ANTENNAS

Here is some more practical wit and wisdom from W1ICP on our favorite subject. It's not all that difficult to learn about, build, and use a variety of antennas, and it can be a lot of fun.

The Multiple Dipole Antenna

One of Amateur Radio's Most Economic Antennas

BY LEW McCOY*, W1ICP

Years ago I came up with the idea of feeding multiband dipoles with a common feed line—50 ohm impedance coax. Don't misunderstand. I did not invent the system of feeding several dipoles with a single feed line. However, I believe I was among the first to publish an early article on the subject.

Over the years I have experimented with many types of multiple antennas fed from a common feed line, and I know I have garnered some useful information worth passing on. One thing I found out at the beginning was that this is about the cheapest way to get good antennas without hocking the family jewels.

There are a couple of basic rules you should follow when making a wire dipole. Once you learn a few simple facts about these popular antennas, the whole project becomes a piece of cake. For example, the formula for making a half-wavelength dipole is simple. The length of any half-wave antenna can be found by dividing 468 by the frequency to be used. For example, a 20 meter dipole, say for 14.2 MHz, would be 468 divided by 14.2, or 32.9 (32 feet 11 inches). It is important here to point out to any beginner that for the HF bands, 80 through 10 meters, these dimensions are not really critical. For example, if the antenna happened to come out to, say, 33 feet, it would work just as well at 14.2 MHz as one cut exactly. Where inches become important is on VHF, where you should try to make the antenna fit the formula as closely as possible.

To make this whole project easy, I have included the lengths of dipoles for all of the HF bands from 10 through 160. These are listed in Table I.

There are a couple more basic facts that we should touch on to get our groundwork

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Band	Frequency	Length
160 m	1800 kHz	260 ft.
80 m	3500 kHz	133.7 ft.
	4000 kHz	117 ft.
40 m	7100 kHz	65.9 ft.
30 m	10.1 MHz	46.33 ft.
20 m	14,150 kHz	33.07 ft.
17 m	18.1 MHz	25.85 ft.
15 m	21,250 kHz	22 ft.
12 m	24.4 MHz	19.18 ft.
10 m	28,500 kHz	16.42 ft.

Table I– Lengths of dipoles for the 10–160 meter HF bands.

established. The feed-point impedance of a dipole that you hang up in your backyard will range from 100 to 50 ohms or less. The variations in value are caused by the effect of earth, or ground, and the height of the antenna above earth. Normally, we think of a half-wavelength dipole having a free-space impedance of 70 ohms. Sure, there are some astronauts out there, but most of us keep our feet planted on old Mother Earth, and she is the one with the primary controlling factor which determines the impedance of our antennas.

Another point to remember here is that a half-wavelength dipole, of course fed at the center of the antenna, can be very forgiving of many types of configurations as far as staying in that 3 to 1 or less matching range. What do I mean by that statement? I have made countless dipoles for many different bands and have put them up under some crazy conditions. For example, one time I wanted to put up an 80 meter dipole. However, I had only enough room to stretch out straight one half of the dipole; the other half took off at a right angle and then went off in another direction. As I recall, the whole area was only about 60 feet long at most. I ran as much of the 60 feet as straight out as possible and then ran the remainder at right angles. The antenna was a fair match for 50 ohm coax, and with this system I worked all over the world.

Keep in mind, then, that what we are discussing here is a dipole. Make it as high as you can, but don't be afraid to use it as an inverted Vee, an "L" shape, or what have you.

The modern transceiver is designed to work into a mismatch of less than 3 to 1. If the match is worse than that, the transceiver has circuits to make the transceiver shut down. You get a break here because any dipole cut for 40 meters through 10 meters will usually give you less than a 3 to 1match across those bands. Dipoles for 80 or 160 meters have different bandwidth and matching problems. I'll discuss those a little later.

A very popular question asked by new amateurs is "What kind of wire should I use for my antenna?" One basic fact is that the wire should be strong enough to support the coax you are using. I grew up using No. 12 solid copper wire, but I have used copper-covered steel fence wire, all kinds of regular electrical wire, and insulated wire—which brings up a point.

At one point in my career I used a bare copper wire on 80 meters and ran the wire through leafy trees. One night during a contest, a friend was running my station while I happened to go outside. I noticed that sparks were jumping from the wire to the tree leaves! Later I tried using insulated electrical house wire and it worked fine. Some electronic engineers will tell you that insulated wire will change the velocity factor of the wire and thereby change its electrical length. They are right, but only partially so. The electrical length will be very fractionally different—certainly not worth worrying about for HF antennas.

There are several wire dealers listed in *CQ*'s advertising section, and all of these are very reliable. Write or call them and ask for literature. Also, Sears, Home Depot, and other such stores sell electric, single-conductor wire, usually insulated, that will make good antennas. Use either No. 14 or No. 12. If you have access to farm suppliers, electric fence wire, which is usually No. 18 or so copper-covered steel, is really cheap and works out well for long antennas.

One last item worth passing on. During my years of writing about antennas I have had many requests to describe "invisible" antennas, particularly dipoles. Many amateurs do not realize that dipoles made from small-diameter wire make excellent antennas. No. 28 solid copper can be used (Yes, it will easily handle a kilowatt!). It is usually strong enough to withstand windstorms, probably because it offers such low wind resistance. Of course, the trick with such an antenna is getting it to support the coax feed line. I know of one amateur who was in college who managed to drive a hook into a power pole (of course safely below the power line). He then ran his coax out along the ground and buried it slightly below the grass. He then fed some nylon fishing line through the hook on the pole to use as his pulley line. He ran his dipole, made from No. 28, in an inverted Vee configuration and tied the ends of his antenna off to nearby trees. For all practical purposes, the antenna was invisible.

Amateurs at one time were very imaginative, so let your mind roam and see what you can build. It can be a lot of fun.

Let's talk a little about dipole impedances. I'll try to keep it as clear as possible. Let's assume we make a dipole for 40 meters and we are lucky enough to get that antenna at exactly the correct height so that the impedance is right on the nose at 50 ohms. We are happy to have an antenna that is perfectly resonant, so our feed point looks like a 50 ohm resistor.

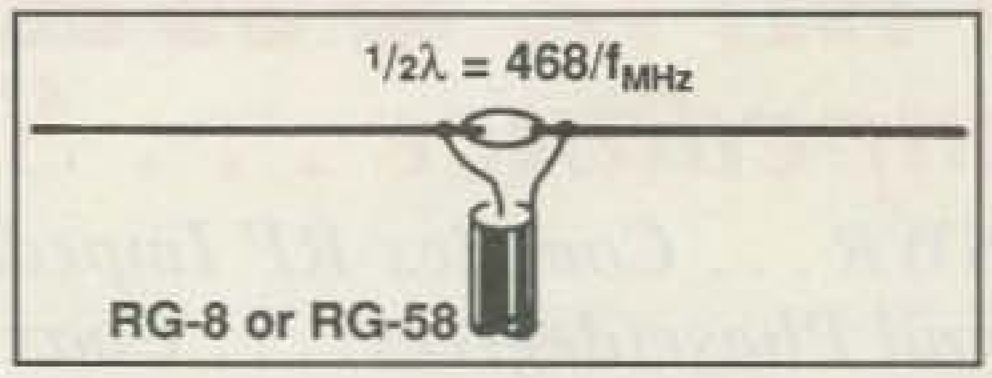

Fig. 1– A standard one-half wavelength dipole. The impedance of such an antenna will depend on its height above ground, but it should be somewhere between 25 and 100 ohms.

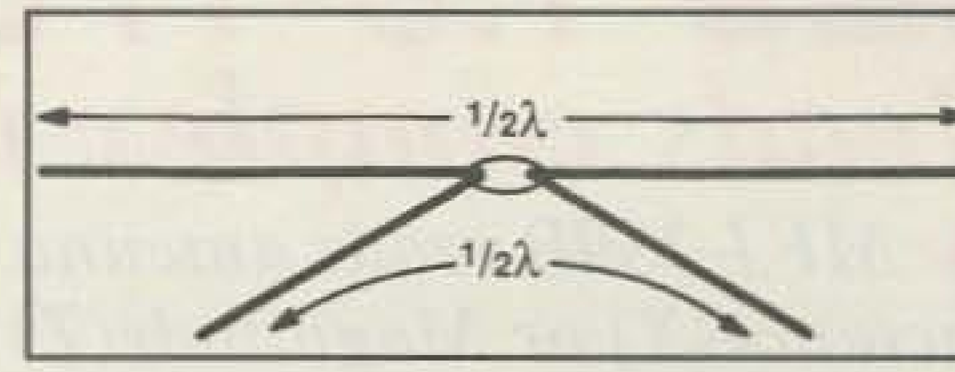

Fig. 2– Here we have two dipoles. As explained in the text, both of these antennas will work for you when fed with 50 ohm coaxial line.

Our standing-wave ratio would be exactly 1 to 1, or 50 ohms divided into a 50 ohm impedance. If we stay on this matched frequency (don't QSY), we will have a perfectly matched condition and our transceiver will love it. However, when we change frequency, we introduce something called "reactance."

Trying to explain reactance isn't easy, because it is a resistance that is not a resistance. Reactance is listed in ohms, and it really acts, to oversimplify, like a gate or a door that stops the flow of power into a circuit—in this case, the antenna. In the case of the antenna, if the antenna is too long for a frequency, it will exhibit what is known as inductive reactance. If it is too short, the antenna will have capacitive reactance. What this does is change the perfect 1 to 1 match to something else.

You'll see the term "SWR bandwidth" in antenna system advertisements. For example, such ads might show an antenna system with a 200 kHz of 3 to 1. Simply, this means that the system will not exceed an SWR (standing wave ratio) of more than 3 to 1 across the 200 kiloHertz. We have determined the impedance of our dipole. What else must we consider?

What we have to think about now—and it isn't too technical to understand—is tying more than one band to another with a common feed line. Fig. 1 shows a single dipole. Fig. 2 shows two dipoles; let's say one is for 40 and the other is for 80. We use 50 ohm coax. Actually, RG58 is suitable for these bands simply because the coax isn't too lossy at these frequencies (more about that in a moment). Let's assume that we have managed to get a dipole impedance on the 80 meter antenna of somewhere close to 50 ohms. Across this feed point we hang on our 40 meter dipole. When we go on 80 meters, our transmitter is going to see a load that it can work into without being affected too much. The 40 meter dipole is going to be highly reactive to our 80 meter portion and is not likely to take any power. When we switch to 40, we now see another 50 ohm load, or something close to it. However, on 80, our 40 meter signal is looking at somewhere around 4000 ohms plus a lot of reactance. Therefore, our signal goes into the more reasonable impedance of the 40 meter dipole.

I said earlier that I would discuss bandwidth and SWR. A lot of amateurs realize that good bandwidth and SWR are very hard to come by on 80 or 160 meters. Many newcomers don't realize why this is so. The following example shows us why this is true.

The 80 meter band is 3500 to 4000 kHz, or 500 kHz in width. Divide 4000 by 500, and we come up with a ratio of 8 to 1. If we use the low end, the ratio is 7 to 1. Now let's look at the ratio on 20 meters (14,000 to 14,350 kHz). We have a band that is 350 kHz wide. Divide 14,350 by 350, and we have a ratio of about 40 to 1. Therefore, when we move across 20, we have a

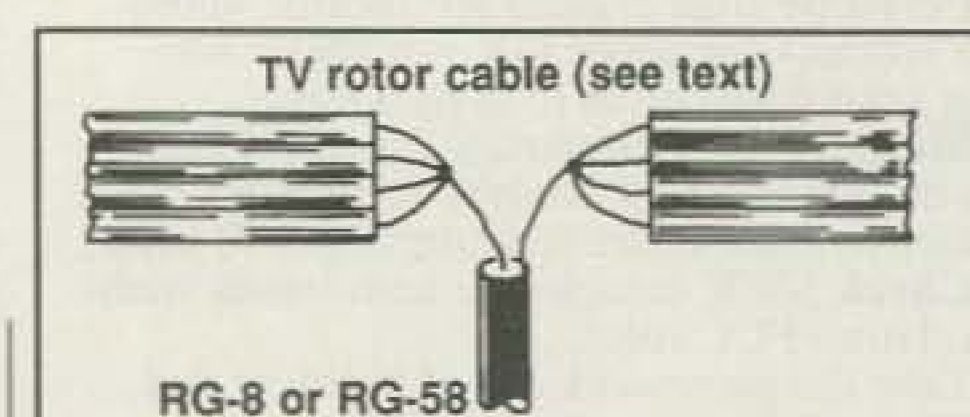

Fig. 3– TV rotor cable makes good multiband dipoles when fed with a single coax. Many configurations are possible.

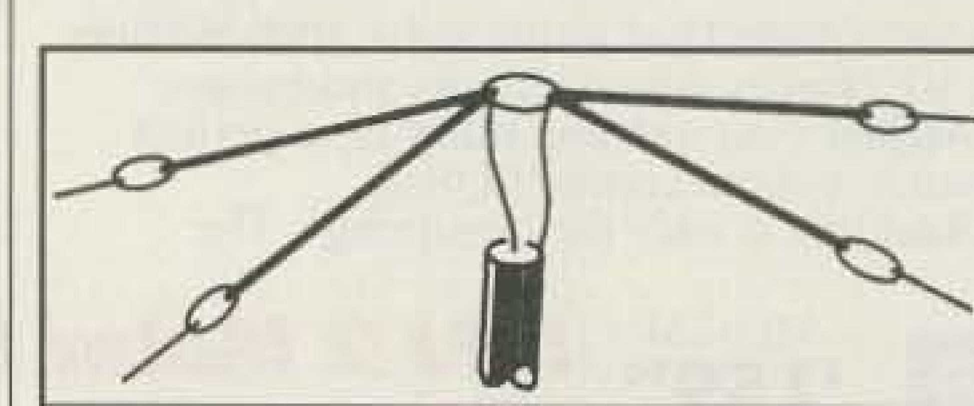

Fig. 4– Don't be afraid to run multiband dipoles off in different directions to suit your location. They will work for you.

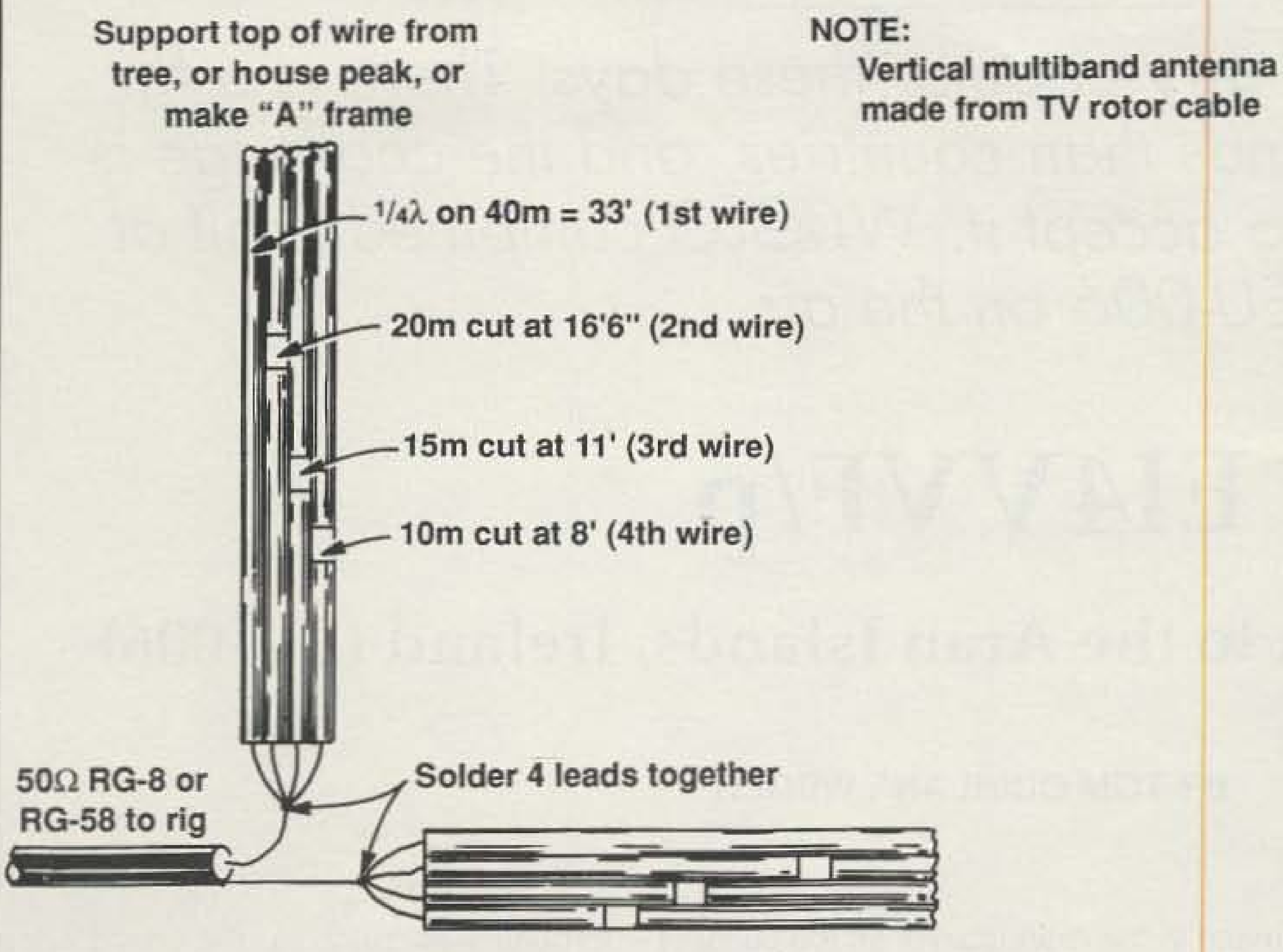

Fig. 5– This is a very good multiband vertical, and one that does not suffer trap losses. It is cheap, easy to make, and a very good performer.

rather small change to deal with. Usually, a dipole for 20 will have 2 to 1 SWR bandwidth or very close to it. But on 80, with our 8 to 1 ratio, the SWR can be very high, running from as much as 10 to 1 at the low end, down to 1 to 1, and then back up to 10 to 1 at the other end of the band. This is why many amateurs have spent years trying to design a broad-band 80 meter antenna that will stay below 2 to 1 across the band. It hasn't been done.

Getting back to actual construction, any handbook shows how to make a simple "A" frame as a single support for wire antennas. If you cannot manage an "A "frame, you may be able to mount a single two by four up on the end of the house, putting a line and pulley at the top. (On holidays I ran the Stars and Stripes up, which kept the neighbors from complaining—Hi!).

In the course of my career, I have tried bunching all the dipoles together. By that I mean the wires are side by side yet insulated from each other.

In fact, one suggestion is to obtain TV rotor cable, the flat type with four conductors (see fig. 3). Don't strip each dipole away from the main stock. Carefully measure from your center point and then cut the end of each dipole. Take out about one inch of the insulating material and wire, leaving the rest intact. Keep in mind that RF voltages get quite high at the ends of antennas, so you need enough space to keep the the arcs from jumping. In fact, I would suggest using electrician's tape to cover each cut-away portion.

I remember one case where I was trying to make an 80 meter dipole that would be fairly flat for SWR across the entire 80 meter band—from 3500 kHz to 4000 kHz (and that ain't easy!). I figured that I could make two dipoles, one cut for 3500 kHz and the other cut for 4000 kHz. Unfortunately, it didn't work worth a darn. What happened was that the longer dipole took over and cancelled out any advantage of the shorter dipole. This accident of course led to a tremendous amount of experimenting. To avoid interaction between dipoles, I found that it helped to separate the ends as shown in fig. 4. Don't misunderstand. Several bands all in one line such as with TV rotor cable will work fine, but the SWR can be improved by separating the ends as much as possible. It would be nice if there were a hard and fast rule one could follow to get repeatable results. Unfortunately, ground conditions, height of the antennas, whether the antennas are inverted Vee style or horizontal, all these things get into the act and can foul up the best of plans. However, even under bad conditions the multiple dipole makes a very inexpensive, good antenna.

One last thing worth thinking about: If you have limited space, you can make a single-feed, multi-band vertical. A 30 foot high "A" frame would take care of 40 through 10 meters. Believe it or not, such a vertical, shown fig. 5 , is as good as or better than some of the trap verticals on the market today.

I once made one for 20 through 10 meters using a 16 foot two by two to support the wires, and I used TV rotor cable for the three bands (at that time 20, 15, and 10). At the base I ran a single length of rotor cable with the three bands cut out, and just laid it on the ground for my other half of the antenna. The darn thing worked like a charm. Fig. 5 illustrates this. If you want, you can call that bottom length the "ground plane," but it really shows the vertical as a half-wave dipole, one part horizontal while the other half is vertical. Believe it or not, years ago when I lived in the Ozarks of Missouri, I built one of these and worked DXCC with it. Try it. You'll save lots of buck and work lots of DX. ■