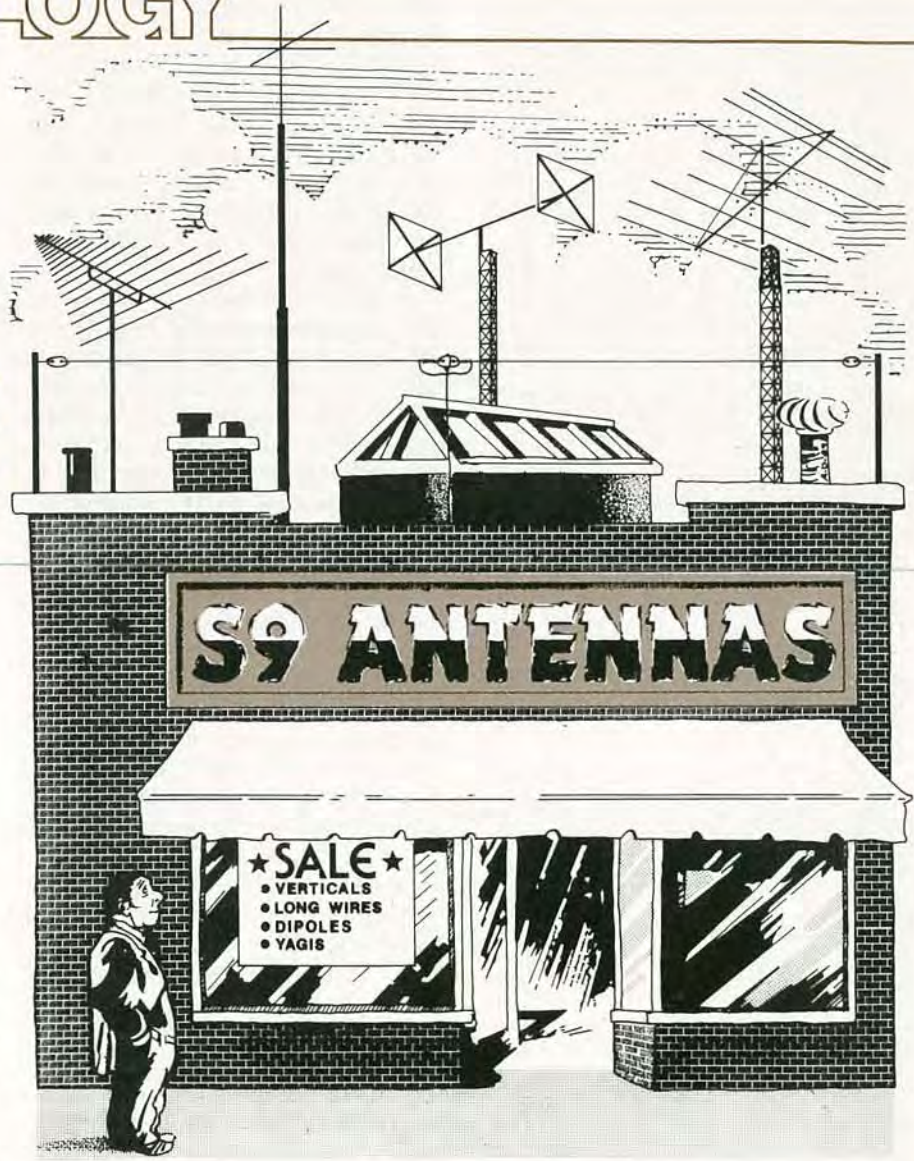
CHOOSING THE RIGHT SHORTWAVE ANTENNA



Boost your shortwave reception using a wire antenna—and a little know-how.

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MOST ARTICLES ON HIGH-FREQUENCY ANtennas are about transmitting, but there's also a body of knowledge purely about receiving antennas. Who can benefit from knowing about receiving antennas? On top of the list is the *s*hort*w*ave *l*istener (SWL); a close second is the amateur radio operator who wants a separate receiving antenna to pull in those weak DX (distant) stations.

Reciprocity

Antennas possess a property called *reciprocity*. That's a fancy way of saying that antennas work as well on receive as they do on transmit; that's usually taken for granted. For example, many hams use transceivers, which commonly use the same antenna for both transmitting and receiving. A half-wavelength dipole that works well as a transmitting antenna on 20 meters works equally well as a receiving antenna on 20 meters. Antenna properties like directivity, gain, angle of radiation, and polarization do not vary between transmit and receive at a given frequency. (Bear in mind, however, that simple wire antennas suitable for reception of shortwave signals are not necessarily suitable for transmitting.)

Antenna properties

Assuming that you want more than a simple longwire antenna (which will be discussed shortly), you will want to explore the antenna properties best suited to your monitoring application. Is the antenna to be fixed or rotatable? Do you want omnidirectional or directional reception? In which polarized plane? What about gain?

Because receiving antennas exhibit the same properties as transmitting antennas, any directional transmitting antennas are directional while receiving, too. Therefore, any specifications given for an antenna's transmitting characteristics can be applied toward receiving characteristics. The common terms you'll come up against when reading antenna specifications are gain, directivity, and angle of radiation. Let's look at each.

Antenna gain stems from the fact that the directional antenna can focus energy. Gain is expressed as the ratio in decibels of the power radiated in a given direction by a test antenna to the power radiated in the same direction by a reference. The two commonly used reference antennas are a dipole (which has a figure-8 radiation pattern) and a spherical point source (which is an isotropic radiator that has an omnidirectional radiation pattern). If an antenna gain is listed as 8 dB over isotropic then, in the direction specified, the radiated signal is 8 dB higher than that radiated by an isotropic antenna.

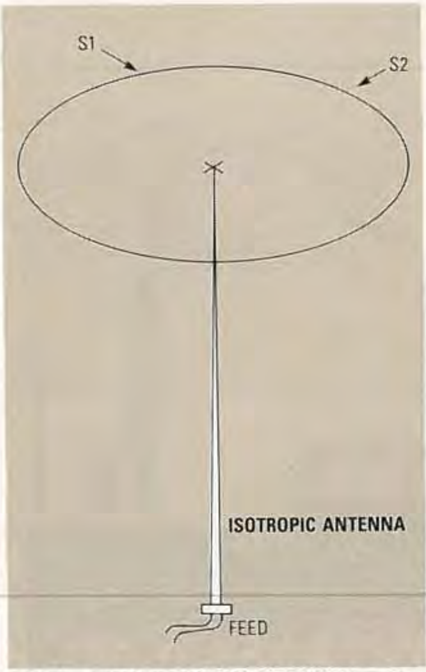

FIG. 1—AN ISOTROPIC ANTENNA is a theoretical construct that receives equally well in all directions.

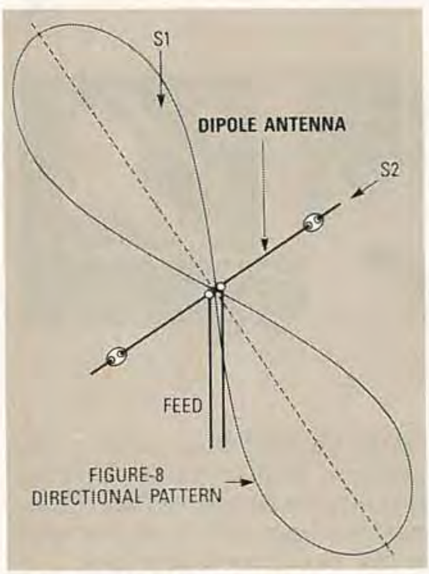

FIG. 2—A DIPOLE ANTENNA has a figure-8 directivity pattern.

So what good is antenna gain? By accumulating more signal, the apparent receiver sensitivity is increased. Note that the antenna gain does *not* create a higher powered signal, but merely increases the *apparent* signal power by focusing energy —like an electromagnetic lens—from a given direction. Note that antenna gain implies directivity.

Directivity is often taken to mean horizontal directivity. But all antennas radiate in three dimensions, so both azimuth and elevation angle of radiation are important. Certain VHF/UHF vertical antennas are listed as "gain antennas", yet the pattern in the horizontal direction is 360 degrees, implying omnidirectional behavior. In the vertical plane, however, lost energy is compressed into a smaller range of elevation angles, so gain occurs by refocusing energy that would have been radiated at a higher-than-useful angle.

A second application of directivity is to suppress interfering signals. On the regular AM- and FM-broadcast bands, each station is allowed a channel (called channelization), permitting receiver selectivity to overcome adjacent channel interference. But in the *h*igh *f*requency (HF) amateur radio and international broadcast bands, channelization is either nonexistent, poorly defined, or ignored altogether. In those cases, interference from adjacent channel signals can wipe out a weaker desired station.

A similar circumstance occurs in co-channel interference when both stations are on the same frequency. In Fig. 1, two 9540-kHz signals, S1 and S2, arrive at the same omnidirectional vertical antenna; both will be heard, or the stronger will drown out the weaker. In Fig. 2, a dipole is used as the receive antenna, so a little directivity is obtained. The main lobes of the dipole are wide enough to provide decent reception of S1 even though the antenna is positioned in such a way that S1 is not along the maxima line (dotted). Better yet, the positioning places interfering co-channel S2 in the null (off the ends of the dipole), weakening response to S2. The result is enhanced S1 reception.

The idea is not to exploit the antenna's gain to increase the response to S1, but rather to place the unwanted signal S2 into the null. Note that the notch is sharper than the peak of the main lobe. If the dipole is placed on a mast with an antenna rotator, the ability to place undesired signals in the null is increased even more.

Another antenna parameter of considerable interest is angle of radiation, which also means angle of reception. Because long-distance HF propagation is caused by skip, the angle of incidence for the signal with the ionosphere becomes extremely important. Figure 3 shows two skip conditions from the same transmitting station. Here S1 has a high angle of incidence a_1, so skip distance D1 is relatively short. For S2, however, the angle incidence a_2 is low, so the skip distance D2 is much longer than D1.

The angular range of effective radiation of an antenna is fixed by its design. The angle of refraction in the ionosphere is a function of ionospheric properties at the time and frequency of interest. For that reason, some well-equipped radio hobbyists use several different antennas. The radiation angle can vary with antenna height as well.

Receiver connection

It's rather naive to state, I suppose,

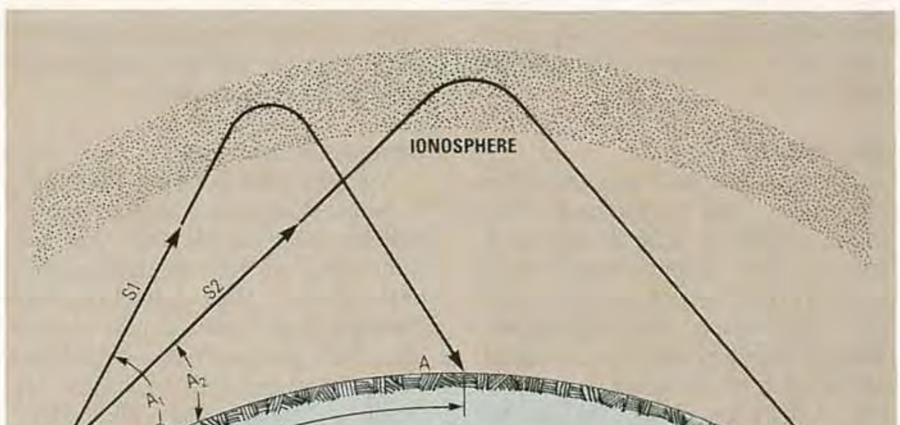

FIG. 3—THE SKIP DISTANCE OF A RADIO WAVE depends upon the angle of elevation at which it's transmitted.

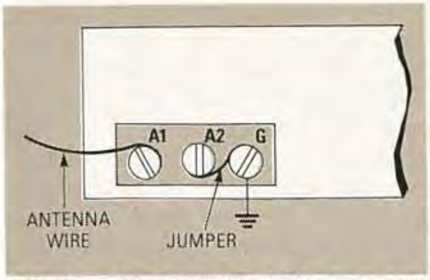

FIG. 4—A RECEIVER'S BALANCED antenna input can be converted to an unbalanced input by connecting A2 and G (ground) together.

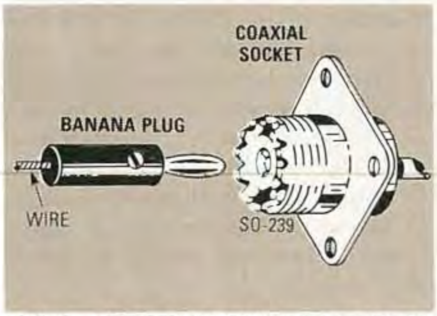

FIG. 5—USE A MINIATURE banana plug to connect your antenna's downlead wire to a standard SO-239 coaxial connector.

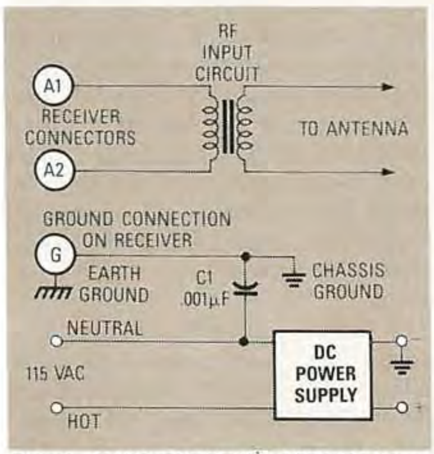

FIG. 6—MANY OLDER VACUUM-TUBE receivers use power supplies that are not isolated from the AC power line. When working on such units, *always* use a 1:1 isolation transformer—for safety.

but let's do it anyway: An antenna must be properly connected to a receiver to be effective. If your antenna uses coax, and the receiver accepts coax, simply attach the proper connector; however, in other cases, non-coaxial cable antennas are used.

There are two major forms of antenna connectors used on shortwave receivers. One uses two or three screws for wrapped wire leads or spade lugs, while the other uses some type of coaxial connector. Consider first the screw-type connector (Fig. 4).

If only two screws are found, then one is for the antenna and the other is for the ground. Those screws will be marked something like "A/G" or "ANT/GND," or with the schematic symbols for antenna and ground.

Three-screw designs are intended to accommodate balanced transmission lines such as twin-lead or ladder line. When balanced parallel lines are used, connect one lead to A1 and the other to A2. Of course, the ground terminal G is connected to Earth ground. On the other hand, for single-lead antennas, connect a jumper wire or bar (a short piece of bare No.22 solid hook-up wire) between A2 and G to convert a balanced input to unbalanced. As an interesting aside, shortwave listeners sometimes use ordinary AC-line cord (called zipcord) as a twin-lead transmission line. Zipcord has an impedance that approximates the 75-ohm impedance of a dipole.

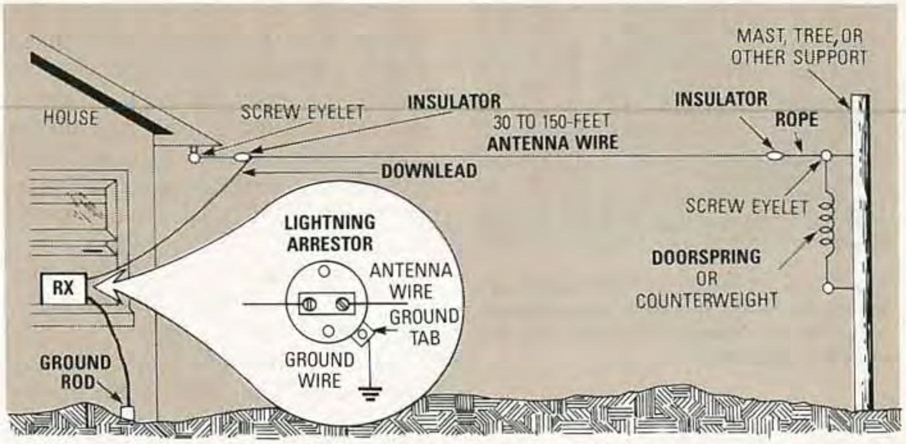

FIG. 7—HERE'S A TYPICAL LONG-WIRE INSTALLATION. Notice the insulator, rope, and spring mechanism, which helps holds the antenna steady when the wind is blowing.

On receivers that use an SO-239 coaxial connector, there are two techniques to connect a single-lead antenna. First, using a PL-259 mating plug, solder the antenna lead to the center conductor pin, and then screw the connectors together. An alternative that's easy enough, as shown in Fig. 5, is to attach a (miniature) banana plug to the downlead wire, and then firmly to insert that banana plug into the SO-239 receptacle.

Grounds that bite

Danger! Certain low-cost receivers, especially older vacuum-tube models, have a so called AC/DC (transformerless) internal DC power supply. On most modern receivers the DC common is the chassis, which also serves as the RF common. However, on older AC/DC models the neutral AC power-line wire serves as both DC common and RF-signal ground. In Fig. 6, C1 sets the chassis at RF ground potential, while isolating the DC common from the 60-Hz AC. A danger exists if either the AC plug is installed backwards, or someone wired the socket in the wall incorrectly (which often happens)!

Even if C1 is intact, you can get a nasty shock by touching the antenna ground (G or GND) terminal. The capacitive reactance of C1 is about 2.7 megohms for 60-Hz AC, so you'll get

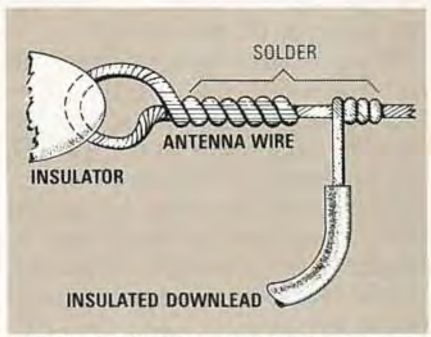

FIG. 8—A GOOD MECHANICAL connection will keep your antenna from falling down prematurely. Solder will keep the electrical connection from corroding to quickly.

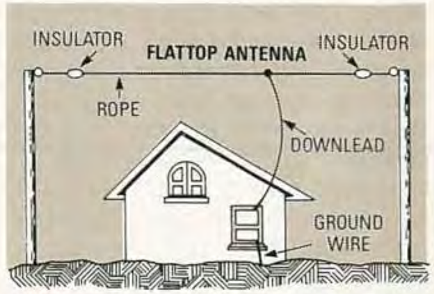

FIG. 9—A FLATTOP ANTENNA is a long wire tapped in the center.

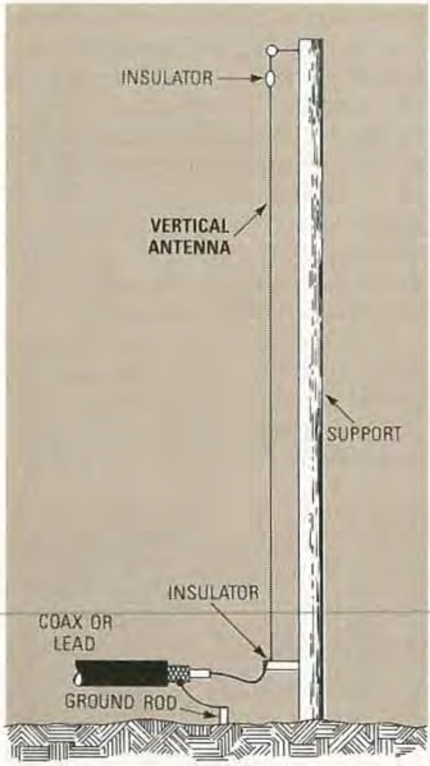

FIG. 10—A VERTICALLY POLARIZED antenna should be at least a quarter wavelength of the lowest frequency that you expect to receive.

a "bite." But if that capacitor is shorted, as is likely on older receivers, then the bite might prove *fatal*. The problem is that a reversed polarity AC-line will set the hot line from the AC socket on the ground lead.

The usual advice given to owners of such radios is to make sure that C1 is intact before using the radio. A better solution might be to use a 110:110 VAC isolation transformer to isolate your receiver from the AC power lines. Using such a transformer is standard practice in repair shops, and should be standard practice in your house, too.

Wire antennas

Figure 7 shows the common receiving longwire. The antenna element should be 150 to 300-feet long. Although most texts show it horizontal to the ground and, indeed, a case can be made that performance is better that way—it is not strictly necessary. If you must slope the wire, then it's doubtful that you will notice any reception problems. The far end of the wire is attached to a supporting structure—a building, tree, or mast—through an insulator and rope.

Wind will cause motion in the antenna wire, and its supporting structure. Over time, the wind movement will fatigue the antenna wire and cause it to break. Also, if a big enough gust or a sustained storm comes along, then even a new antenna will either sag badly or break altogether. You can do either of two things to reduce the problem. First, as in Fig. 7, a door spring can be used to provide some variable wire slack. The spring tension is selected to be only partially expanded under normal conditions. When the wind begins to blow, the wire's tension will increase, thereby stretching the spring. Make sure that the spring does not become over-stretched, or it won't work.

Another tactic is to replace the spring with a counterweight that's heavy enough to keep the antenna nearly taut under normal conditions, but light enough to move in wind. In other words, antenna tension should exactly balance the counterweight under normal conditions, and not stretch the antenna wire excessively.

The antenna wire should be either No.12 or No.14 hard-drawn copper, or stranded wire. The latter is actually steel-core wire with a copper coating. Because of "skin effect," RF signals only flow in the outer copper coating. Soft drawn copper wire will stretch and break prematurely, and should be avoided.

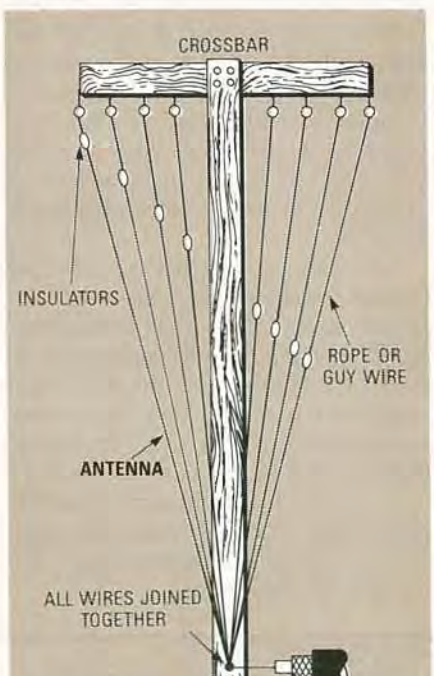

FIG. 11—TUNE IN THE WORLD with eight antennas in one.

The antenna downlead should be insulated and stranded; stranded wire breaks less easily than solid wire. Again, use No.12 or No.14 wire, although No.16 could be used. The point where the downlead and antenna wire are joined should be soldered to prevent the joint from corroding over time. Do not depend on the solder for mechanical strength, for it has very little. Instead, as shown in Fig 8, mechanical strength is provided by proper splicing technique.

There are several ways to bring a downlead into a building. If you can tolerate a slight crack in the junction of the sash and sill, then run a wire underneath the sash and close the window. However, the job looks mechanically nicer with a flat strap connector that passes under the window. Of course, you can always drill a hole in the wall, slip the coaxial cable through, then putty around the seam for a snug fit.

Grounding

The ground lead should be a heavy conductor, such as heavy wire, braid, or the shield stripped from RG-8 or RG-11 coaxial cable. For reception purposes only, the ground may be a cold-water pipe inside the house. Do not use either the hot-water pipes (which are not well grounded), or gas pipes (which are dangerous). Also, be aware that residential air-conditioner liquid lines look like copper cold-water pipes in some cases—don't use them.

A lightning arrester is a safety precaution, and *must* be used. It provides a low resistance path to ground in the event of a lightning strike. Don't consider the arrester optional—it isn't. Besides the obvious safety reasons (which are reason enough), there may be legal and economic reasons for using the arrester. Your local government building and fire codes may require one. Also, your insurance company may not honor your homeowner's policy if the lightning arrester required by local code is not used.

Warning! Do not ever attempt to install an antenna by crossing a power line! No matter what you believe or what your friends tell you, it's never safe—and it may very well kill you.

What about antennas other than the receiver longwire? The flattop antenna is shown in Fig. 9. That antenna is a close relative of the longwire, with the exception that the downlead is in the approximate center of the antenna section. The flattop antenna should be at least a half wavelength (492/*f* MHz) at the lowest operating frequency. The advantage of the flattop antenna over other designs is that it allows maximum use of available space in the configuration shown.

It is also possible to build vertically polarized shortwave receiving antennas; Fig. 10 shows one such version. The support structure (a tree or building) should be at least a quarter-wavelength high on the lowest operating frequency. The vertically polarized antenna is fed at the base with coaxial cable. The center conductor goes to the antenna element, while the coaxial cable's shield gets connected to the ground rod at the base of the support structure.

It's possible to install the wire (or multiple wires of different lengths) inside a length of PVC plumbing pipe. The pipe serves as the support, and the conductors go inside. If you use a heavy pipe gauges of PVC, then the antenna support can be disguised as a flag pole (townhouse dwellers take note)!

Different conductor lengths (L = 246/*f* MHz) are required for different operating bands. In Fig. 11, several bands are accommodated from the same feedline using the same support. In fact, eight different antenna elements are supported from the same tee-bar. Be sure that you insulate them from each other, as well as from the support; again, PVC piping can be used for the support structure. Figure 12 shows a method for accommodating several bands by tying the upper ends of each antenna wire to a sloping rope.

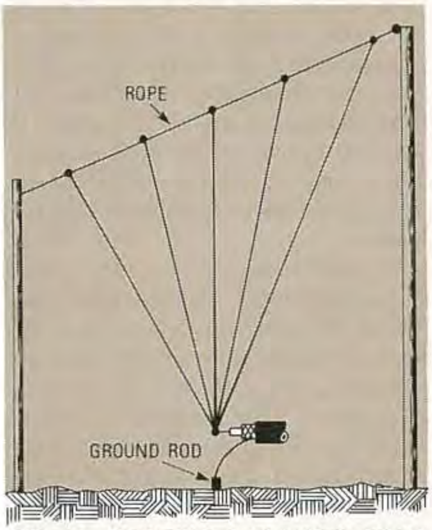

FIG. 12—BY USING A SLANTED ROPE, you can tied together any number of antennas tuned to different wavelengths.

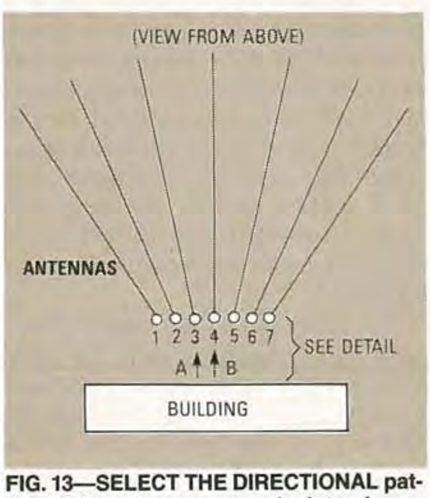

FIG. 13—SELECT THE DIRECTIONAL pattern of the antenna system by interchanging antenna elements of different wavelengths and position.

Directional wire antenna

A directional antenna has the ability to enhance reception of desired signals, while rejecting undesired signals arriving from slightly different directions. Although directivity normally means a yagi beam, a wire-quad beam, or at least a rotatable dipole, certain designs and techniques allow fixed antennas to be more or less directive. One crude but effective approach uses pin plugs or a rotary switch to select the direction of the antenna's reception.

Figure 13 shows a number of quarter-wavelength radiators fanned out from a common feedpoint at various angles from a building. At the near end of each element is a female banana-jack. A pair of balanced feedlines from the receiver (300-ohm twin-lead, or similar) are brought to where the antenna elements terminate. Each wire in the twin-lead has a banana plug attached. By selecting which banana jack is mated to which banana plug, you can select the directional pattern. If the receiver has a balanced antenna input, then connect the other end of the twin-lead directly to the receiver; for receivers with unbalanced inputs, you will have to use a balanced-to-unbalanced (balun) antenna coupler.

Figure 14-*a* shows a balun antenna coupler tuned to the receiving frequency. The coil is resonantly tuned by the interaction of the inductor and capacitor. Antenna impedance is matched by selecting the inductor taps to which the feedline is attached. A simple RF broadband coupler is shown in Fig. 14-*b*. The transformer is wound over a ferrite core using 12 to 24 turns of No.26 enameled wire, with more turns for lower frequencies, and fewer turns for the higher frequencies. Experiment with the number of turns to determine the correct value.

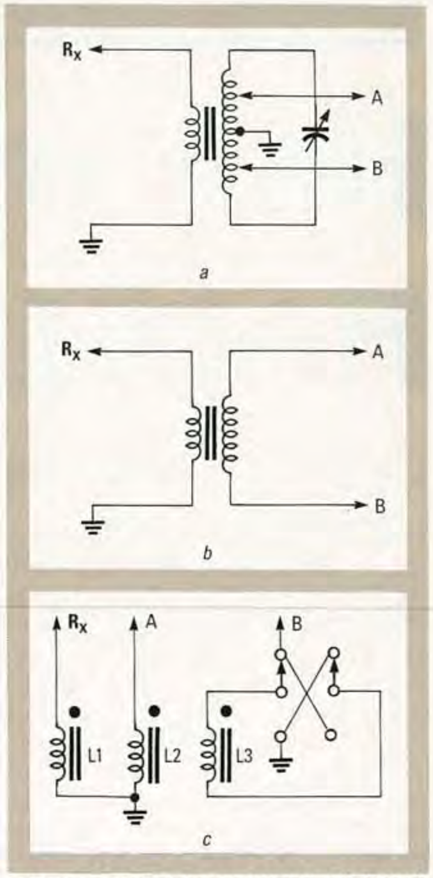

FIG. 14—MATCH A BALANCED ANTENNA with an unbalanced receiver input using any of three methods, *(a)*, *(b)*, or *(c)*.

By combining the right antenna and matching network, the best of both worlds can be had. For example, the antenna in Fig. 13 works by phasing the elements so as to null or enhance the reception in certain directions.

The nulling operation becomes a little more flexible if you build a phasing transformer, like the one in Fig. 14-*c*. Windings L1, L2, and L3 are wound trifilar style on a ferrite toroidal core using 14 turns of No.26 enameled wire. The idea is to feed one element from coil L2 (the A port), the same way all the time; that port becomes the 0-degrees phase reference. Port B is fed from a reversible winding, so it can either be in-phase, or 180-degrees out-of-phase with port A. **R-E**