antennas

BY KENT BRITAIN,* WA5VJB

Trap Antenna Basics

We welcome Kent Britain, WA5VJB, as our new Antennas Editor as of this issue, succeeding Arnie Coro, CO2KK. Arnie's other time commitments prevented him from continuing to do a regularly scheduled column. CO2KK will remain a CQ Contributing Editor at Large and we will look forward to sharing his articles with you when his schedule gives him time to write.

WA5VJB has been part of the CQ "family" since 1995, writing about antennas for CQ VHF, the now-defunct CB Radio magazine, and Popular Communications. We welcome him to the pages of CQ as well. —*W2VU*

I have been writing antenna construction articles for three of CQ Communications' other magazines for eight years. At Dayton this year, Rich, W2VU, caught up with me and invited me to write for the big one. Perhaps you could characterize his recruiting technique as being much like the way the British press gangs Shanghai'd sailors, but we'll have fun and cover a wide variety of antenna topics, starting, perhaps appropriately, with "trap" antennas.

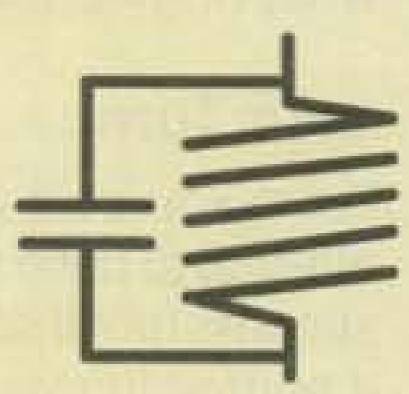

Fig. 1– A parallel tuned circuit, consisting of a coil and a capacitor, is one of the most basic electronic circuits.

It all starts with the parallel tuned circuit (fig. 1), which is a basic circuit of electronics. At resonance, the parallel tuned circuit has a very high impedance, meaning it is very hard to make a signal on the resonant frequency go through the circuit. As an example, let's say we make a tuned circuit tuned to a local AM radio station at 1000 kHz (fig. 2, Circuit A) and a parallel tuned circuit tuned to the same frequency (fig. 2, Circuit B). In the first circuit every signal coming down the antenna goes straight to ground, except the signal for which the parallel tuned circuit is tuned. Since the 1000 kHz signal can't go through the coil, it goes through the diode and earphone instead. Bingo. We have a crystal radio.

However, let's say the 50,000 watt transmitter for that station is just down the road and it's wreaking havoc on the front end of your HF rig. Now we can take advantage of the blocking effect of a parallel tuned circuit and use the tuned circuit (shown in fig. 2, Circuit B) to allow every frequency *but* 1000 kHz into our HF rig.

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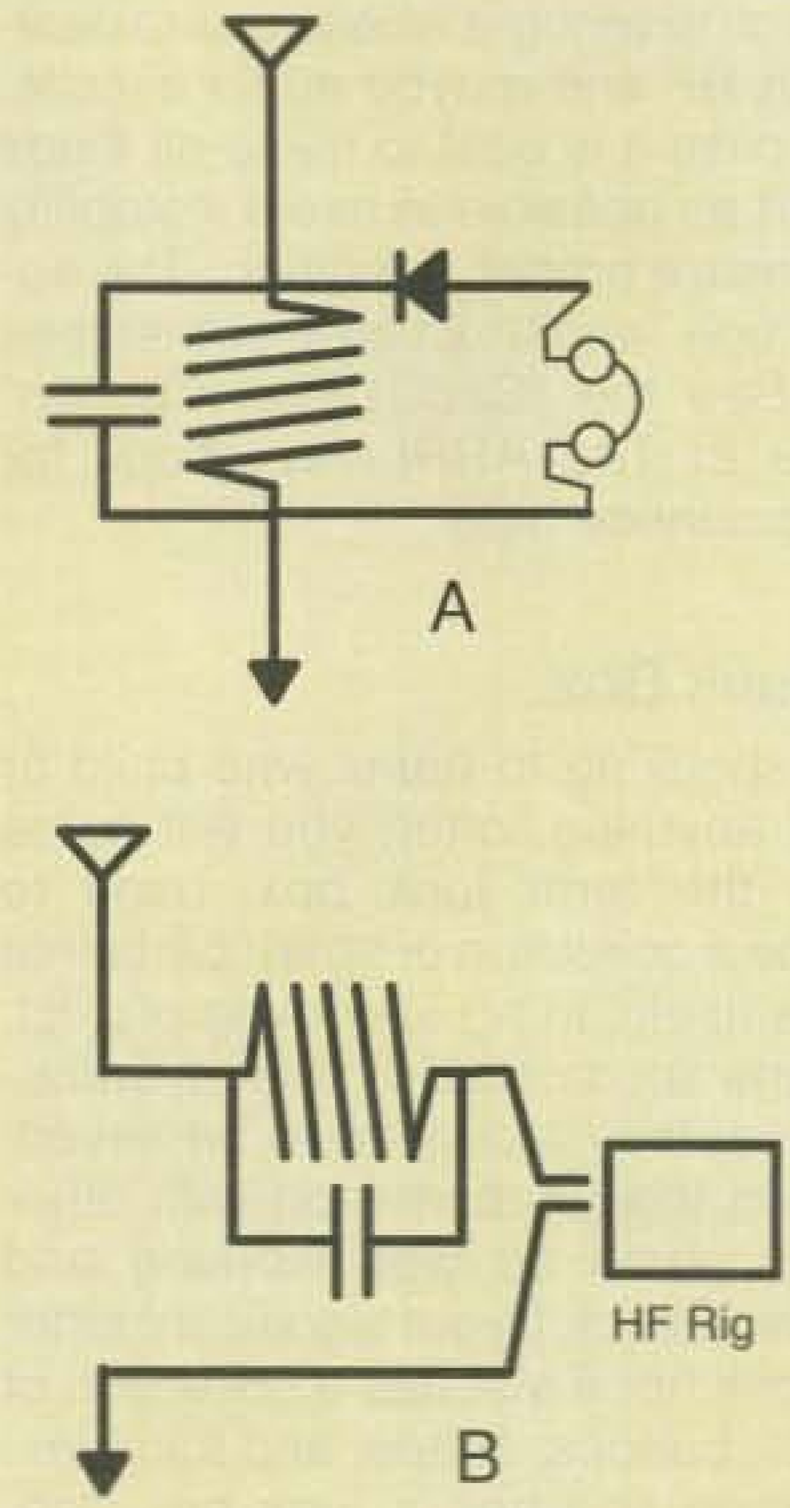


Fig. 2– Circuit A shows how a tuned circuit in a crystal set sends most signals to ground and signals on the selected frequency to the diode and headphones. Circuit B puts a similar circuit to work between an antenna and an HF rig. (See text for details.)

I'm going to over-simplify a bit here, but when a parallel tuned circuit is tuned to, say, 1000 kHz, it looks like an inductor to signals below 1000 kHz and looks more like a capacitor to signals above 1000 kHz. It's that property of looking like an inductor below resonance that we want to use in our trap vertical antenna.

Ahhh . . . but how much inductance? There are thousands of combinations of inductance and capacitance that will result in a parallel tuned circuit at HF (some would say an infinite number, but let's not waste our time with changes that don't move an antenna's resonant frequency even 1 Hz!). As you can see in fig. 3, I can make the trap heavy on the inductance side or heavy on the capacitance side, depending on how I plan to tackle the next step.

Building a Trap Vertical

Let's see how a triband (10/15/20 meter) trap vertical goes together. We start out at the bottom with a quarter-wave vertical for 28 MHz and a parallel tuned circuit for 28 MHz (fig. 4). When I mount the tuned circuit on the top of the vertical, not much happens. The 28 MHz signal can't pass through

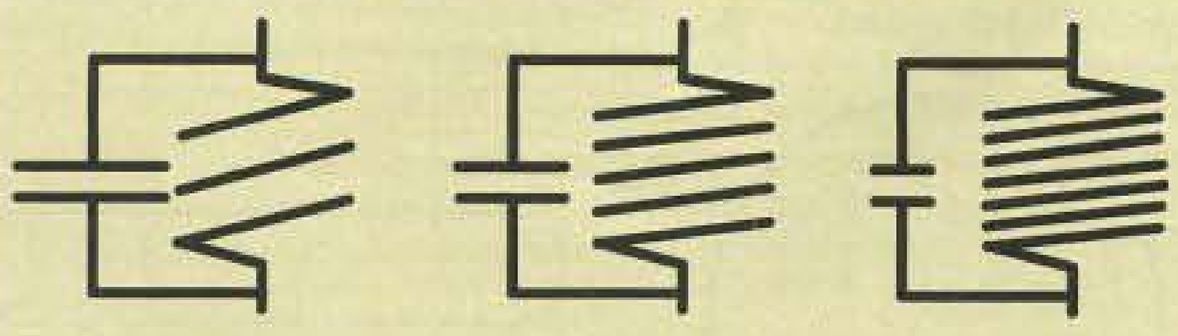


Fig. 3– Different combinations of inductance and capacitance vary the resonant frequency of the tuned circuit and the length of the straight element that will be needed for the next band segment.

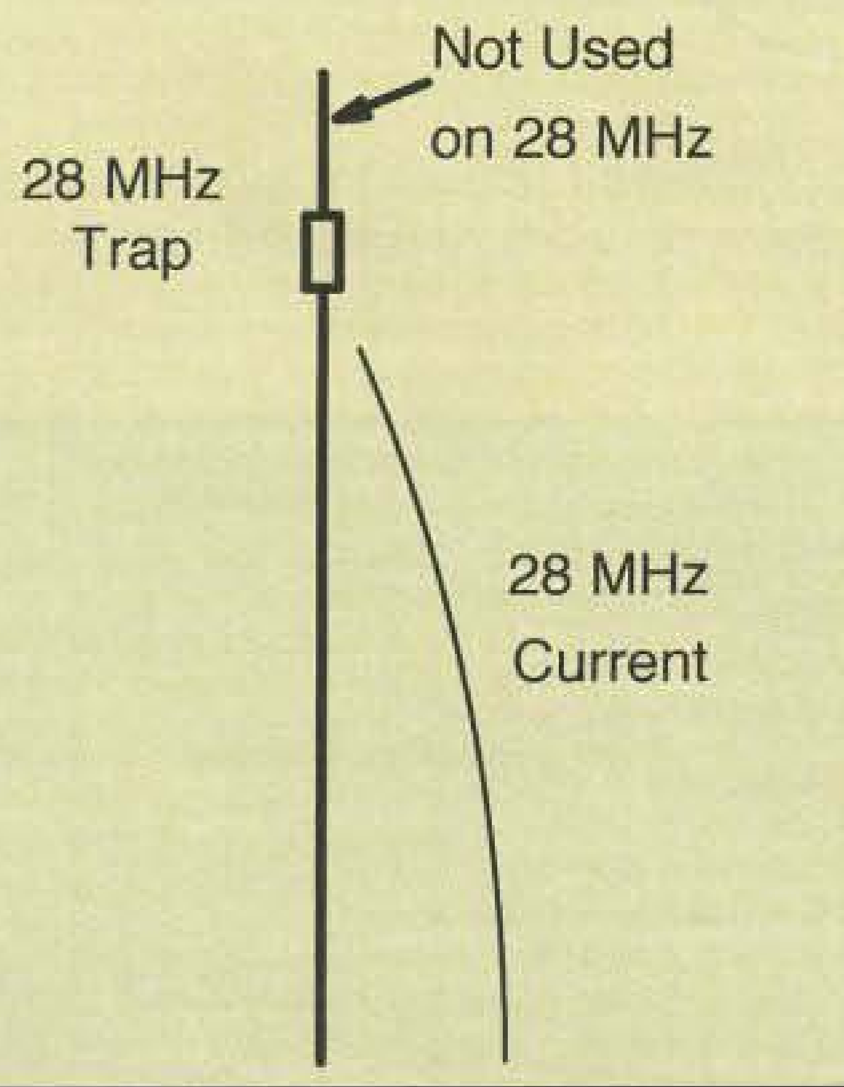


Fig. 4– On a trap-topped 28 MHz vertical, a 10 meter signal "sees" the trap as the end of the antenna.

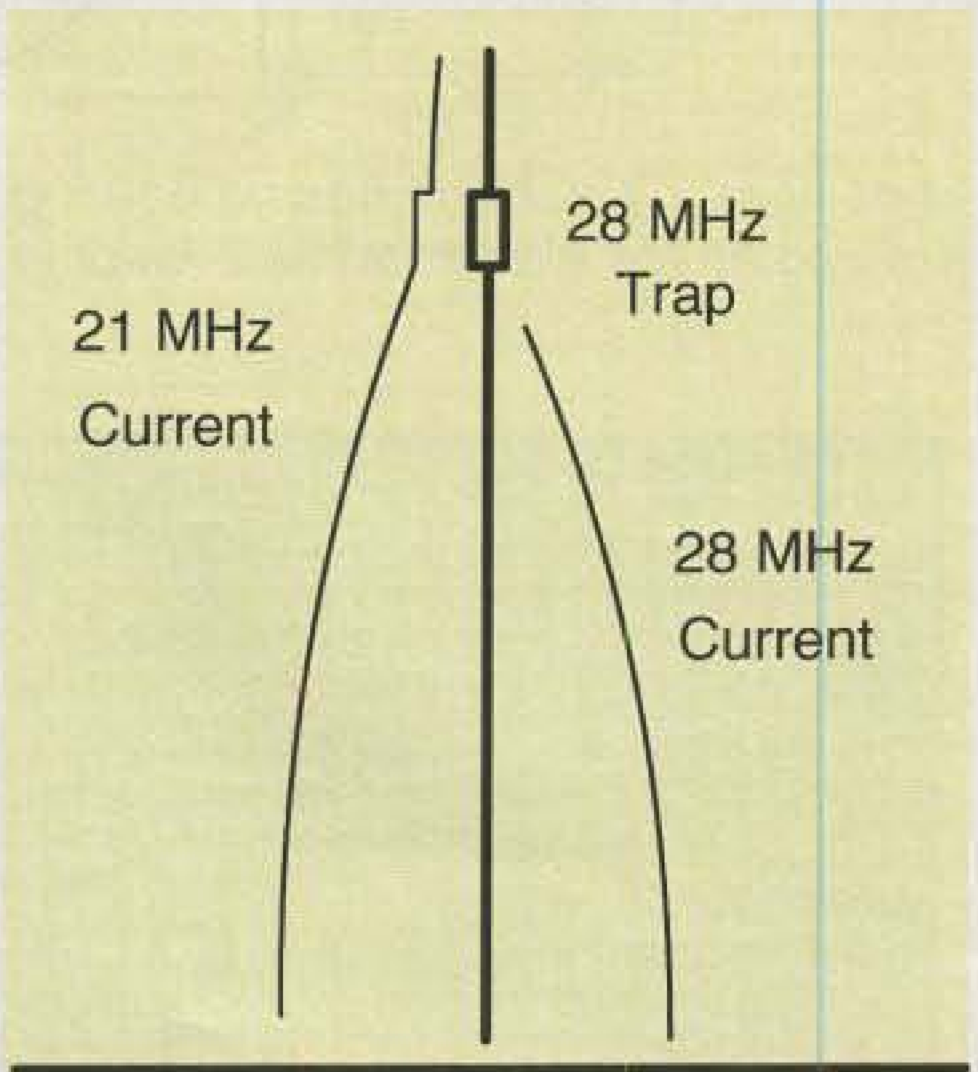


Fig. 5_ A 21 MHz signal sees the coil as an inductor and passes easily through it to the end of the 21 MHz section.

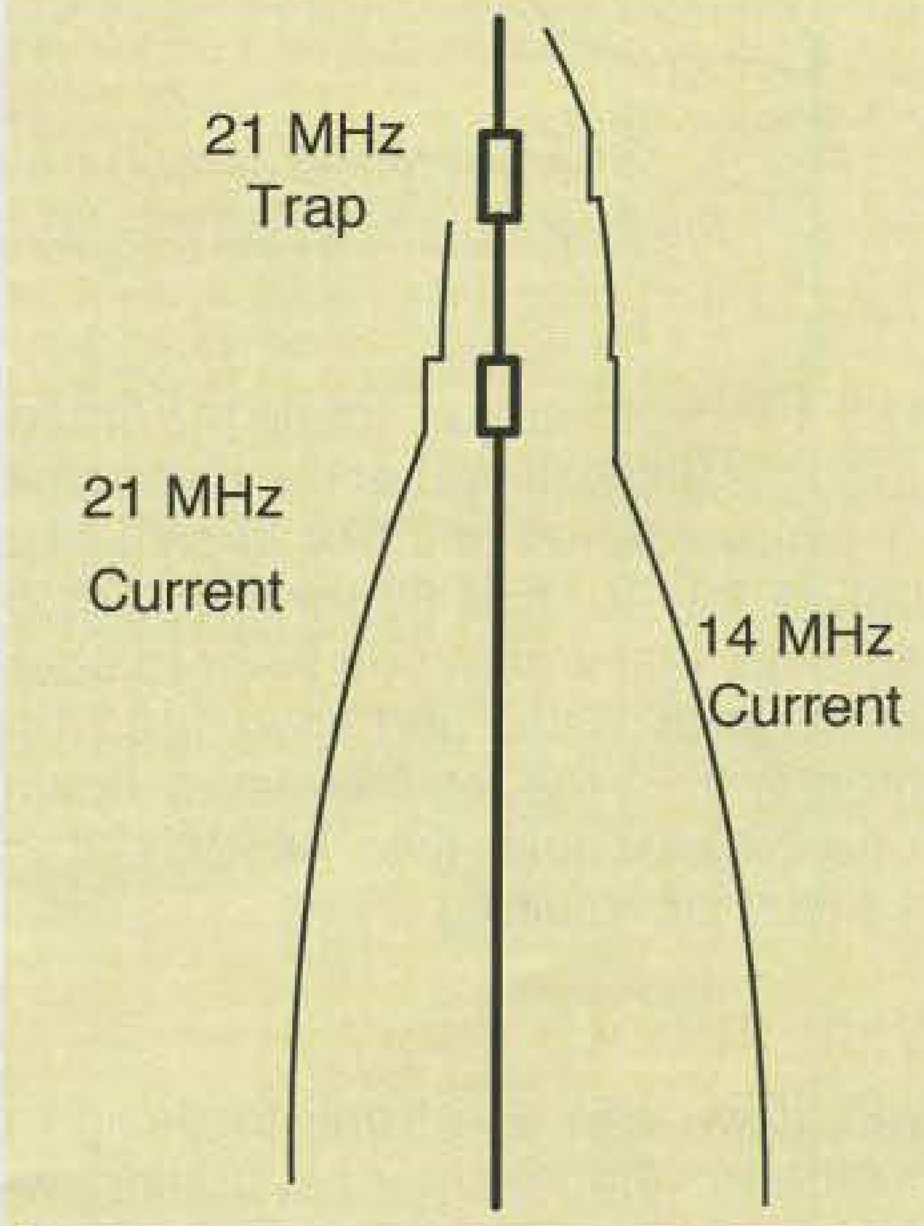


Fig. 6– Going a step beyond fig. 5, we now have a 14 MHz vertical with two traps, producing a single antenna that is resonant on 20, 15, and 10 meters.

the tuned circuit, and the wave is "trapped" in that section of the antenna. Any aluminum above the 28 MHz trap is invisible to the 28 MHz signals. As far as those signals are concerned, the antenna ends at the trap. However, for a signal at 21 MHz, that 28 MHz trap looks like an inductor and we can take advantage of that in the next step.

The trap is now a loading coil for the 15 meter vertical, and I have a vertical that works on both 10 and 15 meters with one feed (fig. 5). Here is where a lot of design considerations come into play. I can design my trap with a lot of inductance, and the antenna above the trap is short. Less inductance and more capacitance, and the antenna above the trap is longer. Of course longer is better, but as you'll see shortly, we many not have room for as much as we want.

Let's repeat the process, adding a 21 MHz trap and another section of tubing, and we now have a 20 meter vertical with two loading coils that also operates on 15 and 10 meters. How far can we take this? Well, the most complicated vertical I've seen so far worked on nine bands and had eight traps. For these examples, I used 28, 21, and 14 MHz, but there are no technical reasons why you can't build a 28/24/10 MHz version or a 24/18/7 MHz version. It's all marketing at this point. The antenna manufacturers are going to concentrate on building antennas for the most popular bands, because that's how they recover their investment in design and tooling (presumably, along with some profit). From an engineering point of view, the ratio of inductance to capacitance in each trap is very important to antenna efficiency and antenna impedance. Fortunately for us, though, the manufacturers take care of all that and we won't cover it here.

Tuning a Trap Vertical

Tuning up a trap vertical can be really fun. On most trap verticals, the sections between the loading coils are adjustable, so you can tweak the antenna to your favorite part of each band. Except for perhaps 10 meters, a trap vertical usually will not tune the entire ham band, so you will need to decide if you want to do most of your operating at the high, the middle, or the low end of each band. Deciding ahead of time can save you a lot of work later.

One important thing to keep in mind is that adjustments often affect more than one band. If I make the 10 meter section just a little longer to work better

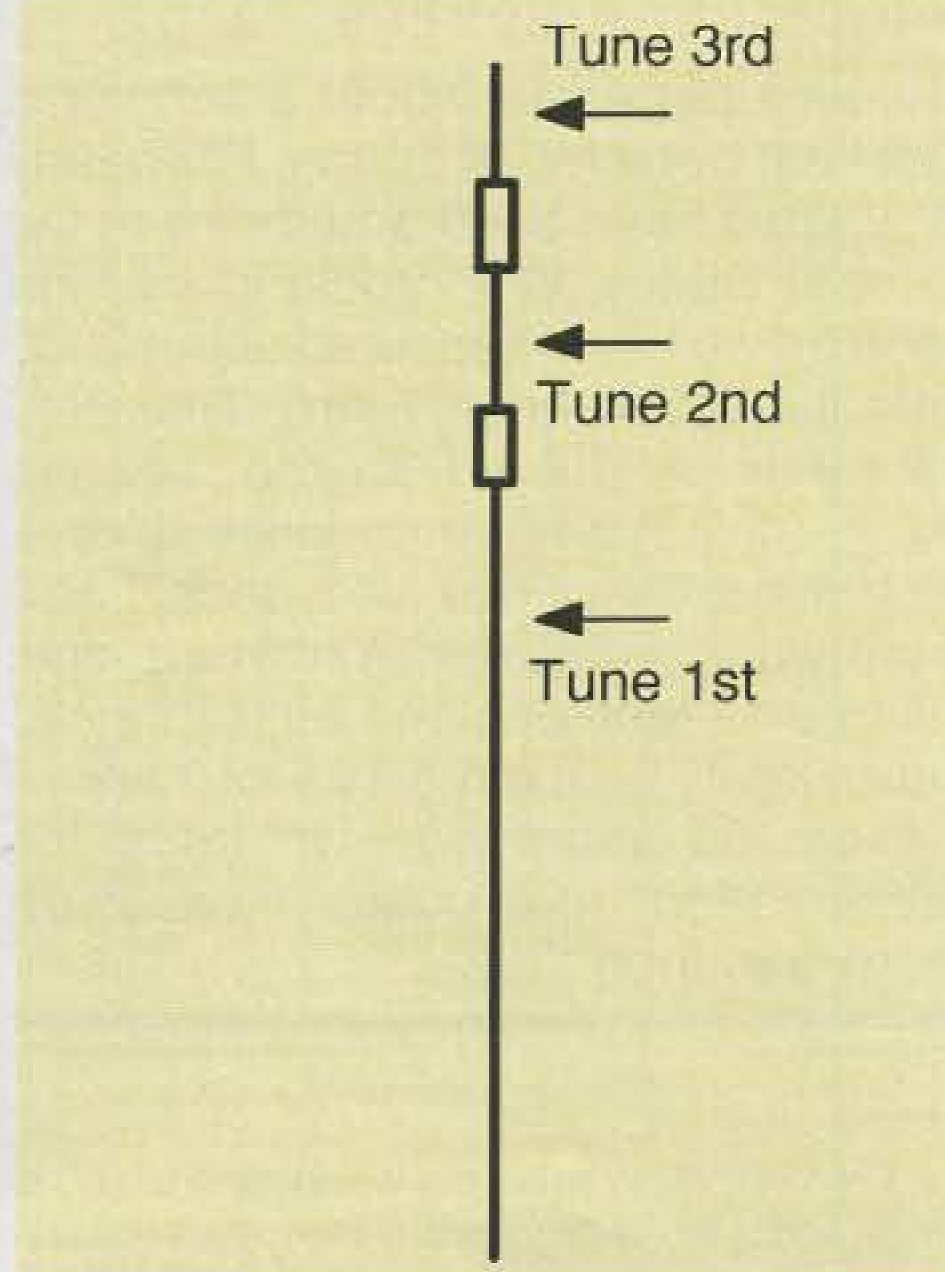


Fig. 7– When tuning a trap vertical, always tune up from the bottom, starting with the highest frequency segment.

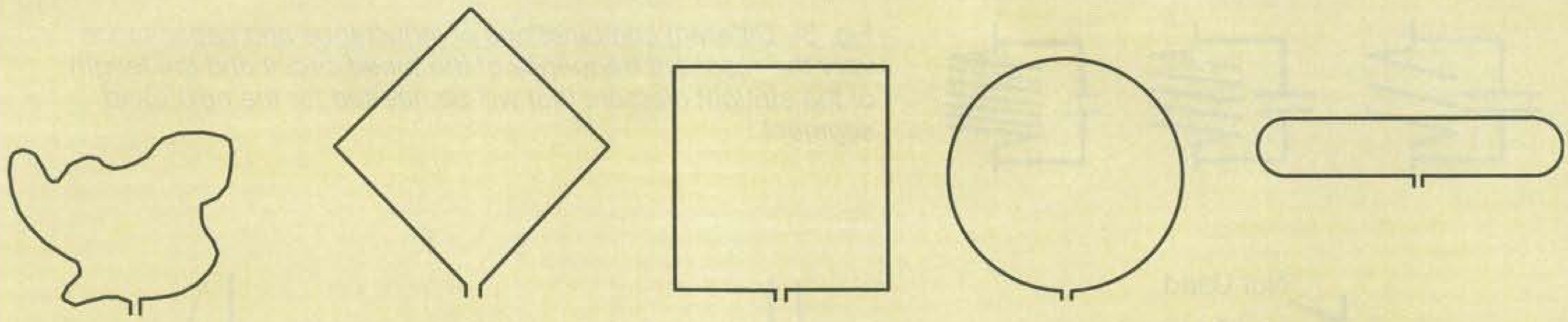


Fig. 8– Different types of loop antenna designs. The shape has no bearing on polarization. Because all are fed on the bottom, these all are horizontally polarized elements. Side feeding will give you vertical polarization.

at 28.1 MHz, then I just made the antenna longer for all the other bands as well. If I tweak just 20 meters, then I also change 30, 40, and 80 meters. Again, figure out just where you want to operate in each band and then tune the antenna from the top frequency down. Tune 28 MHz first, then 24 MHz, then 21 MHz, etc. (see fig. 7).

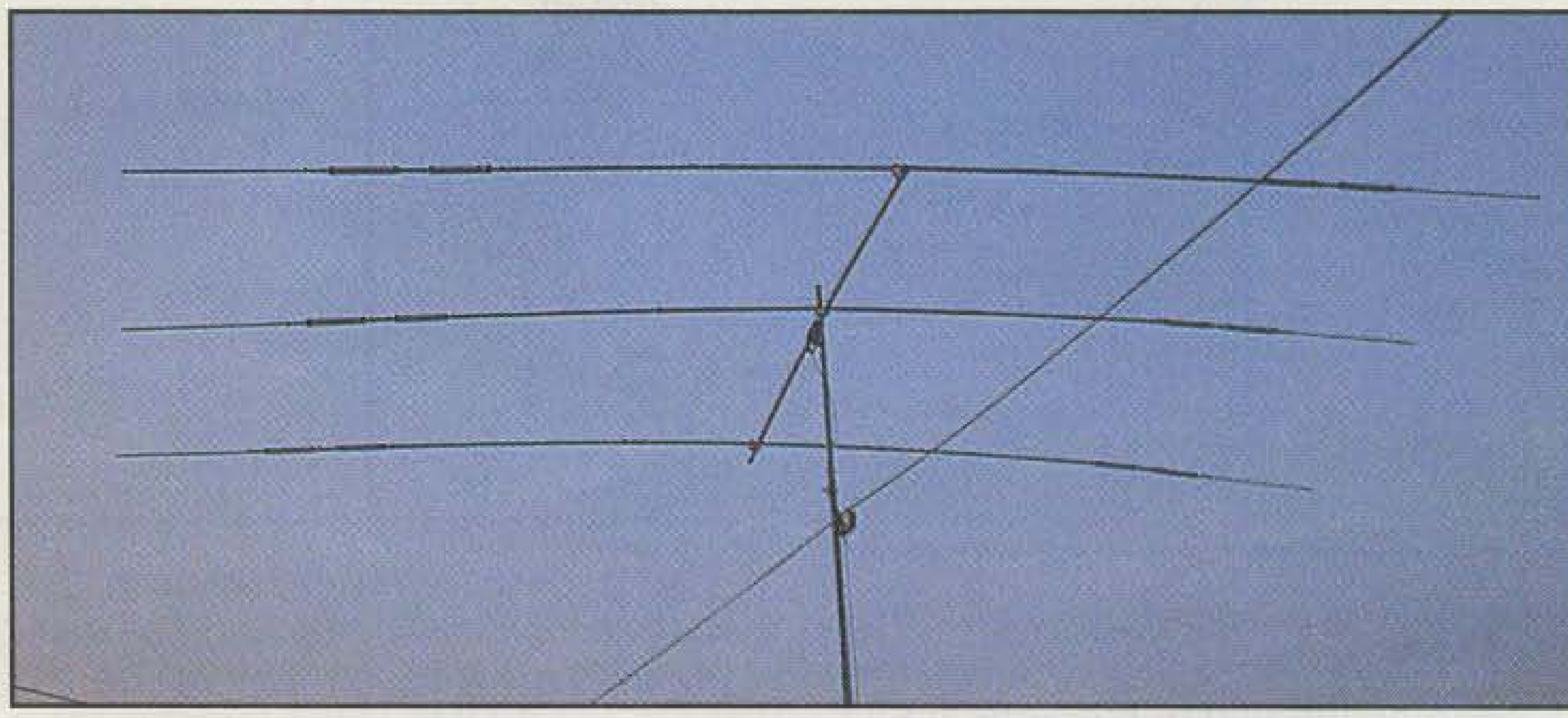
What About a Yagi?

Well, if we can use traps to design a multiband vertical antenna, putting two of them together end to end gives us a multiband trap dipole. Put together two or three trap dipoles and (over-simplifying again) we have a multiband trap Yagi. Sounds like a good topic for a future column.

Pet Peeves Regarding Antennas

My main pet peeve about antennas is that I am not a fan of quads. For nearly 20 years I have been an umpire at the Central States VHF Society antenna contest; we have measured about 2000 antennas over those years. The quad antennas we tested on the antenna range have never come close to their reputation. Only once, yes, once, has a quad won. That was eight years ago, when a 42 foot long 144 MHz monster quad barely beat out a 16 foot Yagi.

From 55 years ago we have the "observation" that quads have 2 dB more gain than Yagis.



Take a half-dozen trap verticals, arrange them in three groups of two each laid end-to-end, and you have an overly simplified approach to building a three-element triband Yagi. However, that's basicically what you're doing.

The more correct statement would be: "Moore's carefully tweaked quad had 2 dB more gain than Moore's slapped together, non-optimized Yagi." Ladies and gentlemen, it was not a level playing field!

Another urban myth is that quads transmit vertical and horizontal polarization at the same time. I can firmly state that it is *impossible* for a simple structure to transmit an electromagnetic wave. It has its electric field in two planes, and at the same time it has its magnetic field in two planes. *You can't do it!*

Okay, for those of you who are qualified to write this column, yes, there is circular polarization. However, while a 145 MHz CP antenna changes from vertical to horizontal polarization 290 million times a second, it is *never* vertical and horizontal at the same time. A light bulb transmits a confused polarization, but the emitting structure is millions of wavelengths across, and it is emitting an extremely wide bandwidth of energy—hardly a coherent wave.

Back to quads. . . . When you have a loop encompassing a volume (and a quad is basically a loop), the shape of the wire is not important as far as polarization is concerned, just the feedpoint relative to the loop. Because all of the driven elements shown in fig. 8 are fed at the bottom-center, all of these elements are horizontally polarized. To get vertical polarization, you would feed them on the side.

I once had a 1296 MHz Loop Yagi that looked a lot like that first one in the diagram after an owl got its claws tangled up in it. The owl had landed on the element, and then the element crushed under its weight, trapping its feet and claws. Fortunately, the owl figured out how to get itself loose, but the antenna didn't work very well after that.

Now to back up a bit, quads obviously work, and there are some excellent reasons for using a loop as a driven element. These include impedance, bandwidth, dissipation of static, multiple bands, and a host of other sound technical benefits. However, I will not credit these antennas with violating Maxwell's equations for electromagnetic waves or for curing diarrhea, gout, or arthritis.

Letters and Questions

Over the years my best topics for articles have come from your questions. Feel free to write to me at my Callbook address or via e-mail to <wa5vjb@cq-amateur-radio.com>.

73, Kent, WA5VJB

Oops...

Our Ohm's Law calculator was broken when we were writing up the description of the power requirements for Kenwood's as-yet-unnamed new HF + 6-meter mobile radio in August's "Hot Stuff at Hamvention" article. On the 200-watt model, the maximum power drain is 40 amps at 12 volts DC. The radio does have two DC power inputs, but the maximum draw on each of them is 20 amps, not 40. For home use, according to Kenwood, the radio may be powered by dual 20-amp supplies or a single 40-amp supply split to the two inputs. If only one 20-amp supply is used, the radio will sense it and automatically drop down to 100 watts.