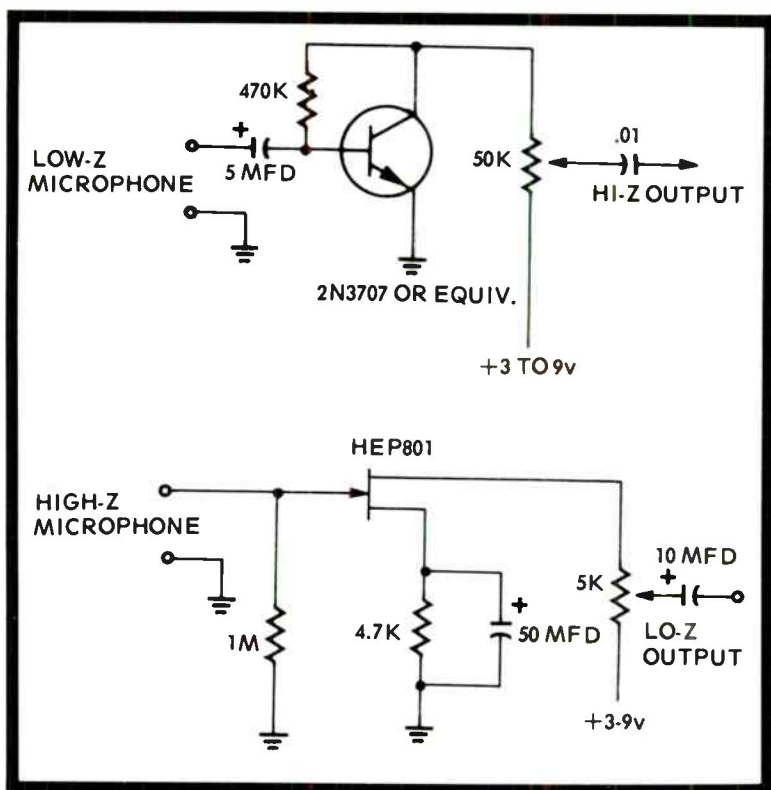


Fig. 8-15. Impedance converter circuits designed for microphone-transmitter matching.

unit, unless it is specifically manufactured for dual operation, you must provide a source of 110-volt power to the unit. Power converters (called inverters) are available which convert 12v DC from a car battery to 110v AC. However, the output waveform produced by such units is a square wave, not a sine wave, and not all transmitter power supplies will operate well with this type of input waveform. If possible, check with the manufacturer of the unit to determine whether or not operation with a DC-to-AC inverter is possible. If this information cannot be obtained, operate the transmitter with the inverter for short periods at first to see that it does not overheat. Various interference difficulties may also be experienced when the base unit is used in a mobile situation, unless the automobile used has been treated to prevent the generation of interference. The points involved are covered in Chapter 12.

The use of a mobile unit in a base station location usually is a simple matter. A 12-volt battery or small power supply, producing a well-filtered DC output, can be used to power the transceiver. Battery chargers can usually be used as a power source if additional filtering (several 1,000-mfd 35-volt capacitors in parallel) is used on the output of the charger to eliminate the ripple voltage present.

LINEAR AMPLIFIERS

Linear amplifiers are not allowed for CB operation, but they are legal for certain business 2-way radio applications. The power boost provided by the amplifier will extend the communications range or at least improve the quality of communications within an existing service area. It is usually not worthwhile to use a linear amplifier unless you can raise the power level by about 10 times (which corresponds to 10 db). The 10 db increase in power output can also, of course, be achieved in a specific direction by a very directive antenna having a 10 db gain, if an omnidirectional antenna is being used.

A linear amplifier does not contain any modulating section of its own; rather, it simply amplifies the entire modulated waveform produced by a low-power transceiver. Distortion should be held to a low level in such an amplifier if its purpose is to be achieved. As far as the user is concerned, this means that the amplifier should only be inserted in an antenna system which has already been correctly matched throughout. Improper loading on such amplifiers will lower the output and raise the distortion of the amplified signal. The amplifier is connected between the transceiver and antenna and usually

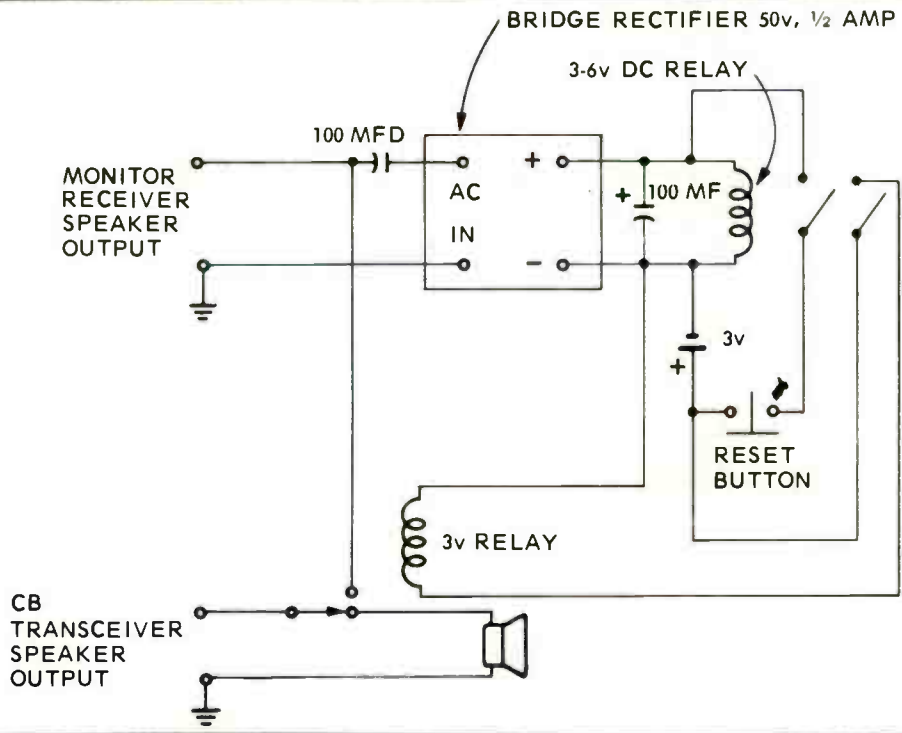


Fig. 8-16. Automatic override circuit which disables the CB receiver speaker and substitutes a monitor output.

contains a bypass relay so that it is switched out of the antenna line during receive periods. If installation conditions permit, where a long, lossy transmission line is used, the linear amplifier should be located at the antenna. The output of the linear amplifier will not be attenuated then by the transmission line loss.

MONITOR RECEIVER OVERRIDES

Very often you may want to continuously monitor certain emergency channels while operating on another channel in 2-way communications. The monitor receiver is kept on with the squelch set to quiet it, or you can provide an override from the monitoring receiver to the transceiver being used so that, if a call is placed on the emergency channel, the transceiver will be disabled. A suitable circuit for this type of operation is shown in Fig. 8-16. When a call is received on the monitoring receiver, it produces a DC voltage via the bridge rectifier, which in turn closes the sensitive relay. The contacts of this relay, when activated, perform two functions. One set of contacts locks the relay closed by placing 3 volts across its coil. The other set of contacts activates a relay which switches the speaker in the transceiver to the output of the monitoring receiver. This setup remains in effect until the reset button is pressed to restore the system to its standby mode.

The parts used are all simple, readily available items and the only connection required between the override circuit and the transceiver goes to the loudspeaker output terminals. By extending the system with additional relays, you can provide for more monitor receivers or even for response only to monitor calls when more than one occurs at one time in a given order of priority.

AUTOMATIC RECORDING

There may be times when you'll want to record the communications on emergency channels or even be able to leave a message at an unattended base station via 2-way radio. The easiest way to do this, by far, is to use a voice-activated tape recorder. If you have such a recorder, the receiver audio output is simply coupled by a small audio transformer to the microphone input of the recorder. Usually, a transformer with a 4-ohm to 1- or 2-thousand ohm ratio will work nicely. The receiver audio gain is adjusted so that when the squelch is overridden by an incoming signal, the proper recording level is obtained.

If you do not have a voice-operated recorder, a fairly good setup can still be realized by using an accessory type voice-operated microphone with an existing recorder. The microphone is placed close to the speaker on the monitor receiver and its trip level control adjusted so that the speaker volume activates the unit. The switching part of the microphone circuit is used to control the power supply to the recorder (which is left set up in the record mode). Usually the battery circuit of a recorder can be controlled directly by such a microphone. In the case of a line-operated recorder, an extra relay can be used to switch the power on to the recorder. After the audio output from the receiver ceases, the microphone circuitry will switch off the recorder. If interference conditions tend to make a recorder respond to too many false messages, a selective calling tone unit, available commercially, can be installed to provide private calling and recording.

Chapter 9

Tape Recorders & Phonographs

Recorded sound material, or even picture material in a TV tape recorder, has become a common product of most home installations. Unfortunately, the devices used to reproduce such material are often the most troublesome to keep in proper operating condition. This is usually because the units involved (tape decks, turntables, etc.) are rather intricate mechanical-electronic devices. The material in this chapter is basically aimed at helping you to perform simple preventive maintenance on such units; that is, maintain the performance and in many cases prevent minor difficulties from developing into real repair problems. Should the latter develop, you should have the unit serviced by a professional technician. We've also included tips for connecting such units into hi-fi systems to enable you to achieve the best performance from these units.

CONNECTING TO A HI-FI SYSTEM

If you have an elaborate hi-fi receiver-amplifier, the equipment usually is furnished with very complete instructions on how tape recorders and turntables can be connected into a system. Also, the equipment itself usually has a variety of input connections to accommodate almost any signal level from accessory equipment. The area where many hobbyists become confused, however, is in the selection and use of the best cable assemblies for interconnection purposes. Foreign equipment, particularly that with DIN type connectors, can be confusing. The interconnecting assemblies themselves are covered in the next section. Here, we are concerned with things to observe when trying to interconnect units which do not have all the elaborate connectors for such purposes.

The connection of a phonograph or a turntable to an amplifier system is usually an easy matter, since the turntable is simply a 1-way device; that is, the signal is simply transferred from the turntable pickup into an amplifier system. The pickup element in less expensive phonographs is usually a crystal or ceramic cartridge which has a high output level (0.5 volt or more) at a high impedance level. Better turntables use other forms of cartridges, such as magnetic

types which have a lower output level but better frequency response. The situation parallels that of crystal and dynamic type microphones.

If you have an amplifier available with a high-impedance microphone input, it may seem an easy matter to just connect the output of a turntable directly to the microphone input. It can be done, of course, and may sound acceptable, but fundamentally it is incorrect. The reason for this is that disc recordings are made according to special frequency response standards established by the RIAA (Recording Industry of America) and if you do not compensate or equalize in the amplifier for this response, the full range of sounds from the disc will not be properly reproduced.

Fig. 9-1 shows the RIAA curve for recording as a solid line. If you played back such a recording through an amplifier with a good flat response, there would be a lack of bass sounds and an overexaggeration of higher frequency sounds. To equalize the response, the amplifier curve should resemble the dashed line in Fig. 9-1. You could set the tone controls on an amplifier to give the bass-treble response desired, but this is not the best method, since the frequency response equalization should take place at the amplifier input for the best noise-free

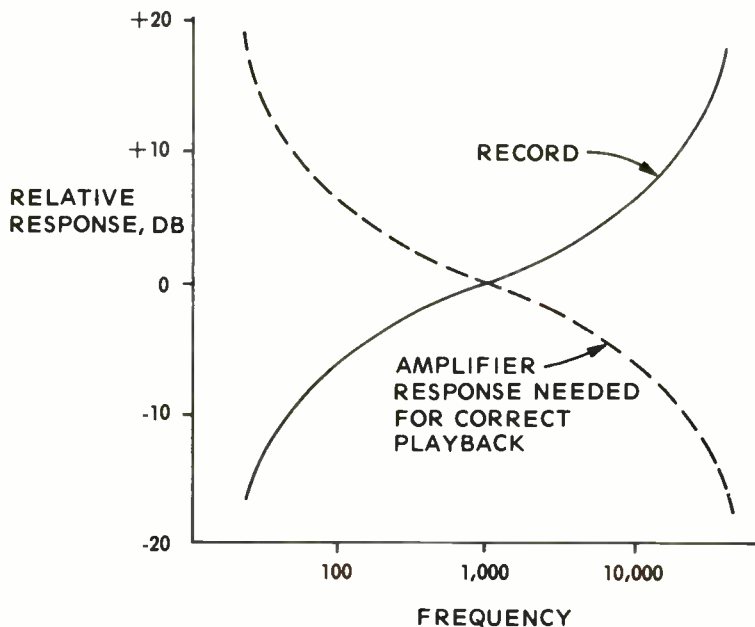


Fig. 9-1. Most records are made according to the weighted RIAA frequency response curve.

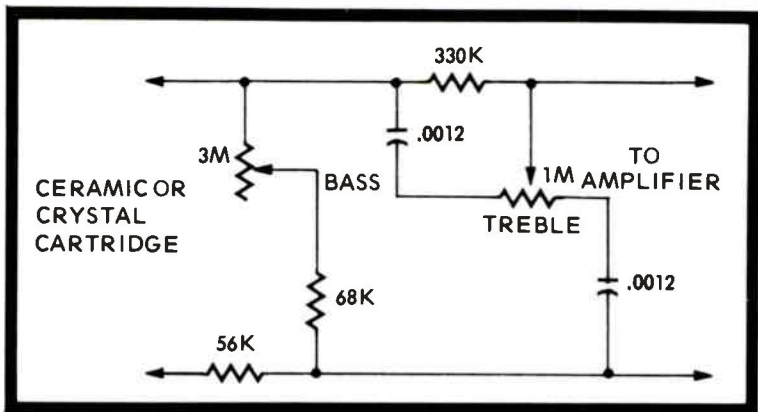


Fig. 9-2. RIAA equalizing circuit designed for a high-impedance cartridge feeding a high-impedance amplifier.

reproduction and to ensure that the amplifier input is not overloaded by strong signals at the higher frequencies before it adequately reproduces the low-frequency sounds.

Where a high output cartridge (crystal or ceramic) is connected to a high input impedance amplifier, an equalizing network can be placed directly between the turntable output and the amplifier input. A suitable, adjustable network is shown in Fig. 9-2. The network provides adjustment of both the bass and treble frequencies. Usually, the required setting can be determined while listening to a record. If you have a frequency test record, the controls are adjusted, with the amplifier's tone controls set for a flat response, for an overall equal level output of all frequencies. The controls, once adjusted, need not be touched again. Therefore, an inexpensive printed-circuit board trim potentiometer should be used to build the circuit instead of a regular panel type potentiometer.

If a low-level output cartridge is used, a magnetic type, for example, it requires the same type of frequency compensation. So, a preamplifier specifically designed for phono use should be used, not an ordinary microphone preamplifier. Although the latter will provide the necessary gain, it does not have the frequency compensation required nor the ability to handle the greater dynamic range of sound levels which musical recordings usually have. Once such a preamplifier is used, it can usually be connected to either a high- or low-impedance amplifier input, since sufficient reserve gain is available. A switch can be used at the amplifier input to choose either the phono input or the normal input (microphone, tuner output, etc.).

A few last tips: The wire lead from the phono cartridge should be shielded but not grounded at the phonograph end. Two-wire shielded cable is usually the best to use. If a considerable distance (over 10 feet roughly) is involved between the phonograph and amplifier, and if a phono preamplifier is used, place the latter directly at the phonograph to protect against noise buildup on the cable run.

Connecting a tape recorder to an amplifier is somewhat different in that it is usually used as a 2-way device. That is, you want to play back recorded material as well as to record material. There is no problem of frequency response compensation, however, because tape recorder units come with their own electronics. The playback function is connected in the same manner, basically, as a phonograph, but without the need for any network between the playback outlet of the recorder and the input to an amplifier. If the tape recorder does not have any terminals for connection to an external amplifier, the headphone jack on the recorder can be used for such an output. The recording function connections can be made to the microphone input. If making recordings from a

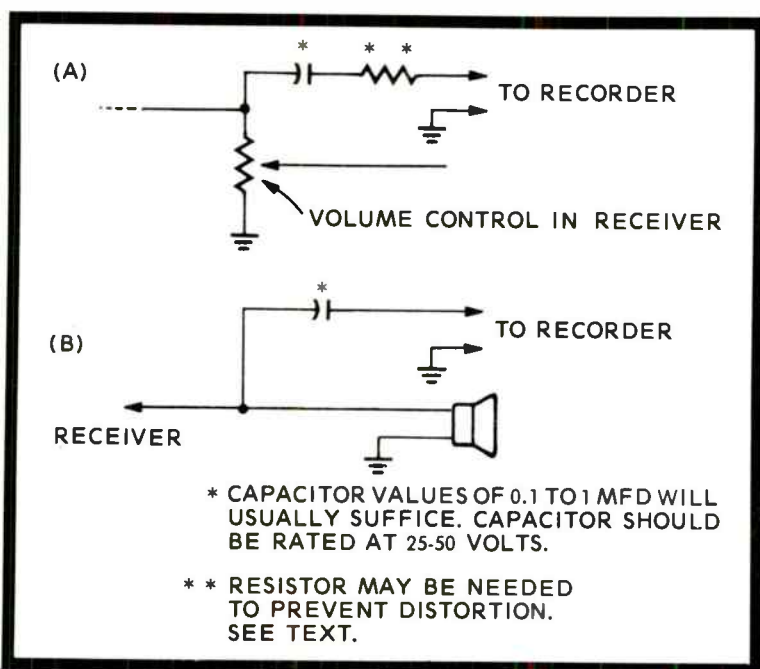


Fig. 9-3. The diagrams show two ways to connect a tape recorder to the output of a receiver.

radio, you can utilize either of the two connection schemes shown in Fig. 9-3. The connection at Fig. 9-3A requires that you get to the volume control in the receiver. The reason for connecting the recorder in this fashion is that the recording quality is not influenced by the quality of the audio system in the receiver and the volume control of the receiver may be adjusted without affecting the recording level. The connection shown at Fig. 9-3B is far simpler, since it requires access only to the speaker terminals in the receiver. You must remember, however, that varying the speaker level also will affect the recording level, which then must be separately readjusted on the recorder.

CONNECTOR ASSEMBLIES

By choosing the correct connector assembly to use between items of hi-fi equipment, you can ensure proper interconnection and at the same time avoid the jumble of wires behind the scenes which frequently characterizes any hi-fi installation. The wide variety of connector assemblies available is impossible to describe here, but they are available with almost any combination of different types of plugs. Fig. 9-4A illustrates a setup for a stereo tuner-amplifier combination with a phonograph and tape recorder. Individual cables are used for the required interconnections. Fig. 9-4 shows exactly the same equipment setup but 2- and 4-wire cable connectors have been used to simplify the installation. The installation at Fig. 9-4B is much neater and there is far less chance of crossing up the interconnections.

DIN (German Industry Standards) type connectors are often found on imported equipment because this type of connector is widely used in Europe. DIN connectors are often referred to as Hirschmann connectors, but this is only the name of a particular manufacturer of such connectors. If you have equipment with DIN sockets on each piece of equipment, interconnection is particularly easy because the connections used on DIN sockets have been standardized. For instance, if you have a 5-pin DIN socket on a recorder which is labeled "radio" and another 5-pin DIN socket on an amplifier labeled "recorder," a standard cable assembly is used between them and all the connections have been made for stereo record and playback. The more usual problem, however, is the case where you have a piece of equipment, usually a recorder or receiver, with only a DIN output that you want to interface with a piece of equipment having the usual RCA-type phono plugs. Connector assemblies are available for this type of conversion, but they tend to be expensive. At the expense of a

somewhat less neat installation, this is one area in which you might be better off to purchase just the necessary DIN plug and make up a cable assembly.

DIN sockets are wired in a standard manner as shown in Fig. 9-5 for both stereo and monaural equipment. A separate shielded cable is used for each pin connection (inner lead going to pins 1, 3, 4 and 5 of Fig. 9-5A) with the shields con-

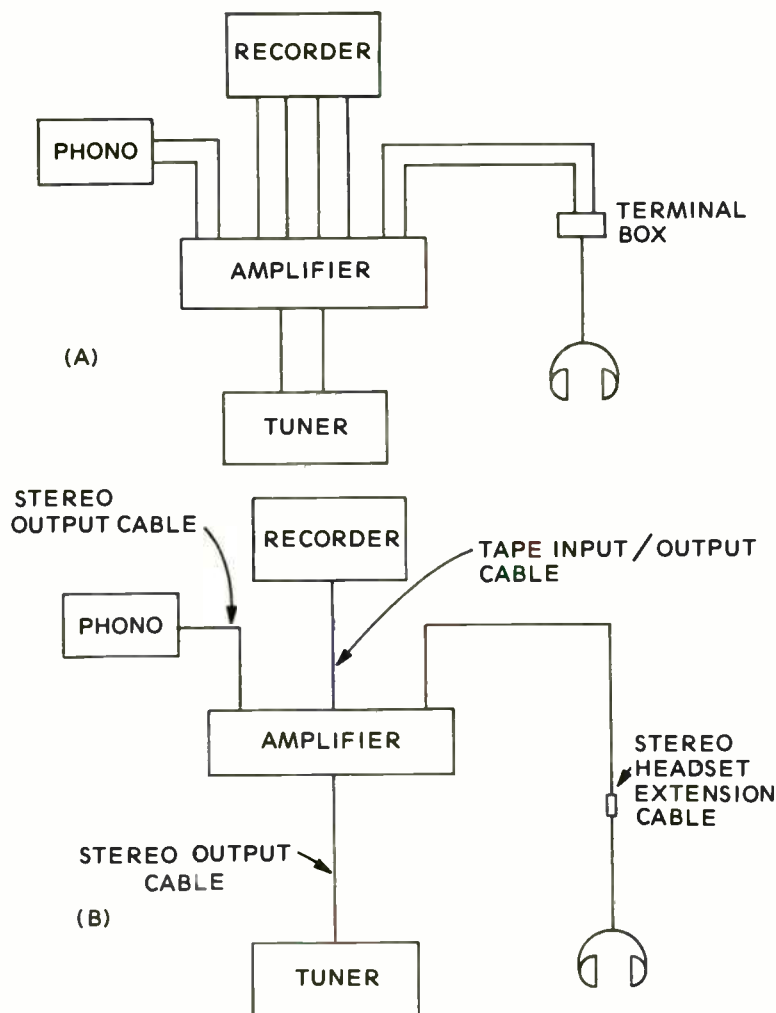


Fig. 9-4. Cable assemblies simplify inter-equipment connections and result in neat appearance.

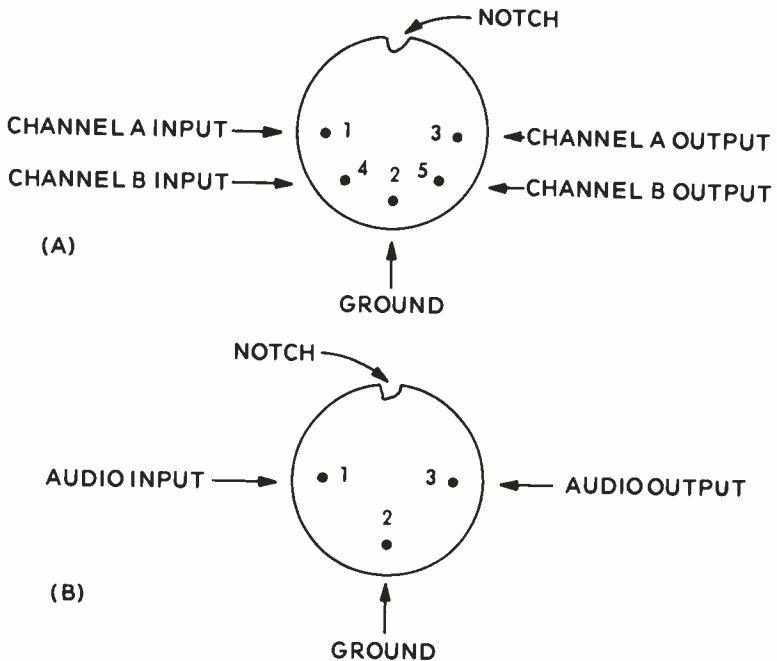


Fig. 9-5. Wiring standard used for DIN sockets found on imported equipment.

ected together to ground. To the other end of each shielded cable is attached a standard phono-type plug. Occasionally, a 5-pin DIN socket is found on a monaural piece of equipment. In this case, only pins 1 and 3 are used for signal leads and pin 2 is still the ground. If only an audio output is present, such as on a radio, pin 3 is the signal output and pin 2 the ground.

If you look carefully at a DIN plug, you'll see that the pins are numbered in the same manner as described here, so you merely solder to the correctly numbered pin. Unfortunately, the 5-pin DIN socket has two series of pin spacings. That shown in Fig. 9-5A is the current standard (Hirschmann Mas series); however, there is an older form where the five pins are spread almost evenly around the face of the socket. The difference is very apparent when looking at the socket on a piece of equipment. The pin connections are the same in any case, however.

REPLACING CARTRIDGES AND NEEDLES (STYLI)

Except for some very inexpensive types, the needle or stylus assembly can be replaced in virtually all phono car-

tridges. Usually, this is all that is required to ensure continuing performance, unless the cartridge itself has been physically damaged. Steel needles, which are becoming rare, are very inexpensive but they last only for about 30 hours playing time. If used longer, they will damage the record surface. Diamond needles usually last for 1,000 to 2,000 playing hours and are almost the universal replacement type used. Of course, cartridge manufacturers make replacement needles, but there are also less expensive universal-type replacements for almost any cartridge. Unless you have broadcast studio type equipment, no difference in performance will be noticed when using a universal replacement needle. However, you should be sure to buy a replacement for the type of cartridge in use, since there are a number of different needle fittings.

Needle replacement is a simple matter; you simply unclip or unplug the present needle holder and insert the replacement. A look at the replacement and how the needle is currently mounted should quickly reveal the way the needle assembly is held in place. When inserting the needle assembly, leave the guard on the needle, if possible. Avoid contacting the exposed needle tip itself with your fingers. After replacing the needle, it is a good idea to recheck the tracking force of the tone arm, as described in the following section.

When replacing a cartridge, it is not absolutely necessary to use exactly the same type again. Indeed, many hi-fi system owners like to upgrade the quality of their system by using better cartridges. Cartridge mountings are fairly universal, and even if a cartridge mounting is different, the manufacturer usually supplies the necessary adapter hardware with the cartridge so it can be mounted in any type of tone arm. Before mounting the cartridge, notice carefully how the old one is wired and mark or make a note of which wires go to the terminals on the new cartridge. A wiring diagram is usually included with a cartridge. In any case, don't solder directly to the terminals of the cartridge but use a connector or slip-on sleeve over the cartridge pin terminals. Replacement of a cartridge requires that the tracking force be reset for the tone arm.

PHONOGRAPH SPEED AND ARM WEIGHT ADJUSTMENTS

Tone-arm weight adjustment is necessary to check that the needle is pressing down on the record grooves with the desired force (usually called tracking force and stated in grams). Each manufacturer specifies how much this tracking force should be. The lighter the force used, the less the wear on

the record. Too little pressure cannot be used, however, or the full sound quality of the record will not be reproduced.

The force can be measured by setting the needle, with the tone arm in the middle of the turntable bed, on a measuring instrument. Such instruments are inexpensive and are calibrated in grams. The very simple type, which consists of just a small pendulum arm where a weight is moved along slots in one arm to correspond to different gram settings (1 to 10), is adequate for most applications. The force is adjusted to the specified value by an adjustment screw on the tone arm, located at the swivel end of the arm. In operation, if you notice any difference in sound quality with a lighter tracking force than that specified, and if the tone arm is not too sensitive to handle, the lighter force should be used, as it will conserve both the record and the needle surfaces.

On many phonographs, speed adjustments are possible with a control that allows a 10 percent or so range of variation. Some makes do not provide for any speed adjustment, but in any case it is useful to still determine whether or not the speed is correct. An easy and a quite accurate way to check turn-

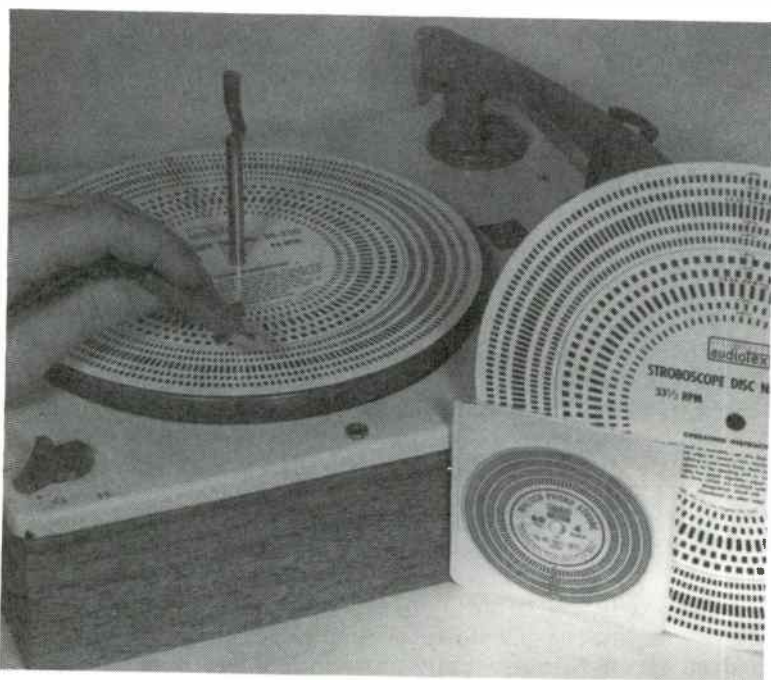


Fig. 9-6. A strobe disc and small neon lamp are used to check the speed of a turntable.

table speed is with a strobe disc. These discs (see Fig. 9-6) are available in paper, plastic, and metal versions at very low prices. The disc is simply placed on the turntable and, with the turntable running under an incandescent light, the ring on the disc corresponding to the speed to which the turntable is set is observed. When the turntable speed is correct, the ring will appear to stand still. An incandescent light source is essential since the power line frequency is actually being used as the speed standard. Although you don't see it, the lamp does not burn continuously; instead, it is actually being turned on and off rapidly at the AC power line frequency. You may also use a small neon lamp held close to the appropriate ring on the disc. The neon lamp has a sharper turn on and off effect than a regular filament-type lamp; therefore, the stationary effect of the ring is easier to see. In any case, remember that a lamp operating from the AC power line—and in no case battery powered—must be used.

SPEED ADJUSTMENTS (TAPE MACHINES)

The speed of a tape machine is rarely adjustable, except during complicated service procedures. You can, however, check the speed of the tape transport mechanism to be sure that it is operating properly. The easiest way to do this is with a so-called tape strobe, an inexpensive mechanism similar to the strobe disc used with turntables. Any tape can be used on the recorder and the tape strobe wheel is attached so that it turns in accordance with the tape speed. The wheel has markings on it for various tape speeds and it is viewed in the same manner as a strobe disc; that is, when viewed under an AC-operated lamp, the markings on the wheel for a specific tape speed will appear to stand still if the speed is correct.

Another commonly used method to check the speed, if you have the necessary test equipment available, is to play a test tape containing known frequencies. You then measure the output frequency reproduced by the tape machine which, of course, will correspond to the test frequency if the machine is operating at the correct speed.

CLEANING AND LUBRICATION

Dust and grime are one of the main causes of premature record and needle wear in an otherwise properly adjusted phonograph. Since abrasive action is normally taking place between the needle and the record surface, the introduction of additional materials will further intensify the abrasion. The best that you can do to insure against such wear is to keep the entire system as clean as possible. Records should be stored in

jackets. The turntable should be covered by a dust cover, even during use. A small dust brush mounted on the tone arm itself is often very helpful in collecting dust from the record surface. More elaborate static electricity dust collectors are also available, although the dust will then accumulate around the needle and has to be wiped off from there.

Try to avoid running a finger across the needle surface, either to clean it or to check whether or not the pickup is working. The needle should be cleaned only with a fine soft brush. Finally, the records themselves can be sprayed with an antistatic spray which will help reduce the amount of dust attracted to the surface. If a great deal of dust still accumulates in spite of these measures, it would seem expedient to carefully consider the location of the phonograph. It may well be that moving it somewhere else in the room, out of drafts or away from heating outlets, etc., will help the problem.

Phonographs should be lubricated very sparingly. About every year or so, a light application of fine machine oil on the moving parts, or better yet, a lubricant spray, may be used. There are several places where you should be careful not to get any lubricant—they are the friction drive mechanisms. Usually, these drives are easily identified if you look carefully at the mechanism. One drive is probably used to turn the turntable itself and another is the speed selection mechanism. If you turn the speed selector switch, you'll notice a small rubber disc moving up and down on different segments of a metal cone-shaped shaft.

TAPE HEAD CLEANING AND ALIGNMENT

In spite of the fact that there is no sharp abrasive action (or shouldn't be) between the moving tape and the tape heads, the continuous sliding of the tape over the heads causes some of the tape material to rub off. The result is a brownish residue on the heads which, on the record-reproduce head, can degrade the high-frequency response. This residue can be removed by periodic cleaning and by their lubrication to reduce the friction between the head and tape.

Tape head cleaners are available in aerosol type cans from which you simply spray the cleaner (via a plastic extension tube) directly on the head to wash away the residue. If used frequently, such sprays are effective. They are also very handy for those hard-to-reach tape installations, such as in an automobile. However, a spray will not always remove a residue which has become caked on a head. For home recorder use, it is better to use a head-cleaning kit which consists of both a tape head cleaner and a tape head lubricant. The cleaner can be applied to the head with a nonlinting swab

(cotton or soft foam plastic) and lightly rubbed over the head until you can see that all the tape residue has been removed. The lubricant is then applied liberally over the head with another swab.

If the tape mechanism has pressure pads (small cloth pads which press the tape against the heads), they will also accumulate a great deal of tape residue. Although the accumulation will not affect frequency response performance, it should be removed with the tape head cleaner. If the pads show any sign of wear or breaking apart, they should be replaced.

Another portion of the recorder that will accumulate a good deal of tape residue is the capstan and pressure roller. This is the shaft and the hard rubber wheel which presses against the tape. The capstan drive actually supplies the force to pull the tape across the tape heads at the prescribed speed. The wheel can be cleaned with tape head cleaner, but it should never be lubricated in any manner. In fact, you can even buy a "no-slip" liquid to apply to the drive wheel to ensure that its surface is free from any oil or other material that would tend to reduce the effectiveness of the friction drive. The same liquid is also useful when applied to belts or other friction drive mechanisms to ensure that they do not slip.

Tape head alignment should be checked periodically, because if the head is not aligned correctly, the result can be a loss of output level, loss of high-frequency response, or a combination of both effects. The location of the adjustment screws for a particular recorder should be determined from the recorder manual. A special test tape, with a 6-kHz signal recorded on it, is suitable for alignment. While the tape is running, the head is adjusted for maximum sound output (on any one channel). Only this one simple adjustment is necessary for recorders which have a combination playback and recording head. If it's a more elaborate recorder, with separate heads for recording and playback, as well as a monitoring head (so you can hear how material was recorded immediately following the record head), the playback and monitoring heads are aligned first. The record head is then adjusted for proper reproduction through the monitor head as you record a single high-frequency tone.

DEMAGNETIZING TAPE HEADS

Tape heads accumulate a small amount of magnetization over a period of use. The effect is an increase in the noise level of recorded material. It is easy to demagnetize the heads, and it should be done on a regular basis. Few people are aware of the noise buildup on the tape until it becomes rather obvious,

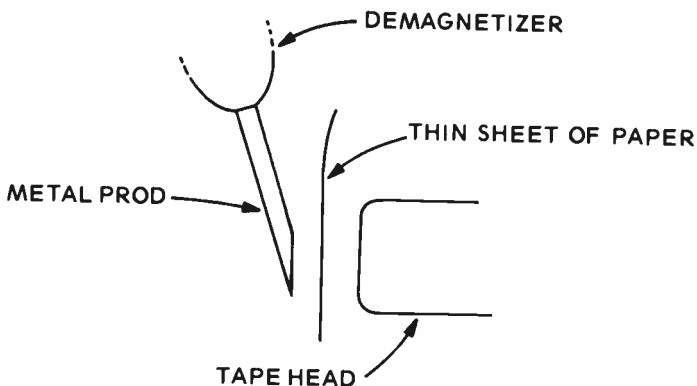


Fig. 9-7. A sheet of thin paper should be placed between the tape head demagnetizer prod and the head to prevent scratching. The prod should be moved over the entire head area.

because it builds up so slowly. A simple check, just to see if a problem exists, can be made by playing back a tape erased by the recorder and comparing its noise level to that of brand new unused tape (or tape erased by a bulk eraser). If the latter tape has significantly less noise, the recorder heads are probably magnetized.

Demagnetization is an extremely simple process, using any of the commercially available demagnetizer units. As shown in Fig. 9-7, the demagnetizer prod need only be placed near a tape head for a few seconds. The prod should not touch the head, since it may scratch the head surface. If the prod surface is not covered by a plastic film, place a thin piece of paper between the head and the prod to ensure that they do not touch. Each head should be done in turn, preferably after the heads have been cleaned. When dealing with a cassette machine, be sure to depress the "play" function to move the heads out where you can get to them (without a cassette loaded, of course).

FREQUENCY RESPONSE, BALANCE AND OUTPUT LEVEL CHECKS

Frequency response and output level checks are probably the best overall performance indicators for either a phonograph or tape recorder. They are simple to make, and even if you do not wish to make any adjustments on a machine, the checks can be used to indicate when servicing is warranted.

Both records and tapes are available with recorded test tones. A quality recording of this sort should be purchased and stored carefully to use as a test reference.

One common mistake is to listen to a standard recording, and if all the tones are heard, declare a hi-fi system to be in order. Perhaps as a crude check this is sufficient, but any really useful check of a hi-fi system requires more care. Specifically, the standard tapes should be used in conjunction with an output level meter, preferably connected directly at the phonograph or recorder output. Such sensitive meters are expensive, so a simpler output meter of the type that connects to the loudspeaker terminals, as shown in Fig. 9-8, will suffice. Be aware, however, that using the meter at this point means that the entire amplifier system is being checked also. If some difficulty arises, it still has to be isolated to the piece of equipment at fault.

The controls on the recorder and those on the amplifier should all be set to some reference position, usually for flat frequency response and midrange volume. The test record or tape is then played and the output meter set to zero for a 1-kHz tone. Then, as other tones are played, the output level is noted without readjusting any controls. If these levels are recorded on paper and the test repeated periodically in the same manner, you can tell if there is any change in the frequency response and output level of the equipment. A drop in high-frequency response might indicate dirt accumulation in the recorder mechanism, a reduced output level might indicate a change in the tone-arm pressure or a misaligned head in the case of a tape recorder, etc. The most important thing is that the test be repeated each time under the same conditions.

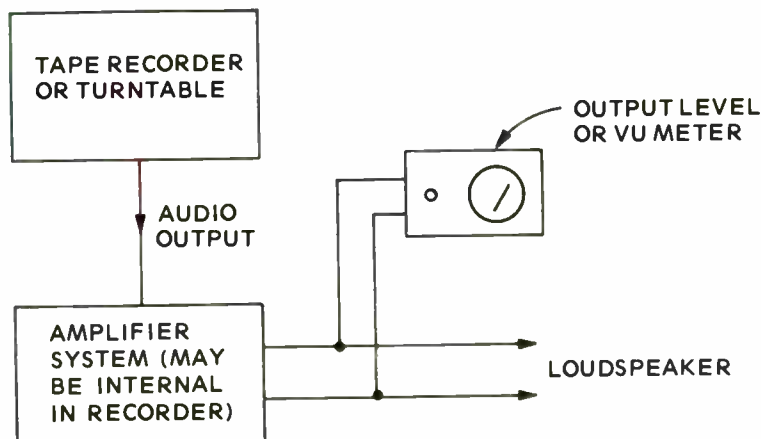


Fig. 9-8. Setup for a frequency response and output level check.

During the above test, stereo channel balance and separation can be checked by switching to the opposite channel from which a test tone is on. The "spillover" level can be noted on the output meter at each frequency, and it should remain the same each time the test is repeated. Again, reduced separation, as shown by an increase in the spillover level, can be due to a fault at many points in the reproducer-amplifier chain. One of the first components to check, however, is the tape head or cartridge in a phonograph for dirt accumulation and proper alignment or pressure. If the test equipment is available, you can make a simultaneous speed check during the above tests by noting if the frequency of the output signal corresponds exactly with that of the recorded reference frequency.

TAPE SPLICING

At some time or other, every one who owns a tape machine is confronted with the need to splice a tape. If a tape machine breaks tapes frequently, such as during rewind or when sudden starts and stops are made, it is an indication that the braking mechanisms in the machine are improperly adjusted. They grab too suddenly or over-stress the tape. The opposite effect, where the tape continues to unreel when the machine is stopped, is also an indication of a brake adjustment fault.

In a pinch, ordinary transparent adhesive tape can be used to make splices, but it is not designed for the purpose. Specially made splicing tape with a Mylar base should be used for dependable and long-lasting splices.

You can make splices with just a razor blade and splicing tape, although a simple tape splicing holder is far more convenient if you have a lot of splicing to do, as when editing a tape, for example. The tape to be spliced is first cut diagonally where the two pieces are to be joined. If the ends have been bent sharply so an impression is still evident in the tape, these pieces should be cut away also, because they will likely cause another break. After the cut is made, a small length of splicing tape is placed over the two ends on the shiny side of the tape, not the oxide or dull looking side. The dull side—the oxide side—passes over the recorder heads. The splicing tape should be cut so it does not extend beyond the tape on either side or some of the adhesive from the splicing tape will get on the recorder heads.

Fig. 9-9 shows how the completed splice should appear. Notice that it is not necessary to splice the tape on both sides, nor is it necessary to make the splice an elaborate affair. The base tensile strength of the tape is easily duplicated by a single side splice and, of course, there is no need to make the splice

stronger than the tape itself. Bulky splices simply hinder the tape movement through the recorder.

OFF-THE-AIR RECORDINGS

One of the main uses of a tape recorder are off-the-air recordings from an AM or FM radio. The connection of the recorder to the receiver, as previously discussed, should be made at one of the early audio stages in the receiver. For recorders with a more limited frequency response, such as some of the inexpensive cassette types, a simple connection to the speaker system will serve as well (see Fig. 9-3).

You should first test the recording setup to be sure that recordings can be made without distortion. If distortion occurs, there is obviously some fault in the interface between recorder and receiver. If a connection to the volume control proves inadequate, try instead a connection to the receiver's speaker system. If the distortion continues, insert some resistance (a 1 megohm potentiometer) between the receiver takeoff point and the recorder. Also, a small coupling capacitor (20 to 50 mfd) may be tried. By a simple bit of experimentation, you should be able to find an interface connection that allows distortion-free recordings to be made.

Some users are often surprised at the amount of background noise in a recording, especially when it wasn't apparent in the output of the receiver. The recorder, of course, doesn't discriminate against noise, so it picks up the full frequency range of which it is capable. After a test recording of this sort, you may find that good quality off-the-air recordings are not possible until the signal level coming into the receiver is improved by a better antenna, antenna preamplifier, etc. Of course, you can insert some form of tone control

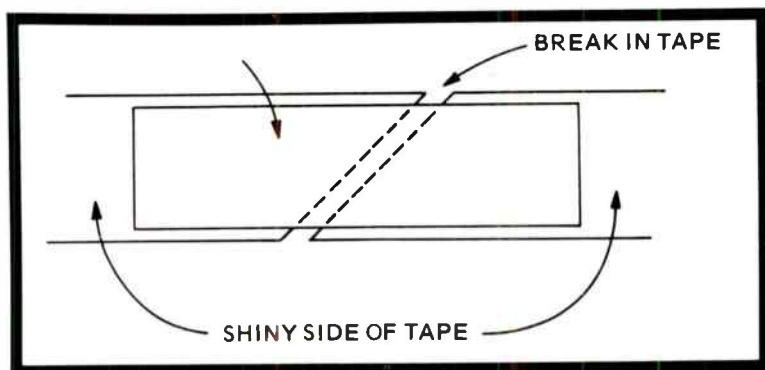


Fig. 9-9. A correctly made tape splice should resemble this drawing.

network between the receiver and the recorder to tailor the frequency response to the point where it sounds acceptable. But this defeats the purpose of a good recording, since the reproduction will have a peculiar frequency response. The recording should be made with as flat a frequency response as possible. Then, on playback through amplifying equipment, you can always set the tone controls to the response characteristics favored at the moment.

Adjustment of the optimum level on the recorder also requires some practice. If the recorder has a built-in automatic level control, it should be switched off, if possible, to record music. Otherwise, the music will sound flat or lacking in dynamic range. The proper setting of the recording level can be determined only by some practice. Too high a setting will overload the recorder and cause distortion; too low a setting and the background noise will be exaggerated. "Riding" the gain control (manually adjusting the gain during the recording) should be done with care. Actually, it is one of the best techniques and is used by professionals. However, if you try to equalize the recording level too much, the effect will be like that of having an electronic automatic level control. Used with care, it can be used to make excellent music recordings where there is a wide variation between very soft and then very loud passages. For stereo recordings, try to keep the recording level for both channels constant. Upon playback, you can always emphasize one channel or the other if desired, but this is difficult to do if the recording was made with a greatly unbalanced level between channels.

RECORDER REMOTE CONTROLS

The remote control of levels on a recorder can be done in the same manner as that suggested for a TV or radio receiver see Chapter 4. The technique of remoting the potentiometer controls with a lamp-photocell module is particularly recommended for the record level function, since you need to take special care not to introduce any external noise or hum into the recording.

The remote control of many of the other functions on a recorder is not possible in any simple fashion, since they often involve a combination of mechanical and electrical actions. Where switch actions are purely electrical, such as is the case with some recorders for "play," "rewind," etc., a remote switch need only be wired to parallel the switch contacts in the recorder.

One of the most useful functions available in many recorders is a "pause" switch, which is used to stop the recording process temporarily, such as during a commercial,

and then when the switch is released the recording resumes. It is one of the handier remote controls to have if you have to run to a recorder to stop it everytime an announcement comes along. For recorders equipped with such a control, it can be remoted by simply paralleling the switch contacts with a remote toggle or push type on-off switch. If the recorder does not have a pause control, it usually can be added with a bit of care, although it does involve going inside the recorder case.

With the recorder set up to record, notice which motors are turning in the recorder and try to locate the power lead to them. The power lead is then simply remoted with a switch, as shown in Fig. 9-10. Doing this with cassette recorders is particularly simple since only one motor is involved. With some recorders you can make the whole affair even simpler by interrupting the AC power line to the recorder. Try it by unplugging the power line to the recorder when it is in the record mode and see if it continues to record when the line power is again connected. Some recorders have solenoid arrangements which fall out after power is removed, thus it is necessary to restart the recorder after power is reconnected.

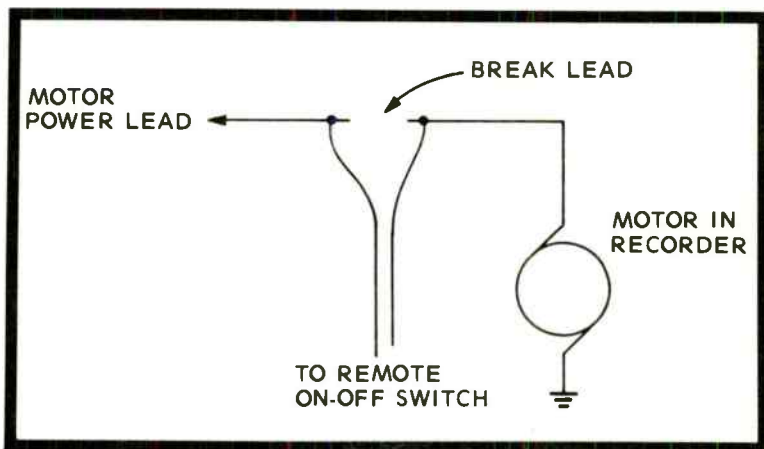


Fig. 9-10. This sketch shows how to install a remote "pause" control in a tape recorder.

Chapter 10

Hi-Fi Amplifier Accessories

Since a hi-fi system is a means of good quality, high-gain amplification and radio reception, there is a wide variety of additional uses to which this equipment can be put. Its availability allows you to try a number of other electronic devices with a minimum expenditure. Of course, you may not want to tie up expensive hi-fi equipment permanently for some application where a much simpler amplifier would suffice, but at least to try an idea, the hi-fi amplifier is ideal. The feasibility of using hi-fi equipment for many other applications is based largely on the fact that most equipment now is solid state. It can be left turned on for many hours or even continuously with no deterioration of the equipment due to overheating and without excessive power consumption costs.

IMPROVE TV AUDIO

One of the simplest but most worthwhile uses for hi-fi equipment is improving the quality of the sound reproduced by the average TV set. TV audio is also frequency-modulated and of hi-fi quality, although it rarely sounds like it after it is reproduced by the small speaker in a TV set. An auxiliary input on a hi-fi amplifier can be connected to the TV audio system and the hi-fi system used to reproduce the TV sound. A good improvement in sound quality will be achieved, especially during musical shows.

The methods of interconnection between the amplifier and TV audio are the same as those previously described for headset connection in Chapter 2 or for connecting a recorder to the audio system of a radio in Chapter 9. (Refer to Fig. 9-3.) Even the simple takeoff from the speaker terminals in the TV set will result in a considerable improvement in the quality of the TV sound.

REMOTE MONITORING

The phono input on a hi-fi amplifier designed for use with a magnetic phono cartridge represents a very sensitive, high-

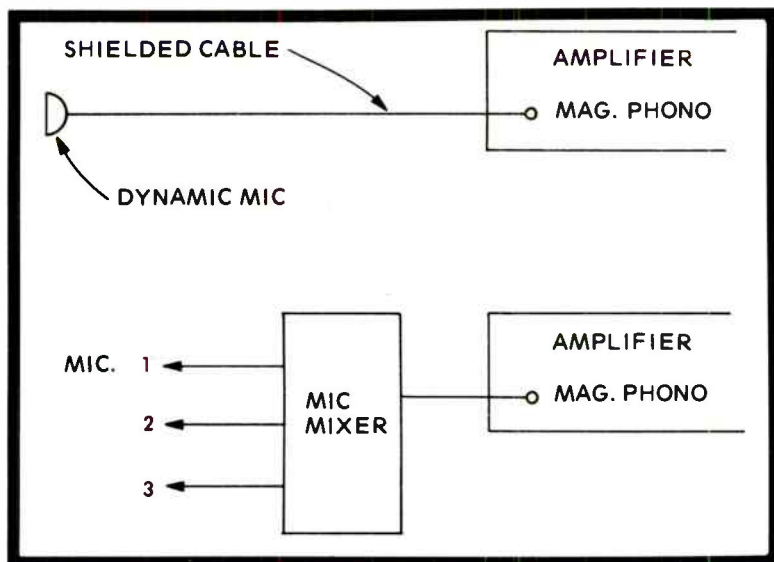


Fig. 10-1. If an amplifier does not have a microphone input, a magnetic phono input can be used.

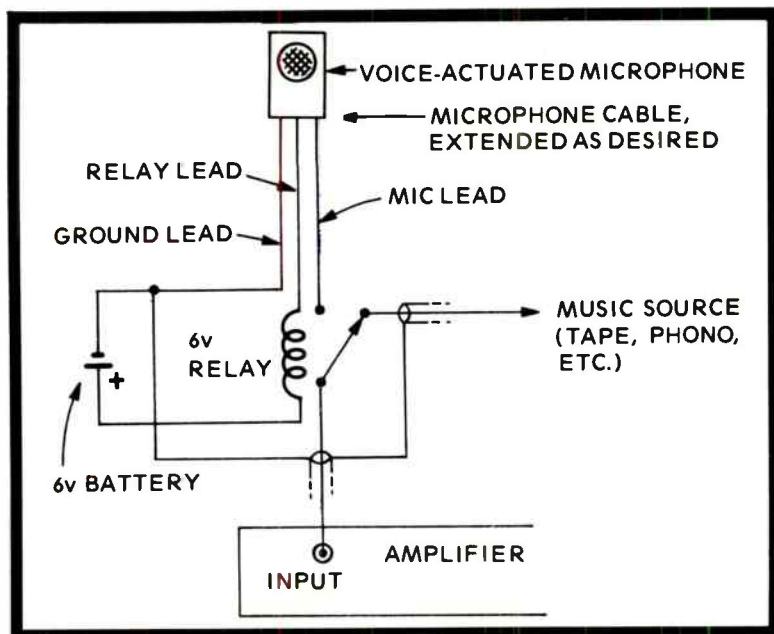


Fig. 10-2. Voice-operated switch wired for automatic switching to a remote monitor location.

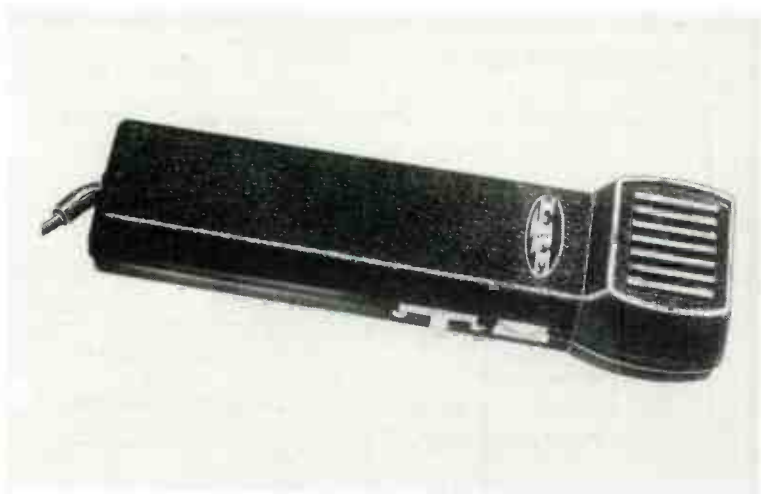


Fig. 10-3. Voice-operated switch. (Courtesy Lafayette Radio)

gain input circuit which is the equivalent of a sensitive microphone preamplifier. The only difference is that the phono preamplifier frequency response emphasizes the lower frequencies. Nonetheless, a microphone can easily be connected to this input for remote monitoring, as shown in Fig. 10-1. Also as shown, several mikes can be used via a switching network or a mixer network. Any low to medium impedance microphone (50K) should work well, and for remote speech monitoring it need be only an inexpensive type.

The above installation might be useful for purposes such as baby sitting where you occasionally switch to the microphone input to check that everything is in order. Another variation of this idea, but one that can be far more useful for someone who likes to listen to a hi-fi system yet needs to know when someone is calling him, is shown in Fig. 10-2. In this case, a so-called VOX or voice-operated microphone is used at the remote monitoring point. This type of microphone is available as a complete assembly (Fig. 10-3) or you can purchase a VOX module which will convert any normal microphone into a voice-operated microphone.

When a voice signal of given amplitude is picked up (the sensitivity can be adjusted) the VOX microphone not only transfers the electrical signal along a cable, as any ordinary microphone does, but also activates a relay. As shown in Fig. 10-2, this relay function is used to switch another simple relay at the hi-fi amplifier, which disconnects the music source and connects the amplifier to the remote microphone. As shown,

the relay simply switches the phono input, but the relay can be wired to interrupt any other input and switch the microphone in the circuit. If you wanted to eliminate the relay at the amplifier, the relay line from the VOX mike could be used to operate a small battery-powered buzzer. Then you could manually switch the amplifier over to the phono input to which the microphone is connected to hear what is being picked up.

INTERCOM SYSTEM

The monitor system above can easily be expanded to an intercom system, particularly where an intercom is needed only occasionally or where a good amount of power is needed for an intercom, such as in an outdoor application. A suitable circuit is shown in Fig. 10-4. A simple dynamic speaker, used at the remote location, functions as both a microphone and as a speaker. The output of the speaker, when connected to the phono input of the amplifier, may be sufficient so that a direct connection can be made to the amplifier. In any case, it should be tried first. If it does not work, a low-impedance microphone preamplifier module can be used at the amplifier.

The simple circuit in Fig. 10-5 would be adequate. One advantage in using such a preamplifier is that its output level can be adjusted as desired so you don't have to readjust the gain control on the amplifier when switching back and forth from "talk" to "listen." The "talk" or "listen" function is controlled by the switch at the amplifier. Rather than use one of the hi-fi system speakers as a microphone, although it could be done, a separate microphone is more appropriate. All you

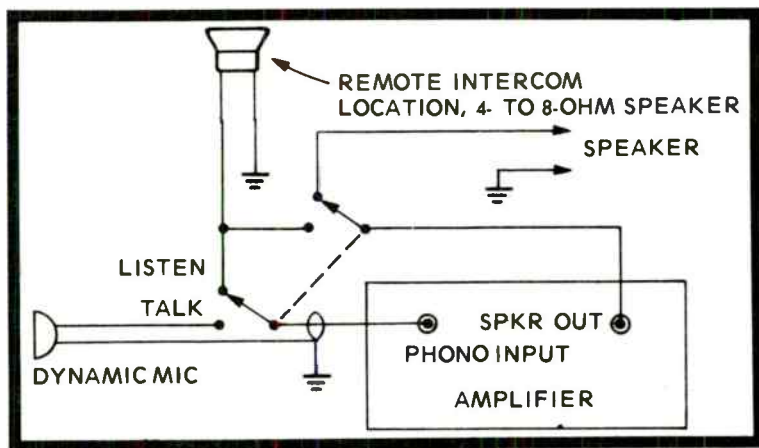


Fig. 10-4. A hi-fi amplifier can be used as an intercom system with several remote stations.

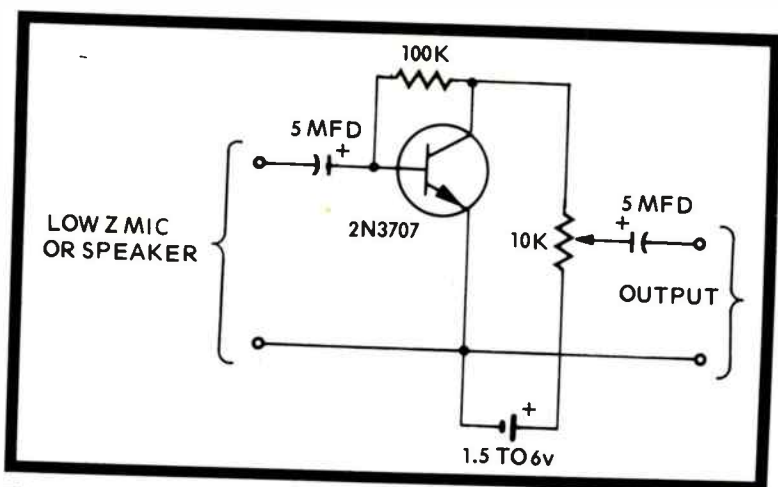


Fig. 10-5. Simple preamplifier for the intercom system.

need is an inexpensive dynamic type microphone, since only speech quality reproduction is desired.

The basic system can be expanded as desired, with the addition of a means to switch to each remote location. It can also be combined with the voice-operated microphone technique previously described. In some cases, it would be useful to provide the facility necessary to tie all remote speakers together so a general announcement or alarm can be transmitted to all locations. Since the remote locations have no control over the talk-listen function, they cannot prevent such an announcement from being received.

WIRELESS BABY SITTER OR MONITOR

If an AM or FM tuner is a part of your hi-fi system, all that is needed to connect it to a remote monitoring system is a small transmitter module. FM modules are particularly good for several reasons. The usual hi-fi tuner is more sensitive on FM, the antenna required at the module is shorter and FM modules usually require only a simple 1½-volt battery instead of the 6- or 9-volt battery needed for the AM transmitter modules.

These modules are amazingly compact, and, as shown in Fig. 10-6, the wiring is also simple. You just connect a battery, a microphone, and a piece of wire for an antenna. The sensitivity of the pickup can be considerably increased by the addition of a small preamplifier for the microphone. A preamplifier module can be used or the circuit in Fig. 10-5 can be modified for the purpose. Instead of the potentiometer, use

a 10K fixed resistor, and connect the output capacitor to the top end of the resistor, the collector terminal on the transistor.

The transmitter module can be tuned to any clear point on the FM dial. Place the module fairly close to the FM tuner for the initial tuning, then it can be moved to any desired location. The sensitivity and pickup of these modules, if a microphone preamplifier is used, can be quite amazing. For instance, such a unit placed in the living room, 100 feet or so away from the tuner, will easily transmit conversation taking place in the room at normal speaking levels. This circuit when properly disguised and sometimes further miniaturized is, in fact, the main tool used in a great deal of electronic eavesdropping.

TELEPHONE AMPLIFIER

A hi-fi amplifier may be used to amplify telephone conversations. A telephone induction pickup coil (Fig. 10-7) is attached to the base or the handset of the telephone. The exact placement of the pickup to obtain the best output level may require a bit of experimentation, using the dial tone. The output leads of the pickup are connected to the crystal or magnetic phono input of an amplifier or, even better yet, to a high-impedance microphone input. Thus, the incoming telephone conversation can be amplified to any desired level for group listening.

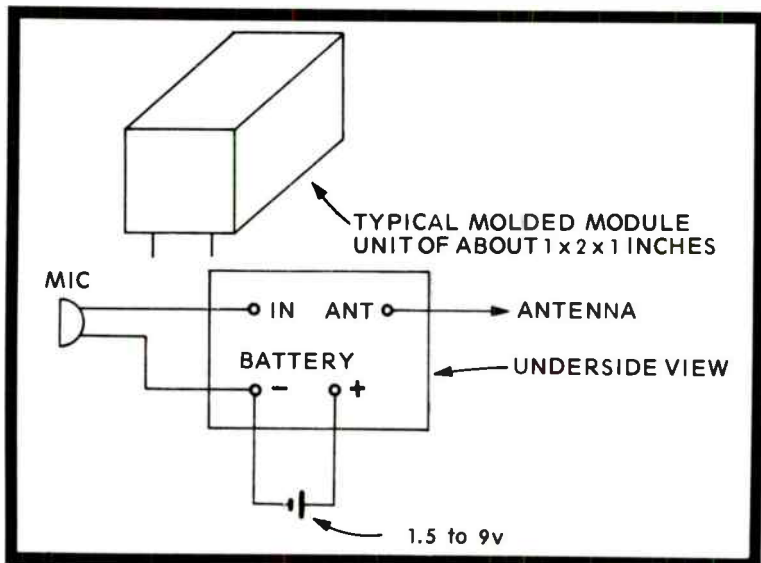


Fig. 10-6. Wiring diagram for an AM or FM transmitter module.

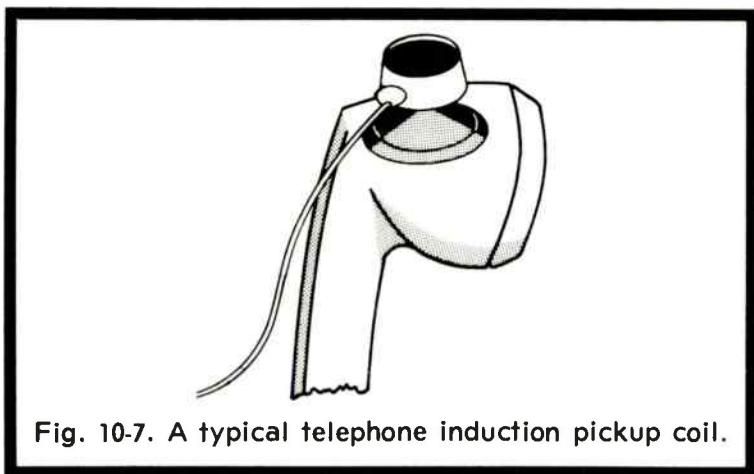


Fig. 10-7. A typical telephone induction pickup coil.

To make a 2-way conversation complete, you may want to arrange a way for more than one person to speak into a telephone. A direct electrical connection of accessory items into the telephone system is generally not allowed or at least is subject to many restrictions. However, there is no reason why an acoustical connection cannot be made to the telephone system. For instance, a small 2-inch loudspeaker can be clamped directly on the mouthpiece of a telephone handset with a cover of foam plastic material, as shown in Fig. 10-8. These devices are commercially made also, although they may be a bit difficult to find. The speaker can be driven by the hi-fi amplifier, using any type of microphone. Multiple microphone pickups, as described in Chapter 5, can be used, too.

One thing that must be particularly guarded against in such a setup is feedback; that is, the microphone channel must be cut off when you are listening on the telephone pickup device. If a single hi-fi amplifier is used for both pickup and microphone amplification by switching back and forth between these functions, feedback will not, of course, be possible. As an alternative, you can equip each speaker with headphones. Then, the headsets and microphones can be left on simultaneously without causing feedback, since there is no direct acoustical path between the headset and microphone each person is using.

PUBLIC ADDRESS SYSTEMS

It may seem that all you would have to do to use a hi-fi amplifier as a PA amplifier is to connect a microphone to it

and install speakers where desired. In essence this is correct, and a hi-fi amplifier does make an excellent temporary PA amplifier because of its high power output. However, the main point that is usually overlooked when a hi-fi amplifier and associated equipment is used in this manner is that intelligibility—not fidelity—is the principal aim of a public address system application. PA systems usually operate against a high background noise level, and in such an environment the faithful reproduction of low- and high-frequency sounds is lost. Perhaps more than lost, since an amplifying device can handle only a certain maximum input level. If this level is reached by frequencies which are ultimately useless, the desired effect at those frequencies which contribute most to pure voice intelligibility (300 to 3,000 Hz) is minimized.

You can adjust the tone controls on an amplifier for maximum effectiveness in a PA application, which is recommended in any case. But for the best results, use a microphone specifically designed for PA, rather than trying to adapt a good hi-fi microphone for such usage. Also, a PA microphone is desirable not only because of its frequency response but because of its directional pickup characteristics. These features are discussed in some detail in Chapter 5. If you don't want to invest in a good PA type microphone, use an inexpensive microphone designed for speech pickup only.

A wireless microphone can also be used with the hi-fi tuner-amplifier combination. Such units can be purchased completely assembled or built from a basic transmitter module, as described in the preceding section. For a

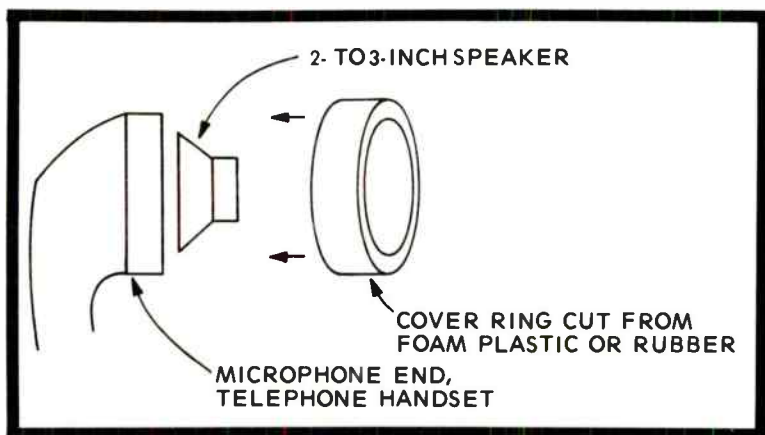


Fig. 10-8. Drawing of a method of applying an acoustical connection to a telephone mouthpiece.

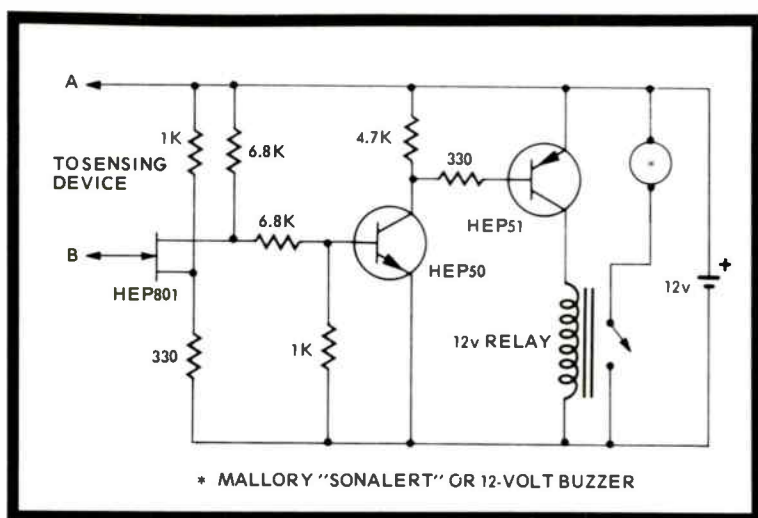


Fig. 10-9. Alarm circuit suitable for a wide variety of sensing applications, including moisture, heat, light, etc.

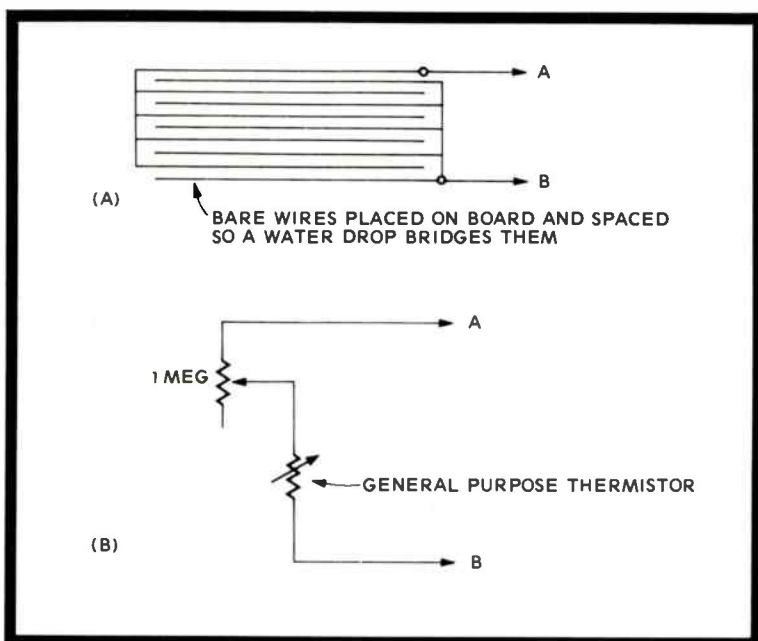


Fig. 10-10. Moisture (A) and fire (B) sensing units for use with the circuit in Fig. 10-9.

microphone type application where you will be speaking close to the microphone, a preamplifier module should not be used with the transmitter module.

MOISTURE & FIRE ALARM AMPLIFICATION

Electronic kits are available to construct both moisture and fire alarms, or you can build such units from scratch. The circuit of Fig. 10-9, for instance, can be made to function as either a fire or moisture alarm by using the desired sensing element. It is very similar to the circuitry used in many kits. The disadvantage of such a unit is that the power output required to sound an alarm is rather low. For really effective distribution of the alarm signal, you can connect the alarm output via a small capacitor (10 to 25 mfd) to an auxiliary input on a hi-fi amplifier. If you don't want the hi-fi amplifier turned on continuously for this purpose, a relay with an extra set of contacts can be used in the circuit of Fig. 10-9; the extra set of contacts is used to turn on the power to the hi-fi amplifier. You would, in effect, have a dual alarm system with the battery-operated unit always functioning, even in the case of a power line outage.

The circuit in Fig. 10-9 is basically a switching unit that can be activated by many types of sensing units. The only requirement is that the sensing unit provide a low resistance across the sensor unit terminals for the condition being sensed. The switching unit as shown activates a relay which turns on a Mallory Sonalert. The latter is a form of electronic buzzer which emits a loud high-pitched tone. The relay contacts can be used to turn on any other desired form of device—buzzers, tone oscillators, lamps, etc.

Two possible types of sensing units which can be used for moisture and heat detection are shown in Fig. 10-10. The moisture detector is simply a series of interleaved metal fingers (bare wire glued on a small board, for instance). A drop of water serves to short two of the interleaved fingers, thereby providing a resistance low enough to activate the unit. The heat detector utilizes a thermistor element, which has the characteristic of reducing its resistance when the temperature rises. It is a form of temperature-dependent resistor. The potentiometer in series with the thermistor can be used to control the point at which the circuit is activated. The activation point can be set by bringing a match close to the thermistor (but not touching it). With some imagination you can think of many more sensing devices for use with the basic circuit. For instance, the weight of accumulated water in a small pan could close a microswitch (a very easy-to-trip form of a toggle switch), or a very thin piece of wire could be used to hold a switch open until the wire is broken or has melted.

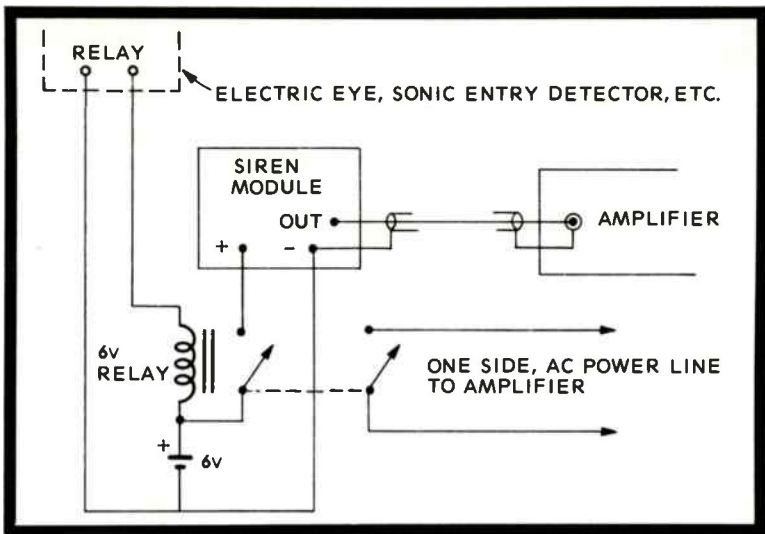


Fig. 10-11. Diagram showing the use of a hi-fi amplifier as part of an entry alarm system.

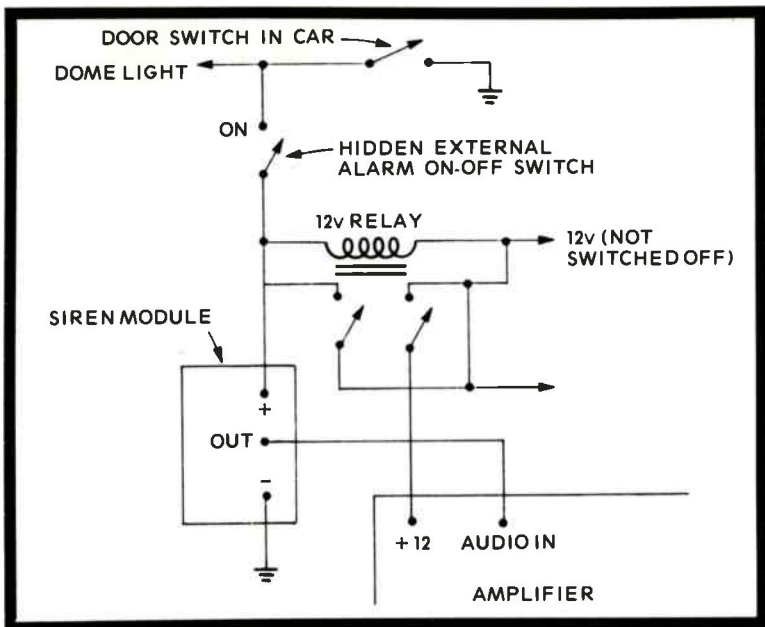


Fig. 10-12. With the few additional components shown here, an auto hi-fi system can be turned into an entry alarm.

USES WITH ENTRY ALARM SYSTEMS

Entry alarm systems come in many types: simple window and door switches, electric-eye types, sonic detectors, etc. They all provide a basic function of turning on a circuit when some specific action takes place, such as breaking the light beam in an electric-eye system or movement in the area of a sonic detector system. The type of alarm used with a basic detector system is usually left to the choice of the buyer. A hi-fi amplifier, when it is not being used for normal service, can function either as the alarm system or as a backup for a battery-operated alarm system. The power available from the hi-fi system makes it ideal for this type of application.

A hi-fi amplifier can be wired into an alarm system as shown in Fig. 10-11. In this case, to avoid unnecessary power drain which occurs when a hi-fi amplifier is left on continuously (although this is not a great problem with transistorized equipment) a relay contact from the alarm system is used to activate another relay which supplies power to the hi-fi system and also turns on a siren sound module which is connected to the auxiliary input of the hi-fi amplifier. Since distortion is not a criterion here, the volume on the amplifier can be turned up as high as possible (if the speakers are sturdy enough) to utilize the maximum power output capability of the amplifier.

VEHICLE ALARMS

If you have a reasonably high-power hi-fi amplifier installed in an automobile, it can also be used with an existing entry alarm system or used by itself as part of an effective system. The advantage of building a system around the electronic equipment already in the car is that only relatively simple components and wiring is required, all of which can be concealed behind the dashboard or the hi-fi equipment.

Fig. 10-2 shows a self-contained alarm system. In this case, as in many entry alarm systems, the door contact switch line (which turns on the dome light in the car) is used. The switch provides a grounding contact each time a door is opened, which activates a small relay that turns on a siren module and the amplifier power. The siren module is connected to the amplifier input. Normal operation of the equipment is unaltered since power to the amplifier only is supplied via a normal power line connection controlled by the ignition switch. Once the alarm on-off switch is turned off, power cannot be supplied to the siren module.

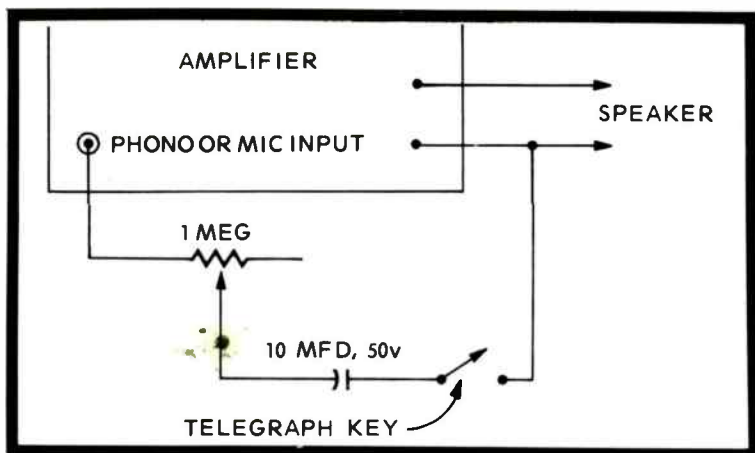


Fig. 10-13. The three components shown convert any amplifier into a code practice oscillator.

CODE PRACTICE OSCILLATOR

The output of a standard code practice oscillator can be connected through a hi-fi amplifier system for extra volume and possibly for group distribution of a signal. Many oscillators have output terminals for connection to an external speaker. If yours doesn't, a connection can be made from the oscillator's built-in speaker terminals to the input of an amplifier via a small 5 to 25 mfd capacitor. The same is true with a modular oscillator; connect the amplifier input to the terminals marked "speaker."

An even simpler oscillator can be made, using only a capacitor and a resistor between the output and input of an amplifier, as shown in Fig. 10-13. Try the circuit first to see if it works at a very low amplifier volume level. The potentiometer will control the oscillation frequency over a narrow range or the capacitor value can be modified to more drastically change the frequency. The circuit is not ideal for real code practice but certainly good enough to have a basic try at code operation and to see what it sounds like.

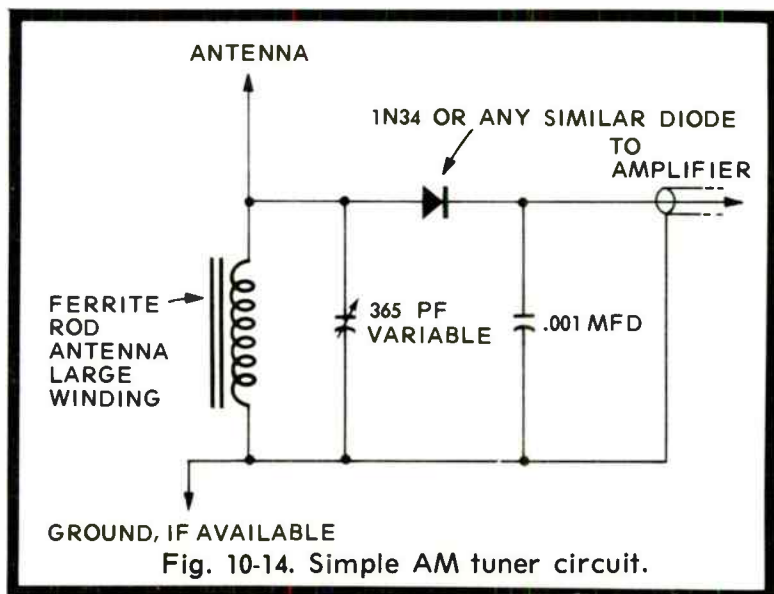
AM FOR THE FM RECEIVER

Although many hi-fi enthusiasts rarely tune away from the FM band, and indeed usually have equipment which can only receive this band, there are times when it is desirable to tune in a local AM station for special events, weather reports,

etc. The capability can be added by feeding the headphone output of a cheap AM transistor receiver or the output of a simple reflex type AM receiver kit to the auxiliary input on a hi-fi amplifier. However, for just local reception, the simple diode circuit in Fig. 10-14 will produce a sound quality that really can be surprising. The sensitivity of such a circuit is so low that it will pick up only local stations without any interference from distant stations. On the other hand, its frequency response is not restricted in any manner by the usual circuits in a conventional receiver and so you essentially hear the audio quality present in the AM transmitter. The output of the circuit can be connected either to the auxiliary high-level input or a microphone input to determine where the best results are achieved.

ADDING SIMPLE SHORTWAVE RECEPTION

Shortwave reception can be added to an AM tuner or almost any simple transistor radio a converter module. These modules usually cover the range of 7-12 MHz, which is a useful range because it includes three shortwave broadcast bands, maritime and aeronautical communications bands, and a time signal frequency. The module is connected to the receiver as shown in Fig. 10-15. A small piece of wire (10 to 20 feet or more) can be used initially to check reception. You should not



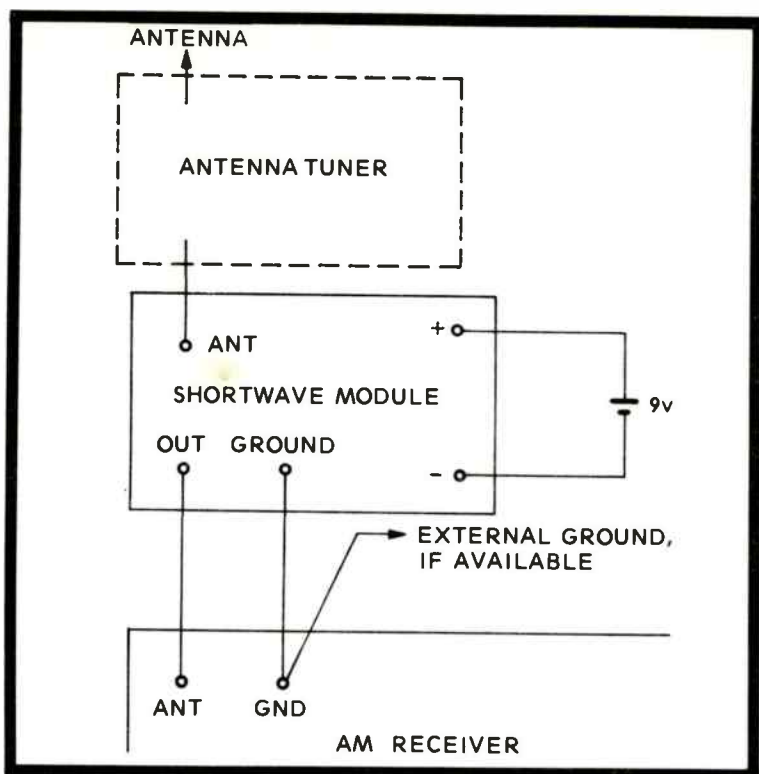


Fig. 10-15. A shortwave module can be added to almost any AM receiver.

expect too much performance from such a simple setup, but you can still hear many interesting stations.

When using this setup, patience is necessary while tuning the system. The module itself has a tuning control, but it covers a great range of frequencies over a very small area of rotation. This situation can be improved somewhat by first setting the AM receiver to the medium-wave frequency output of the module (usually 1600 kHz), then by tuning the module control until a signal is heard. Don't tune the module any further at this point; instead slowly tune the AM receiver around 1600 kHz. In this manner, the receiver tuner functions as sort of a bandsread.

If you can, by patience or by comparing reception with a regular shortwave receiver, establish approximately where the module is tuned, the following are the most interesting bands in the 7- to 12-MHz region:

POLICE-FIRE-AIRCRAFT FREQUENCY MONITORING

A variety of other simple modules and tuners are available that will enable you to extend the coverage of an AM or FM tuner to receiver other services such as the local emergency bands (police, fire, etc.), aircraft communications frequencies, CB bands, etc. These modules cannot take the place of a proper receiver, but they are certainly an inexpensive way to establish a basic reception capability on these bands.

A very confusing situation often arises when you are considering all the converter modules that are available: Which converters can be used with what type of basic receiver? The situation becomes confusing because certain FM signals can be received on a simple AM radio or tuner by a process called slope detection, although the receiver-tuner is normally only designed for AM reception. The "slope" simply refers to the slope side of the signal bandpass response curve in a receiver. In some cases, FM modulated signals can be received on an AM receiver by tuning to the side of the signal rather than directly for a peak as is done for AM signals. AM signals cannot, however, be received on a receiver designed solely for FM reception.

Fig. 10-16 is a table which lists the various possibilities for using converter modules with different types of tuners or receivers. In any case, where a converter unit permits such operation, it is always best to match the modulation type used in the band of interest with the modulation type that a receiver is primarily designed to receive.

7 MHz: Radio amateur band and foreign shortwave broadcast band

8 to 9 MHz: Maritime and aeronautical international communications

9.5 MHz: International shortwave broadcast band

10 MHz: WWV time-frequency standard station (exactly on 10 MHz)

12 MHz: International shortwave broadcast band

You will hear many stations in this frequency range which you cannot tune in properly because of the type of modulation used or because they are keyed (CW) signals. You can add accessories to a simple receiver setup to allow the reception of such stations. For example, a BFO (beat frequency oscillator) accessory will allow CW signals to be heard as keyed audio tones. But, in general, it is not worthwhile to go very far in this direction, since you will end up with a collection of small ac-

CONVERTER TYPE

	CB	Police 30-50 MHz	Police 150-174 MHz	Aircraft 118-140 MHz	Marine Band	Shortwave Bands
BROADCAST BAND AM RECEIVER	*	**	—	*	*	*
FM BAND RECEIVER	—	**	*	—	—	—

— RECEPTION NOT POSSIBLE

* USE USUALLY POSSIBLE

** USE POSSIBLE DEPENDING UPON CONVERTER TYPE

Fig. 10-16. Table of available converter modules and their compatibility with basic receiver types.

cessory items. A better approach, if you are interested in shortwave reception, would be to invest in an inexpensive shortwave receiver or receiver kit.

One thing you can do fairly easily to improve reception is add a simple antenna tuner and possibly a preamplifier. The use of an antenna tuner alone (the simple circuit described in Chapter 7, for example), plus a simple shortwave antenna (also describe in Chapter 7) will considerably improve reception. The advantage of adding these items first is that they will prove useful even with a regular shortwave receiver if purchased later.

The converter modules are wired to the receiver or tuner in the same simple manner as the shortwave converter shown in Fig. 10-15. The receiver is set to a "set" frequency and the module is tuned. Vernier tuning can be achieved by slightly retuning the receiver around the "set" frequency, as suggested earlier. Unlike the shortwave or marine band converters, however, where you can more or less just use a long length of wire as an antenna, good reception on the VHF bands is very much dependent upon a good antenna system. The antenna system need not be elaborate, but it should be designed for the band of interest, rather than using a random piece of wire. The simple antennas described in the beginning of Chapter 6 will work very well. Also, as a first try, you can use the converter modules with an existing TV or FM outdoor antenna. The converter designed for the so-called high VHF band (150 to 174 MHz) can also tune in the very useful U.S. Weather Service forecasts. The frequencies of these broadcasts are either 162.5 or 163.3 MHz, but you should check first with the local office of the Weather Service that such broadcasts are indeed made in a local area before you fruitlessly search around for them.

Chapter 11

TV & Hi-Fi Equipment Care & Repair

The "care and repair" of electronic equipment can be categorized under two terms: preventive and corrective maintenance. Preventive maintenance means caring for equipment properly so it doesn't become defective, or at least noting as soon as possible when a defect does develop, and corrective maintenance means to do something about the defect. A hobbyist can easily do most of the work required by the first category and a surprising amount of the second type.

By far the great majority of service problems that equipment owners refer to professional technicians involve minor repairs which, with some patience and common sense, the equipment owner could have discovered himself. A smaller but still significant number of service problems are caused by equipment owners who try to adjust and repair equipment when they don't have any clear indication of what they are adjusting and if it can really correct a defect. In other words, they hope that by adjusting some internal control setting that suddenly a defect will be cured. Hopefully, the material in this chapter will enable the reader to judge what he can do, himself, and when he should seek professional service for his equipment. Recording equipment and phonographs are covered in Chapter 9, so the material in this chapter deals with receiving equipment (radio and TV), amplifiers, and accessory equipment.

SIMPLE RADIO RECEIVER CHECKS

Among the main receiver checks a hobbyist can periodically make are sensitivity (ability to pick up weak stations), tuning accuracy, the frequency response, audio distortion, and the power output of a built-in audio amplifier. All of these things can be checked easily if you have access to the proper test equipment. However, it is assumed that this is not the case and that you merely want to periodically check the performance to detect the development of any major fault.

The best way to check receiver sensitivity is to observe whether or not distant stations can still be received. However, the reception of distant stations varies greatly from time to

time; therefore, such a sensitivity check must be a continual process, rather than a test made at a specific time. What you need is a constant signal source which will provide a known reading on the receiver signal-strength meter.

A good, constant signal source is a local or nearby station. When the receiver is known to be working properly, you should record the S-meter reading. Then at any time you can tune in that station and check the present reading against the standard. If the two agree, you know the receiver sensitivity is normal. Of course, the same antenna must be used if a comparison is to be valid. A more sensitive test can be made with the antenna disconnected from the receiver in each case. If there is no reception with the antenna disconnected, you can try adding a small wire antenna of minimum length (a few inches) until only the strongest station is heard. This "calibration" antenna is used in the future to see whether or not the same reception is still possible. In essence, you are duplicating the reception of a very weak station by this method, a station which should always have approximately the same signal availability. If the receiver does not have a signal-strength meter, you can still use this check, basing your judgment on a barely audible sound level at a reference volume control setting.

The receiver's tuning scale accuracy can be checked by comparing the scale reading for a station to that published in newspapers, program guides, etc. The AFC in FM receivers should be turned off for this purpose. The check is useful mainly to indicate that the oscillator portion of the receiver is stable and that the mechanical portion of the tuning mechanism is not becoming loose. If the point at which different stations are received keeps changing, it could indicate that the oscillator section is developing problems or there is slippage or backlash in the mechanical tuning mechanism.

The frequency response of the entire receiver can most easily be checked by finding a strong station which periodically sends a test transmission of different frequency tones. Such transmissions are usually broadcast at the start of special hi-fi or stereo programs. These checks are only useful, however, when coupled with a check of the audio output level of the receiver at a reference setting of the volume and tone controls. That is, if you are receiving the station at the same signal level as usual and the receiver controls are all set the same as before, the audio output level as measured by a VU meter across the speaker line should be the same for each audio tone as it was during the first check. The level normally will not be exactly the same for each specific audio tone.



Fig. 11-1. A typical audio oscillator.

The power output of the audio section of a receiver or amplifier in absolute terms is near impossible to measure without the use of proper instruments. This difficulty arises because power output alone doesn't have much meaning unless it is coupled with some knowledge of the distortion produced. In simpler words, its not only the quantity of audio produced that is important but its quality as well. You can obtain an indication of whether the power output is falling off or not, however, during the frequency response test just described. You can also play a tone test tape through the amplifier system and notice if the output level remains the same for each tone frequency at the reference settings of the amplifier controls on the receiver.

Distortion can be detected by a listening test only in a very coarse sense because distortion of several percent may not be noticeable and the ability to hear distortion varies from person. The best that you probably can do is simply listen to the tones on a test tape at both very low and loud volume settings and try to detect any buildup of distortion. If you can turn up the volume loud enough (or using headphones), there will occur a point where distortion becomes apparent in any case. Any change in this point to a lower volume setting could indicate that some problem is developing within the system.

The above checks are by no means meant to measure anything in specific terms. They are, in fact, only a possible, orderly way to check by ear whether any condition in a receiver is changing. The important point is that any shift in a receiver's operating characteristics when it is used con-

sistently under exactly the same condition indicates that some change is taking place in the receiver circuitry which could mean that a problem is developing.

AMPLIFIER CHECKS

Amplifier checks can be carried out in the same simple manner as those described for a receiver with a built-in audio amplifier; that is, by tuning in a station with a test tone transmission or by using a test tone tape in conjunction with an output level meter. If one wants to invest in an audio oscillator, a simple-to-use and not too expensive piece of test equipment, you can make fairly good checks on amplifier performance. Such oscillators come in a variety of forms, both kit and assembled, at a wide range of prices. The main requirement, however, is that the unit have at least a calibrated frequency selector dial and an adjustable output control. The oscillator frequency should range from 10 Hz to 20,000 Hz and the output should be a sine wave. Fig. 11-1 shows a typical unit.

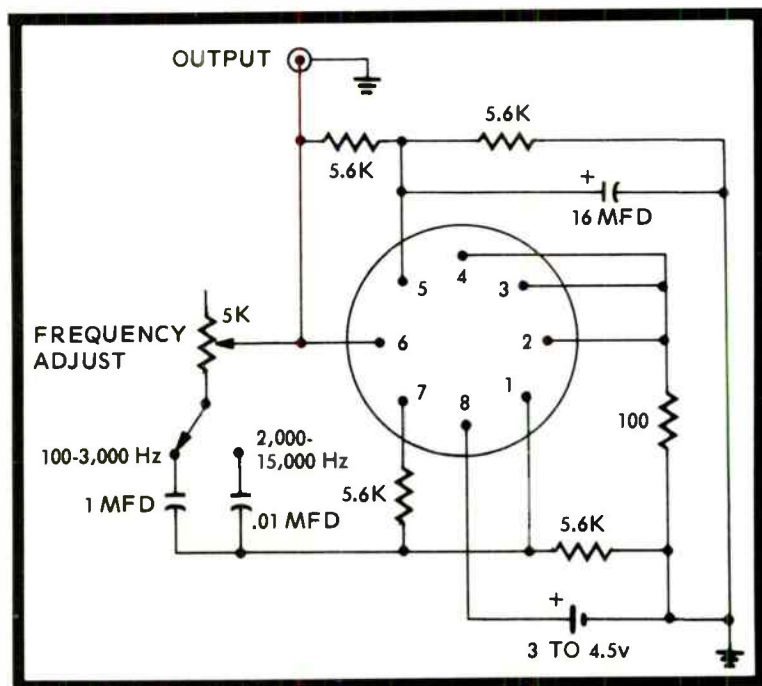


Fig. 11-2. Inexpensive audio oscillator circuit using a Fairchild UL914 integrated circuit.

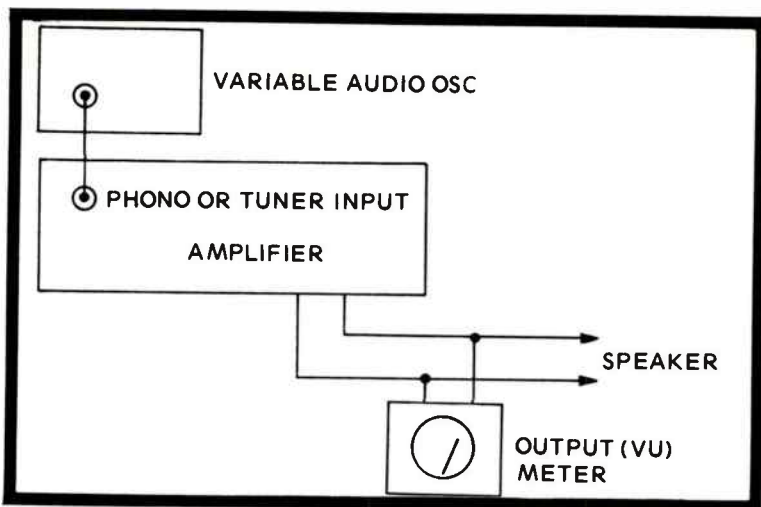


Fig. 11-3. Frequency response test setup using an audio oscillator.

Many simple circuits also are available if you wish to build a simple test oscillator. The circuit shown in Fig. 11-2 is easy to build. It uses a single, inexpensive integrated circuit which is wired in a circuit the same as a transistor. It doesn't produce a pure sine wave output, as a good oscillator will, but it is good enough for maintenance checks. The potentiometer which controls the frequency can be calibrated by comparing the generator output to that of a calibrated oscillator or it can be approximately calibrated during a test tone sequence transmitted by an FM station by comparing the tone provided by the station and that of the oscillator; it is necessary to switch quickly between the two for the comparison.

One of the most useful checks you can make with an audio oscillator is a measurement of an amplifier's frequency response. The equipment is set up as shown in Fig. 11-3. The oscillator output is kept constant (preferably monitored with a meter if the oscillator has one built-in) and its frequency is varied from the lowest range of which the oscillator is capable to about 20,000 Hz. The output meter level reading is noted for each frequency used. If you tape these results and note them in graphic form, the result should resemble the curve in Fig. 11-4A. The form of the graph changes, depending on the volume control level used, although the test should be made at the usual listening level. You can check very easily the effect of various tone controls, "loudness" switches, filters, etc., if you plot the response with each of these functions switched in or

out. To periodically check the performance of the system, you should carefully note the control settings used for each test.

An audio oscillator is quite useful to check an amplifier's dynamic range. For any given volume control setting and frequency, if the output of the oscillator alone is slowly increasing, you should note a corresponding increase in the audio output of the amplifier. However, a point will be reached when an increase in input level does not produce a linear increase in the output level. The results can be plotted as shown in Fig. 11-4B. This characteristic is particularly important for music reproduction, since, if it changes, the full volume range cannot be faithfully reproduced without distortion; it is an indication of aging components within the amplifier, also.

Once you have established the range of input levels which the amplifier can handle without producing distortion, it is possible, with the use of the oscillator, to also make a meaningful measurement of the amplifier power output. This is done with the same test setup as shown in Fig. 11-3. However, the output meter is replaced by a VOM which is set to measure AC voltage. The oscillator output level and the amplifier volume control are set to positions which are known not to produce distortion (before the knee of the curve of Fig. 11-4B). The oscillator frequency can be any one desired, but 1,000 Hz is a good standard to use. The AC voltage across the speaker line is measured and the output power calculated as being equal to V times V divided by R , where V is the measured AC voltage and R is the impedance of the speaker system (4, 8 ohms, etc.). Such a measurement is not 100 percent exact because speaker impedances which are nominally stated as 4 or 8 ohms may, in fact, vary 10 to 20 percent from this value. Nonetheless, you can obtain a very good idea at least whether the amplifier is delivering the power which it is rated to produce.

CLEANING CONTROLS AND SWITCHES

One of the most common complaints which develops in any receiver or amplifier after a period of time is noisy controls or switches. Such problems are due to the fact that these units cannot be sealed completely from the atmosphere at a reasonable cost. Therefore, with time, dust will find its way into switch contacts and potentiometer surfaces.

It is a relatively simple matter to clean such controls and switches, thanks to the aerosol spray can, and it should be done on a regular basis. There are many types of control cleaners on the market, variously labeled as contact cleaners,

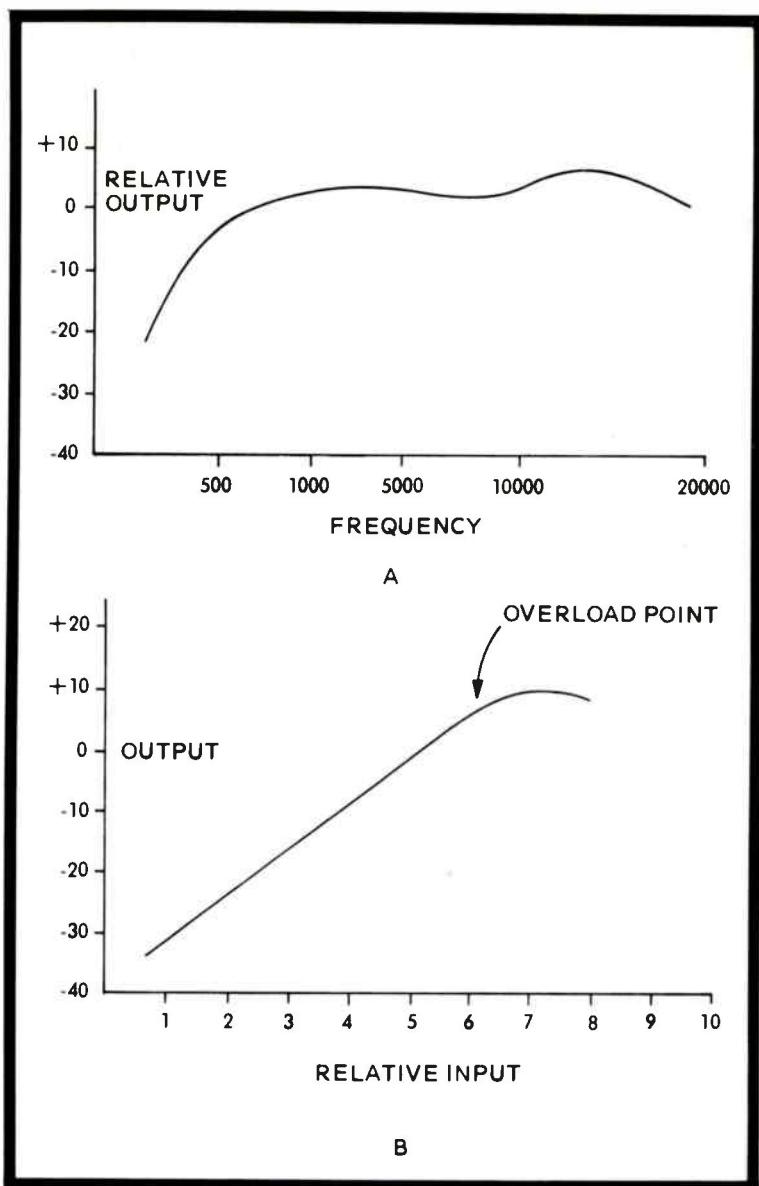


Fig. 11-4. Frequency response (A) and overload characteristic (B) of an amplifier. Such curves cannot be compared exactly with the manufacturer's specifications, but they do provide a good check on continuing performance.

control cleaners, tuner cleaners, etc. Any of these sprays can be used interchangeably. Be sure that the spray is labeled as being safe for plastics and that it doesn't leave a residue. A spray can that comes with a plastic extension tip from the nozzle is very convenient when you have to reach into difficult corners.

The use of a spray is simple. The idea is to spray the cleaner as near as possible to or on the contacts that are to be cleaned. In the case of a TV tuner, this may mean that the back cover of the set may have to be removed to get at the tuner contacts. But before you go to that trouble, try to remove the tuning knob and spray in from the front of the set. Volume controls and other potentiometer-type controls should be sprayed from the front at the point where the rotatable shaft enters the control; the knob should be removed from the shaft, of course. Since the spray cleaner only has the effect of washing residue away and is quite mild in its action, the switch or control being cleaned must be rotated or switched slowly while the cleaner is being applied; otherwise, the cleaner will not be very effective.

If you have difficulty reaching certain controls with a spray cleaner, or if there is problem with getting the spray on the front panel of the equipment, adapters are available which fit over the control shaft (once the knob has been removed) and screw onto the threads of the potentiometer body. A spray burst directed down the hollow center of the adapter is guided into the potentiometer. If such an adapter is not readily available, any hollow plastic tube can be used for the same effect. The tube must, however, be wider than the potentiometer shaft, since the cleaner must enter the potentiometer where the shaft rotates in the threaded portion of the potentiometer case.

VISUAL INSPECTION

Many faults and potential troubles can be found by a simple visual inspection of any piece of electronic equipment. If it fails to function when switched on, or if an obvious fault is noticed (lack of power or picture, no sound, distortion, etc.), you should switch the equipment off again and conduct a careful visual inspection of the components. If the equipment fails to turn on at all, a fuse may be all that is involved. Obviously, if new fuses continue to blow, a more indirect fault may exist. Carefully check the components to see if any is clearly burned or broken. Small resistors often break in two. Faulty capacitors may develop "bubbles" on their otherwise

smooth surfaces. A burned-out power transformer often leaves a residue of wax and resin by the base.

In a tube-type set, you can search for faulty tubes by noting if their filaments light. For most TV sets, this means that you must arrange to bypass the power disconnect on the back of the set, since when the back is removed the power is disconnected. Special "cheater" power cords are used by servicemen for this purpose. With some tube types, the lighted filament is difficult to see and a check may better be made by touching the glass bulb to see if it is warm. The touch test does not apply to tubes in the metal high-voltage "cage," where you could get a nasty shock—even with the power turned off! Difficult-to-see corners can be reached by means of a pencil-type flashlight and a small pocket mirror.

A visual inspection can be concentrated in a given section of a piece of equipment if you can broadly isolate the fault area. For instance, if a TV set has picture but no sound, you would concentrate the search around those tubes areas designated on the tube chart within the set as having to do with sound functions. If a radio receiver's audio section works fine on tape playback but no station can be received, you would suspect something in the tuner, IF sections, etc.

Visual inspection is greatly expedited if you have some basic knowledge of which sections perform various basic functions. Even lacking this knowledge, such an inspection is worthwhile if done with patience. Probably half of the faults in a piece of equipment are revealed by some form of visible indication on a component or control. If a clearly defective component is located, it can be replaced after it has been properly identified. A later section discusses this subject.

CHECKING CONNECTIONS

A frequent cause of trouble in amplifying and recording equipment, particularly, are the cable and component connections within a system. An ohmmeter is very useful to check the continuity of cables and to be sure that shorts do not exist. Where wires enter connectors, there is usually strain and such points should be among the first checked. Also, wires that must flex, for example, those in cassette recorders where the recording heads move in and out of the cassette, are prone to break after extended use. Often such breaks occur in the internal wire strands and are not visible because of the insulation. An ohmmeter must be used to check such leads. Check the leads to switches, also. Many switches mounted on printed-circuit boards appear rigid, but they actually flex during operation.

If an ohmmeter is used to check the leads to a recorder head, the current that the meter sends through the head will not harm it but undoubtedly will magnetize it. Therefore, the head must be immediately demagnetized.

Soldered component connections usually do not change. However, there are cases where a solder connection is not made properly to begin with and a so-called "cold" solder joint is making only intermittent contact. Such a joint is difficult to discover because it may appear to be good. If you have isolated such a difficulty to a certain section in a piece of equipment, it is often necessary to resolder every connection. Another approach that sometimes works is to spray a cold-producing liquid on each joint to see if it is the faulty one while listening for the result. The freezing of the joint may make the elements of the joint contract enough to open up the connection. Special freezing sprays are available, but contact or tuner cleaner can be used, too, since the carbon dioxide propellant in the spray can will also cool the joint.

Printed-circuit boards which flex during the operation of a switch or tuning control can develop particularly difficult to detect connection faults. These faults are often hairline cracks in one or more metal runs on the board. If the board can be held up to a light, the cracks are sometimes visible. You can also try freezing sections of the board, if the contact appears intermittent, to try to isolate the faulty area. If the board is small and simple enough, you can also go over the board, carefully running solder over all metal surfaces. Be careful, though, that solder slivers do not inadvertently connect adjacent circuits!

In installations subject to weather conditions, corroded connections are to be suspected. Usually, such connections can be detected visually, but there are instances where connections were not made correctly to begin with and each metal surface has built up an oxide coating which is not visible but nonetheless does open the connection. Flexing cables are another problem source outdoors, especially if the cable ends have not been properly sealed. Moisture can enter the cable and corrode the inner conductors at a point within the cable away from the end. Also, the appearance of corroded spots anywhere along the cable is a sign that moisture has entered the cable, perhaps through a nick in the insulation, and is corroding the inner conductors.

REPLACING COMPONENTS

Once a defective component has been located, the next problem is to properly identify it. The chart in the Appendix

shows the color coding scheme used for resistors and diodes. Most capacitors are marked with a value, except for some mica types which are also color coded. Whenever possible and if it is available, you should check the wiring schematic of the equipment to see that the value stated on the component removed corresponds to what the schematic calls for. At times, you will find components which are marked only with a manufacturer's part number. The schematic may reveal the component value or you may just have to make an intelligent guess, depending upon whether it is possible to trace the circuit in which the component is used. In many cases, guesswork can be dangerous, so it would be wise to consult a technician familiar with the equipment.

Generally, you should try to replace a component with one of the same value, unless, for instance, a certain resistor is constantly burning out because its wattage rating is insufficient. When replacing small size capacitors, it is usually best to use the same value. When replacing larger capacitors (5 mfd or larger electrolytics), the exact value is rarely critical. The tolerance on such capacitors as they are normally manufactured may range up to 50 percent away from their nominal value. Except for electrolytic capacitors, as just mentioned, the factors that should be observed are the resistance and capacitance ratings. The wattage rating of a resistor or voltage rating of a capacitor may be any value at least as high as that of the component being replaced.

Diode replacement is usually simpler in the sense that its number specifies its characteristics. Unless a diode is used in a critical application, a general purpose replacement closely matching the specifications of the original can be used. Zener diode replacements depend upon the circuit application. For instance, in a speed control circuit in a recorder, an 8.5-volt type should not be replaced with a 9.1-volt type, although this substitution would probably work fine for regulating the voltage to an audio preamplifier. Zener diodes also have dissipation ratings, similar to resistors, which must be observed. The diodes used in power supplies are frequently unmarked. Since such diodes are relatively inexpensive, and lacking any exact data, you should replace them with types that have a voltage rating of several times that of the DC voltage output of the supply (as marked on a schematic) and a current rating several times that of the power output of the unit divided by the normal DC supply voltage.

Transformer replacements should be made with equivalent types. There are several universal TV power transformer replacements. For other equipment where the

transformer has a single secondary winding and the transformer ratings are available, you should compare the manufacturer's replacement cost against that of a mail order house replacement type. The latter will often be much less expensive. If there is some special feature about the transformer, such as multiple secondary windings, a manufacturer's replacement may have to be used. The only other possibility may be to replace a single transformer with two or more single secondary types, if there's room in the equipment.

CHECKING AND REPLACING TUBES

If all the tube filaments light and you have checked for obvious component connection faults, it may still be worthwhile to check the tubes in a tube tester. Many faults occur within a tube besides a filament burn-out. On the other hand, checks with a simple tube tester do not always guarantee that the tube is really good, although this will be the case 80 to 90 percent of the time. Some exceptions develop because no tube tester can completely duplicate the actual circuit conditions under which a tube is used and because some testers check only the tube as a diode and not as an amplifying device.

If you have a great deal of tube-type equipment, an investment in a tube tester may be worthwhile. Simple units, such as that shown in Fig. 11-5, are not expensive and can be used to periodically check tubes in receivers, amplifiers, tuners, etc. Most such units also provide a useful bonus in that



Fig. 11-5. A typical inexpensive tube tester.

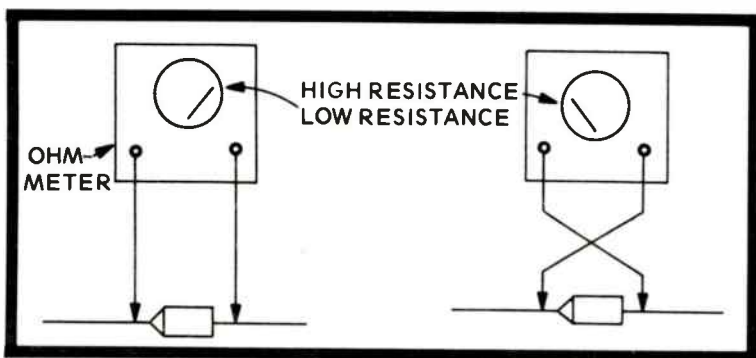


Fig. 11-6. Drawings show how to check signal and rectifier diodes.

they can be used to check diodes and transistors also for basic quality.

Many tube types are interchangeable in general purpose applications. Tube substitution manuals are available, and stores that sell replacement tubes usually have cross reference lists. Even if you don't use the mail order houses for securing tubes needed in a rush, it is still a good idea to use their price lists as a reference to check what you are being charged locally. Unbranded tubes are usually somewhat less expensive than tubes from major U.S. manufacturers. Generally, there is no difference in performance between branded and unbranded types in normal receiver or amplifier application.

CHECKING AND REPLACING DIODES & TRANSISTORS

Diodes for most applications are easily checked with an ohmmeter, as shown in Fig. 11-6. The ohmmeter leads are placed across the diode terminals, the meter reading noted, and then the ohmmeter leads reversed across the diode terminals. You should read a high resistance of at least several thousand ohms in one direction and a low resistance of less than a hundred ohms in the other direction. As long as the difference is in a ratio of 10 to 1 or more, the diode is probably in order. If some doubt exists, try to test the diode in the manner described and then check the results against those obtained with a diode known to be good.

Soldering in most power type diodes does not require any special precautions, although the soldering iron should not be applied any longer than necessary. When installing small signal diodes, a heat dissipator should be used or a small loop

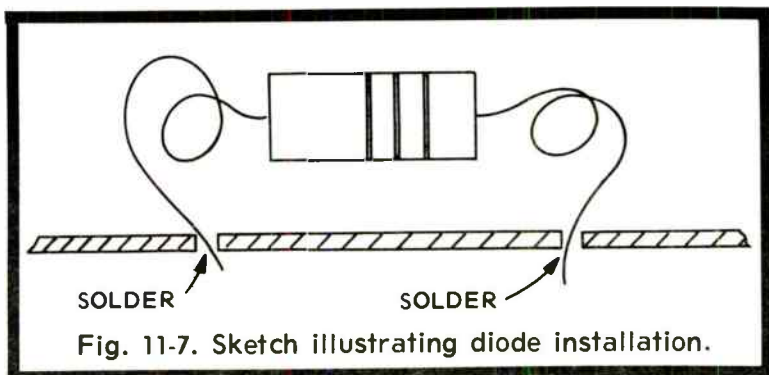
should be formed from the end lead on the diode before it is soldered in place. This technique, as shown in Fig. 11-7, is frequently employed in the commercial assembly of diodes on printed-circuit boards to avoid having to use a heat dissipator while soldering the diode.

Transistors can be checked in basically the same manner as diodes by simply treating them as two separate diodes with the base as the common lead. This technique is illustrated in Fig. 11-8. The readings for each "diode" will not be the same, but each diode should act as a good diode. This test technique works fine for the great majority of transistors, which are of the junction type. Field-effect transistors cannot be tested in this simple manner. Commercially made transistor testers make more exact tests on the gain and other characteristics. Since transistors do not age in the same manner as vacuum tubes, however, there is no need to periodically check the state of transistors.

Transistors are replaced by simply soldering them in place, again with a minimum application of heat. If you are not practiced in soldering, a heat dissipator should be used, or better yet a transistor socket. The latter is soldered in place, then the transistor leads are clipped and pushed into the socket. This technique is especially recommended for the replacement of field-effect transistors where static electricity effects during the soldering process can ruin some types of these transistors.

TV DEGAUSSERS

One of the banes of a color TV set is the effect of stray magnetic fields which interfere with the very exact convergence path that must be followed by the deflected beams in the picture tube if it is to excite the proper color positions. The



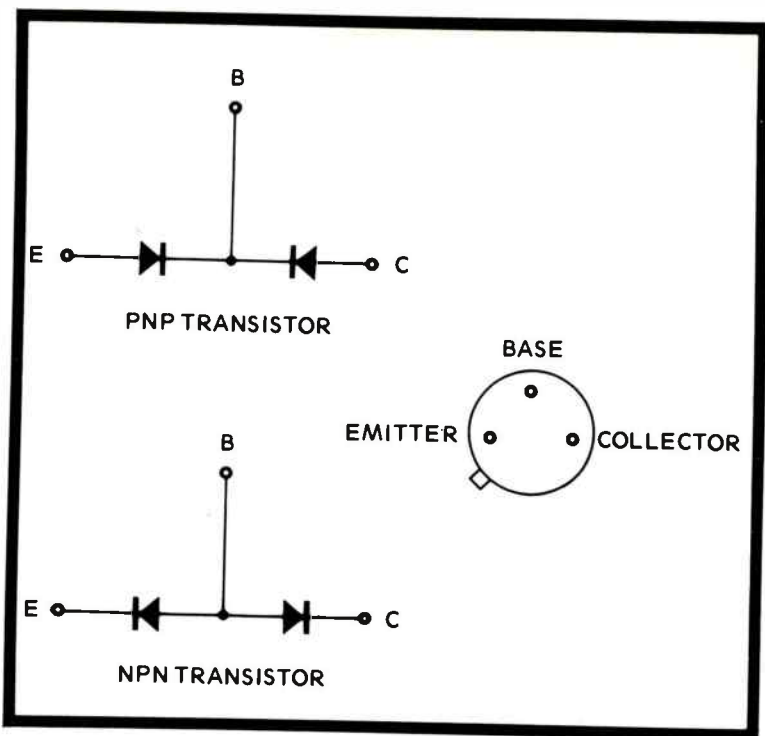


Fig. 11-8. These drawings show how a transistor can be checked with an ohmmeter by visualizing them as two diodes.

shield of the tube, the chassis, and other metal objects in the area can become magnetized by a combination of the electromagnetic fields that exist in the set as well as the normal earth magnetic field. The result is that the picture loses sharpness during color reception.

If the set does not have a built-in degausser, an accessory item of this sort, as shown in Fig. 11-9, can be purchased. The unit is simply plugged into an AC outlet and moved in small circles in front of the TV screen and the general area in front of the set. Most degaussing coils have a momentary push-button switch to turn them on and off. Don't depress this switch on and off while the degausser is in front of the screen. Hold the coil several feet away from the screen, press the power switch and degauss the screen. Then, with the unit again several feet away from the set, release the pushbutton switch before unplugging the unit. When not in use, the degausser can be left hanging on the back of a set.

PICTURE TUBE REJUVENATION

A fading picture, showing a lack of contrast, either black-or-white or color, is often due to decreased electron emission from the filament of the picture tube. There is really nothing that can be done to reverse the faulty condition. However, a temporary measure that sometimes works well is to install a picture tube rejuvenator or brightener. These gadgets are essentially little autotransformers that increase the filament voltage on the picture tube by 10 to 20 percent. They plug directly on to the base of the picture tube without any wiring. Before installing a rejuvenator, determine from the set's schematic, if available, whether the filaments of the tubes in the set are wired in series or parallel. If you don't have a schematic, try unplugging a tube in the set. If all the filaments go out, the set is obviously series wired.

Such rejuvenators are a temporary fix, but they help to squeeze a bit more life out of an expensive picture tube. Usually, after the use of such a device, the picture tube filament simply opens after awhile and the picture completely disappears, of course. If you decide to purchase a replacement picture tube, don't overlook the value of the "dud" or burned-out tube. The "dud" allowance is usually only very nominal for most black-and-white tubes (several dollars), but it can range up to \$20 for a large color tube.



Fig. 11-9. TV degaussing coil.

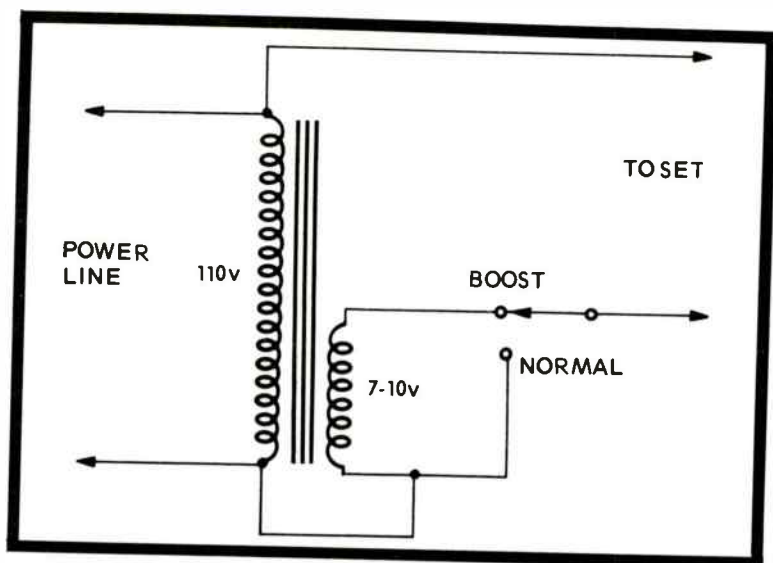


Fig. 11-10. Filament transformer wired for power line boost.

VOLTAGE ADJUSTERS

The reception of many TV sets and even a few radio receivers is affected adversely by line voltage fluctuations in local areas. Especially during heavy electrical power demand hours, the line voltage may fall below 110 volts. As a result, the TV picture may shrink and the circuits in other electronic equipment may start to act erratically. In areas with poor power service, even turning on heavy power devices in the same house will cause this effect.

There are several types of devices that will correct this condition by boosting the line voltage when necessary. The first type (and most expensive) is a constant voltage output transformer which holds the output voltage at 110 volts for a 10 percent or more increase or decrease in the power line voltage. It simply connects between the set and wall outlet. A less expensive type of device, sometimes confused with the constant voltage transformer, is an automatic voltage regulator or booster. This device simply steps up the line voltage through autoformer action whenever the line voltage falls below 110 volts. It will step up the line voltage under these conditions by some fixed amount (usually 10 volts), but it does not continuously maintain an exact 110-volt output. However, for a normal TV and radio set applications, this sort of

regulator is satisfactory. The last type is a manual regulator with a step control. You simply adjust the knob to keep the output voltage (monitored on a meter) at 110 volts. The advantage of this unit is that it can compensate for high as well as low line voltage; it is also less expensive than the completely automatic constant 110-volt output regulator.

If you have a chronically low line, a simple booster can be contrived with a filament transformer wired as shown in Fig. 11-10. With the switch in the boost position, the secondary voltage is added to the primary voltage in autoformer fashion. Notice that the secondary must be wired as shown (bottom of secondary winding to bottom of primary winding). If this is not done, the output voltage will decrease instead of increase. The current rating of the filament winding must be comparable to that of the primary and both must be able to handle the required power level.

TV TUNER REPLACEMENT

Since the tuner is one of the most frequent causes of problems in a TV set, and since refurbished tuners are available at prices of \$10 to \$15, you may encounter the need to replace the tuner in your receiver. Of course, some mechanical and electrical skill is necessary, and it is highly desirable to have a wiring diagram for the set. Each connecting wire should be carefully labeled as it is removed. Most tuners have five or six connections, including the 300-ohm antenna input, the IF output, AGC, B+ lead, filament lead and possibly a separate ground lead. The rest of the extraction process is one of mechanically removing the tuner.

Most replacement tuners are designed for a picture (video) IF frequency of 45.75 MHz and a sound IF of 41.25 MHz. The filament requirement is usually 6.3v for parallel filaments and either 450 or 600 ma for series filaments. If there is any doubt as to whether a replacement tuner will work with a given set, make a specific inquiry of the tuner supplier, giving complete model details of the set involved. If you can wait a week or two, it might be better to send your tuner to a repair shop (advertised in many electronic magazines), as many TV servicemen do. Then, you can wire in the returned tuner in the same manner as it was removed.

CABINET SCRATCHES

One of the quickest ways to brighten the appearance of any piece of equipment is to remove minor blemishes from its

enclosure or cabinet. Many servicemen do this as a matter of routine when returning sets. There are many types of refurbishing kits on the market for wood, paint sprays for metal enclosures, etc., but one of the most useful is liquid scratch remover. It is a very darkish brown liquid with a mild licorice odor. It doesn't really remove scratches, of course, but by staining them slightly, it makes them far less noticeable. The scratch remover is applied with cheesecloth or cotton along the scratch and then over the entire side of the unit where the scratch is located. After leaving it dry several minutes, the entire area is wiped clean. The process may have to be repeated several times, depending on the depth of the scratch. It is important, however, to apply the remover over the entire surface to make the scratch blend into the general appearance of the area. Another substance which can be used with good results is ordinary shoe polish. The color stains the scratched surfaces very slightly to make them blend in with the rest of the surface. The results can be controlled by using some cleaner to remove any excess wax.

Chapter 12

Interference Control & Suppression

One thing that can very quickly ruin the enjoyment of any radio, TV, or hi-fi system is interference which produces background noise and distortion. In severe cases, it can make the use of such equipment totally impossible. This is true of a home, mobile, or marine installation. A particularly annoying thing about interference is that so often a piece of equipment sounds fine in a test setup or on a serviceman's bench, but when placed in its operating location, the interference is still there.

This chapter discusses some of the basic ways that interference is generated and then how to deal with it in various types of installations. Tracing and curing interference is greatly simplified if you can logically isolate both the source and the method by which it is being conveyed to a piece of equipment.

BASIC INTERFERENCE PATHS

If interference is defined as the presence of some unwanted externally generated signal, there are only several basic paths by which such interference can enter the equipment. Fig. 12-1 illustrates these basic paths. In the first case, the interfering signal can be radiated and picked up by the antenna of a receiver. A simple example of this is encountered when an auto with a defective ignition system passes by. The ignition system, because of its sparking contacts, transmits a wide range of signals over many frequencies. Some of these frequencies may effect the receiver being used.

It is important to realize that the interference frequencies which may effect the receiver are not only those to which the receiver is tuned. For instance, a TV receiver tuned to Channel 2 will pick up interference on the Channel 2 frequency, plus other frequencies to which the receiver is sensitive. Most TV sets are receptive to signals on the IF frequency since the front end (tuner) does not completely reject such signals when they are present in sufficient strength in the antenna system.

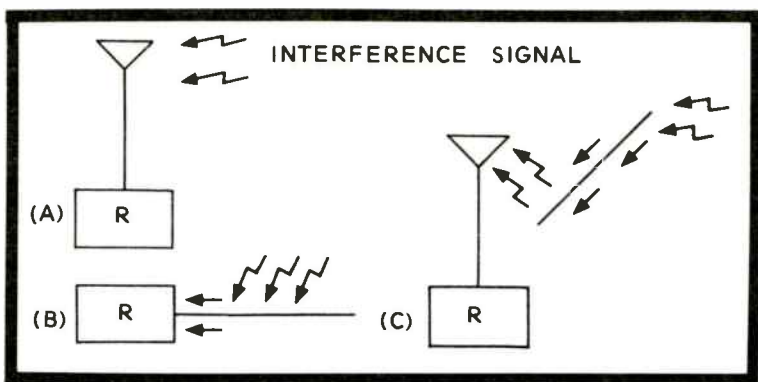


Fig. 12-1. Various paths by which interfering signals can enter a receiver.

In the second basic case illustrated in Fig. 12-1, an interfering signal (again at any frequency to which the receiver is sensitive) can enter the receiver unit by conduction on the AC power line or any wire that enters this receiver. Radiated interference is picked up by a wire lead going to the receiver and thus is conducted to the receiver, or the interference signal may be conducted entirely by a wire lead which runs from the interference source to the receiver.

The third basic case illustrated in Fig. 12-1 is generally referred to as re-radiation; that is, a source capable of interfering with a receiver but far enough away or otherwise situated so that by itself it would not normally interfere. However, some metallic body between the interference source and the receiver picks up the interfering signal and re-radiates it again in the vicinity of the receiver. This intermediate body may be a wire line, metal surface, or even some moving body such as an automobile or airplane.

In home installations, many types of interference can be traced to a single path. More complicated cases, and particularly those found in mobile equipment installations, are due to the presence of several interference paths. The isolation of these paths is discussed in a later section.

SELF-GENERATED INTERFERENCE

A receiver sometimes generates its own interference under the influence of either internal or external causes. Defective components, of course, can cause a variety of disturbances in any receiver or amplifier. Normally, you'll notice such faults by their sudden development after a period

of satisfactory performance. Interference from internal causes doesn't seem to follow any pattern but seems to be constantly present whenever a set is turned on. A typical example of self-generated interference is the sudden appearance of a bar across the TV screen as compared to an interference problem where wavy, constantly changing lines appear across the screen at irregular intervals. Of course, when trying to determine the cause of internally generated interference, you must consider the economic design limitations that are present in any receiver. This situation is particularly noticeable with less expensive radio receivers where even with an antenna disconnected, you can hear tone signals as you tune across certain sections of the dial. Again, these built-in faults can be distinguished from external interference by their constant presence.

Another type of self-generated interference is that caused by an external signal having no relationship to the frequency range of a receiver or amplifier. This type of interference occurs when the external signal is strong enough to cause some element in the receiver to generate a spurious signal. Such situations frequently occur in receivers located close to a relatively high-power transmitter (broadcast, police, amateur, etc.). The strong field created by the transmitter overloads the receiver input stages, driving one or more into oscillation. The spurious signal generated causes the interference you see or hear. Also, wires leading into a hi-fi amplifier can pick up a signal from a transmitter field, conduct it into the amplifier where it is rectified by a diode or other element in the amplifier. In other words, the amplifier acts like a one-station receiver. The question of whether the transmitting station should be made to reduce its power or whether equipment should be made less prone to accept such outside signals has led to many legal entanglements in such situations. The cure, assuming the transmitter power cannot be changed, can be effected only at the receiver or amplifier.

RECOGNIZING SIMPLE INTERFERENCE TYPES

The type of interference that you hear on a radio or amplifier or see on a TV screen can often provide a clue as to its source. Sometimes the source will be obvious if you can connect the beginning of the interference with the start of some appliance.

The following types of interference are frequently heard on a receiver or amplifier:

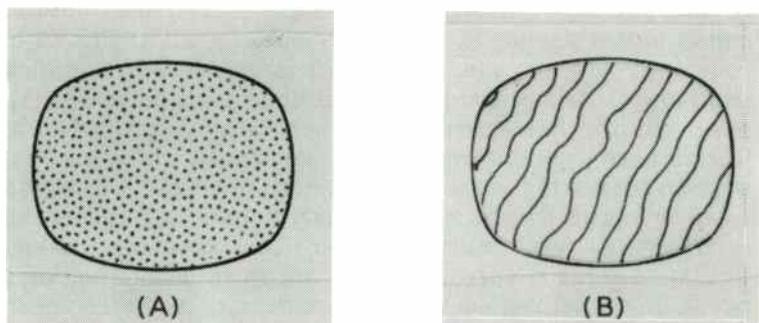


Fig. 12-2. Two frequently encountered TV interference patterns, caused by sparking contacts (A) and a radio (RF) signal (B).

Buzzing noise: Frequently caused by some electrical contact which is opening and closing at a very rapid rate. Examples are electric razors, door buzzers, vibrators on spray painting equipment, etc.

Whining noise: May be caused by the rapid commutating action in an electrical machine. Examples are any one of the many motors used in a tool shop, automotive or other DC type generators, portable electric generators providing a DC battery-charging output, household appliance motors, etc.

Clicking or snapping noise: Often produced by an electrical contact being opened and closed at a relatively slow rate. Examples are telephone dialing, any sort of switch or relay, electric typewriters, electric flashers, etc.

Sputtering or burst type noise: Sometimes caused by electrical contacts which are faulty or deliberately intermittent in nature. Examples are electric welders, diathermy machines, neon signs, any sort of loose contact in the electrical power system, some electric office machinery, etc.

Hum: Hum is actually not a noise but a signal picked up from the low-frequency AC power line by some wire external to the receiver. Hum pickup can occur if a wire is placed for too long a length in parallel with an AC power line or it may be due to a defect in the receiver (poor filtering). Defective tubes in filament type equipment and possibly broken ground connections are common causes, too.

The following types of interference are often seen on a TV screen (refer to Fig. 10-2). Irregular appearing specks (A) are the result of electrical contacts being opened and closed rapidly. The specks also may be due to the ignition system of a passing auto or to almost any of the sources just described for clicking, whining or buzzing noises in a receiver or amplifier. The wavy black line pattern (B) is due to a "beat" with another strong radio signal. Except for interference from radio transmitters (discussed above), it is most often due to the use of diathermy equipment at home or in a medical office.

LOCATING SOURCES OF SIMPLE INTERFERENCE

A portable radio receiver, even if it covers only the medium-wave AM band, makes an excellent device to trace an interference source. Transistor radios, which have a built-in ferrite loop antenna, can be used as they are. Those receivers which have provision for an external antenna on the short-wave bands can be provided with either one of the two types of antennas for interference tracing shown in Fig. 12-3. The loop antenna (A) is made from a few turns of any stiff piece of wire. The loop need not be placed directly at the receiver antenna terminals, but if it is remotely located, it must be connected to the receiver via a shielded wire. Shielded 300-ohm twinlead is suitable, with the shield connected to the receiver ground terminal. The advantages of this type of antenna is that sometimes the directional characteristics of the loop allow you to obtain a bearing on the source of interference. If the

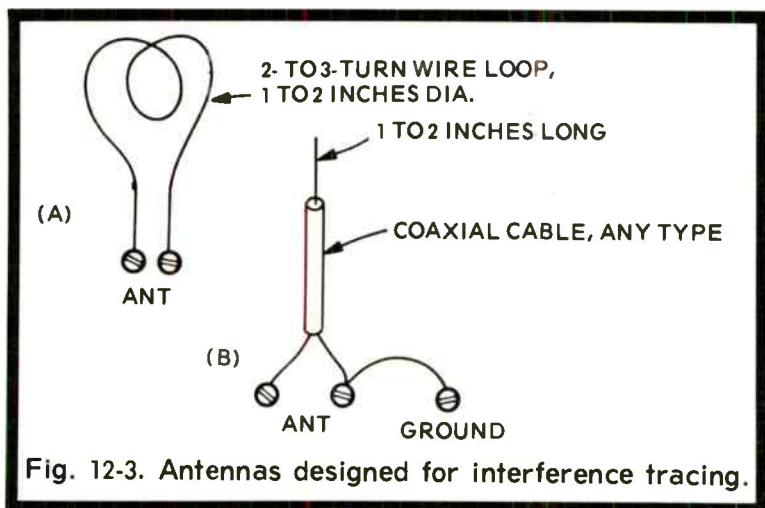


Fig. 12-3. Antennas designed for interference tracing.

receiver being used has an AVC or AGC on-off switch, this function should be switched off.

The probe antenna is made by removing the shield on a piece of coaxial cable for 1 to 2 inches at the extreme end. The other end of the cable is connected to the receiver with the shield of the cable going to the receiver ground terminal. Thus, the receiver is operated with one side grounded. The tip of the antenna serves as a probe and is very handy to get into odd corners when trying to pinpoint the exact source of interference, once its general location has been established. As a safety measure, the tip of the probe should be wrapped with electrical tape so there's no danger of accidentally touching electric power connections.

To begin the sometimes tedious task of tracking a source of interference, tune the receiver to any frequency in its range at which the interference sounds loudest. Make sure you have the same interfering signal by carefully observing its characteristics on both receivers. If a loop antenna is used (either built-in or external), turn it to see if the noise has directional characteristics. With the loop positioned for minimum pickup, the noise source should be at right angles to the plane of the loop (in and out of the page for Fig. 12-3).

Now, try tracing the source of the noise by walking with the receiver in the direction which produces the loudest signal. Rotate the antenna frequently to be sure you're moving in the right direction. Don't be surprised if this process just leads you around the house in a circle. But even if it does, you have gained valuable information since it localizes the general source of interference. Then you can use a probe antenna or the loop to more exactly locate the interference source by turning down the volume control until the noise can just be heard, while you continue to move in the direction which increases the pickup. You may end up tracing along the power line until it finally leads to some defective electrical device.

A frequent occurrence is that you'll trace the interference to the point where the power line enters the house or building. The difficulty in going much further is that its source may be miles away. You can, of course, explore the immediate area. The interference may be caused by some defect in the power line system itself or it may be that the power line is simply transferring a noise picked up somewhere along the line. Nonetheless, since the power line system is involved, you should contact the local utility company. Most companies have special interference tracing equipment or can obtain such equipment. Generally, a power company is responsible for helping since they cannot guarantee without investigation

that their system is not at fault. Frequently, a poor transformer or other connection in a power distribution system is at fault. Just be sure to inform the power company that an effort was made to trace the interference and the strongest point seemed to be at the power line entrance.

SUPPRESSING CONTACT INTERFERENCE

If interference has been traced to some appliance, motor, or other electrical device, the problem remains of how to suppress or eliminate the interference. One approach that sometimes suffices is a form of spark suppressor across the contacts of a switch, relay, etc., which is producing interference. Such a suppressor consists of a capacitor and resistor in series, as shown in Fig. 10-4. The resistor and capacitor values can vary over a range, but it is wise to try several combinations to see which works best. Several typical combinations are: 1000 ohms with 0.5 mfd; 1000 ohms with 0.25 mfd; 500 ohms with 1 mfd; 100 ohms with 0.1 mfd; and 10 ohms with .01 mfd. Generally, the combinations with the higher resistance should be tried first on contacts which control small currents and those with the low resistance are usually more effective on motor and other high-current contacts.

To suppress noise caused by automobile ignition systems, try using simple spark plug suppressors. Shielding of parts of the ignition system high-tension wiring and bypassing the breaker points may also be necessary. Additional measures are suggested later. Complete kits of parts are available specifically designed for auto ignition suppression.

Simply bypassing a set of contacts may not suffice in all cases to prevent interference. In some units there are no contacts involved or they may not be accessible. In these cases the only alternative is to shield the unit and insert some form

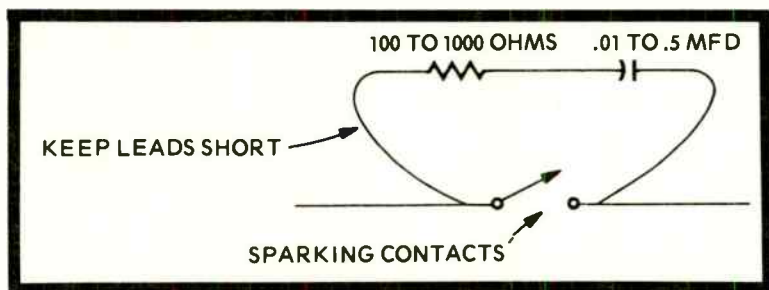


Fig. 12-4. Typical spark suppressor. Specific component values are listed in the text.

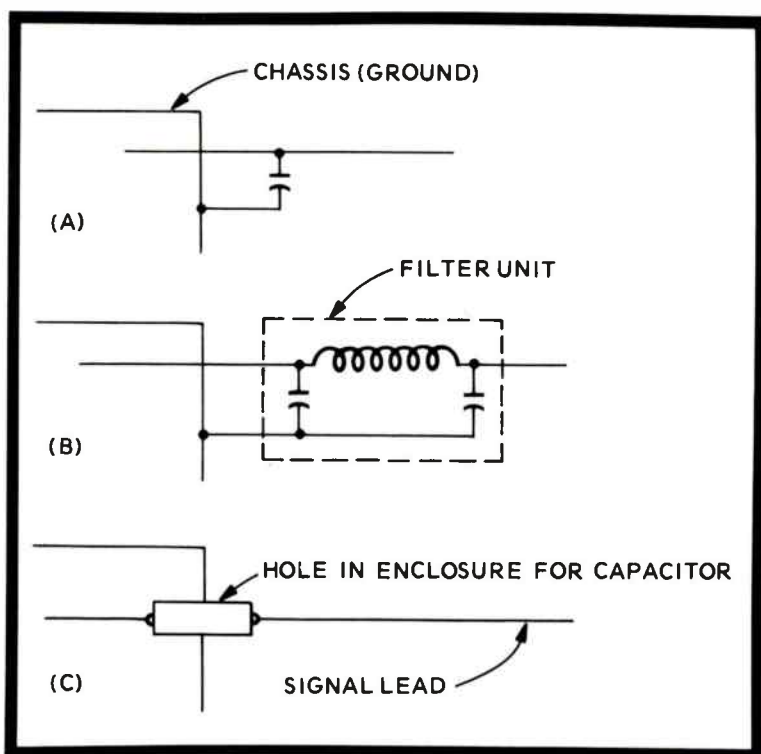


Fig. 12-5. Several techniques used to filter the wire leads connected to an interference-causing piece of equipment.

of filtering at the output leads. "Output" leads as used here means all connecting wires over which interference signals can get out of the unit. For instance, an electric motor can feed interference into the power line through its connecting wires.

Shielding protects against interference radiation. But before you start to eagerly shield an interfering unit, especially electric motor devices, check the bonding and grounding of the unit. Bonding means tying together all metal parts with a good low-resistance connection. Often, paint or other materials prevent the metal parts of an existing enclosure from making contact. Connecting surfaces which obviously were meant to be electrically joined should be clean, bright, and firmly held together. Where parts of a machine must move, they should be connected to the stationary metal base with a flexible copper strap, which should be kept as short as possible. If a bonding strap is too long, it could form an inductance which acts to isolate the connected points

at the interference-causing higher frequencies; it's as though there were no connections (RF choke action).

Besides attention to bonding, the proper grounding of electrical devices will often help to reduce their interference potential. Ground leads should be kept as short as possible and, again, made to equipment with care to be sure that a really good low-resistance connection exists. In no case should the ground for an interfering piece of equipment be near to or exactly the same as that used for part of the receiver system.

If good bonding and grounding are established and interference problems still exist, a high-conductivity metal shield may be tried. Copper (sheet or screen) or aluminum are good shielding materials for general purpose applications. Necessary holes or other openings in the shield, required for wires, etc., leaving the unit, should be kept as small as possible. The shield should surround the unit as completely as possible on all sides and the shield material itself properly bonded together where pieces join. Copper screening is particularly handy in this regard since it can be soldered along seams to keep them tight.

If the interference is being radiated, shielding may suffice to suppress it. Usually, however, it is necessary to filter all leads entering and leaving the unit. If temporary shielding tests indicate that the shielding of an existing unit cannot be improved, then filtering is the only recourse left. In some applications, a simple capacitor bypass on each lead, as shown in Fig. 12-5A, or a more complicated LC filter, such as shown at Fig. 12-5B, may work.

Simple capacitor bypassing can be effective for interference in the medium wave AM band and some of the lower frequency shortwave bands. However, it starts to become ineffective above a few MHz because the capacitor leads start to resonate. This is shown graphically in Fig. 12-6. Notice how the attenuation of the .05-mfd bypass capacitor is fairly good at the shortwave frequencies, but by the time the FM or TV band frequencies are reached, it is practically useless. The solution in such a case is a so-called feedthrough capacitor as shown in Fig. 12-5C. Feedthroughs connect directly to the metal enclosure; therefore, there are no leads to resonate. They provide useful attenuation of unwanted signals in a bypassing application up to frequencies including the UHF TV channels.

Filters which consist of inductive as well as capacitive elements provide still greater attenuation of undesired signals. These filters are available commercially in a wide variety of forms. For instance, such filters may be broad

enough to cover the shortwave frequencies or they may be tunable for use on the CB or marine band frequencies. Generally, tunable filters are used only in mobile installations, while broadband power line filters can be used at the receiver if interference is coming into it via the power line. Generally, however, interference suppression is more effective if you trace the stray signal back to the source and use a filter at that point.

INTERFERENCE PATH ISOLATION

Interference suppression is simplified if you can isolate the path (or paths) by which the interfering signals are entering the equipment. In a receiver, an obvious entrance path is the antenna system. Simply disconnect the antenna and see whether the interference disappears. Obviously, you cannot leave the antenna disconnected, but once this path of entry has been established, filters can be placed at the interfering point, if you can find it, and in the receiver antenna lead. If this check produces no results, try disconnecting all other leads, except the power lead, to see if any of them are bringing interference into the system. The only way to check the power lead is to operate the receiver on a battery supply or an auxiliary AC generator. If this cannot be done, try to bypass the AC power line with a line filter. If some reduction in the interference level occurs, it may mean that all or only part of the interference is traveling on the power line. Again try disconnecting the antenna and other accessory leads to see whether or not any further reduction in the interference level occurs. Quite often, interference enters by a combination of routes. Usually, if you persist, you can determine how interfering signals are entering a receiver with this simple step-by-step isolation procedure.

TRANSMITTER INTERFERENCE TO HI-FI AND RADIOS

Transmitter interference to radio and amplifier equipment is often difficult to understand. Obviously, once verified, the transmitter signal is the source of interference, but the responsibility for the actual interference becomes mostly a moot question. A transmitting station, if it is properly licensed and is using properly adjusted equipment, has a right to operate. However, most receivers and amplifiers are not designed to operate in close proximity to transmitters, since this would require building extra features to suppress interference into the equipment. Many name-brand equipment

manufacturers do recognize the problem, however, and will send the set owner helpful information on what to do if problems exist.

Interference from a nearby transmitter is easily identified. (Of course, the existence of a transmitting facility is sometimes obvious by the presence of its antenna.) The interference may or may not be tunable; that is, it may occur only on certain spots on the dial where you actually hear the station (not necessarily clearly, but you can recognize that someone is speaking) or it may be superimposed upon each station tuned in. In some cases, the interfering signal is heard all over the dial, regardless of which station is tuned in. Such interference is caused by the presence of RF energy from the transmitter in the receiver circuitry. In receivers which have a built-in antenna, the interfering signal almost always enters the receiver via the AC line cord. A filter placed in the power cord usually cures the problem, but in such cases the very simple capacitor type (which sells for 50 cents or so) is totally ineffective against any sort of high-frequency signals. AC power line filters referred to as low-pass types and costing several dollars are well worth the extra cost. Low-pass filters usually contain an inductive element (coil) as well as simple capacitors.

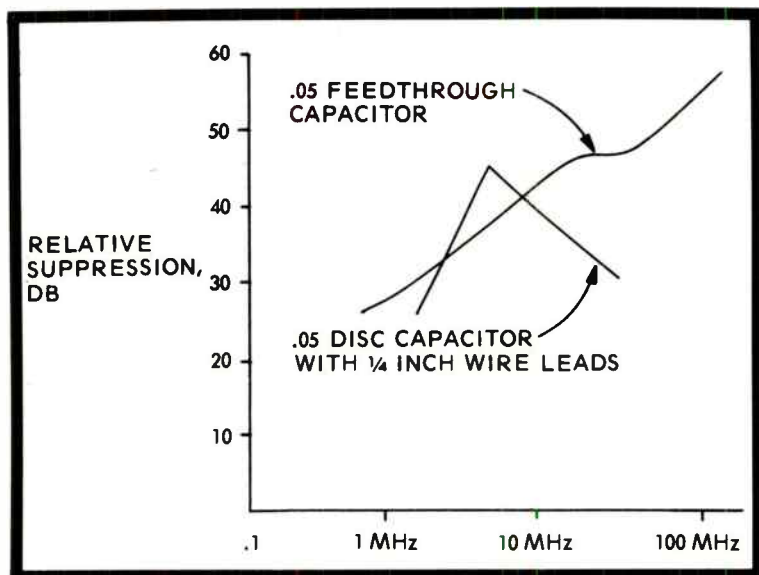


Fig. 12-6. Curves showing the performance of capacitor bypasses at various frequencies.

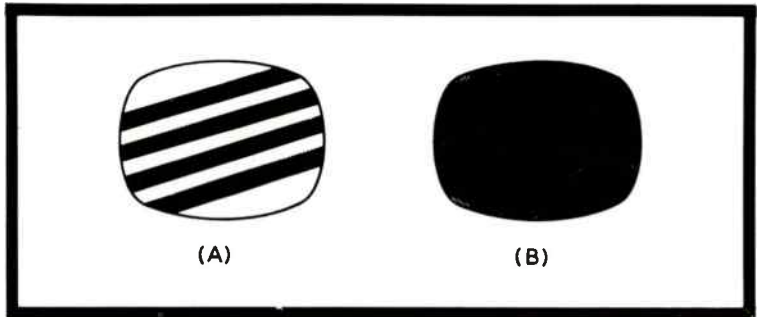


Fig. 12-7. Severe TV interference can result in modulation bars (A) or a complete blank out.

In extreme cases of transmitter interference, the signal is picked up directly by the receiver wiring. Under these circumstances the interfering signal can be heard regardless of where the receiver is tuned. Shielding can cure this situation. However, if the signal pickup is the result of a simple process called audio rectification, a suitable filter network must be placed in the receiver or amplifier. But unless you are well acquainted with receiver circuitry, the installation of this filter should be left to a qualified technician. If you recognize the simple circuit functions of a piece of equipment, try connecting a 250-pf capacitor from any terminal (except the ground one) or a receiver's volume control to ground or from any one of the inputs of a hi-fi amplifier to ground. Very often, this simple capacitor bypass will cure the situation.

If an outside antenna is being used, it could be picking up the interfering signal; disconnecting the antenna will quickly verify this. In order to prevent interference from entering the receiver via the antenna, one of several methods can be used, depending upon the receiver type and the frequency of the interfering signal. A method that is effective is to improve the selectivity or narrow the range of signals which the receiver will accept. An antenna coupler or tunable preamplifier for shortwave receivers is effective. A tunable preamplifier for FM receivers is also effective. In any case, the preamplifier must be tunable, not the broadband variety.

If you know the transmitter frequency, other measures may prove effective. For instance, if a CB transmitter is causing the problem, a high-pass filter (discussed under the next heading) may cure it. This is also true for amateur radio and broadcast transmitters operating on medium-wave or shortwave frequencies. A high-pass filter will not work when the interfering transmitter is operating in a frequency range

close to that being received; for instance, if FM reception is impaired by a station operating in the VHF aircraft, 2-meter amateur, or marine band. Only a filter at the receiver input, designed to accept only the received frequency, can help. If interference persists in spite of such a filter, you may have a legal complaint against the transmitting station. Harmonic radiation (radiation at two or three times the fundamental frequency) of the transmitter may not be properly suppressed according to legal requirements.

TRANSMITTER INTERFERENCE TO TV RECEPTION

TV interference caused by a nearby transmitter is a common problem. Again, it is questionable who is at fault—the transmitting station or inadequate TV receiver design. But, in most cases, the matter of blame is overshadowed by the need for a cure, especially since a solution may not be complicated or expensive.

TV interference appears in a variety of forms. A mild case is indicated by the wavy line pattern in Fig. 12-2B. Severe cases produce the displays shown in Fig. 12-7. The interference represented by Fig. 12-7A is caused by the modulation (sound or voice) on the interfering signal. The pattern is often referred to as “modulation bars.” As shown in Fig. 12-7B, severe interference produces a complete blackout of the TV screen whenever the transmitter is turned on. An intermediate condition exists if the picture is reversed; that is, whenever the transmitter is on, the picture is reversed in tone—blacks become white and vice versa.

Although you can try power line filters as a first approach, in almost all cases the interfering signal enters the set via the antenna terminals. By far, the most common causes of such interference are commercial, amateur, or CB transmitters operating in the high-frequency region. The cure for TV interference usually requires one of two approaches: eliminating the radiation from the transmitter which invades the TV channel frequencies, and making the TV receiver input insensitive to signals outside the TV channel frequencies.

The first approach is accomplished by a frequency cutoff filter. Such filters, inserted in the antenna line of a transmitter, are referred to as low-pass filters and readily available for both CB and amateur transmitters. If you are trying to operate a CB transmitter in the same location with a TV receiver, such a filter is usually necessary. If a nearby amateur or commercial station causes interference, they are required to certify that they have installed a suitable filter or

otherwise reduced their signal radiation in the TV bands to an acceptable minimum.

Most interfering stations willingly cooperate in cases of interference, but the set owner always has the option of filing a complaint with the FCC (Federal Communications Commission) whenever any doubt exists. The TV set owner can also prevent such interference from entering the set via the antenna lead-in by installing a high-pass filter in the antenna lead. Such filters, which are inexpensive, insert directly in the TV lead-in and have the effect of attenuating any stray signal coming into the set below about 40 MHz.

A number of TV set manufacturers will supply such filters free if you write to them, quoting the model number of the set. Again, the economic factor discourages many TV set manufacturers from including such filters in the original production of the set because relatively few set owners are bothered by interference due to nearby transmitters.

In cases where the interference is coming from a station operating above 40 MHz, or from spurious radiation (harmonic radiation) from a station operating below 40 MHz, a simple highpass filter will not cure the problem. In the latter case, it is generally the responsibility of the transmitting station to eliminate these harmonic radiations. In the former case, special filters can be used in the antenna lead-in.

MOBILE AND MARINE INSTALLATIONS

The use of receiving and-or transmitting equipment in a mobile or marine installation is subject to various interference problems not only from external sources but from the interaction of equipment in the installation. While many of the problems differ from those experienced in a fixed or land-base installation, the causes, the method of tracking them down, and the paths traveled by interfering signals are basically the same.

Aside from those problems associated with mobile environment, multiple transmitter or receiver installations pose additional problems. Each transmitter will have some spurious output; that is, it will emit signals on frequencies other than the transmitter's operating frequency. Spurious emissions are normal in any installation and they are usually of such a low level as to be harmless in a fixed installation. But in the tight quarters of a mobile or marine installation, even low-level signals can cause interference problems. Also, receivers often radiate signals from the internal oscillators. Such signals can cause interference to a nearby receiver

being used simultaneously or a receiver which shares the same antenna system.

Before tackling the more involved interference problems which occur in a mobile or marine installation, it is best to concentrate first on those problems which arise when individual receivers or transmitters are being used alone, not simultaneously. As is the case in any interference hunt, before an attempt is made to correct these problems, the sources of interference must be isolated. To do this, you must have a clear picture of the various methods by which interference can enter a piece of equipment. The basic routes shown in Fig. 12-1 are all applicable to a mobile and marine installation and only one or all three may be present at any one time.

Whether the resultant interference level is tolerable or not depends upon the type of reception or the degree of performance required. After all, there is little point in going through elaborate noise suppression techniques if only very strong signals, which normally override the interference level, are of concern. This is often the case in a mobile or marine installation where the transmitter power used will communicate only with a base station that produces a strong signal at the mobile unit because of its much higher transmitter power. In other words, elaborate noise suppression for a mobile receiver will quiet it, but if the mobile transmitter can't reach the base station because of its lack of power at a given distance, the noise suppression effort did not extend the two-way communications range. In such a case, the use of a noise limiter or squelch (if the receiver doesn't already have one), which keeps the mobile receiver quiet until a strong signal is received and which serves to simply reduce the annoying effects of the noise caused by interference, might be all that is worthwhile.

Following are some of the methods that can be used to trace and suppress interference problems in a mobile or marine installation. In general, they are similar to those techniques used in a fixed installation. An interfering signal may flow over practically any wire or metallic connection (including long ground connections) which are common to the source and the troubled unit. To check for such interference, the antenna input should be removed from the unit subject to interference. If possible, the various control leads, output leads, etc., should be disconnected one at a time until it is determined which lead or leads are conducting the interference. Simultaneously, all potential interference-generating sources should be shut down, one at a time, until the offender is isolated. The interference source can be a

commutating or brush-type electrical device, switching equipment, a power supply or an inverter, relay, regulator, etc., where there is a direct wiring interface or a common wire (such as a powerline) running between the source and the unit being subjected to the interference.

If each possible source of interference cannot be shutdown entirely, or if the individual potential sources of interference within a unit cannot be disconnected independently, the only alternative is to trace it to the source. The portable battery-operated receiver with a short "probe" antenna as suggested earlier is ideal. Of course, the receiver should cover the same frequency range as the equipment experiencing interference. In many cases, however, a simple inexpensive battery-operated transistor radio will serve the same function. Since the radio has poor front-end selectivity and an unshielded enclosure, when held close to wire leads conducting interference of any magnitude, it will emit a buzzing or rasping output and can be moved directly along the wire leads towards the source of interference.

There are two ways to trace radiated interference. To determine, however, whether the interference is really picked up on the transmission line or on the antenna, the transmission line should be disconnected from the antenna and dummy-loaded. A reference level of noise output should be established on the receiver. The dummy load should then be moved directly to the receiver's antenna terminals (with the transmission line disconnected). If the receiver noise level changes more than 3 to 6 db, there is some indication that the line shielding is inadequate. Either double-shielded coaxial cable may be tried, or you can try to reduce the magnitude of the radiation from the interference source.

If the transmission line test is satisfactory but an excess amount of interference is produced when the antenna is connected to the transmission line, such interference will follow either of the paths illustrated in Fig. 12-1A or B. Direct radiation can usually be traced by a probe antenna since a receiver will indicate the source, especially if it is possible to shut down various potential interference sources in turn so that only the main source is active. With radiated interference, the directional pickup properties of a small transistor radio should be utilized. By orienting the ferrite loop antenna for maximum pickup, it is easy to determine the approximate direction of an interference source and resolve the 180-degree ambiguity by trying to move further away or closer to the source and noting whether the signal level decreases or increases.

Often, in an installation where a gasoline motor is operating, some direct radiation will be generated by the ignition and generator system. The interference from the ignition system can be suppressed by the use of a .1-mfd feed-through type capacitor on the ignition coil primary, a suppressor resistor on the distributor lead, suppressors on each plug, or the replacement of the wiring to each plug using special carbon pile shielded wire.

Many kits are available for such filtering and the one recommended by the motor manufacturer should be considered first. Often, such kits also include generator filtering, such as a .1-mfd feed-through type capacitor to be used at the generator output. In severe cases of generator interference, it may be necessary to run a series resonant trap circuit from the generator output to ground to suppress interference at the desired operating frequency. The difference between ignition and generator interference is discernable by the noise effects they produce, but it also can be separated by quickly accelerating a motor, turning off the ignition circuit, and then listening for the residual generator produced interference.

A peculiar type of interference, sometimes present in mobile installations, is due to wheel static. It shows up particularly when driving over very dry streets at moderate speeds as sort of a "popcorn" sound in a receiver. Modification kits to continuously ground the wheels of a vehicle and "static" powder to insert in a tire are available from major automobile dealers and will cure this type of interference.

Radiated interference in marine installations may also be traced to various electrical devices used on board. These devices may require shielding or filtering in the same manner as the equipment used in fixed or mobile installations. One special problem in a wooden hull vessel is establishing an adequate ground connection to which a shield or filter is connected. If a ground plate is installed on the vessel, you should be sure that a low-resistance bond exists between the main ground strap and straps going to individual pieces of equipment. The adequacy of such a ground can be established only by the use of a resistance bridge, since the bonding resistance should measure .01 ohm or less. An ohmmeter check can be taken only as an approximate indication of an adequate bond. Another point to check in marine installations is the grounding of shock mounted equipment. Normally, such mounts do not provide grounding; therefore, a separate ground strap around the shock mount is necessary for adequate equipment enclosure grounding.

Re-radiated interference (Fig. 12-1C) is often one of the most difficult to trace and evaluate. The same techniques previously described are useful, but the problem is often getting to the source rather than just to the re-radiating items. Often, it is expedient to ground the re-radiating items as a "fix." This means grounding the enclosures for wire-ways, bonding together (with copper straps) the major sections of an automobile which are normally electrically insulated (the exhaust and muffler, for instance, with straps around their hangers), using shielded wires for unshielded control cables running between compartments, bonding hinged metal doors and access plates, etc.

When checking an installation, you should not dismiss a piece of equipment as an interference source because it appears to be shielded, grounded, bypassed or filtered. A great deal of the effectiveness of such devices depends upon the degree of workmanship with which they were installed. As was just mentioned, the adequacy of a ground strap or the bonding between metal pieces can be checked only with a resistance bridge.

A filter which shows fine attenuation characteristics on a bench check may be ineffective in use due to inadequate component grounding. Even the effectiveness of a simple bypass capacitor can be changed greatly by the manner in which it is installed.

FILTERS, REVIEW OF TYPES

A number of types of filters have been discussed in the preceding sections and it might be a good idea to review the basic types available so that you can understand where and for what purpose each one is useful.

A simple capacitor bypass to ground is the simplest type of filter. It is useful when you want to suppress energy above a certain frequency. Fig. 12-6 shows the effectiveness of such a filter. The main point is that suppression is gradual, beginning at the point where the filtering or bypassing action starts.

Series or trap filters consist of an inductive and capacitive network. Usually, they are meant to prevent energy of only a single frequency from traveling along a wire. Such filters can be made for any desired frequency and inserted in an antenna lead or a power lead. An example of such a filter is the so-called alternator or generator filter designed for an automotive installation. Such filters are inserted in the power lead from these devices, and models are available for the

marine band, CB band, and on special order for other frequency ranges. The filter is actually tuned to the frequency being received to suppress all generator- or alternator-produced interference.

Another basic type is the low-pass filter. As its name implies, it passes all signals below its cutoff frequency. Many such filters are commercially available, particularly for use in transmitter output circuits. For instance, a common low-pass filter is the 40-MHz cutoff type which allows all energy below 40 MHz to pass from an amateur, marine or CB transmitter. However, the same filter sharply attenuates any spurious outputs above 40 MHz which may interfere with nearby reception on frequencies above 40 MHz (TV, FM, VHF police bands, etc.).

A filter complementary to the low-pass type is the high-pass type which is usually used in the antenna lead of a receiver. As its name implies, it passes all frequencies higher than its cutoff and suppresses those below its cutoff. If such a filter had a cutoff frequency of 40 MHz, for instance, it would pass all higher frequencies (TV channels, FM, etc.) but suppress interference on lower frequencies (such as those from a nearby AM broadcasting tower, marine transmitters, CB transmitters, and high-frequency amateur transmitters).

A wide range of filters is available commercially, and by consulting textbooks you can build one for almost any special situation. Receiving filters can be made from ordinary circuit components. Transmitting filters must be constructed more carefully and the components used must be rated to handle the transmitter RF power output level.

Chapter 13

Home Video Recorders

Inevitably video (TV) recorders are bound to be one of the most popular items in the home inventory of electronic equipment. In fact, right now a number of such recorders are available at reasonable prices. Some perform very well, but not all tapes are interchangeable; that is, recordings made on one type of machine cannot be played back on certain other makes of video recorders. Hopefully, this situation will be cleared up with the advent of cassette video recorders. Nonetheless, video recording remains a fascinating aspect of home electronics. By their nature video recorders are more complex than audio recorders and the instructions of the manufacturer—especially in the area of adjustments—must be very closely followed for good performance.

VIDEO RECORDER BASICS

A video recorder is capable of recording and playing back a complete TV signal containing both the picture and audio information. The input to the recorder can come from a camera and microphone combination, a TV set, or from a video signal distribution line. A video tape can be played back through a TV set by connecting the recorder to the receiver antenna terminals or another output can be applied to a TV monitor.

The signals—both picture and sound—are recorded on a much wider tape than that used for conventional audio recordings (usually 1-inch wide tape), but the same type tape is used. The transport mechanism is somewhat similar to an audio recorder. There is a supply reel, a tension device to keep the tape taut, a scanning assembly, capstan drive assembly which actually determines the speed of the tape, and the end take-up reel for the recorded tape. All of these elements are basically the same as in an audio recorder, except, of course, larger due to wider tape involved.

The one element that is most different, however, is the scanning assembly which contains the video and audio

recording and playback heads. The tape itself moves across the scanning assembly at a speed similar to that used in audio recorders. But the scanning assembly is moving very rapidly—often at a few thousand RPM. So, as you can see, the movement of the scanning is the one feature that most distinguishes and complicates video recording as compared to audio recording.

In a magnetic tape recording system, the signal is recorded by passing the tape across a recording head. The recording head is energized by the signal to be recorded, either in original or modified form. This signal produces a magnetic field in the recording head core and this magnetic field is recorded on the tape by the head core which is in contact with the tape. Now that the recording is done, what happens on playback? If the recorded tape is passed over a head (such as an inactive recording head), a signal will be induced in the winding of the head by the recorded magnetic field on the tape. The output signal amplitude which can be achieved during the playback process is determined by the size of the gap in the head, the frequency of the recorded signal, and the relative speed of the tape.

In any tape recording system, the upper frequency limit is reached when the wavelength of the signal being recorded equals the gap length. For instance, to record only a 20,000-Hz audio signal, the gap length has to be .05 mm. The lower frequency limit occurs when the magnetic field induced in the tape is too weak to generate enough output on playback.

So, the head gap problem is a limiting factor in any magnetic recording system and particularly in a video recording system where the video signal extends up to 3,500,000 Hz (3.5 MHz). A head gap small enough to reach this frequency cannot be produced. But, since this frequency range must be recorded to include all the picture information, there is no choice but to increase the relative head-to-tape speed. The required speed depends on the gap used and can range up to 1,000 inches per second. Since tape can't possibly move this fast, the high relative head-to-tape speed is achieved by moving both the tape and the head.

In most video recording systems, an additional feature is also included. The signal to be recorded is changed to a frequency-modulated signal. On playback the FM signal is demodulated in much the same fashion as is done in a FM receiver. The frequency-modulation technique is used because more octaves of bandwidth can be gained by this process, as compared to recording a "raw" video signal, and the low-frequency response is enhanced also.

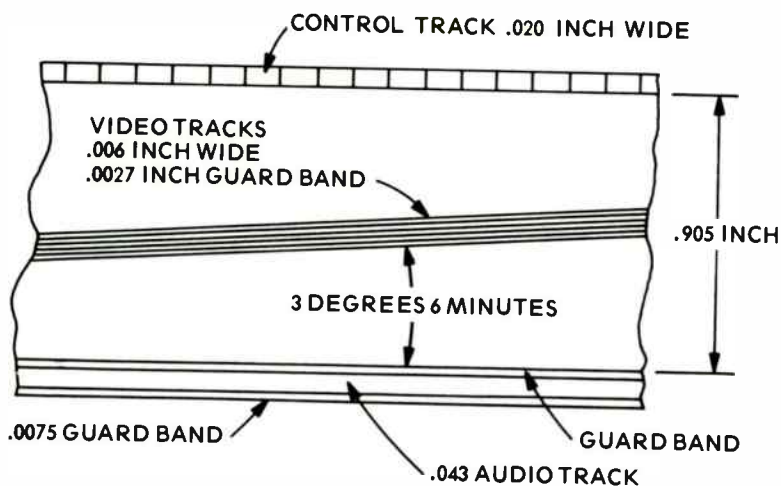


Fig. 13-1. Video tape recording format used by one manufacturer. All are generally similar.

The way all this information is put on a tape is not completely standard, as you can see in Fig. 13-1. The drawing shows the location of the video (picture), the audio channel, and a control track. The control track is an internal signal for the recording machine which serves on playback to regulate the accuracy of the speed of the scanning head assembly.

RECORDER INSTALLATION

A video recorder requires more care in installation than an audio recorder simply because it is a more complicated and sensitive piece of equipment. A level mounting surface free from vibration is a basic requirement. Consideration should be given to the exposure of the recorder. Dusty areas spell certain trouble because of the high speeds used in the scanning assembly. Dust, if present at all, will accumulate rapidly around the assembly and the result will be excessive head wear and a loss of picture information on the recording. Areas having strong magnetic fields must also be avoided, too. In the presence of magnetic field, a video recorder is far more vulnerable to eventual head magnetization and a resulting deterioration of picture quality on playback.

A video recorder can be used in various ways. An elaborate installation which shows just about every possibility is shown in Fig. 13-2. The picture to be recorded can come from any one or all of three cameras and-or a TV receiver. In

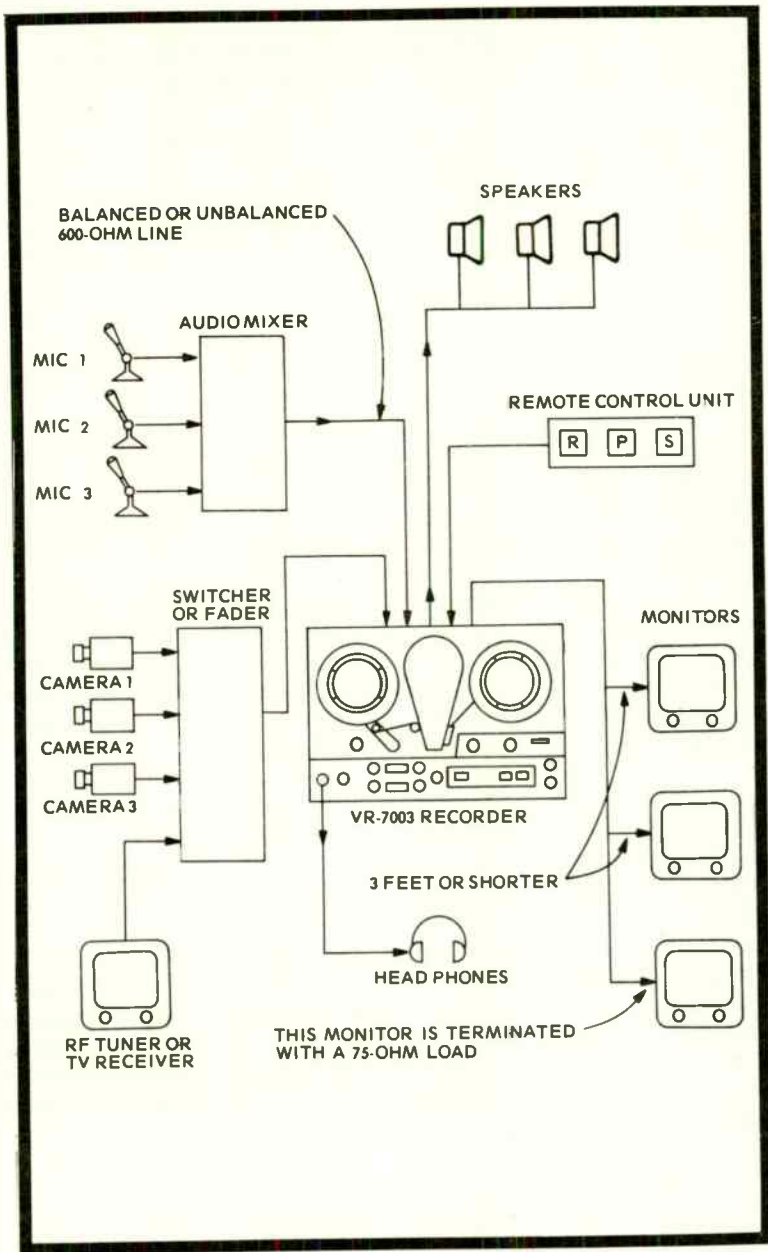


Fig. 13-2. Most video recorders accommodate a number of input and output options. The setup in this drawing centers around an Ampex VR-7003.

the setup shown, it is possible to switch between these sources or a fader (equivalent to a mixer control for microphones) can be used. The audio input to the recorder can come along with the signal from the TV receiver, or from any of three microphones when the cameras are being used.

On playback the outputs can be fed to one or more TV monitors; three are shown in the system in Fig. 13-2. The audio output can be distributed to additional speakers, as shown. Headphones may be used to listen to the audio playback and to the audio as it is being recorded (as, for instance, you adjust the audio mixer). Another feature possible with some recorders is a remote control unit. The system shown in the diagram provides for remote control of tape rewind, play, and stop functions.

The connection of the TV monitors as shown in Fig. 13-2 deserves special attention. The monitors, which may be TV sets, have been wired to accept a video signal directly, much like the tape recorder input of a radio receiver-amplifier combination. Depending on the capability of the recorder, many monitors at distances up to several hundred feet may be connected to the recorder. This is possible because only the video signal (with frequencies extending up to 3.5 MHz) is being distributed over a coaxial cable to each monitor. Notice that the last monitor in the system has to be terminated with the proper resistance. If this is not done, reflections will form on the line and become "ghosts" in the picture.

Besides the "video" output, most recorders also provide an output in the Channel 2 or 3 range. This output can be connected directly to the antenna terminals of any TV set. You simply tune the TV set to Channel 2 or 3 to playback the recording. The disadvantage with this playback mode is that the TV set must be located close to the recorder. It is impossible to distribute the much higher Channel 2 or 3 frequency signal (as compared to the video signal only) because of the loss in the cables. Of course, you can put in boosters and other devices to distribute the signal to remote TV sets. In essence, the Channel 2 or 3 recorder output must be treated like a signal being taken from a TV antenna and then distributed.

CONTROLS

Most controls found on a video recorder are labeled a bit different than those on an audio tape recorder. Some control functions are reviewed here because instruction manuals may assume the operator knows these functions. The audio record

level and audio level meter are the same as those on an audio recorder. The level is adjusted so the meter peaks at the "0" or 100 percent level, depending upon the meter scale used. The video record level control and video level are similar to the audio controls. The video level meter should indicate a "0" or 100 percent level, again depending on the meter scale, when a white scene appears.

Record levers: These controls differ from machine to machine. Some provide independent audio and video record or play switches, while others combine both functions into a single control. If independent controls are used, just be sure that both are set to record when you're taping a scene or you'll have the picture without sound or vice versa.

Thread control: This control moves the tape guides away from the scanning assembly so you can properly thread the tape. Whenever recording or playing back, this control must be set so the tape is moved back into its operating position.

Tracking control: When present on a recorder, this control is used during playback to adjust the head-to-tape tracking for the best picture output. It can be adjusted while looking at the picture or, if the video level meter operates on playback, for maximum deflection on this meter.

Slow motion control: Some recorders have this feature. It is used on playback only and simply varies the playback video field frequency. The effect is similar to slow motion movies.

Tape tension control: If the picture pulls or breaks apart at the top of the screen, the tape tension control should be adjusted.

Some video tape recorders have a back panel control which adjusts the output TV channel frequency. Set the TV channel selector to a channel within range of the recorder's TV output (usually Channel 2 or 3), set the receiver's fine tuning at mid-range and adjust the channel frequency control on the recorder for the best picture. Use the receiver's fine-tuning control to touch up the picture quality when necessary.

OPERATING HINTS

Proper usage and handling of video tape is essential for good performance. Always use the size and quality recommended by the recorder manufacturer. Video tape is expensive, but good tape pays off in picture quality and in durability. Because of its large size, video tape may give the impression of being overly rugged. However, it deserves careful handling. Do not touch the tape surfaces unless necessary and avoid stretching it in any manner. It should be

stored away from heat and moisture in a cool, dry location. Keep it in a proper container and away from stray magnetic fields. A careless pass of a demagnetizer over a tape can destroy major portions of the picture information.

When threading a tape on a recorder, follow the manufacturer's instructions to the letter; be careful not to unduly stretch the tape. If a brand new tape is used, throw away the first layer, since it may have adhesive traces on it which, if they ever reach the scanning assembly, could cause immediate problems. Regardless of the manner in which the tape is threaded on the machine, be sure the dull oxide side of the tape contacts the head assembly.

When the recorder is working and the rotating scanning assembly seems to be erratic in operation, it may be because the tape is wrapped around it too tightly, preventing the scanning assembly from reaching full speed. Loosen the tape a bit and listen to hear if the assembly doesn't reach a steady sounding speed level. When making recordings, don't forget it is necessary to adjust both the audio and video recording levels. When playing back tapes, don't forget to adjust the tracking and tape tension controls for the best picture on the TV monitor or TV receiver.

SPLICING VIDEO TAPES

Fortunately, video tape can be spliced and in basically the same manner as audio tape, but there is a difference in technique. Notice again in Fig. 13-1 how information is put on a video tape. The exact dimensions shown are those supplied by one manufacturer, but the general idea remains the same. The picture information is contained in the series of diagonal tracks in the middle of the tape. Each track contains the information for a field or one half of a picture. The length of one such track varies, but in the system shown it is about 16 inches. An ideal splice would be parallel and along the length of these diagonal tracks. Obviously, a 16-inch long splice is not a simple thing to do and all sorts of specialized equipment are necessary to get the splice angle correct. In very special circumstances, however, it can be done and will result in an immediate transition of one scene to the other on a TV screen. Most viewers will hardly notice the break if it is well done.

The next best type of splice is made in a way that leaves the control track in the proper sequence. This track functions in different manners, according to the recorder involved, but it synchronizes the scanning assembly speed with the tape during playback. Again, special equipment is required, but

you splice the tape to start the next scene, beginning always at the top of the viewing screen, after the break.

The best general purpose splice is a straight cut as vertically as possible—not the diagonal cut characteristic of audio tape splices. To do this, the pieces of tape to be spliced are cut as carefully as possible across the tape so they join together, butt to butt, with no overlap and with the edges exactly in line. Splicing tape is used to join the two pieces. The splicing tape is applied only on the non-oxide side and it must not in any case extend beyond the edges of the tape. In fact, the splicing tape should be cut slightly narrower than the video tape so this cannot happen. If it does, adhesive from the splicing tape may get on the scanning assembly and possibly damage it. The general appearance of a correct splice is shown in Fig. 13-3. This method of splicing may result in a picture roll of up to two seconds, or less, depending upon how the splice, by chance, happens to cut the control track on the tape.

OWNER MAINTENANCE AND CARE

In spite of the complex nature of a video recorder, some fairly simple but continuous maintenance by the owner will ensure both continued high quality performance and often hinder the development of problems requiring service shop attention.

More so than with any audio tape recorder, the single most difficult problem with video recorders is the accumulation of tape oxide on the scanning assembly and other various parts

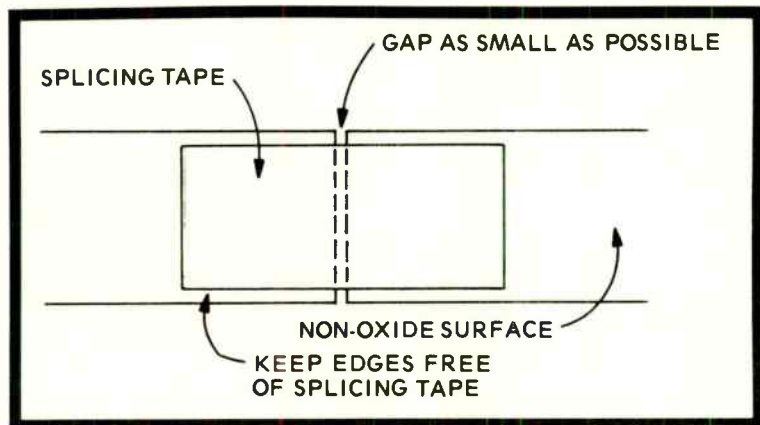


Fig. 13-3. Sketch showing the correct way to splice a 1-inch video tape.

of the tape transport mechanism. Cleaning of these surfaces is required much more frequently than for audio recorders, at least after every two reels of tape. If cleaning is neglected, the first indication will be poor picture reproduction with frequent rolling, etc.

Using a clean, lint-free cloth wetted with one of the available cleaners, wipe all surfaces which come in contact with the tape, including the tape guides, the drums, capstan shaft, and the scanning assembly heads. A swab can be used to clean the difficult to reach surfaces. The rubber capstan wheel should be cleaned with denatured alcohol instead of head cleaning fluids; head cleaning fluid may contain a slight bit of lubricant. Aerosol sprays may also be useful, but they wash away the oxide rather than remove it; therefore, you must be careful of the area into which all the oxide is eventually being deposited.

Periodic demagnetizing or degaussing (both mean the same) is required, the same as for an audio recorder. The heads especially should be demagnetized, as well as the entire transport mechanism including the tape guides, capstan, etc. Before starting, the AC line power to the recorder should be disconnected. With the demagnetizer operating, bring its tip close to—but do not touch—the part to be demagnetized. Make a few passes over the desired area, keeping the tip as close as possible without touching. A thin piece of paper can be used as a separator. Move the demagnetizer several feet away from the recorder, then release the pushbutton to deactivate the demagnetizer. The same type of demagnetizer used for an audio recorder is appropriate. Those types which have a thin plastic sleeve over the metal tip to avoid a metal-to-metal contact are particularly recommended.

Further checks which a recorder owner might wish to make involve the rewind tape tension, takeup tension, and tape holdback tension. These factors can be measured with a small tension gauge, but the correct ratings are specified by the recorder manufacturer. A change in any tension beyond the allowed range may mean the belts and pulleys associated with the mechanical power drive need to be cleaned or adjusted. Rubber pulleys and belts can be cleaned with denatured alcohol. The rubber surface of the capstan drive wheel can also be cleaned with denatured alcohol if the transport seems to be slipping.

Appendix

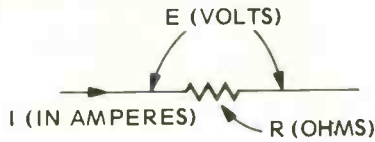
Reference Data, Charts, and Formulas

The length in inches of a half-wave dipole for any frequency is equal to 5540 divided by the frequency in MHz as shown. For TV channels, use the mid-frequency in each case.

TV-FM CHANNEL DESIGNATIONS AND ANTENNA LENGTHS

Channel Number	Band (megahertz)	Channel Number	Band (megahertz)
2	54-60	43	644-650
3	60-66	44	650-656
4	66-72	45	656-662
5	76-82	46	662-668
6	82-88	47	668-674
7	174-180	48	674-680
8	180-186	49	680-686
9	186-192	50	686-692
10	192-198	51	692-698
11	198-204	52	698-704
12	204-210	53	704-710
13	210-216	54	710-716
14	470-476	55	716-722
15	476-482	56	722-728
16	482-488	57	728-734
17	488-494	58	734-740
18	494-500	59	740-746
19	500-506	60	746-752
20	506-512	61	752-758
21	512-518	62	758-764
22	518-524	63	764-770
23	524-530	64	770-776
24	530-536	65	776-782
25	536-542	66	782-788
26	542-548	67	788-794
27	548-554	68	794-800
28	554-560	69	800-806
29	560-566	70	806-812
30	566-572	71	812-818
31	572-578	72	818-824
32	578-584	73	824-830
33	584-590	74	830-836
34	590-596	75	836-842
35	596-602	76	842-848
36	602-608	77	848-854
37	608-614	78	854-860
38	614-620	79	860-866
39	620-626	80	866-872
40	626-632	81	872-878
41	632-638	82	878-884
42	638-644	83	884-890

SIMPLE OHM'S LAW EQUATIONS FOR DC



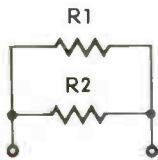
P (WATTS) IS EQUAL TO EI OR $\frac{E^2}{R}$ OR I^2R

E (VOLTS) IS EQUAL TO IR OR $\frac{P}{I}$ OR $\sqrt{\frac{P}{R}}$

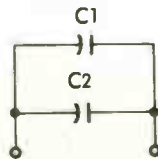
I (AMPERES) IS EQUAL TO $\frac{E}{R}$ OR $\frac{P}{E}$ OR $\sqrt{\frac{P}{R}}$

R (OHMS) IS EQUAL TO $\frac{E}{I}$ OR $\frac{E^2}{P}$ OR $\frac{P}{I^2}$

SERIES-PARALLEL EQUATIONS



$$\text{EQUIVALENT } R = \frac{R_1 R_2}{R_1 + R_2}$$

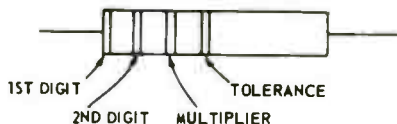


$$\text{EQUIVALENT } C = C_1 + C_2$$

INDUCTANCE IS THE SAME AS RESISTORS WHEN EACH COIL IS SEPARATELY SHIELDED OR SEPARATED.

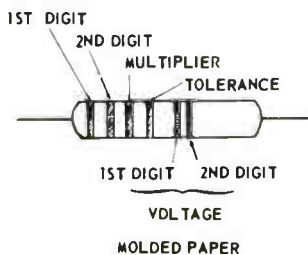
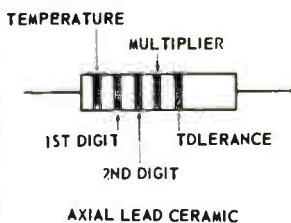
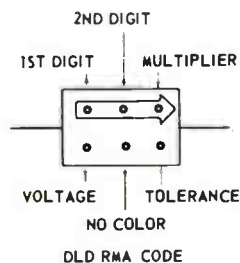
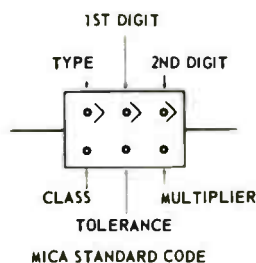
RESISTOR/ CAPACITOR COLOR CODING

RESISTORS



COLOR	1ST DIGIT	2ND DIGIT	MULTIPLIER	TOLERANCE %
BLACK	0	0	1	
BROWN	1	1	10	
RED	2	2	100	
ORANGE	3	3	1000	
YELLOW	4	4	10,000	
GREEN	5	5	100,000	
BLUE	6	6	1,000,000	
VIOLET	7	7	10,000,000	
GRAY	8	8	100,000,000	
WHITE	9	9	1,000,000,000	
GOLD			0.1	5
SILVER			0.01	10
NO COLOR				20

CAPACITORS

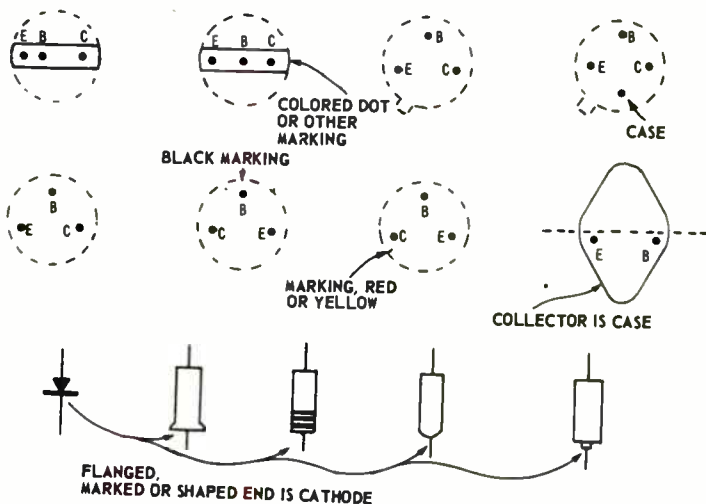


CAPACITOR COLOR CODE

COLOR	1ST DIGIT	2ND DIGIT	MULTIPLIER	TOLERANCE		TEMPERATURE PARTS/MILLION DEGREE/C°
				OVER 10 PFD	UNDER 10 PFD	
BLACK	0	0	1	±20	±2	0
BROWN	1	1	10	±1		-30
RED	2	2	100	±2		-80
ORANGE	3	3	1000			-150
YELLOW	4	4	10,000			-220
GREEN	5	5	-	±5	±5	-330
BLUE	6	6	-			-470
VIOLET	7	7	-			-750
GREY	8	8	.01		±.25	+30
WHITE	9	9	.1	±10	±1.0	+120 TD -750
GOLD						
SILVER						

BYPASS OR COUPLING

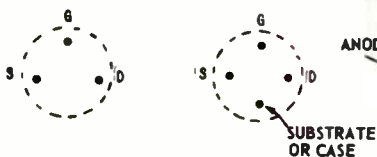
DIODE/ TRANSISTOR LEAD CHART



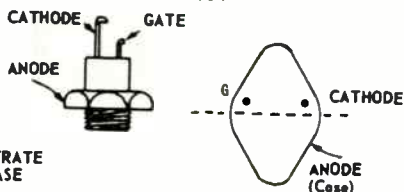
COLOR CODED "IN" DIODES



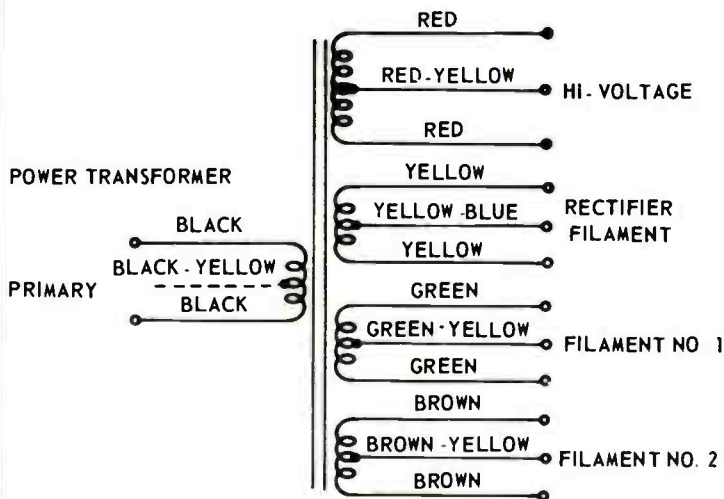
FET



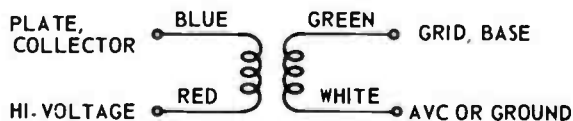
SCR



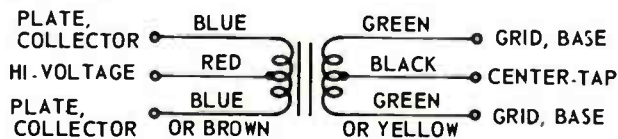
TRANSFORMER WIRE COLOR GUIDE



IF TRANSFORMER



AUDIO INTERSTAGE



Gain

Loss

DB	Gain		DB	Loss	
	Power	Voltage		Power	Voltage
0	1	1	1	1	
5	1.12	1.06	.89	.94	
1	1.26	1.12	.79	.89	
2	1.59	1.26	.63	.79	
3	2.00	1.41	.50	.71	
4	2.51	1.59	.40	.63	
5	3.16	1.78	.32	.56	
6	3.98	2.00	.25	.50	
7	5.01	2.24	.20	.45	
8	6.31	2.51	.16	.40	
9	7.94	2.82	.13	.36	
10	10	3.16	.10	.32	
15	31.6	5.62	.03	.18	
20	100	10	.01	.1	
25	220	18	.005	.06	
30	1000	31.6	.001	.03	
35	2200	56	.0005	.02	
40	10,000	100	.0001	.01	

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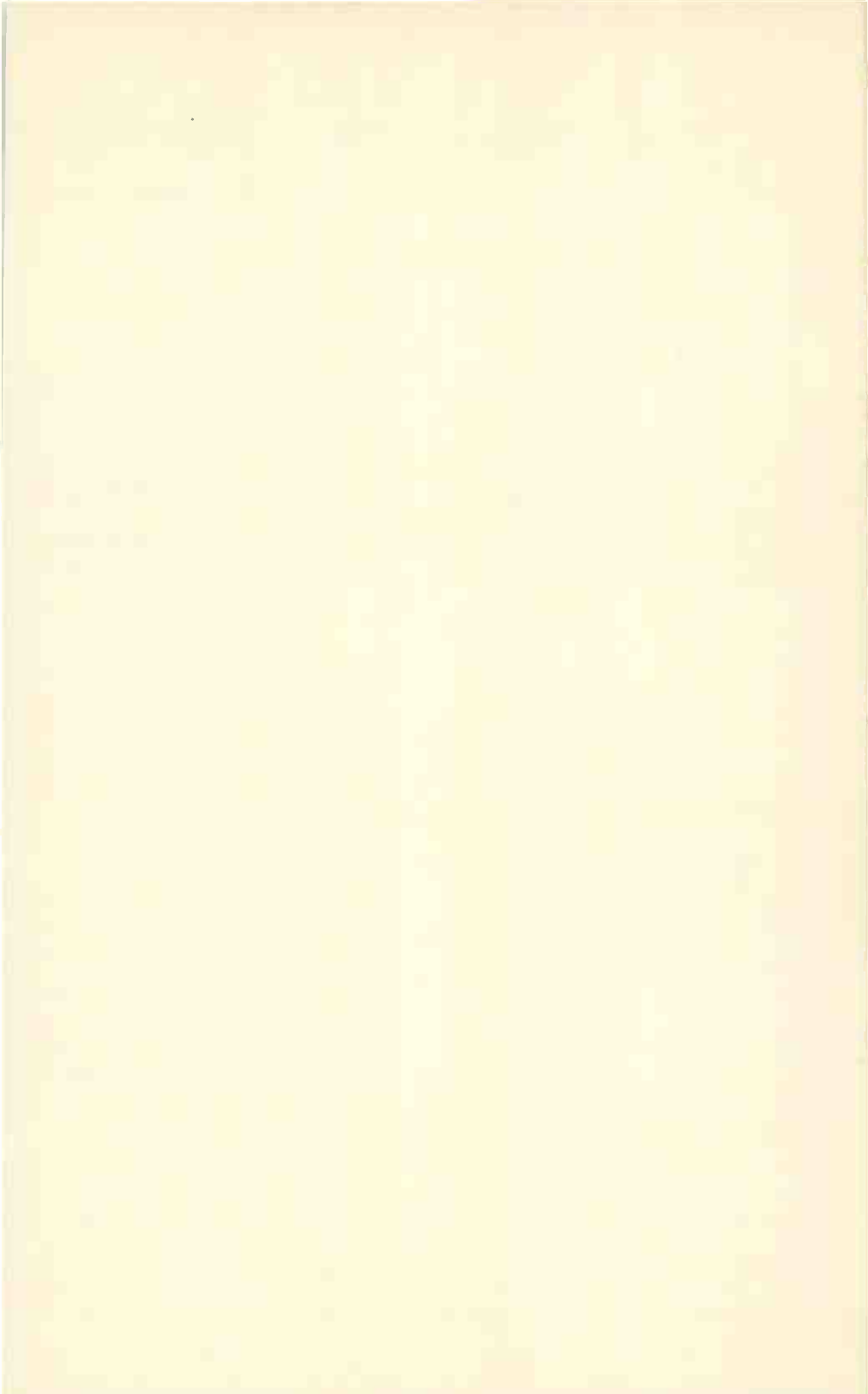
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- 542 — TRANSISTOR PROJECTS FOR HOBBYISTS & STUDENTS. Steckler. 192 pages, 140 illus. \$4.95
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