Slopers—The Lowest Cost Directional Antennas? Part I

Sloping antennas provide gain and directivity at the lowest possible cost. There perhaps is no better way to make optimum use of a single support structure than by installing a "sloper" system. Believe it or not, when properly set up, a sloping antenna can very closely match the performance of a small beam antenna.

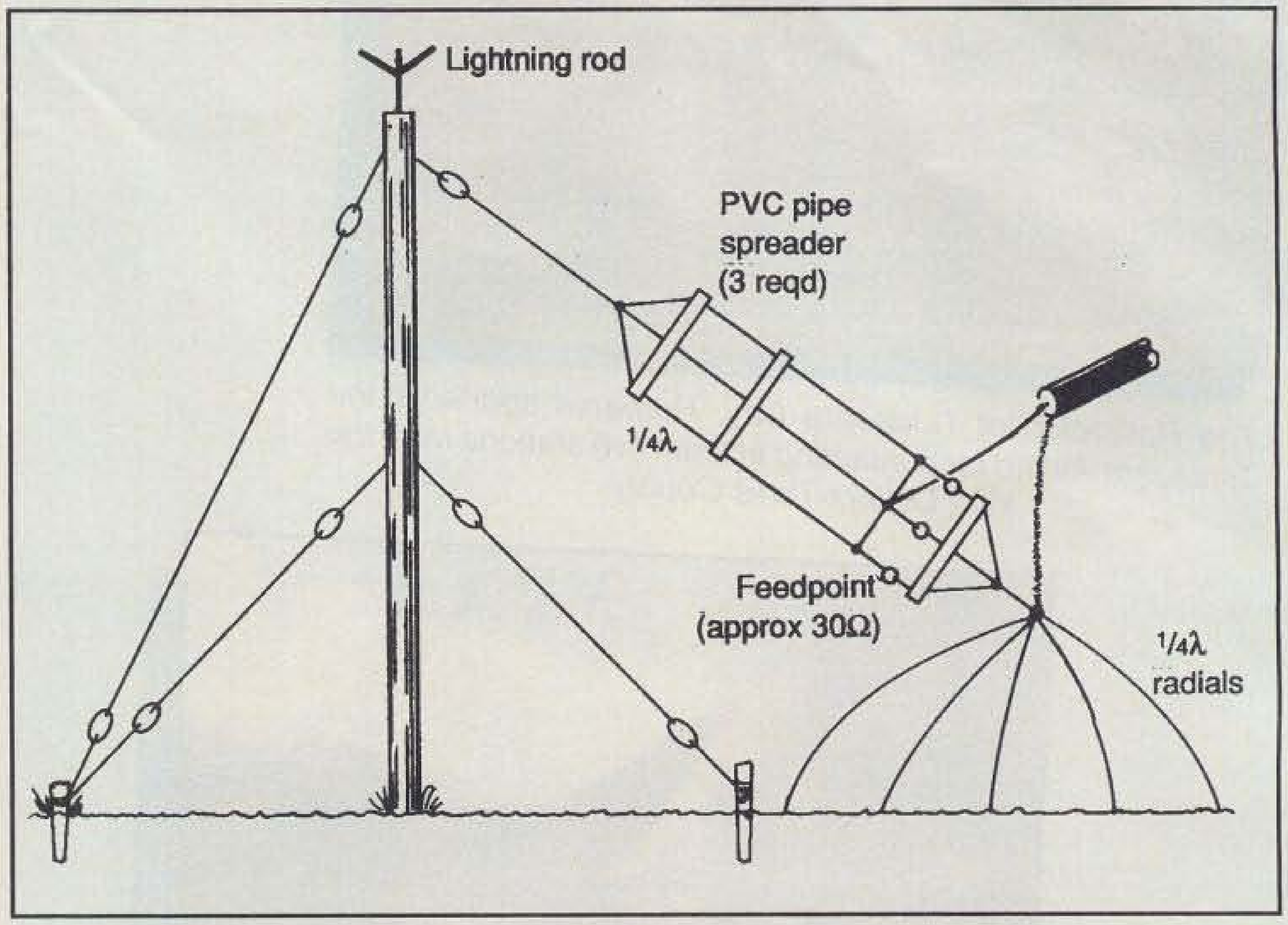

Fig. 1– Of the many possible and effective configurations for sloper antennas, the broadband, bottom-fed three-wire system is one of my favorites. Making the wires 1/4 wave for the 40 meter band, the antenna also works very well as a 3/4-wave sloper system on 15 meters. There must be at least 4 radials (minimum; 12 or more is better) located at the feedpoint. I use a combination of interleaved radials for 40 and 15 meters, which works very well. The antenna feedpoint impedance is very dependent on the specific installation conditions, and that's why I recommend using a remotely switchable two-band tuning unit.

Sloper Saves Contest Station

The contest is just a few minutes away and a summer thunderstorm hovers over our multi-single station site. Heavy rain and high-speed winds hit us with brutal force, and the 3-element beam starts vibrating at the top of its mast. Despite the guy wires and well set anchor posts, the tribander hits the ground and, as may be expected, is damaged beyond any possible field repairs.

Weeks of careful preparation now seem lost. Suddenly, however, one of the operators on our team brings all of us back into contest tempo. "Arnie," he shouts in the middle of the rain shower, "let's start making *slopers!*"

Thanks to our well-organized efforts and teamwork, plus wire and coax taken to the contest site as we always do "just in case," less than an hour after the disastrous end of the tribander we have two slopers up and running, one for 40 and the other for 20, which are followed by two more for 15 and 10 meters.

While some team members operate and keep the logs, the rest of us continue to work at a fast pace with the big roll of wire that was left after we made the 160 and 80 meter dipoles.

Quarter-wave and half-wave slopers for Top band and 80 soon are also up and running, the two coming down from a water tower, giving the station not only a viable alternative to our damaged beam, but also a set of very effective skywires that worked very well throughout the contest.

The results? Absolutely amazing! Our sloping wire antennas make themselves heard even on the most difficult pile-ups, and from that day on, although our contest stations still use single-band Yagi-type beams, slopers are now an essential part of our contest package.

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For permanent installations, sloping wire antennas in many cases are able to provide the only viable alternative for HF operation from locations that allow the installation of a single support or can make use of an existing structure.

Although some amateurs may advocate the installation of a delta loop when only a single mast is available, slopers not only provide a low TOA (take-off angle), they can also be oriented to favor a particular area, or they may be moved around maypole fashion to target different azimuths.

Facts About Slopers

Here are some facts about slopers:

1. You can make good use of 0.25, 0.5, and 0.75 wavelength slopers.
2. The quarter-wave sloper *does require* a ground system (more about this topic later).
3. Optimum sloping angle is 45 degrees, but you can use any angle from 30 to 60 degrees with good results.
4. Decoupling the transmission line from the sloping antenna is essential in order to achieve the low take-off angle you want for working DX.
5. Adding a ground counterpoise system at the low side of the antenna will improve the low-angle radiation of the three most popular sloper types—the 1/4-, 1/2-, and 3/4-wavelength antennas.
6. Conductive or nonconductive masts or supports? A good question which I'll try to answer later.

Before we start with the practical side of this month's column, let's add that the controversial TTFD (Tilted Terminated Folded Dipole) is certainly a very special case of sloping antenna *that is almost non directional,* making the exception to the rule of sloping antennas.

Practical Sloping Antennas For Radio Amateurs

I have tested slopers from 1.8 MHz all the way up to 50 MHz, and my findings show that even under nonideal installa-

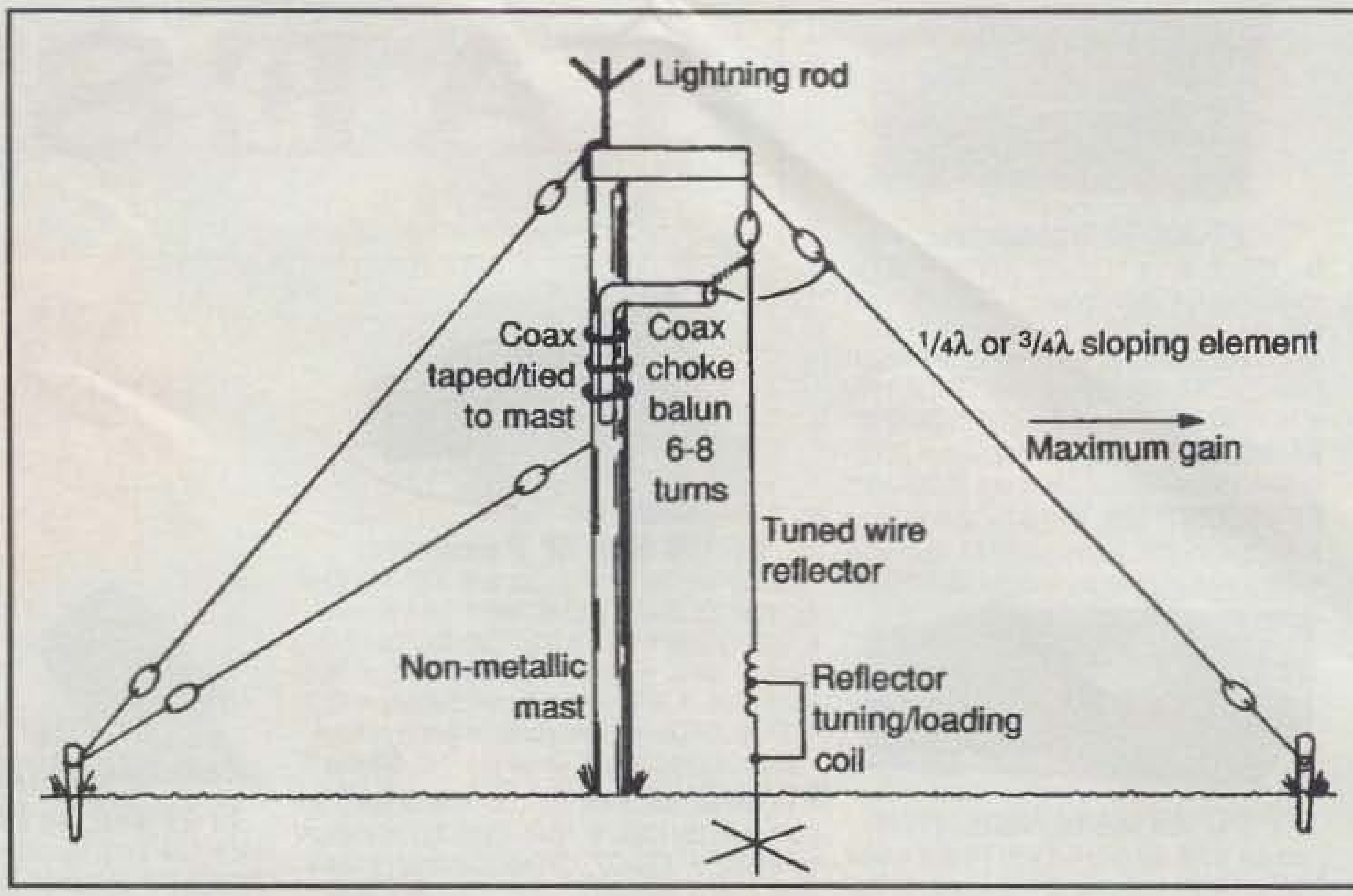

Fig. 2– The "Tuned Reflector Sloper." A nonconductive mast requires using a 0.25 wavelength counterpoise (which is actually a tuned reflector) optimized by tuning it to resonate –5% lower in frequency from the 1/4- or 3/4-wave sloping radiator. Otherwise, the sloper won't work properly and the antenna pattern will not be the desired one. Adding a coaxial cable choke at the feedpoint is essential to keep the coax braid from radiating and distorting the antenna's vertical pattern. A metal mast can also be made to resonate, and the coaxial cable will be decoupled properly by sending it down via a hole in the mast's wall; it exits through a similar hole near ground. In this case you can do without the coaxial choke.

tion situations these systems give at least some gain and directivity, *always in the direction in which the antenna is sloping!*

Let's start with the 0.25 wavelength long antennas. The 1/4-wavelength slopers are usually the most popular ones for 160 and 80 meters for obvious reasons. Top feeding them places the *high current section* at the maximum height available. However, many installations fail to take into consideration the characteristics of the support structure and the real possibility of the coaxial feedline becoming another radiator, which will distort the radiation pattern due to improper decoupling.

Let's build a quarter-wave sloper system for 40 meter DXing. First things first: How high should the mast be? Elementary trigonometry tells us that if we need to use the minimum possible mast height (for the 30 degree angle antenna), the mast should be no less than 8 meters (or some 26 feet) high, considering that the closer-to-ground antenna end should be no less than 0.1 wavelength above average terrain, which is roughly 4 meters (or about 13 feet) in round numbers. Take a look at fig.1 and you will realize why this antenna system is so forgiving from the supporting-structure standpoint.

The height necessary for the "ideal" 45 degree tilt, again with the minimum 0.1 wavelength separation from ground, is 12 meters (or nearly 40 feet), so your design margin goes all the way from 6 meters (20 feet) for 20 degree tilt, to 12 meters (40 feet) for the 45 degree version, and you can even try a 60 degree tilt angle successfully.

Slopers are "hands on" antennas, and they do require a good amount of cut and try before you can consider them working optimally. The fact is, however, that suboptimum (but rather nice) results can be obtained without much effort.

Our first example design for the 45 degree tilt quarter-wave antenna for 40 meters is shown in fig. 2. Notice that we are considering a *nonconductive* mast! That's the reason for using a 0.25 wavelength counterpoise, coming from the top of the mast all the way down to ground. The "vertical radial" running close to the nonconducting mast is connected to the coaxial cable braid, and the coax itself *must be coiled* to form an RF choke at the feedpoint. This will discourage the so-called "antenna currents" from flowing down the coax shield, radiating from there and thus distorting the antenna's vertical radiation pattern.

If you use a *metal supporting structure*, such as a steel or aluminum mast or a tower, the coaxial cable may be routed through a hole at the top of the mast, exiting at the bottom through another properly placed hole, thus effectively decoupling the cable from the radiating element.

In the case of a tower, the cable can be placed in close contact with one of the tower's legs, achieving somewhat similar but not as good results as when the cable travels inside a metal mast in the effort to decouple the downlead from the antenna.

Start with a little more than 0.25 wavelength. (I prefer to make the radiator of the quarter-wave sloper 0.28 wavelength long in order to raise the theoretical feedpoint impedance to near 50 ohms, and although the extra length of wire will introduce a reactive component, this can easily be tuned with a series capacitor).

Use wire of no less than 14 gauge (which, by the way, is considered universally by electrical safety codes as the minimum diameter for external antennas) and feed it at the top with 50 ohm coaxial cable (RG58-U or similar for short runs; RG213, RG8-U, or similar for longer runs).

Use two insulators at both ends of the sloping wire, separated by a 15 cm or 6 inch length of Dacron® rope or similar insulating cord. (This will improve the antenna's performance under rainy conditions.)

Remember to *decouple* the feedline from the antenna by making a coil of about 20 cm (or 10 inches) diameter right next to the feedpoint. The coaxial cable choke should have no less than 6 to 8 turns, and it can be kept in shape using plastic cable ties. Don't forget to use this transmission-line decoupler or coaxial choke! It makes a *lot* of difference in the performance of these antennas!

One Important "Add On"

Quarter-wave slopers with added radials located at the lower end of the system—and with either a tall enough conductive mast or a nonconductive mast with a vertical wire acting as counterpoise—provide anywhere from 2 to 3 dB gain. This depends on how you measure it and the actual TOA of the antenna's main lobe, which in turn gives the angle of incidence on the ionospheric layer we want to use to communicate.

That's why I take sides with the concept of *apparent antenna gain*, a phrase you are going to see used from now on here in *CQ*'s "Antennas" column. The 0.25 or 0.28 wavelength systems will require tuning for a reasonable SWR at

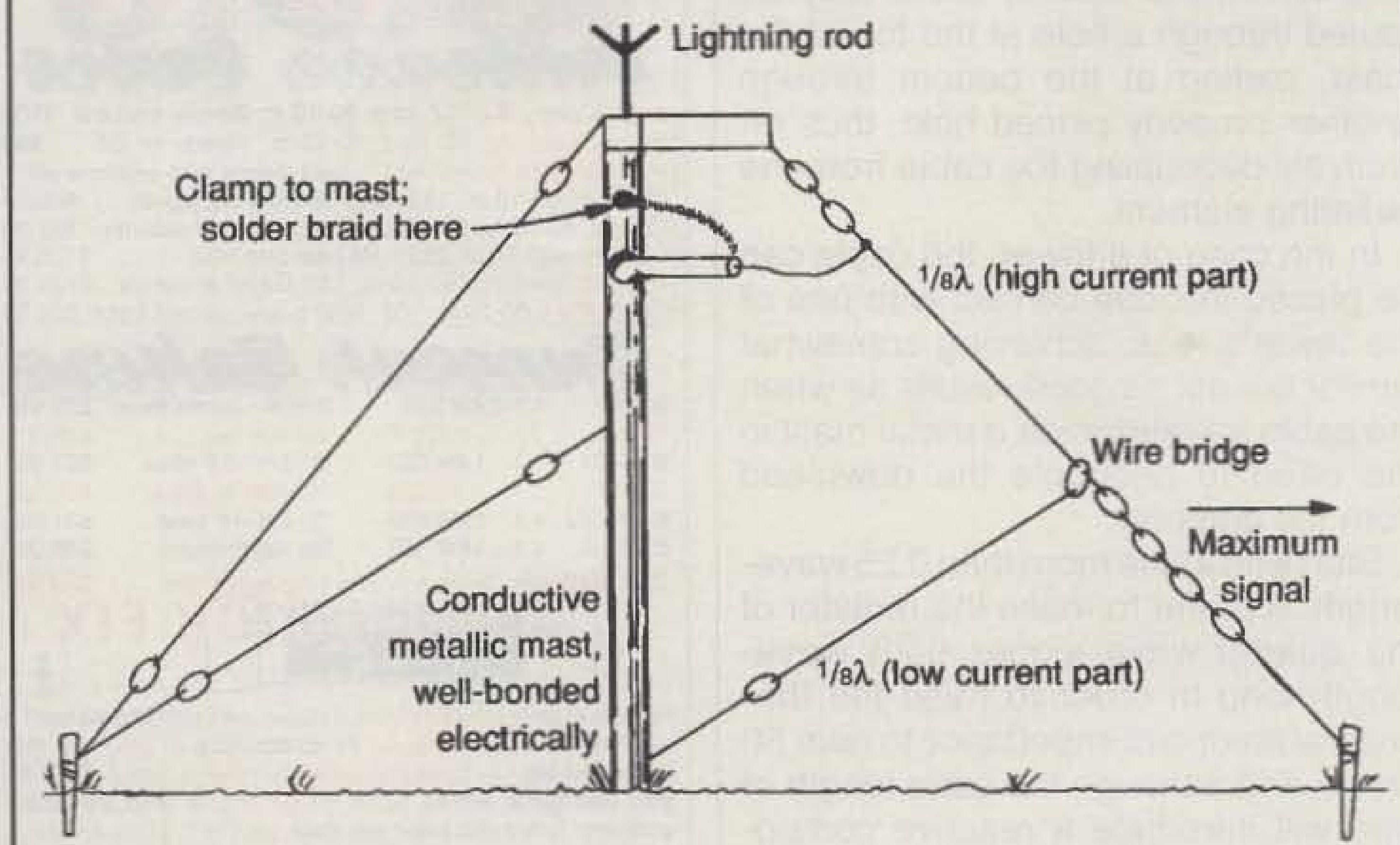

Fig. 3– A bent sloper is a practical approach for the lower bands when space is limited. It requires using insulated ropes to keep the antenna in place. Efficiency, while not as high as the fully extended sloper, is good enough to make its installation worthwhile, especially on 160, 80, and 40 meters.

the center operating frequency, but keep in mind that it is *always* a good idea to use an antenna tuner at the transmitter for many valid reasons. If your 0.25- or 0.28-wave sloper system shows a 1.5 or 1.7 to 1 SWR at the planned operating frequency, you certainly can try to optimize it by carefully cutting or adding length to the radiator, but let me tell you that I seldom spend time trying to push the SWR at the center operating frequency down once I reach 1.4 or even 1.5 to 1. I simply rely on the nice antenna tuner right close to the transmitter and disregard the very small losses caused by the SWR on the coaxial cable.

This is especially true when you are running transmitters in the QRP to about 250 watt range; and even when operating kilowatt rigs, an SWR figure of about 1.5 to 1 is perfectly admissible without any signs of overheating of the coaxial transmission line or its connectors (more about connector losses in an upcoming column).

Quarter-wave slopers for 160 and 80 meters, and of course for 40 meters too, can be installed in a very special way to save space, while at the same time keeping the advantages of horizontal directivity and low take-off angle. The method (see fig. 3) is simply *bending the sloper,* leaving the high-current top section sloping at a 45 degree angle and the rest of the antenna folding back into the supporting structure.

Tests run at CO2KK on the 40 meter band showed that the "bent" or "zigzag" sloper shows both gain and directivity comparable to the "full-size" version of the antenna. This "bent" sloper requires the use of Dacron® or similar insulating material rope used as "long insulators," and tuning is rather more critical than with the "full-size" antenna. The "bent sloper" is really a full-size system, with its high-current part sloping in the desired direction. I also found that adding two full-length radials at the base of the mast did improve the SWR bandwidth of the "bent sloper" for 40 meters.

Start Planning Your Quarter-Wave Sloper!

Now is a good time to test drive one of these simple, but good wire antennas. In our next column we will bring you details about the ever-popular *half-wave sloping dipole,* some very interesting results obtained by providing a better ground system to that antenna, and references on how to install a three- or four-sloper system with a simplified switching arrangement. Part II will also present a full description and illustration of CO2KK's ASCD (Asymmetrical Sloping Counterpoised Dipole) 6 meter sloper, which has proven very valuable for field work, as the antenna can be transported in a very compact form.

Send your antenna related questions to: <co2kk@cq-amateur-radio.com>.

73, Arnie, CO2KK

Slopers—The Lowest Cost Directional Antennas? Part II

As solar cycle 23 nears or reaches its peak, many of you surely are thinking about how to add new antennas for the 21 to 50 MHz range in order to benefit from what we expect to be better HF propagation. If you are on a tight budget, here are a few variations on the ever-popular sloper antennas which are easy to build and install, and which provide excellent performance with minimum cost.

Arnie's ASD for 6 Meters (and other bands, too)

The *Asymmetric Sloping Dipole* (ASD) antenna evolved from a very effective 7 MHz "single wire beam" designed by my good friend CO2DC. His antenna consisted of a 1/4-wave wire, a center insulator, and a 3/4-wave or 5/4-wave wire. This is essentially an *asymmetric* system, providing a very good match to 50 ohm coaxial cable (don't forget the choke balun at the feedpoint!) and a rather sharp main lobe in the direction of the longer arm of the antenna.

CO2DC's AD (asymmetric dipole) was really an ASD, or asymmetric *sloping* dipole, as the antenna is installed with a 30-degree slope angle, which certainly adds to its directivity, while also providing a lower take-off angle (TOA) than an all-horizontal system.

After testing a version of this antenna for the 15 meter band at my home QTH, I was so pleased with the results that the experimental system was taken down and replaced by a permanent one, which is again a 1/4-wave wire, the center insulator and, at my downtown location, a 3/4-wave wire sloping gently toward Europe (see fig. 1).

I soon found out that the ASD concept was something to keep working on, because this antenna is a definite improvement over the standard half-wave or quarter-wave slopers!

Testing on 50 MHz

Using my 5-element, 0.75 wavelength boom Yagi as a reference, I decided to try an ASD antenna for 6 meters. Instead of making the long leg of the ASD just 3/4-wavelength long, though, this one was extended to 5/4 wavelengths, and sloping toward the north at a 30-degree angle.

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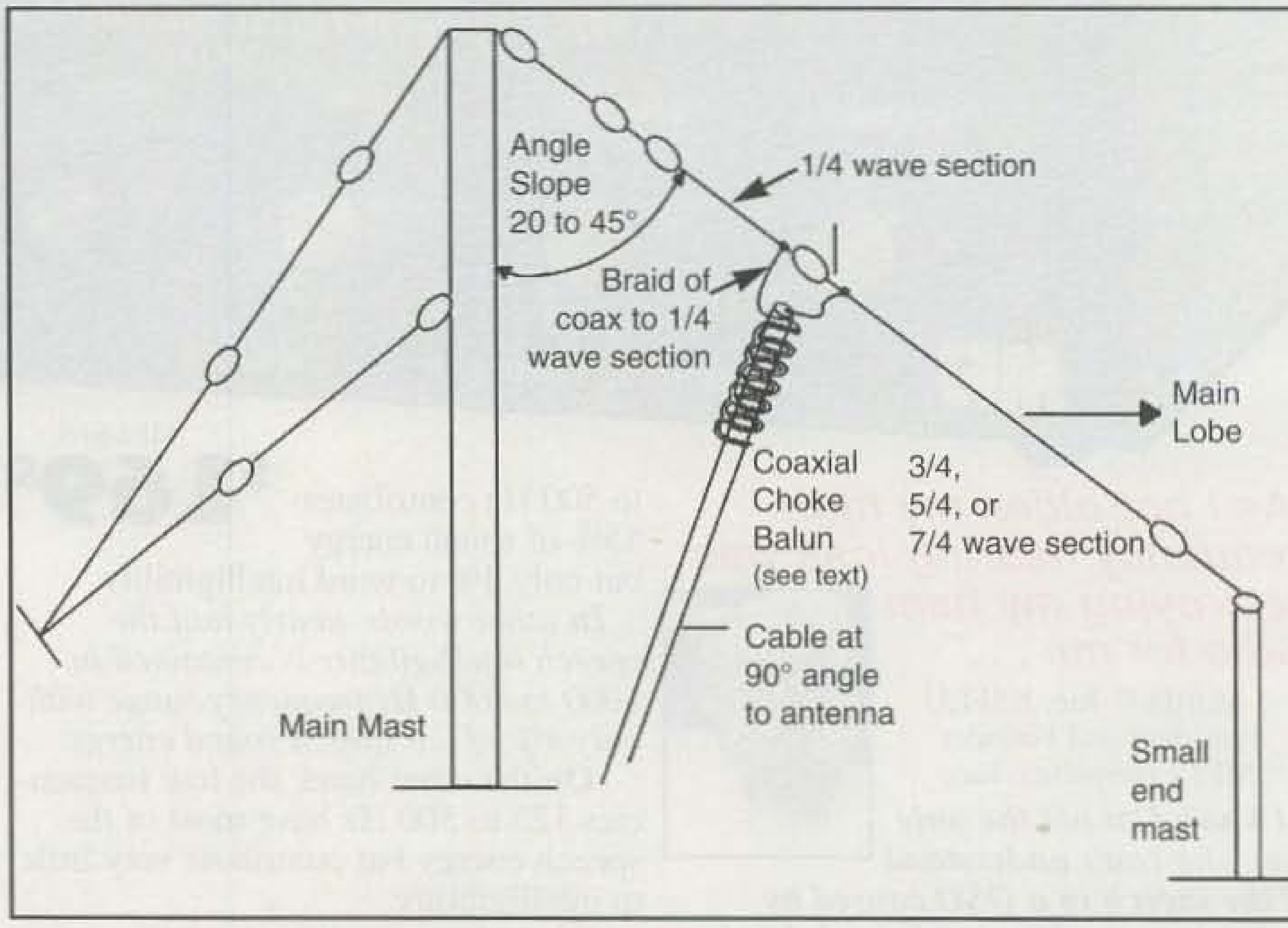

Fig. 1– The ASD, or Asymmetrical Sloping Dipole, consists of a 1/4-wave section, to which the shield of the coax connects, and a longer section—3/4, 5/4, or 7/4 wavelength for your band of choice. Your signal will be concentrated in the direction in which the larger segment is pointing. (Illustrations by Olga Dalmau)

Several summer sporadic-*E* openings proved that the 6 meter ASD provided good signals at the very fringe area of the single-hop *E*-skip. Then, when working at my rooftop installation, I changed the azimuth of the 50 MHz ASD to 300 degrees in order to make room for another experimental antenna. This proved to be very fortunate, as one day in July, suddenly out of nowhere what was obviously *F2* propagation brought several US 7th call area stations from Washington and Oregon for what proved to be a unique test. The ASD 1/4 to 5/4 antenna was switched in and out, comparing the signals with the 5-element Yagi, and the ASD produced very rewarding results.

As a result, here is conclusion number one: If you need a low-cost 6 meter antenna, install an Asymmetrical Sloping Dipole, or even two or maybe three around your tower or mast, and don't forget the coaxial choke baluns at the feedpoint. (Yes, you can also use ferrite toroids to decouple antenna currents from flowing down the coax shield, but they are much more expensive than a simple eight turns of coaxial cable air-wound with a 6 inch or 15 cm diameter.)

The ASTCD Antenna is Born

After the very successful experiments with ASDs, a more elaborate antenna was developed. I named it the *Asymmetric Sloping Terminated Counterpoised Dipole,* or ASTCD (fig. 2). This one is as easy to build and install as the regular ASD, but shows more directivity and what appears to be a cleaner horizontal radiation pattern (yet to be tested at the antenna range).

This version of the ASD uses the same 1/4 wave on one arm of the dipole, and either 3/4, 5/4, or even 7/4 wavelengths of wire on the other arm. However, I prefer to stay at the 5/4 arm length, because the antenna will otherwise show a very sharp main horizontal lobe in the radiation pattern, something that might not be a very good idea when chasing DX on 6 meters!

The ASTCD includes two more elements, a terminating non-inductive re-

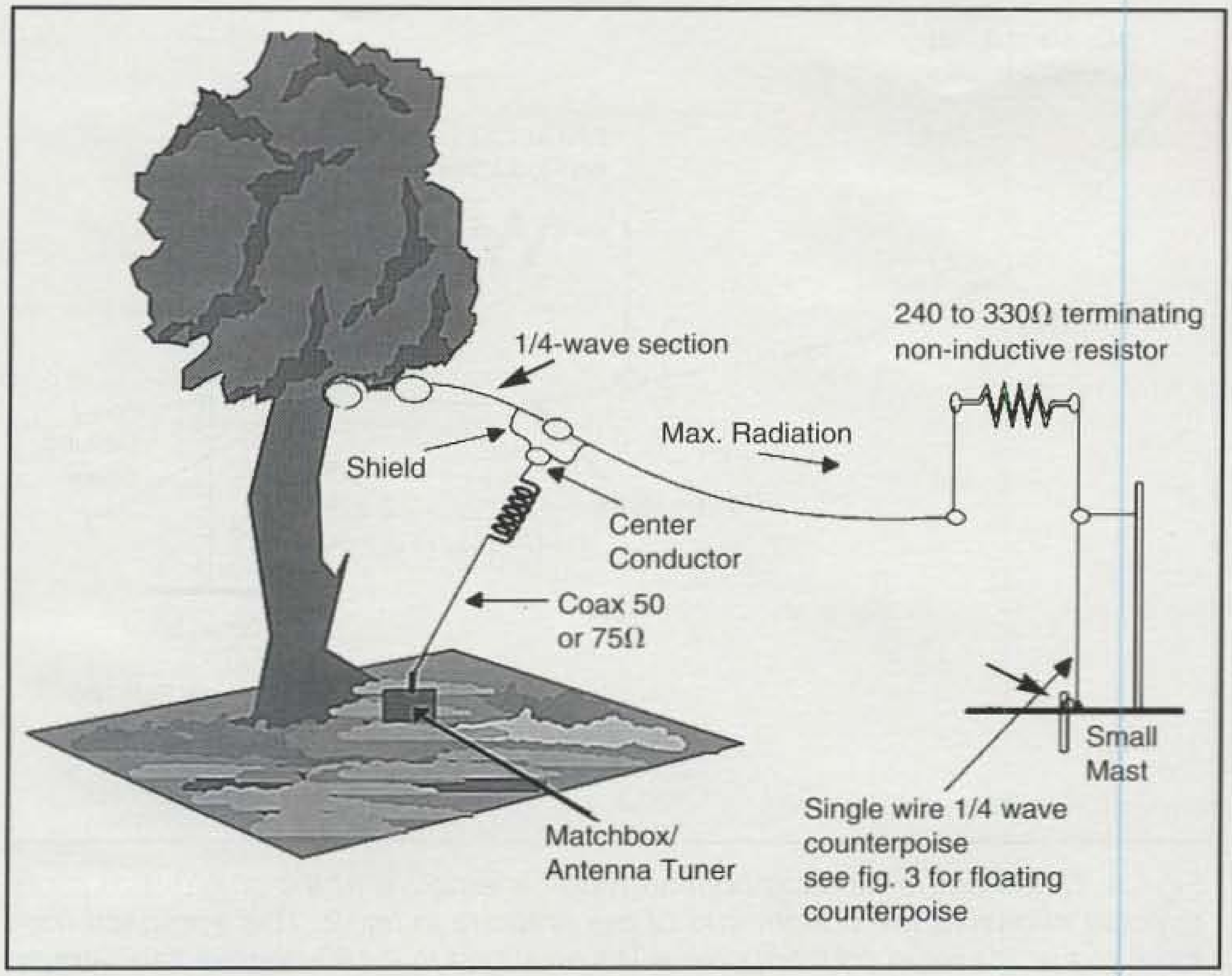

Fig. 2– The Asymmetric Sloping Terminated Counterpoised Dipole, or ASTCD, is a more elaborate version of the ASD, showing greater directivity in the direction in which the longer segment is pointing. Main differences are the addition of a terminating resistor and counterpoise at the far end of the antenna.

sistor and a 3- or 5-wire 1/4-wave counterpoise fanning out at the end of the antenna to which the other side of the resistor is connected (fig. 3). These radials slope toward ground from the support pole at a 45-degree angle (fig. 4).

The 270 ohm terminating resistor for the 50 MHz version of the ASTCD was made from ten 2 watt carbon resistors of 2700 ohms each, connected in parallel (The ideal theoretical value for the resistor is 240 ohms, but any value between 200 and 300 ohms will work here.). One side of the terminating resistor is connected to the antenna's long arm, and the other side goes to the group of 1/4-wave radials described above.

This ASTCD antenna is certainly a very lightweight system for portable use, and it can use a tree or a not-too-tall mast or other structure as the high-end support, while the lower end needs only a very short 3 foot (or 1 meter) high mast. The whole antenna—wire, coax, terminating resistor and counterpoise—plus the small mast can easily be carried inside a backpack! Also, it will weigh much less than a 3- or 4-element Yagi or quad.

Field installation of this antenna is a

Tips For Installing The ASD and ASTCD Antennas

- Keep the 1/4-wavelength element ("top" side of the antenna) at least 1 meter (3.28 feet) away from the supporting structure.
- The coaxial cable should include a decoupling choke at the feedpoint, either a coaxial choke balun (see main text), a ferrite bead decoupler, or a 1:1 balun.
- The coaxial cable should depart from the antenna at a 90-degree angle in order to reduce coupling from the radiating element.
- Select a tilt angle between 25 and 45 degrees; experiments showed that a 30- degree tilt provided excellent directivity and a reasonable front- to-back ratio.
- Performance of both antennas will be very dependent on the surrounding objects, so try to have the long leg extending down into as clear an area as possible and pointing in the desired direction of radiation.
- Final tuning for minimum SWR involves carefully pruning the length of the long side of the antenna. I found that once you set the short side to a resonant 1/4 wave at the center operating frequency, final adjustments can be done by trimming the long sloping element.
- Whenever possible use an antenna tuner, even if you achieve a 1.4 or 1.5 to 1 SWR without the tuner!

cinch! Just decide the main direction toward which you want to try to work DX, hang the antenna with the long leg facing that direction, connect the coaxial cable to your antenna tuner (yes, it does help to use the tuner), and that's it! You can use the antenna without the tuner, as it will provide a very nice low SWR all across the 50 MHz band, but I do recommend using a simple Pi network tuner, which we will soon discuss here in this column.

My experiments with these antennas were on 6 meters, but the design will also work very well on any upper-HF band (see sidebar for details).

What About the ASTCD At Home?

You can install not only one, but two or even three, ASTCDs at home, beaming in the most wanted directions, and provide for switching between them. This antenna seems to have not only a rather low TOA (take-off angle) in the direction at which it is pointing, but also a useful higher TOA, which explains why it works so well with *E*-skip signals.

If there is not enough space in one specific direction, then install the shorter version 1/4–3/4 wavelength system. Best results will be obtained, though, with the 1/4–5/4 or the 1/4–7/4 antennas with the terminating resistor and counterpoise.

Again, extending the antenna more than 7/4 wavelengths on the long arm of the dipole will make the horizontal pattern too sharp, something that may prove to be not a very good idea if you want to bring in DX from as many places as possible.

Any questions? Want to share your antenna experiment results with other *CQ* antenna column readers? Then send your comments via e-mail to <co2kk@cq-amateur-radio.com> or to the magazine's postal address.

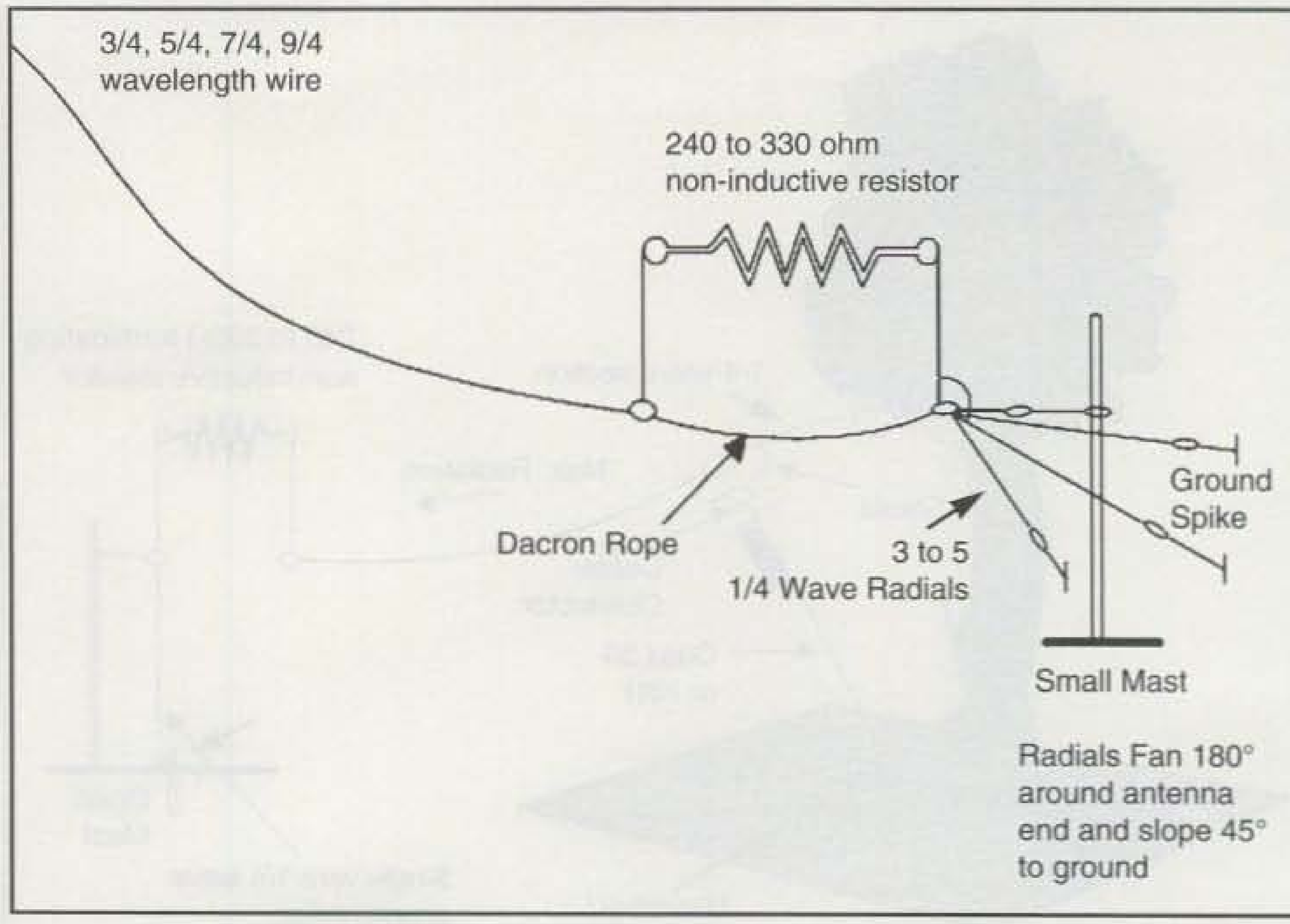

Fig. 3– Detail of the "floating counterpoise" alternative to the single-wire counterpoise shown at the bottom end of the antenna in fig. 2. This approach uses three to five 1/4-wave counterpoise wires arranged in a 180-degree "fan" around the end of the antenna.

Reader Q&A

Reader Jim Kin, K8KN, writes:

Thanks for the articles. I am interested in all things relating to antennas, especially homebrew. My question is regarding an application from your most recent series, the sloper. I use 4–6 wavelength longwires on 10–20 meters. These are fed at 1/4 wavelength with a 4 to 1 balun and a ferrite bead choke just below that. These antennas are tilted so as to lower take-off angle as per several articles and the *ARRL Antenna Book*.

Will I benefit from running a vertical wire from the feed point as with the reflector of the 1/4-wave sloper you describe? I was thinking of extending the 1/4-wave end to about 50 ft. on all, since the feed points of these antennas are at approximately 60 ft.
Will this help with either gain or F/B ratio? Arnie, thank you again. I anticipate the second article in this series.

CO2KK Responds:

Jim, if you already have a 0.25 wavelength section sloping at a 30 to 45 degree angle because your antenna is an ASD (asymmetric sloping dipole), adding a *tuned* 0.25 wavelength vertical reflector alongside the mast will, in my opinion, enhance the front to back ratio of the system. The existing quarter wave to which you connect the braid of the coax does not provide any effective contribution to forming a directional pattern.

But, when adding the *reflector*, be sure it is a *tuned* element, not just a 0.25 length of wire coming down from the top of the tower, which in most cases *will not resonate* as a quarter wavelength without very careful tuning (it is easy to make the wire a little shorter than needed and tune it to resonance with a coil provided with taps).

You will probably get a little extra gain, too, and of course an improved F/B ratio! *But...* why not try the ASTCD in this issue by converting one of your asymmetric slopers by adding the terminating resistor and counterpoise? The ASTCD offers a better front to back and a you will also obtain a little more gain from the same length of wire. The terminating resistor's power dissipation should be around 20 percent of your transmitting power to be on the safe side for SSB; for CW, I would increase it to 33 percent.