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Vertical Antennas at HF
—Part I—

This tutorial uncovers surprising facts about vertical HF antennas.

by Stan Gibilisco W1GV

The Misunderstood Vertical

Hams often disparage HF verticals. They criticize them as antennas that "radiate equally poorly in all directions," that require an extensive ground-radial system to get out at all, and that are too noisy for reception.

Well, there's more to the story than the blanket statements above suggest. When properly set up, verticals—even those without radials—are fine performers on both transmit and receive. This two-part tutorial will serve to separate fact from fiction. But first, a little background.

Polarization

An electromagnetic wave, as the name suggests, has two components—an electric (E) wave and a magnetic (H) wave. These components propagate in planes 90 degrees to each other. When we talk about the polarization of a wave, we typically mean the E-wave orientation. A vertical antenna radiates E-M waves whose E-fields are mostly vertically polarized. It also receives most effectively when the incoming signal is vertically polarized.

In free space, the attenuation presented by a vertical antenna when the incoming signal is horizontally polarized is 30 dB. In practice, however, many factors serve to alter signal polarization. When the wave is a ground wave, then hills, telephone and electric wires, steel-frame buildings, and even trees refract E-M waves and rotate their polarization. (Note, though, that they do not significantly absorb wave energy at HF—regardless of the polarization.) The ionosphere also rotates the HF wave around its propagation axis, altering its polarization and so causing the sky wave to arrive back to Earth with varying polarization. This is why a horizontal antenna works for reception of sky-wave signals that have been transmitted originally by a vertical antenna, and vice versa.

Low Band HF Ground Wave

So, you can see that sky-wave propagation for vertically and horizontally polarized signals at HF differs little. However, the surface wave—a signal that travels using the ground as a conducting circuit—is limited to line-of-sight for horizontally polarized HF signals. This is because their E-M fields are short-circuited by the ground. With vertical polarization, however, the ground doesn't short circuit, but actually assists E-M field propagation over its surface (see Figure 1).

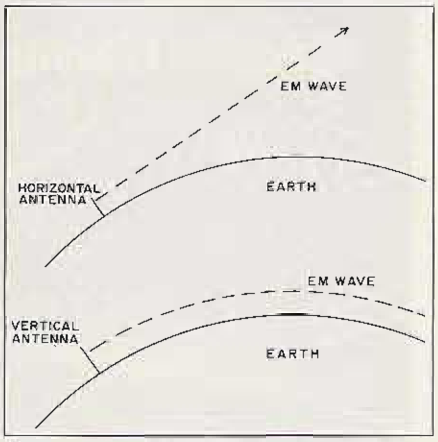

Figure 1. Electromagnetic waves from (a) a horizontal antenna, and, (b) a vertical antenna. This pattern holds true for wave energy up to 10 MHz.

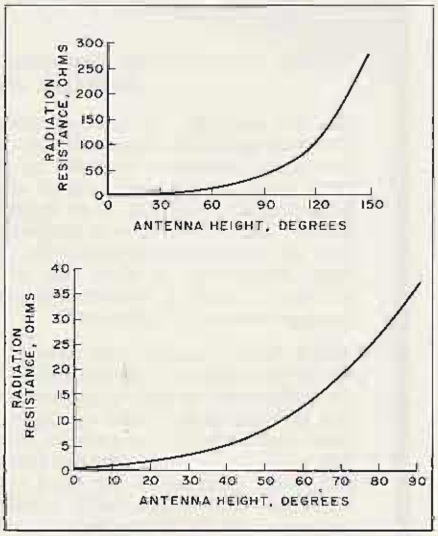

Figure 2. Radiation resistance as a function of height for a vertical radiator over perfectly conducting ground. The feedpoint is assumed to be at the base of the antenna. (a) shows heights from 0–150 electrical degrees. (b) shows them only from 0–90 electrical degrees.

This effect is very slight at frequencies above about 10 MHz because of ground loss, but, as the frequency is lowered, the surface wave reaches further and further from the transmitting antenna. While surface-wave propagation is limited to the radio (line-of-sight) horizon above 10 MHz, a high-powered (1.5 kW output) station may be heard at distances of about 50 miles at 7 MHz, 100 miles at 3.5 MHz, 150 miles at 1.8 MHz, and 200 miles in the standard AM broadcast band in the daytime, all when there is little or no sky-wave propagation.

This is why antennas for standard AM broadcast are almost always vertical! They radiate vertically, so that surface-wave propagation is optimized for maximum coverage during daylight hours.

At frequencies above 10 MHz, there is little difference in coverage between vertically and horizontally polarized wave energy, all other factors being equal.

Longer Skip Length

Vertical antennas (at frequencies below about 10 MHz) often provide good radiation at small angles relative to the horizon, which often enhances DX. A vertical antenna ¼ wavelength high, fed against perfectly conducting ground, will usually radiate most of its energy at an angle of less than 45 degrees with respect to the horizon.

DXers like this because, the lower the angle of radiation from an antenna, the greater the single-hop sky-wave propagation distance will be, requiring fewer hops to reach a given distant point. The upshot is that a signal travels a greater terrestrial distance with less attenuation.

Horizontal antennas must be at least ½ wavelength off the ground to obtain the same low-angle characteristics as a well-designed and installed quarter-wavelength vertical antenna.

Table 1 shows approximate heights of a ¼ wavelength vertical antenna, based on frequency (MHz). Heights are shown for the amateur bands at 160, 80/75, 40, 30, 20, 15, and 10 meters. Lengths are shown for bottom and top band frequencies, except in 30, 20 and 15 meters. The general formula is:

$$L = 230/f$$

where L is length in feet and f is frequency in MHz.

When Ground is Important

A good, highly conductive ground system is essential if a quarter-wave resonant vertical antenna is to perform well. This doesn't always hold true, however, for a half-wave vertical antenna, the other common type of vertical antenna.

The ground reflects electromagnetic energy. Ideally the ground would act like a copper plate—that is, as a perfect conductor and reflector—but this is not true of real earth. Salt water comes closest to the ideal; and black earth and fresh water are also fairly good. The conductivity of sandy and rocky, dry soil is the poorest, scarcely better than no ground at all. You can improve ground conductivity by burying radial wires a few inches below, or stringing them along, the Earth's surface.

Your antenna should have as high a radiation resistance as possible compared to the ground resistance, since the higher that ratio, the greater the proportion of the wave energy entering the antenna/ground system that radiates into the atmosphere. You can achieve this favorable ratio by 1) designing your antenna system to have a greater radiation resistance, 2) by reducing your ground resistance or 3) both. Clearly, a good, low-resistance ground becomes more important as the radiation resistance of an antenna decreases.

It is a fascinating concept, but we will go into only enough detail to graph the radiation resistance as a function of antenna height in electrical degrees (Figure 2a,b).

For a base-fed vertical, the radiation resistance increases with the height of the antenna element. Note that for a vertical 90 degrees (¼ wavelength) high, the radiation resistance is about 37Ω. For an antenna 180 degrees (½ wavelength) high, the radiation resistance is very high, on the order of hundreds or even thousands of ohms, depending on the ratio of conductor diameter to conductor length.

As alluded to above, the efficiency—the amount of wave energy radiated into the atmosphere—of a vertical, base-fed antenna depends on the ratio of the radiation resistance to the total resistance in the antenna system. The total resistance, R_T equals the sum of the radiation resistance R_R and the loss resistance R_L. The value of R_L is determined by the conductivity of the ground in the vicinity of the antenna, and by loss in the antenna conductor and the feedline. In most antenna systems the conductor and feedline loss is less than 1Ω, but the ground loss may be much greater. It is not at all unusual for the ground resistance to exceed the value of 37Ω. This means that it is quite possible for a quarter-wave vertical antenna to have an efficiency of less than 50 percent.

The formula for antenna efficiency, *Eff*, is:

$$\text{Eff}(\%) = 100R_R/(R_R+R_L)$$

For example, suppose we have a quarter-wave vertical antenna with a loss resistance of 15Ω. Then $R_L = 15$ and $R_R = 37$, according to Figure 4. We calculate:

$$\text{Eff}(\%) = 100(37/(37+15)) = 100(37/52) = 71 \text{ percent}$$

Interestingly, this total resistance $R_T = 52\Omega$ means that the antenna, at resonance, will show a perfect 1:1 SWR with 52Ω coaxial feed. We might add a system of 100 radials, each ½ wavelength long, to this antenna and reduce R_L virtually to zero; then $R_T = 37\Omega$ and the efficiency would be 100 percent, but the SWR would rise to 52/37 or 1.4:1. The extra loss caused by the imperfect match on the feedline would be less than the minimum loss detectable, even if the listener were expecting it. But the loss caused by an efficiency of 71 percent as compared with 100 percent would be 1.5 dB, a quite noticeable amount.

Suppose now we put a half-wavelength radiator in place of the quarter-wavelength, and install a matching transformer for the feedline. The radiation resistance of this radiator will be very high, probably at least 600Ω and most likely even more than that. If the loss resistance is still 15Ω and we assume $R_R = 600$, then:

$$\text{Eff}(\%) = 100(600/600+15)) = 100(600/615) = 96 \text{ percent}$$

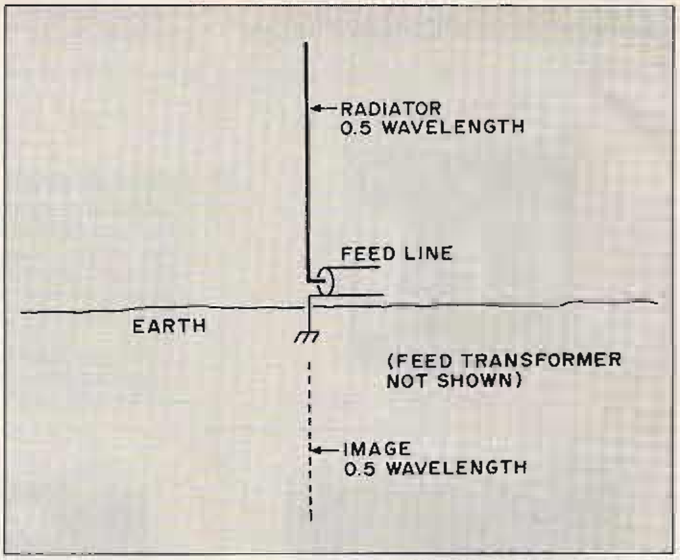

Figure 3. A half-wave vertical antenna without radials, assuming fair-to-good earth conductivity. You need to install radials on this system if the ground conducts poorly.

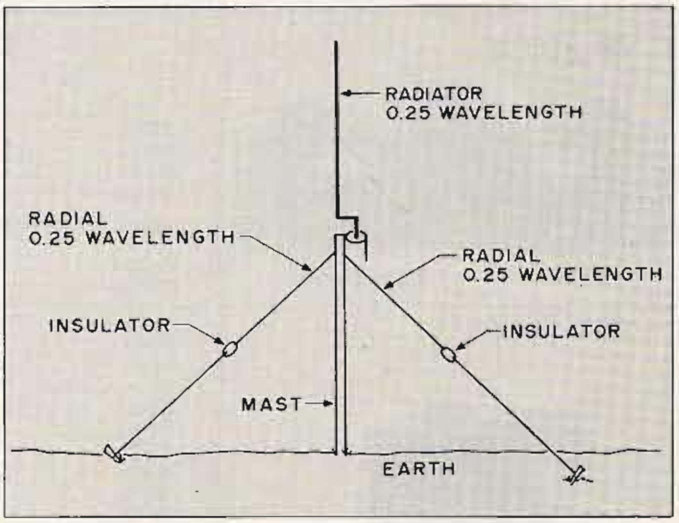

Figure 4. Ground-plane antenna in which the radials do double duty as guy wires. There should be at least three of them.

By installing the radials, we gain only 0.2 dB or so—not perceptible even if the listener were expecting it.

The above shows that a good ground isn't critical for half-wave radiators, but is very desirable for quarter-waves, for improving antenna radiation efficiency.

Ground Planes

A good ground plane is desirable for any vertical radiator because of the reflected image it provides. This "image antenna" produces low-angle omnidirectional gain, especially for a half-wave antenna. In this case the "image antenna" and the actual antenna act like a 2-element collinear array, producing 3 dB power gain over a half-wave radiator working against poorly conducting ground (Figure 3).

The term "effective ground" refers to the physical location of the radio-frequency ground plane. With perfectly conducting ground this would of course be the surface of the Earth in the vicinity of the antenna. If a vertical antenna has an extensive system of radials, then the effective ground is the surface (a plane or cone, usually) described by the web of radials.

For a ground-mounted antenna fed at the base or anywhere else along its height, consider the surface of the Earth as the effective ground location, disregarding minor irregularities, even though the conductivity of the ground may be poor. The primary difference between poorly conducting ground and a surface with near-perfect conductivity is in the loss resistance and in the ability (or lack of ability) of the ground to provide a mirror image of the antenna for gain purposes.

A radial system for efficiency is necessary in the case of a quarter-wave antenna, and for omnidirectional gain in the case of a half-wave antenna. Installing ground radials is *mandatory* for ¼-wave efficiency if the soil

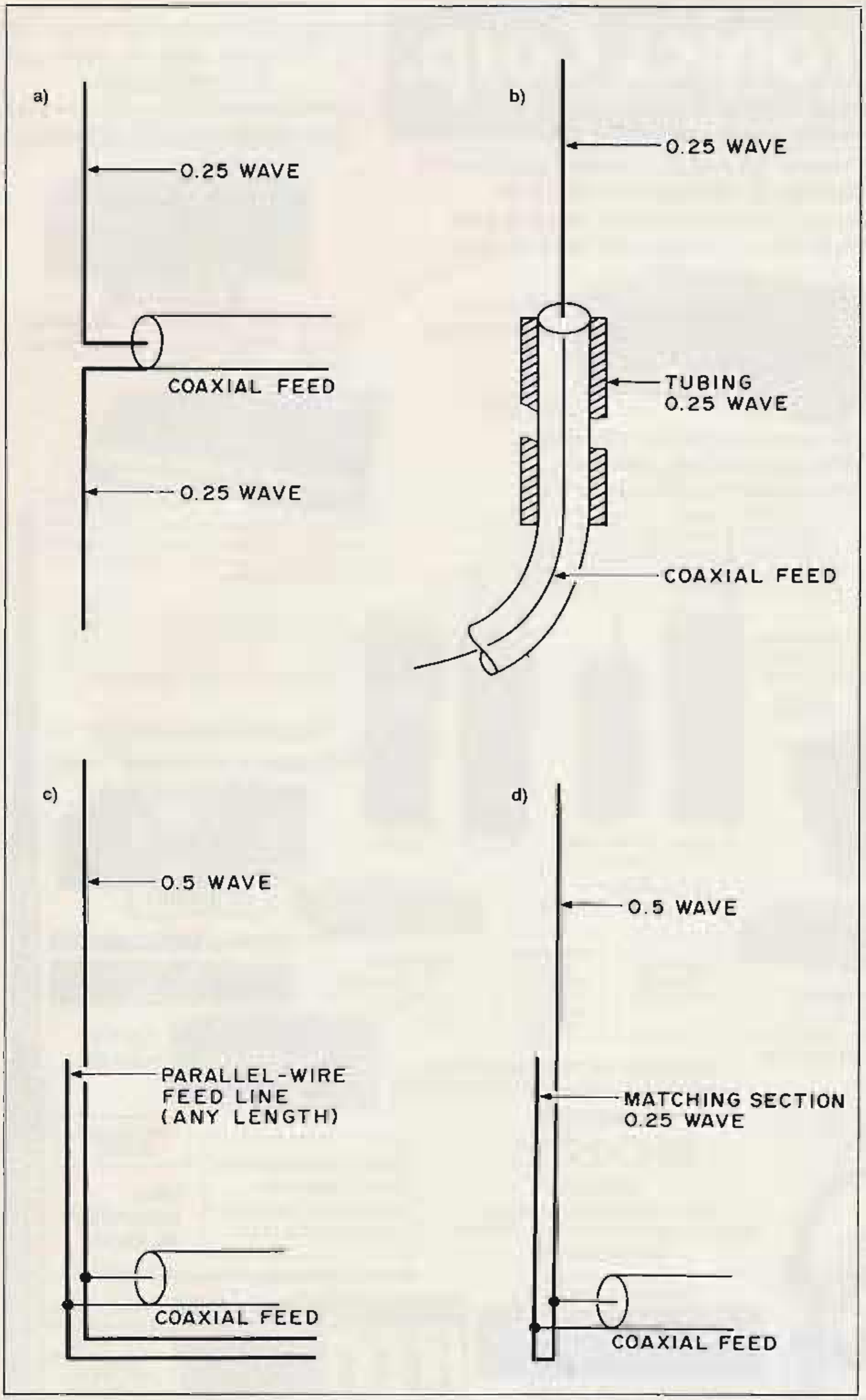

Figure 5. Four radial-less vertical antenna systems: (a) a center-fed vertical dipole; (b) the feedline runs up through the center of the lower tube section of the vertical dipole; (c) a vertical Zepp, the half-wave fed with open-wire line; (d) a variation of the Zepp, commonly known as the J-pole.

poorly conducts. They are still more critical for inductively loaded (short) verticals.

Radial Systems

How many radials does a ground-mounted antenna require? This depends on the type of soil and the available space for installing the radials. Broadcast stations on the standard AM band use upwards of 100 radials, all ½ wavelength. As a rule, at least four ¼-wavelength radials are standard for a quarter-wave ground-mounted vertical antenna, and at least four ½ electrical wavelength for a half-wave vertical antenna. Get them at least as close to that as possible. To a point, you can make up for radial shortness by adding more of them.

It doesn't matter from an electrical standpoint if the radials are buried or laid on the surface or even strung a few feet above the surface. Nor does it matter if the wires are insulated or bare.

Sometimes radial systems are designed for multiband quarter-wave vertical antennas, in which two or more radials are installed for each band. With a ground-mounted antenna this is a misconception—the more the merrier, and make them all at least ¼ wavelength and preferably ½ wavelength for the lowest frequency used.

The Above Ground-Plane Antenna

A vertical antenna does not have to be mounted at ground level. In fact, there are advantages to mounting a ¼-wave vertical well above the surface. If such an antenna is at least ¼ electrical wavelength above the ground, just two or three radials allow good radiation efficiency. Guy wires may double as radials in this installation (see Figure 4).

Cut the radials at ¼ wavelength at the operating band. For multiband antennas, as above, install at least two radials for each band, and space them apart (ideally) equally around a circle. The best slant angle for these radials is 45 degrees, as this gives a feedpoint impedance of nearly 52Ω, providing a good match to most common coaxial cable.

For ground-plane antennas installed less than ¼ wavelength above the ground at the lowest frequency used, add four radials for those bands at which the height of the feedpoint is less than ¼ wavelength, eight at ⅛ wavelength, and so on. In other words, add "n" radials for the band that is less than "1/n" wavelength above the ground. This will give near 100 percent efficiency for a quarter-wave vertical antenna at all operating frequencies.

If a half-wave vertical antenna is placed above the surface, the radials should be resonant at ½ wavelength. The height above ground is not too important, but try to make it at least ¼ wavelength. Use at least two radials for this arrangement.

Vertical Antennas Without Radials

For an end-fed, quarter-wave conductor to work well in most situations, you need radials. Some configurations, however, don't require them. Figure 5 gives four such examples.

At (a), a half-wave dipole is simply turned on its end. The feedline, either balanced or unbalanced, comes away at a right angle to the antenna—that is, horizontally—for a distance of ¼ wavelength or more. If you use open-wire, low-loss line, you may operate this antenna on all bands that are integral multiples of the frequency at which the antenna is ½ wavelength, and obtain resonance. With a wide-range tuner, this antenna loads on all frequencies down to that at which the whole antenna is ¼ wavelength.

At (b), a half-wave antenna is fed by running coaxial cable up inside the lower ¼-wave section. The outer conductor of the feed cable connects to the lower "sleeve" and the inner conductor connects to the top section. This is essentially a ground-plane antenna with the radials folded down into a vertical cylinder that completely surrounds the feed cable. It presents a feedpoint impedance of about 70Ω at the frequency where the whole radiator is ½ wavelength.

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monofilament fishing line.

If possible, bring the feedline away from the antenna at a right angle for at least one wavelength. This is supposed to help prevent the coax from distorting the antenna's omnidirectional radiation pattern. (I have noticed no performance problems, however, with bringing the coax off at angles somewhat less than 90 degrees.)

I built the first Special while still a Novice operating solely on 10 meters, over a year ago. I was delighted to find out, now that I have the General ticket, that a Versatuner 901-B allows me to use the antenna on all bands 20 through 10, and I have the log entries to prove it! Entries include contacts with Japan, Alaska, Sweden, Brazil, Yugoslavia, Guyana, and many spots in between. Some of my buddies have called it the world's ugliest ham antenna, but the bottom line is: It works! I've used it with great success atop mountain ridges and on the seashore, as well as at home. This neat five-bander (20, 17, 15, 12, and 10 meters) is easy to transport by auto or boat, and takes little time to assemble and put on the air. It's also inexpensive—you can build it from readily available hardware for about $20. 73

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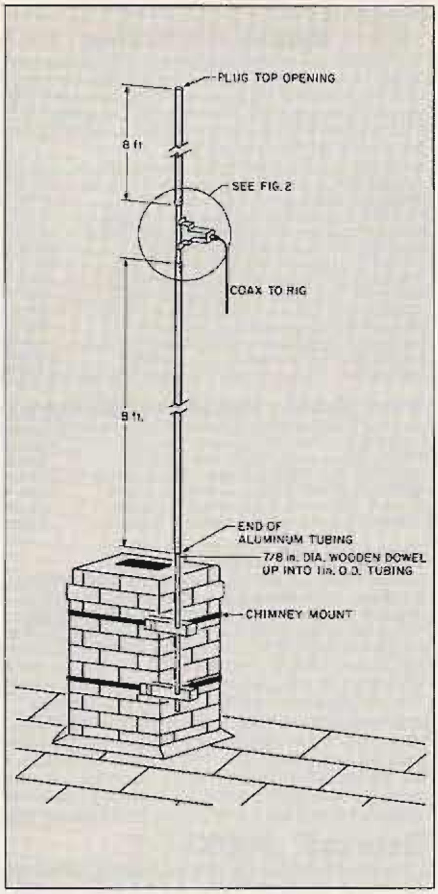

Figure 1. The Safari Special, mounted on a chimney.

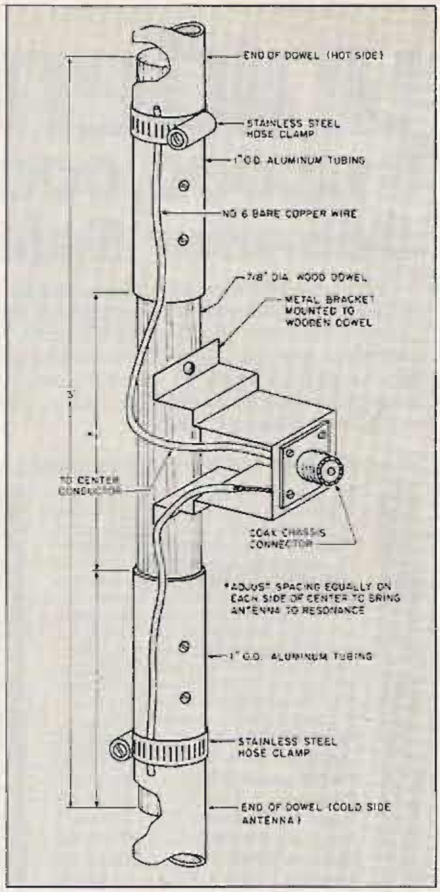

Figure 2. Close-up of the Safari Special center portion, showing connection details.

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At (c), a half-wavelength radiator is end-fed using a collinear length of open-wire line or "twin lead." A tuner must be at the transmitter end of the line. This antenna is in fact a Zeppelin or "zepp" stood on end. Cut the vertical radiator to as close to ½ wavelength of the operating frequency as possible. Ideally, bring the feedline away collinearly with the radiator for at least ¼ wavelength, in order to minimize feedline radiation.

At (d), you find an alternative method of feeding the vertical "zepp." The stub of parallel-wire line is ¼ electrical wavelength. The lower end is short-circuited, and a coaxial line connects about 1.6 of the way up from the bottom. Adjust the exact tap point for the lowest SWR on the coaxial line at the desired operating frequency. This antenna is sometimes called a J-pole because of its shape.

Again, though, radials enhance the operation of even these antennas. Add them at the bottom end of the half-wave or ⅝-wave radiating section, and you'll realize a gain of about 3 dB at low angles (that is, in the horizontal plane) in all directions, as compared to any of these antennas operated over poorly conducting soil with no radials. This doesn't affect the antenna's efficiency, just the principal radiation angle, due to the phase addition of the signal from the actual radiator and its image, reflected by the ground plane. The 3 dB gain is derived at the expense of power radiated at higher angles.

There's More to It than 1:1 SWR

Shorter radiators are often used at 80 and 160 meters with inductive loading. The main problem with short radiators is in getting high efficiency. The radiation resistance drops very quickly as a radiator becomes shorter than ¼ wavelength.

¼ Wavelength Vertical Antenna Heights

Frequency (MHz)	Height (feet)	Height (meters)
1.800	128	38.9
2.000	115	35.1
3.500	65.7	20.0
4.000	57.5	17.5
7.000	32.9	10.0
7.300	31.5	9.60
10.100	22.8	6.94
14.000	16.4	5.01
21.000	11.0	3.34
28.000	8.21	2.50
29.700	7.74	2.36

For example, at 160 meters, a 26-foot vertical is 0.05 wavelength electrically, or 18 degrees of phase. Interpolating Figure 2b, we find the radiation resistance to be about 1.5Ω. This holds true no matter how much wire there is in the tuning or loading coils. If there is no loss resistance, this antenna displays a purely resistive impedance of 1.5Ω at resonance; this mandates using a matching transformer for a good SWR using 52Ω feed cable, and ground loss must be minimized by an extensive system of radials.

Suppose we build an inductively tuned short vertical of this height for 160 meters and find that the SWR is 1:1 with RG-8/U coaxial cable at 1.800 MHz. We would be delighted at our good fortune until we figure the antenna efficiency:

$$R_T = 52\Omega$$
$$R_R = 1.5\Omega$$

$$\text{Eff}(\%) = 100(1.5/52)$$
$$= 2.9 \text{ percent}$$

In other words, for every 100 watts of actual power reaching the feedpoint, only 2.9 watts is radiated, while 97.1 watts is used up in heating the Earth! There is absolutely nothing we can do to increase the radiation resistance of an antenna except to make it longer physically in terms of the portion of a free-space wavelength that it spans.

Don't be discouraged from using short verticals—they work well when you optimize their efficiency via dropping the ground resistance. Recognize though that there is a limit to how short you can make a "short" radiator without some sacrifice in efficiency.

Tune in next month for Part II of this vertical antenna tutorial, where I discuss tuning coils and traps, useful bandwidth, interference, and low band DX considerations! 73

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Vertical Antennas at HF—Part II

More surprising facts about HF verticals.

by Stan Gibilisco W1GV

In Part I in the September 1989 issue of *73*, the aspects of HF verticals I discuss are polarization, ground wave propagation, grounding, use of radials, and calculating antenna efficiency. In Part II of this tutorial, I discuss tuning coils and traps, useful bandwidth, interference, and low-band DX considerations.

Tuning Coils and Traps

My purpose in discussing these is simply to offer suggestions for minimizing the losses they present. The importance of minimizing losses in coils and traps increases as the antenna is made shorter, since the radiation resistance decreases. A coil with 1.5Ω of loss will not seriously degrade the operation of a vertical antenna 70 degrees high, but will devastate the performance of a vertical just 15 degrees high.

Use the heaviest gauge wire for coil winding. Protect the electrical junctions from the elements and they should not, unless unavoidable, be of dissimilar metals (for example, steel and copper). It's best to either weld or solder them. Minimize the total length of wire in the coil by using the smallest possible coil diameter and/or a low-loss powdered-iron core. Make sure the core is rated for the transmit power you want to put into the powdered-iron core.

What's the difference between a coil and a trap? The major difference is that a coil serves only to physically shorten the length of an antenna without changing its electrical length. A trap also has this effect, but it also allows an antenna to operate on more than one band.

In trap construction, the same general rules apply, with the additional constraint that the capacitors have low loss and be capable of withstanding the voltages that will appear across them. Traps should be resonant at the center of each band for which they are designed, or ideally, for the same frequency that represents the median operating frequency in each band used. For example, if you prefer the lower CW parts of the 40 and 20 meter bands, adjust the antenna and traps for about 7.025 and 14.025 MHz; otherwise set them for 7.150 and 14.175 MHz (the centers of the bands).

Useful Bandwidth

The useful bandwidth of any antenna is defined as that frequency range over which the SWR at the feedpoint is at or below certain limits. In practice, a good limit is 3:1, or else that range over which the transmitter can be tuned for optimum operation without the need for an outboard matching network.

A full-size quarter-wave vertical antenna typically has a useful bandwidth of about 5 percent of the resonant frequency. For example, if the resonant frequency is 14.200 MHz, then the useful bandwidth is around 700 kHz—which extends beyond both ends of the band. This value will *increase* with increasing loss resistance, and will *decrease* as the antenna is shortened and inductively tuned. A properly operating short vertical might have a useful bandwidth of only a few kilohertz when the ground plane (radial system) is sufficient for high efficiency. In other words, you can still have an efficient antenna that is electrically short, but the trade-off is narrow bandwidth.

The interesting (and possibly deceptive) point is that a lossy ground system often appears to enhance performance from the standpoint of bandwidth, as well as lowering the SWR if a matching transformer is not used. See the hypothetical case in Figure 8. The SWR-versus-frequency curves are for a 33-foot vertical tuned for 3.800 MHz. The SWR at 100 kHz of either side of resonance, using no matching transformer and assuming a perfect ground system, would be about 7.4:1 (52Ω/7Ω). The bandwidth as previously defined here would be zero unless a transformer were inserted, and this is assumed in Figure 8a.

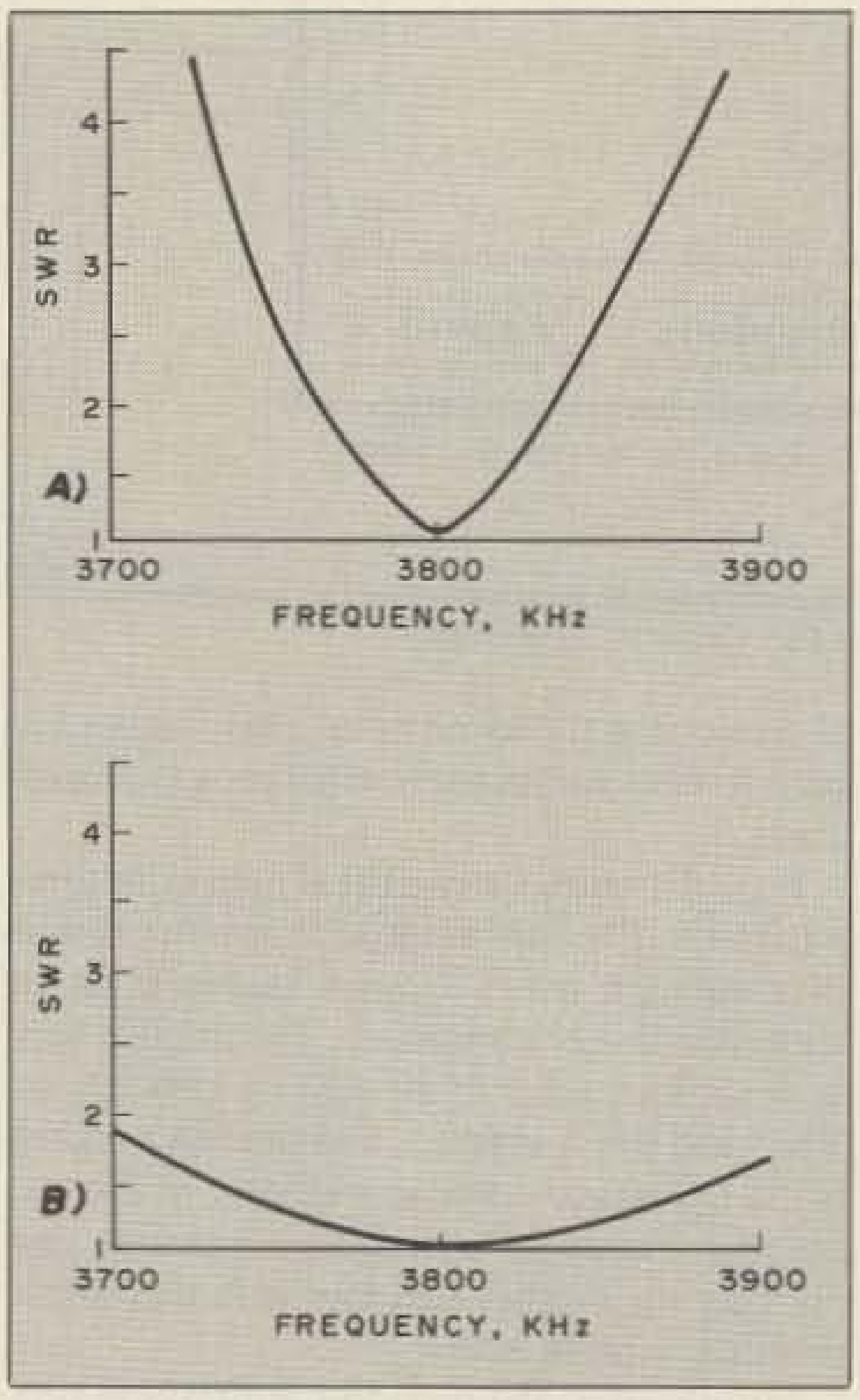

Figure 8. (a) Typical resonant curve for short vertical with inductive tuning, low-loss ground, and matching transformer. At (b) The same antenna without the transformer and with a lossy ground. This graph gives the impression of good performance because of broad-bandedness. Broad-bandedness doesn't always mean high efficiency!

As the loss resistance increases, the minimum SWR becomes lower, and the curve flattens out, giving the impression of broader bandwidth. If the loss resistance were to rise to 45Ω—a quite real possibility with just two or three buried radials—the SWR would be flat at 3.800 MHz, and the curve fairly broad, as in Figure 8b, without the matching transformer. The unfortunate operator would suffer a severely deflated ego if he believed this were a good sign, as the instruments would appear to prove, and then was told, correctly, that:

$$\begin{aligned}\text{Eff}(\%) &= 100(7/52)\\ &= 13 \text{ percent}\end{aligned}$$

Obtaining Gain

We have seen that you can obtain omnidirectional gain with a half-wave vertical antenna with an extensive ground radial system. The ground plane doesn't increase antenna efficiency (although it may by a few percent, if the ground is very lossy), but it reflects the electromagnetic field, in effect creating a 2-element vertical collinear array. You can add more collinear elements and get more gain; doubling the number of in-phase elements increases the power gain by 3 dB. This is done at VHF and UHF, but seldom at HF because of the practical limitation on antenna height.

Vertical elements may be phased to get gain in some directions at the expense of other directions. Two vertical antennas fed in phase and spaced ½ wavelength apart produce 3 dB gain perpendicular to the line connecting both antenna feedpoints (Figure 9a) and zero signal along that line. If the antennas are fed in opposing phase, such as by adding ½ wavelength of feedline into one of the antennas, this pattern is rotated 90 degrees with maximum signal along the line connecting both antenna feedpoints (Figure 9b).

If both antennas are half-wave in height, and there is an extensive system of radials around each antenna, the gain will be 6 dB over a quarter-wave vertical alone, in the favored directions of the phased vertical system.

Other phasing patterns are possible. One common feed system is to space two verticals ¼ wavelength apart and to feed them in phase quadrature (90 degrees out of phase). The result is a pattern with a null in one direction.

This is called a cardioid pattern since it is heart-shaped. There is some gain in the favored direction of this system, but the lobe is very broad.

A Steerable Vertical Yagi

Another way to obtain directivity and gain is to use one or more parasitic elements. The driven element may be a quarter-wave vertical antenna, and the parasitic elements about 5 percent longer (for a reflector) or shorter (for a director) than the driven element. A 2-element vertical yagi may use either a director or a reflector in conjunction with the driven element. The parasitic elements are not connected to the feedline, but instead are short-circuited to their radial systems (Figure 10).

You may move the parasitic elements by manually changing the positions of the elements, moving them in and out of pre-set holes or rods in the ground. This does not make for quick switching of the antenna's direction, but it may be useful if you don't need this feature. Alternatively, you may make the parasitic elements 5 percent shorter than the driven element, and lengthen them with small inductances in series, thus converting from director to reflector.

Figure 11 shows a switchable bi-directional system. The parasitic element acts as a reflector when the relay is open, and as a director when the relay is closed and the coil is short-circuited. The parasitic element is physically 5 percent shorter than the driven element; with the coil inserted, it is electrically 5 percent longer. The 2 elements are spaced 0.15 wavelength apart. This distance, *S*, is given by:

$$S_{\text{feet}} = 148/f_{\text{MHz}}$$
$$S_{\text{meters}} = 45.0/f_{\text{MHz}}$$

This switchable array gives about 5 dB forward gain over a single quarter-wave vertical. You might put such an antenna to good use on 40 or 80 meters for contest work from the Midwest, for example.

Adding the parasitic element lowers the impedance of the antenna at resonance, which most likely causes an increase in SWR. You may use a matching section or transformer to lower SWR, if desired. You can construct a matching section from a ¼-wave section of 52Ω line (the velocity factor of the line must be taken into account) and the main feedline from 75Ω coaxial cable. Most transmitters will work all right with 75Ω feedlines having reasonably low SWR. If a 75Ω feedline is used, however, do not rely on a 52Ω SWR meter for accurate indication.

The gain and directivity of this antenna will be evident for receiving as well as transmitting.

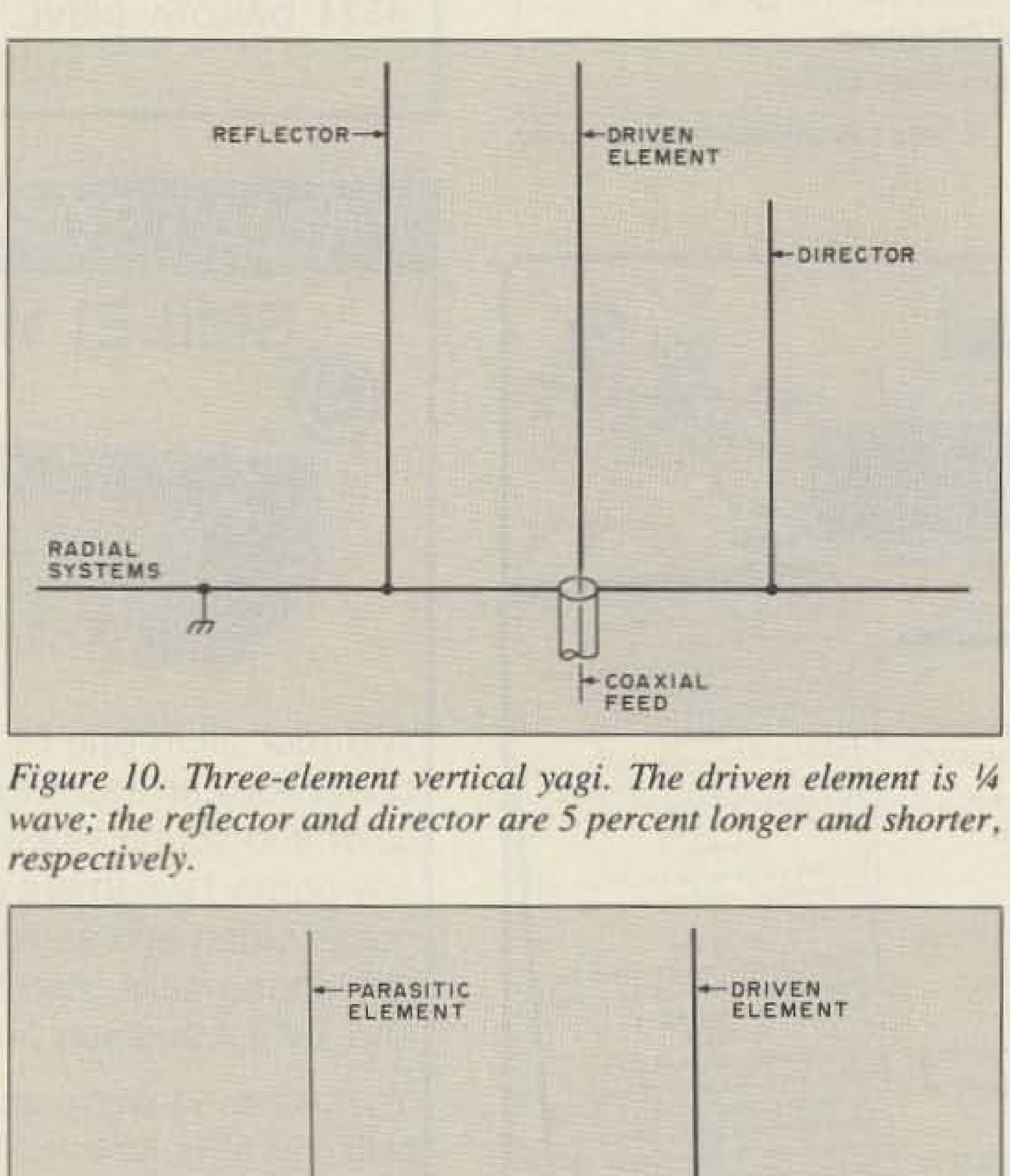

Figure 10. Three-element vertical yagi. The driven element is ¼ wave; the reflector and director are 5 percent longer and shorter, respectively.

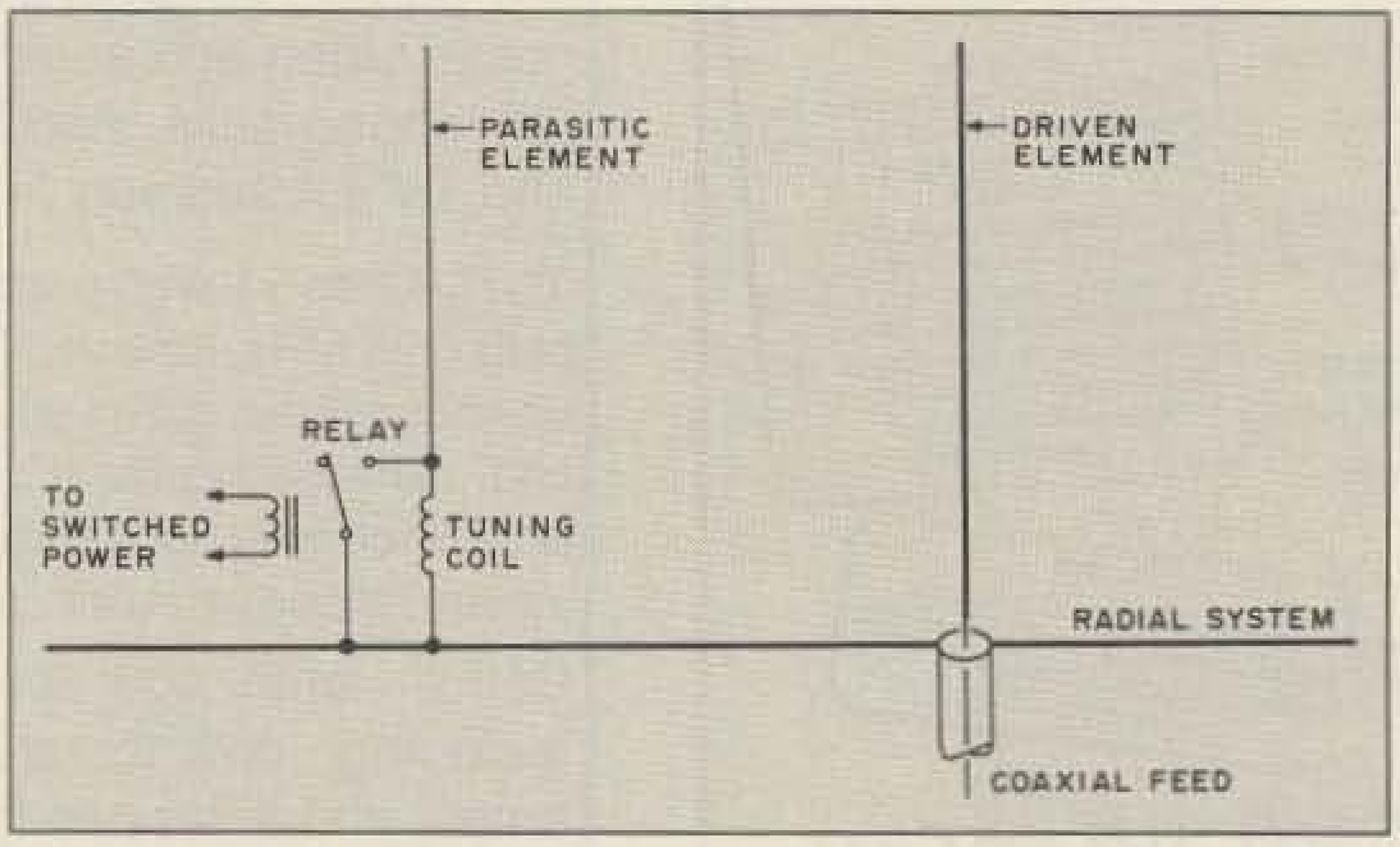

Figure 11. A switchable bi-directional vertical yagi. The parasitic element is physically 5 percent shorter than the driven element, but opening the relay causes the coil to be inserted, lowering the parasitic frequency to that of a reflector.

Verticals and Interference

You often hear that a vertical antenna picks up more manmade interference, especially from appliances such as vacuum cleaners, hair dryers, and electric blankets, than a horizontal antenna. It is true that the vertical component of noise tends to propagate a little further than the horizontal component because the latter is cancelled out by ground plane effects. Nonetheless, you can go a long way to reducing the noise simply by placing the vertical further away from the electrical wires and house. In practice, a vertical antenna may be more likely to pick up interference than a horizontal antenna, simply because the vertical will usually be closer to the sources of interference.

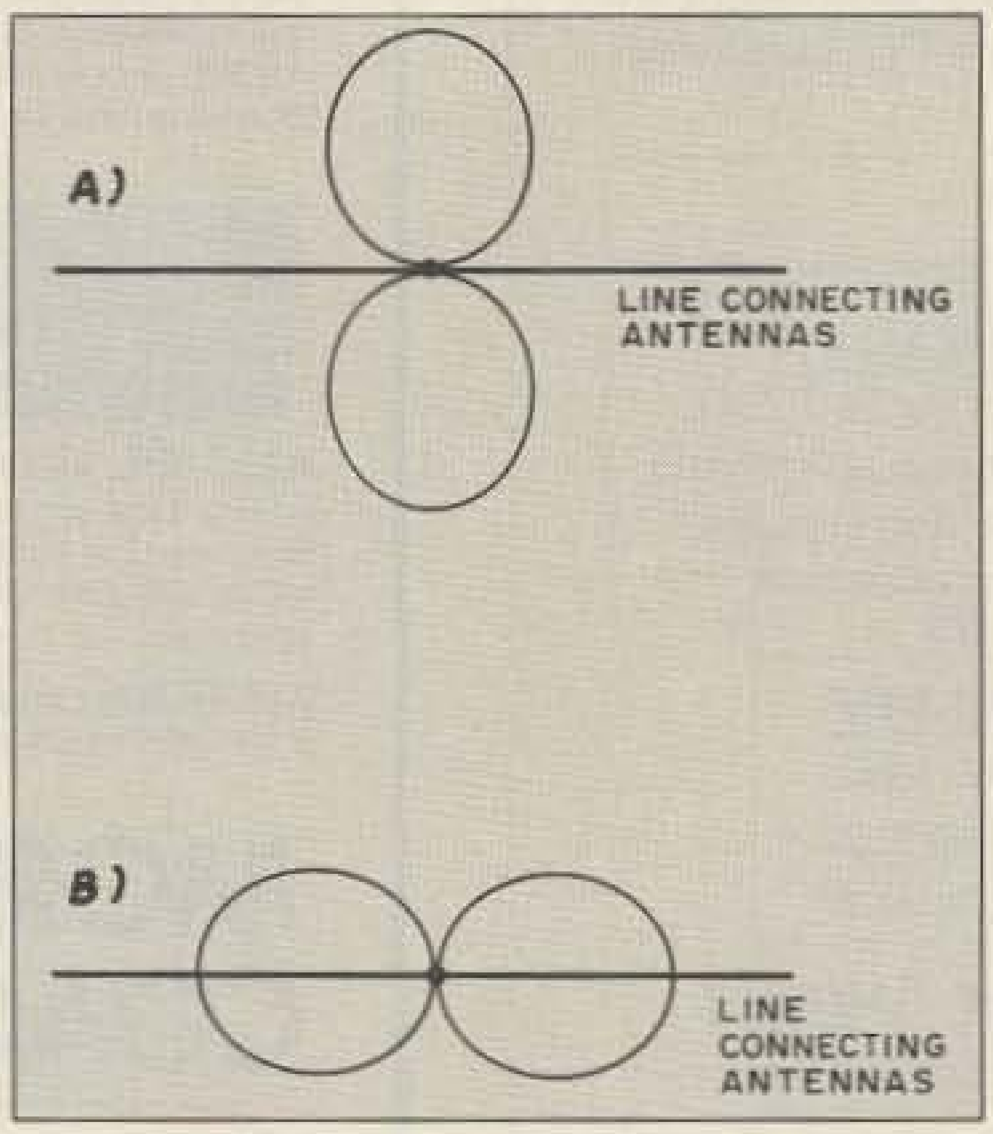

Figure 9. Verticals spaced at ½ wavelength and fed in phase (a) and 180° out of phase (b) produce these directional patterns.

A ground-mounted, backyard vertical antenna is surrounded by houses with their unshielded wiring, and the problem is compounded if utility wires are above ground. In this kind of situation it may be better to mount the antenna up ¼ wavelength and use three or four radials (for each band) that may double as guy wires. Alternatively, you could use a separate receiving antenna, such as a ferrite loopstick with a preamplifier. You can orient this type of antenna to null out the noise.

Vertical antennas may cause more radio-frequency interference (RFI) than horizontal antennas for the same reason; the ground-mounted vertical will usually be closer to home entertainment equipment. Again, the solution is to get the antenna in the clear and well away from home wiring and appliances.

Low-Band DX Considerations

For long-distance communication at frequencies of 7 MHz and below, the vertical antenna is a good choice when space is limited. A dipole antenna must be at least ½ wavelength above the ground to have good low-angle radiation; this will require two supports of that height. But a ¼-wave vertical radiator with a good ground radial system will provide just as much power gain as the dipole, will radiate well at the low angles desirable for DX, and will do it in all directions—with just one support of half the height.

A ½-wavelength vertical without radials will equal the performance of the ¼-wave vertical with radials; adding the radials to the taller antenna will provide 3 dB of power gain at low angles in all directions. Verticals may be phased or combined to form parasitic arrays with directivity and additional gain.

Probably the most visible advantage of a vertical antenna is its unobtrusiveness. Even a quite tall vertical is not an eyesore to most onlookers. You must take care to ensure that the antenna cannot come into contact with utility wires, and some local ordinances forbid manmade structures that will not fall entirely within the owner's property. But for the cost, effort, and space, the vertical antenna may be the best choice for the ham or SWL seriously interested in low-band DX. 73