DOUG'S DESK

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CONSTRUCTION PROJECTS, TECHNIQUES, AND THEORY

Some Answers to Common Antenna Questions

My weekly mail bag contains more queries about antennas than any other amateur topic. It is not difficult to conclude that amateurs at all technical levels are willing to build antennas, even though they have little or no interest in constructing electronics gear. I am constantly amazed at how little some amateurs know about feed lines, baluns, and antennas, even though the antenna system is one of the most important parts of an amateur station. The nearest thing we have to instant antenna knowledge is *The ARRL Antenna Book* and *W1FB's Antenna Notebook*. I strongly recommend that anyone who is skimpy on antenna knowledge add these books to his or her technical library. In the meantime, however, let's go over some of the more common questions that are tossed my way from day to day.

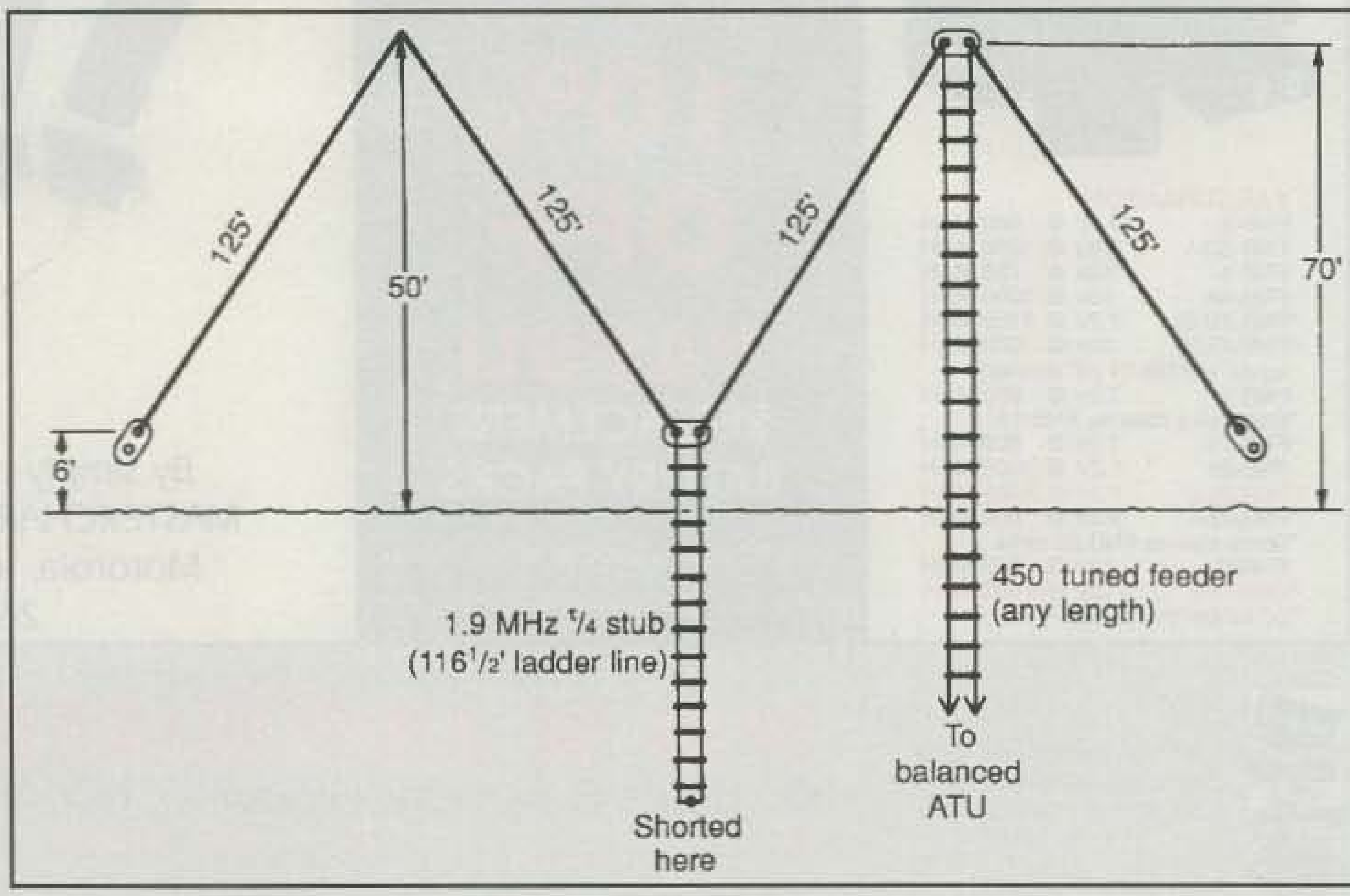

Fig. 1– Physical details of the W1FB double inverted V for 160 through 10 meters. The feed line is a section of commercial 450 ohm ladder line. Ladder line is used also for the ¼-wavelength 1.9 MHz stub.

Which Feed Line is Best?

The war of words concerning coaxial cable versus tuned feeders has been active for decades, and it is unlikely that it shall wane. From a practical point of view, both types of feeder have a rightful place in the world of antennas. The determining factor is founded on the purpose for which the antenna is designed. Certainly, there is little point in using tuned feeders for a single-band HF dipole. Conversely, if that dipole is for use on several amateur HF bands, then it makes sense to use tuned feeders, which enables the operator to use an ATU to match the system to his station equipment for the frequencies of interest. Why can't this be done with coax? A common question. It can be done with an ATU, but the mismatch at the antenna feed point at even harmonics of the dipole fundamental frequency is horrendous. Whereas it is typically 40 to 80 ohms (depending upon dipole height) at the feed point on the fundamental frequency, it can be 1000 ohms or greater at the harmonic frequencies. Feed-line losses become a significant factor under these conditions and damage can occur to the coaxial line at very high power levels. On the other hand, open-wire feeders have the least loss of all feed lines, and even if the line does not match the antenna impedance, the losses remain low.

One advantage associated with coax is that rain, snow, and ice have little effect on it. Tuned feeders, on the other hand, are greatly affected by the foregoing conditions, thereby requiring readjustment of the ATU to ensure an SWR of 1. I find this a minor inconvenience, since one readjustment generally lasts for the period of time I am on the air. Fig. 1 shows an unusual antenna system I have been using for several months. It works extremely well from 1.8 through 29 MHz, and it utilizes 450 ohm ladder line in the tuned feeder and stub system. I have not run it through a MININEC evaluation program as yet, so I can't provide the E- and H-plane patterns for the various HF bands. However, it has proven to be an outstanding antenna. The quarter-wave stub that joins the two 160 meter inverted Vees is cut for 1.9 MHz. On the harmonically related bands it acts as a shorting stub and effectively joins the two inverted Vees at the stub-attachment point. This system can be tailored easily for use from, say, 3.5 through 29 MHz in the interest of minimizing the real estate needed to accommodate it. I have room to spare on my 40 acres, so the side-by-side 160 meter inverted Vees are deployed without bending the lower ends of the legs. In effect, the antenna operates as two half waves in phase on 1.9 MHz, and on the higher frequencies it becomes, in essence, an off-center-fed inverted-Vee long wire. However, rain, snow, and ice change the feed-line properties sufficiently to require readjustment of my antenna tuner.

Commercial ladder line is much easier to work with than home-made open-wire lines. If the latter style of line is not supported in a rigid manner every few feet it can become twisted easily in the wind, and this causes a short circuit across the line. Ladder line is stiffer and has polyethylene insulation, and hence is less prone to the problems mentioned.

I have been asked what the velocity factor is for 450 ohm ladder line. I have never seen published specifications that list the value. Intuitively, I have been using 0.90 as the VF, and recent tests at 28 MHz with a dip meter and a quarter-wave section of line confirmed that my guess was within 5 percent, and that's close enough for my purposes!

Coaxial cable does not present losses that are worth considering at HF if the line is matched to the antenna. RG-58 and RG-59 lines are, of course, more lossy than the larger RG-8 and RG-11 types of coax, but the losses will not show up on the other person's S-meter unless you're using a very long run of feed line.

It is important to recognize that the impedance of a tuned feed line is not impor-

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tant. It can range from 300 ohms to 600 ohms without making enough difference to cause concern. I have employed 300 ohm kw twin line a number of times, and it worked nicely. I have also used 600 ohm hand-made open-wire lines, and they were also good. The true open-wire line is less subject to the effects of moisture than the lines that have polyethylene insulation. The trade-off is up to the builder.

Baluns

If ever there was a nostrum in amateur radio, it's the balun transformer. These devices have their place in a number of applications, but a balun that is added to an HF dipole serves no useful purpose most of the time. It is a passive network, and all such circuits introduce losses, however minor they may be. Baluns are sometimes promoted for HF on the premise that they (1) can reduce TVI and (2) prevent radiation pattern skewing. TVI is not caused by feeder currents, and skewing of the pattern is meaningless with dipoles that are close to ground in terms of wavelength. The typical HF-band dipole is 30 to 60 feet above ground, and this results in high-angle radiation and no directivity whatsoever on 1.8 and 3.5 MHz in particular. Pattern skewing therefore becomes meaningless under these conditions. If we could see the radiation from these antennas, it would look much like an orb that sends energy in all directions. The foregoing applies to dipoles, end-fed wires, and inverted Vees, but not to vertical radiators and inverted-L antennas.

It is not uncommon to hear some amateur remark, "I'd probably be louder if my 75 meter dipole was broadside to you." True, perhaps, if the dipole was a half wavelength above ground, which on 75 meters would be some 120 feet in the air! On 160 meters it requires a height of 250 feet to obtain the classic figure-8 directivity pattern.

Inverted-Vees with an enclosed angle of 90 to 120 degrees are omnidirectional in response. Therefore, it makes no difference what broadside direction you impose. The radiation angle is dependent upon the height of the inverted-Vee apex, as is the case with horizontal dipoles. The higher the antenna the lower the radiation angle, and hence the better the system is for DX use.

Getting back to baluns, they are prone to damage from overheating when subjected to high power under conditions of high SWR. For example, if a 75 meter dipole is resonant at, say, 3.9 MHz (the point of lowest SWR) and the operating frequency is changed to 3.8 MHz, for example, the SWR at the feed point can rise to perhaps 3:1. Correcting this malady at the transmitter with an ATU does not alter the mismatch at the feedpoint, even though the transmitter is presented with a 50 ohm load. The mismatch at the balun causes a high level of RF voltage, and the balun can go up in smoke—quickly. If you experience "creeping" SWR (slow increases) while operating with a balun-equipped antenna, chances are that core heating is occurring as a result of a prohibitive SWR. As the core heats, its permeability changes (sometimes permanently with ferrite) and hence a change in effective inductance of the transformer windings.

When using baluns with HF beam antennas be certain to keep the leads from the balun to the antenna feed point as short and direct as possible. If not, the leads become part of the driven element and can result in detuning of the element. This explains why some amateurs have reported increases in SWR after a balun was installed at the feed point. The problem can be corrected by slightly shortening the driven element after the balun is in place.

Some HF beam-antenna manufacturers recommend installing a 6 inch OD coil of RG-8 coax at the feed point of the driven element. This device is not a balun transformer, even though it is commonly called by that name. It is a decoupling choke (RF choke) that prevents feed-line radiation, which can spoil the radiation pattern of the antenna. The addition of several ferrite sleeves over the coaxial feeder at the antenna feed point serves the same purpose, and this method is less awkward than trying to wind RG-8 cable and keep it coiled as a solenoidal choke. Ferrite sleeves for this purpose are available from Amidon Associates in Dominguez Hills, California.

Effective Antennas For Top Band

Amateurs who try 160 meters for the first time, along with those who are casual users of the band, usually try to "make do" with antennas that are designed for 75 or 40 meters. The temptation is to "force feed" the nonresonant antenna by means of an ATU. Although this makes the transmitter happy, the efficiency of such an antenna is horrible. Most signals heard with these makeshift antennas sound like QRP signals and are usually buried in the noise. The shortfall in signal strength is often enhanced by the use of a "barefoot" rig that produces 100 watts or less. Perhaps the best technique for using a 75 meter dipole on 160 meters is to short circuit both conductors of the feeder at the transmitter end of the line and treat the antenna as if it were a flat-top T fed with a single wire. If the feeder runs to the antenna vertically, the system will function much like a top-loaded vertical. However, the efficiency will be miserable unless a ground screen is used with the antenna, as is true of all high-performance verticals.

I believe that the best solution to temporary antennas for 160 meters is an end-fed wire that is either 1/4- or 1/2-wavelength overall. The greater the height above ground the better. The half-wave wire has the advantage of not requiring a ground screen or counterpoise system under it. Conversely, the 1/4-wavelength wire does need a ground system under it if good performance is to be had. Antennas of this type can take the shape of an inverted L, which results in part of the wire being erected vertically.

Another method worth considering is that of placing a 75 meter trap at each end of a 75 meter dipole or inverted Vee, and then adding sufficient wire to make the dipole resonant on 160 meters. This permits the user to employ a single coaxial feed line.

Operation on 160 meters is not unlike that on 2 meter SSB or CW. This is because on both bands we must deal with noise. The noise on 2 meters comes from within the receiver, whereas on 1.8 MHz it takes the form of man-made and atmospheric noise. The better your antenna for top band the more your signal will rise above the noise at the receiving end of the circuit.

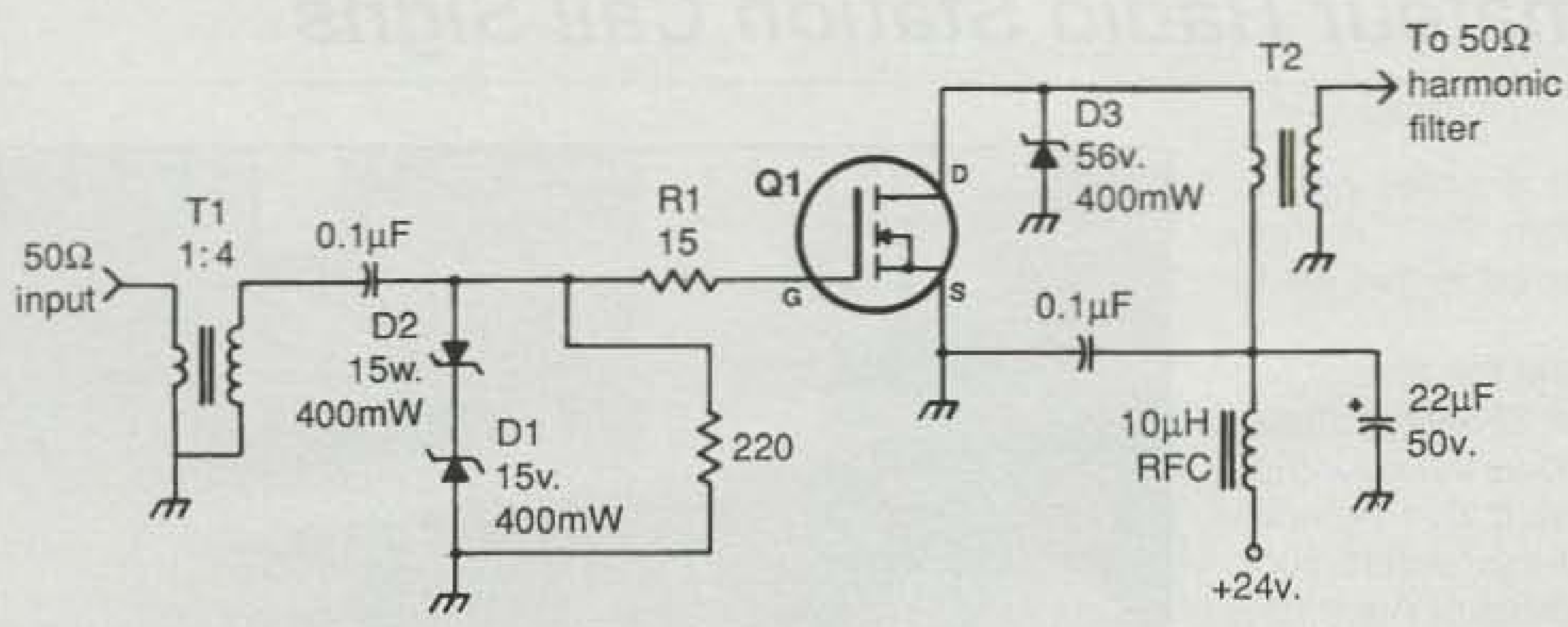
Physically Shortened Antennas

All is not milk and honey when we erect a physically shortened antenna. No compromise antenna of this type can perform as well as a full-size antenna. Despite the popularity of the G5RV dipole, full-size dipoles for the band of choice will deliver better overall performance. Trap antennas are also compromised by their reduced size. Surely, there are solutions in which there is insufficient real estate to erect a full-scale antenna, and these shorter radiators have their place for many city dwellers. However, a full-size dipole can often be used by bending the outer ends of the antenna downward or parallel to ground. The current portion of the antenna is near the feed point in a dipole, and the voltage ends can be bent from horizontal without a significant degradation in performance.

Disappointing results are often experienced when even the best of 160 meter vertical antenna systems are used for short-range communications. The same antenna can be great for DX work. This is because the inherently low radiation angle of a vertical has a "dead zone" from the edge of the ground-wave contour out to approximately 500 miles, depending upon propagation conditions at the time. The best system we can deploy for stateside communications on 160 meters is a

Correction

On page 82 of the January issue in my column there is an error in fig. 3. D1 and D2 are shown incorrectly in a back-to-back, parallel manner. They should be in series, as shown in the corrected fig. 3 included here. As originally illustrated, the diodes both conduct in the forward direction and have a voltage drop of one silicon PN junction. This would cause signal peaks to clamp at 1.5 volts rather than at 15 volts. My thanks to the sharp-eyed readers who called the error to my attention.



horizontal antenna that is not high above ground in terms of wavelength. These "cloudwarmers," as they are fondly called by their users, are effective on 1.8 and 3.5 MHz for all-around communications out to 1000 miles. There are times when they will enable the user to nab some rare DX as well. It can be seen that the choice of antennas for these lower frequencies must be founded on the type of communication desired.

Ground Radials

I can't recall how many times I have been asked about the wire gauge for buried or on-ground radials. There seems to be a general belief that the wire must have a large diameter in order to provide good performance. Not so! Radials carry small amounts of RF current (usually microamperes) and wire gauge is not an important factor. Also, whether or not the radial wires are insulated (another common question) makes little or no difference.

The larger wire gauges, plus insulation, make sense from a different point of view. Soil acids and alkalinity will consume small diameter wire within months in some locales. Insulation helps to protect the buried radials from corrosion, and the larger wire sizes take much longer to be eaten away. With regard to buried radials versus on-ground radials, I have not observed any measurable difference in the antenna field strength or impedance when using either method.

Still another common query is "How many radial wires do I need?" Some work done many years ago by Lewis, Brown, and Epstein for RCA suggested that no further increase in field strength was observed after 120 radials had been deployed. That number has been adopted as a standard by many amateurs. However, effective vertical antenna systems have long been used with as few as a dozen ¼-wavelength radials. If I may offer a workable rule of thumb, I will suggest that you use as many radials as is practicable for your plot of ground. They need not be ¼ wavelength long in order to have them become a working part of the ground screen, but the longer the better. If you can't deploy them linearly from the base of your vertical, fear not. I have found it necessary to wrap radials around both sides of my home, and some were as short as 50 feet for a 1.8 MHz antenna. I used a 50 foot shunt-fed tower with a 90 foot horizontal extender wire for DXing on 160 meters in the 1970s while living in Connecticut. My radial system consisted of 16 wires. Some were 120 feet long, and the shortest ones were 50 feet long. With that antenna and 100 watts I was able to confirm 72 countries in two years of winter-month operating. Oh, yes, one more thought about ground systems: One or more rods driven into the soil at the feed point of the vertical antenna do not constitute a ground system. At best, it provides a DC ground for safety's sake and establishes a reference point of sorts for the outer conductor of the coaxial feed line. Ground rods do not take the place of a ground screen. The radials need to be within the immediate field of the antenna if they are to minimize losses and ensure a low radiation angle.

Some Final Thoughts

I have attempted to answer the most common questions I have been asked about antennas. It is indeed unfortunate that these themes are not covered in detail in most antenna books. At this juncture I am giving serious thought to writing an antenna book that not only deals with antenna design, but covers the nitty-gritty subjects that are overlooked by most book authors and editors. Although I took this general approach in the *W1FB's Antenna Notebook*, there seems to be a need for expansion of the general discussion.

73, Doug, W1FB