BY KENT BRITAIN,* WA5VJB

"Cheap Yagis" for 2 Meters

This month we're going to talk about the 2-meter version of a family of easy-to-build Yagis. These are great for rovers, Field Day, satellite operation, or packet. Since "Cheap Yagis" were first published in 1993, over 70 versions from 50 to 5800 MHz have been developed. Before we get into building one, let's discuss the theory of how they work

Theory

You don't see any gamma matches, shorting bars, or any other adjustments on the driven element of a Cheap Yagi (see photos A and B). We are using *the structure of the Yagi itself* for impedance matching. How do we do that? Let's take a simple dipole antenna; its impedance is roughly 72 watts in free space. As I bring in another element, the second element loads down the impedance of the dipole. If I put this second element at just the right distance from the first, I can load the 72-watt dipole down to 50 watts.

For those of you who like to play with your own Yagi designs, to use just a straight dipole as your driven element, design for a 38-watt driven-element impedance. It works, and is simple enough, but you will not be able to couple much current into the Yagi structure, so there will be quite a compromise between gain and SWR. If you like to use a 300-watt folded dipole for the driven element, design for an 8- to 9-watt driven-element impedance when using 50-watt coax, or if you prefer to use 72-watt coax, then design the Yagi for a 12-watt driven-element impedance. You get more gain with a folded-dipole driven element than a straight dipole, but the elements are very close to the driven element and the dimensions are very critical—kind of hard to build with hand tools.

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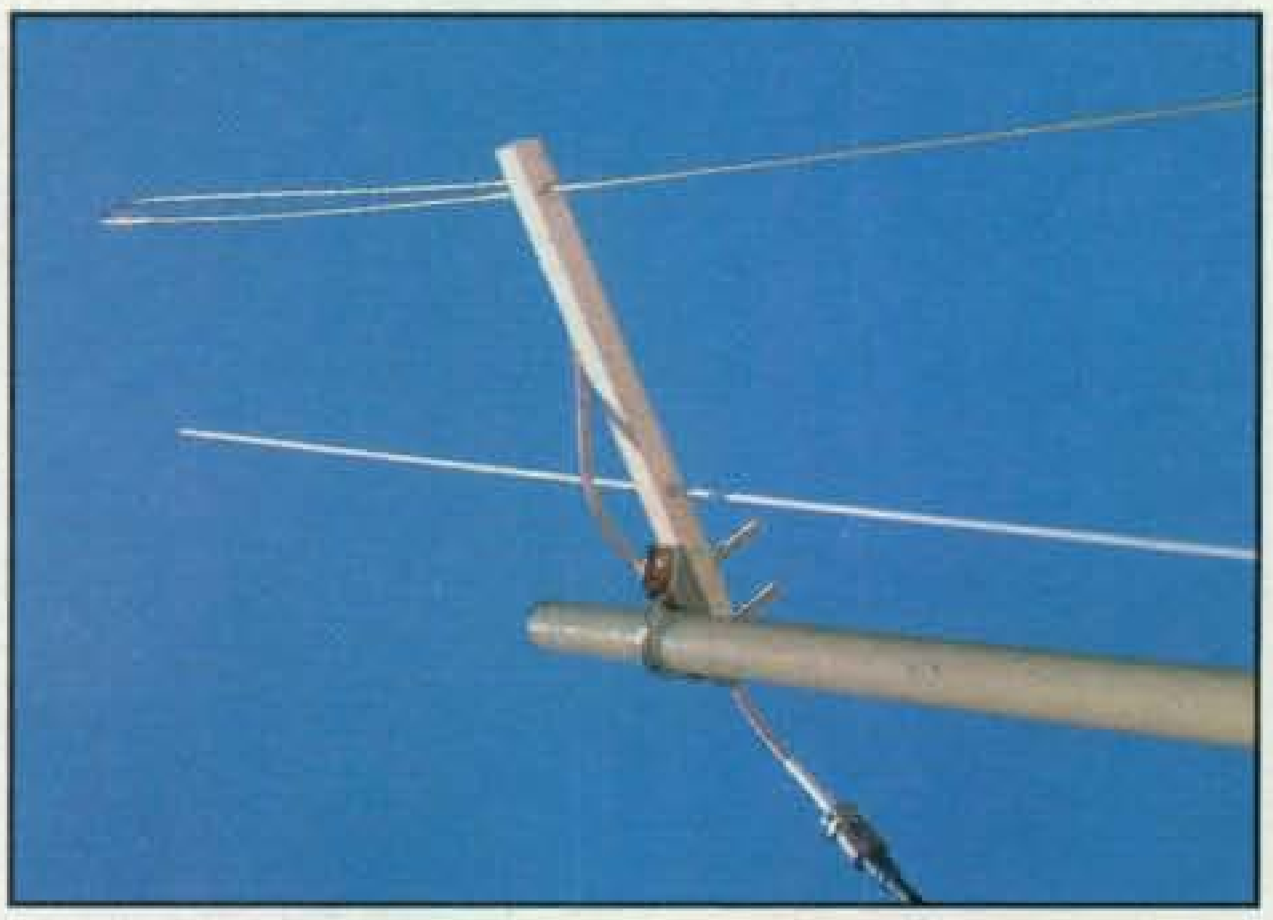

Photo A– Two-element 2-meter "Cheap Yagi."

My designs use a third option, a J element, as a driven element. You can also think of it as three quarters of a folded dipole. Its free-space impedance is about 150 watts, so we can load it down by a factor of two for a 72-watt model, or by a factor of three for a 50-watt version. (For a while, I had thought I just might have invented a new type of driven element, but Zack Lau, W1VT, at the ARRL send me a construction project from a 1950 edition of *Understanding Amateur Radio* with a 2-meter Yagi using a J driven element. Oh well, the story of my life. However, I do have US Patent 6307524-B4 on a highly specialized version of the "Cheap Yagi.")

These antennas have been optimized more on the side of bandwidth than of gain. That's why the dimensions are to a quarter inch instead of 1/10,000 of an inch. (I recently saw a 20-meter beam with dimensions published in 1/10,000's of an inch. Someone needs to take that calculator away from the lad! (Gee . . . Get real!) Optimizing on the side of bandwidth costs about 1/2 dB of gain, but the design tolerates somewhat sloppy construction and the substitution of different materi-

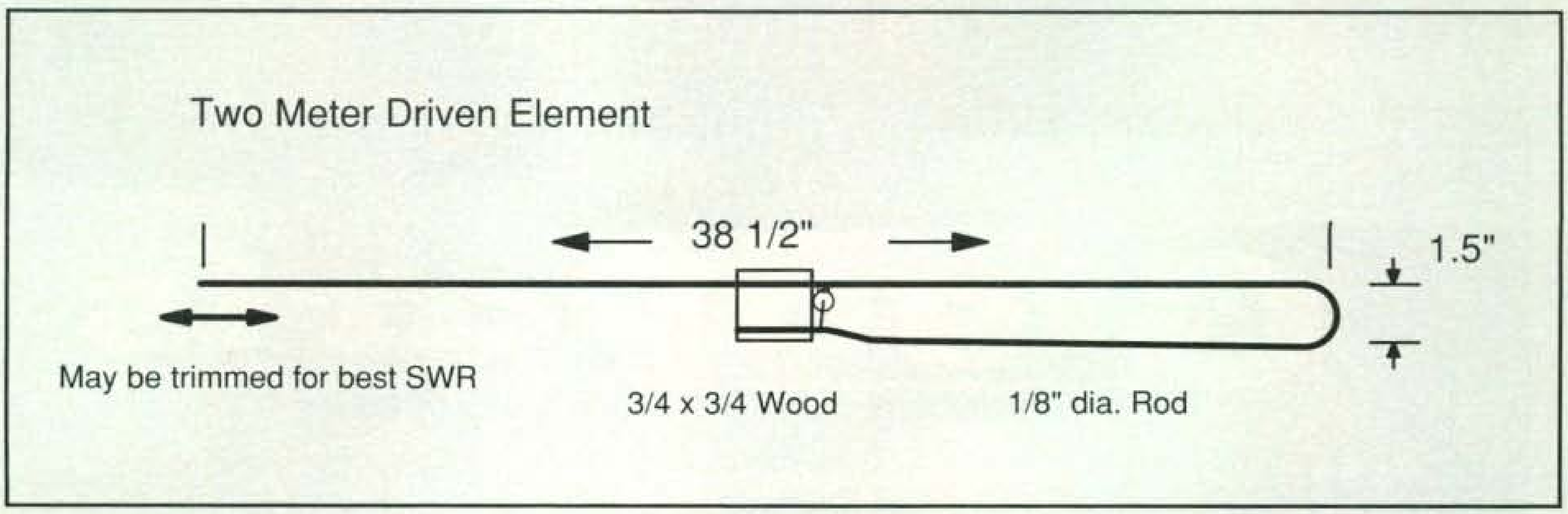

Fig. 1– Dimensions for the driven element used on all versions of the 2-meter Cheap Yagi.

Photo B– Four-element 2-meter Cheap Yagi.

Simulating a Cheap Yagi

Okay, for you chaps who like to keep your NEC4 Kernels up to date, the family of Cheap Yagis was designed with a Larson-based program, not NEC. Larson programs actually pre-date NEC by about 10 years, and assume that the current in a Yagi element is sinusoidal. This is more accurate than NEC (unless you're doing 100+ segments). Of course the current must really *be* sinusoidal. With NEC you can see what your 20-meter beam looks like on 6 meters, while a Larson-based program goes flaky if you depart from the design frequency by more than 10%. If you really want to have fun with a Larson-based program, just try calculating the pattern for your 144-MHz antenna on 288 MHz. Be sure to save your other work, because it's going to give you a bunch of divide by zero errors as the system locks up!

As mentioned in the main text, the J driven element doesn't simulate well, either in Larson or NEC. NEC doesn't like 90-degree bends. You'll need to bust up the 180-degree bend into several small segments for a good model, or substitute a straight dipole for the driven element and look for a 17–18 watt impedance. However, the best way is to just build the thing and talk on it!

Most of my Cheap Yagis start as computer models. Then I build a prototype and test it on the antenna range, where I determine the best length for the driven element. Thus, the driven element is experimentally determined, and the antenna range dimensions are the ones published. Virtually all of my published antenna designs were tested on the antenna range before I published the design.

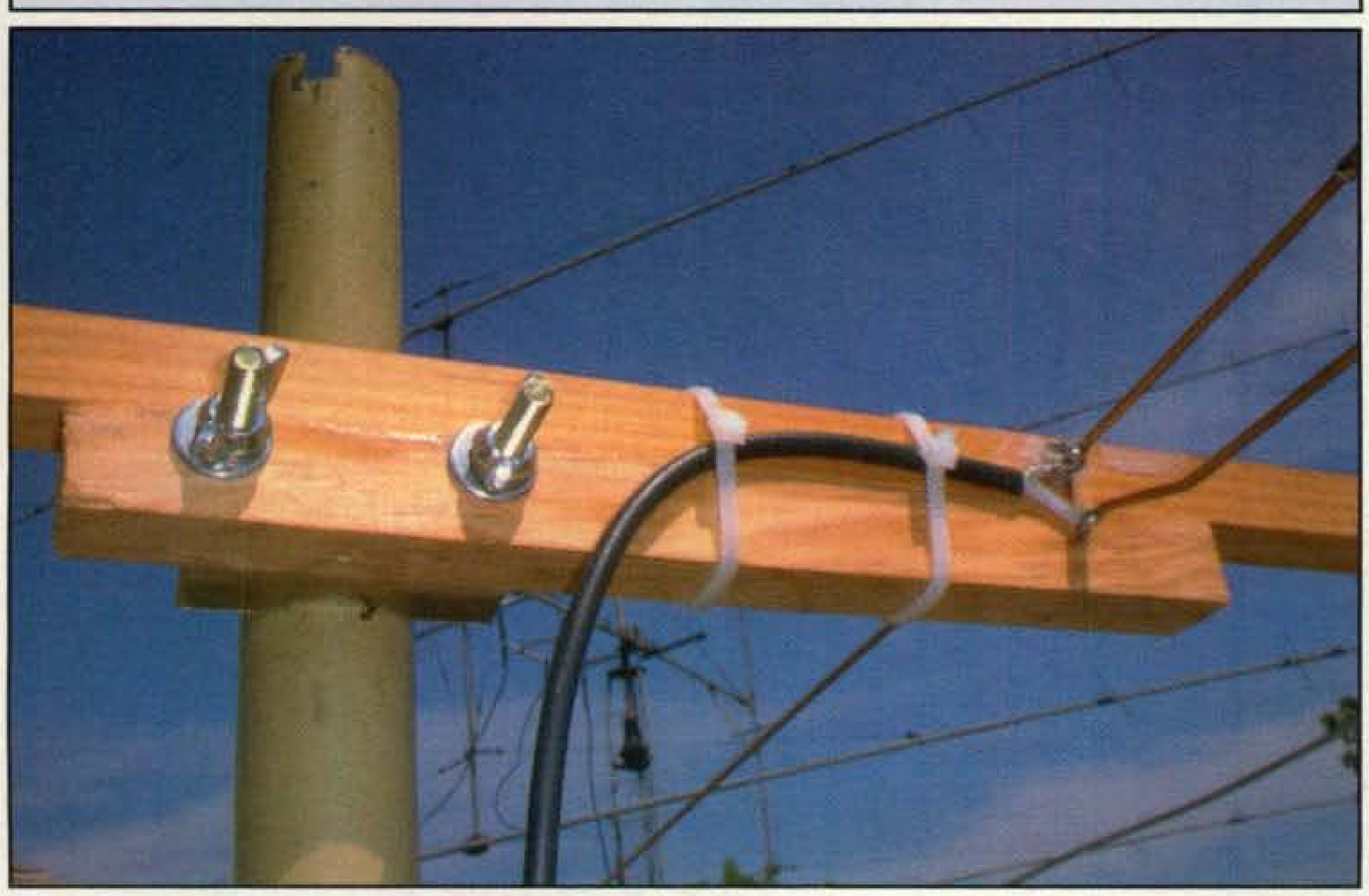

Photo C– The driven element and U-bolt on the 4-element Cheap Yagi.

Dimensions for the FM optimized "Cheap Yagi"

No. of Elements		Reflector	Driven Element	D1	D2	D3	D4
2	Length	41.0	*	—	—	—	—
	Spacing	0	—	7.0	—	—	—
3	Length	40.5	*	36.5	—	—	—
	Spacing	0	8.5	19.75	—	—	—
4	Length	40.5	*	37.0	32.5	—	—
	Spacing	0	8.5	19.0	40.0	—	—
6	Length	40.5	*	37.0	36.0	36.	32.25
	Spacing	0	7.5	16.25	33.5	51.0	69.0

Table I– Element dimensions and spacing for the 2-meter "Cheap Yagi." All dimensions are in inches. Spacings are all from zero starting at the reflector. Reflector and directors are made from 3/16-inch diameter material. If you can't find 3/16-inch diameter material and want to use 1/8-inch material for the elements, you need to make the 1/8-inch diameter element 1/4 inch longer to compensate for the smaller element material.

als. Heck, you can build these antennas for about $5. When it comes to dBs per dollar, you'll find these designs hard to beat. See Table I for element dimensions and spacing.

Construction

For the boom, I like to use 3/4-inch or 1-inch square wood. Fir, oak, or ash is great, but I usually just end up using a piece of pine. I like to put a brace where the driven element and U-bolt holes have weakened the wood, but that's a personal choice. Yes, PVC will work, but I've personally had bad luck with PVC pipe.

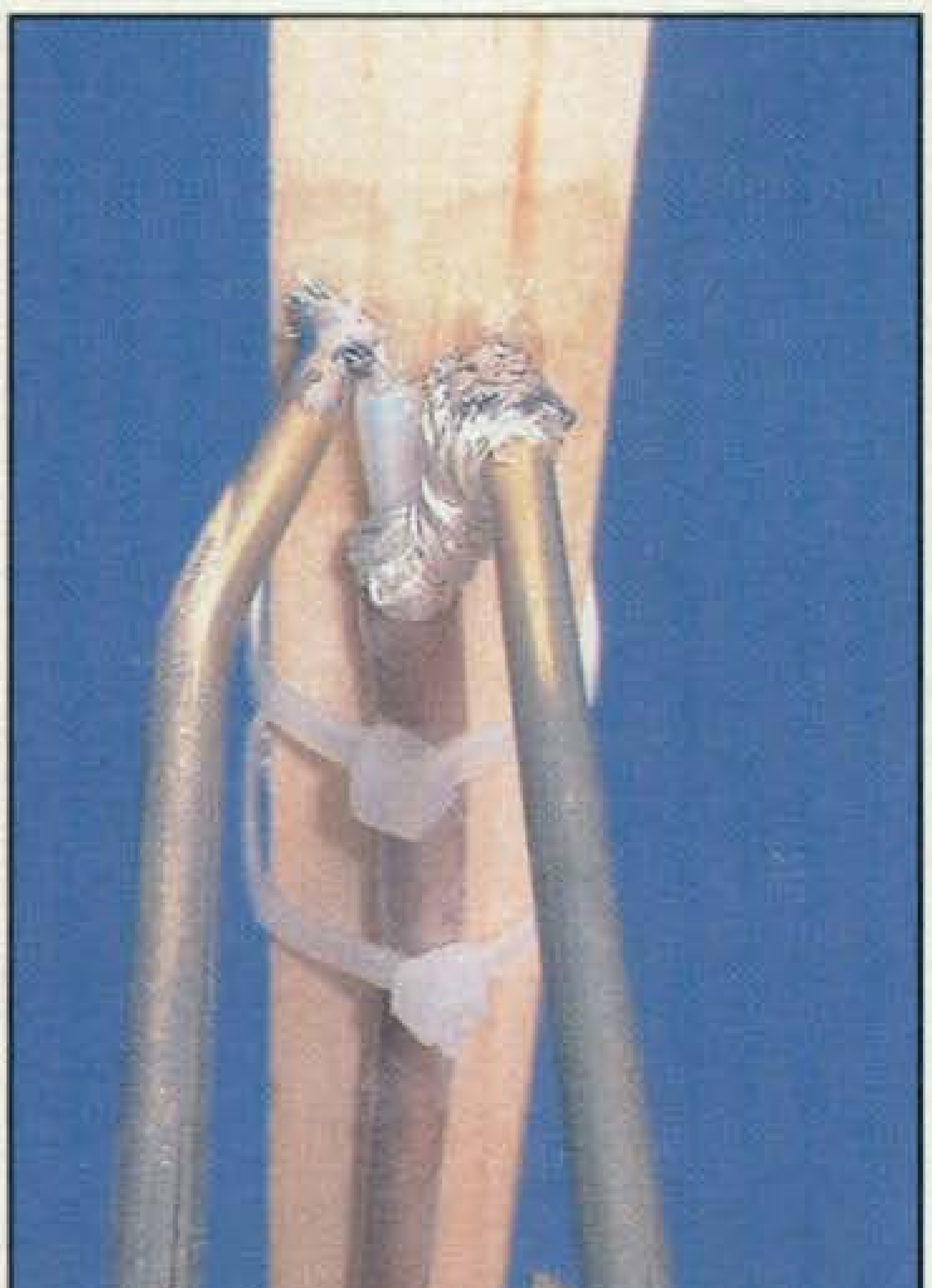

Photo D– Coax attachment on the 2-element Cheap Yagi.

For waterproofing, spar varnish, one of the Water Seal products, or just latex house paint work well, and the antenna should last as long as your house.

Aluminum rod, hobby tubing, #10 and #12 solid copper wire, and solid ground wire all have been used as elements. A drop of "Super Glue" epoxy, RTV, or my favorite—Liquid Nails™—can be used to hold each element in place. On the U-bolt, I've replaced the usual hex nuts with wing nuts. Those wing nuts are worth the few extra pennies when you're putting up an antenna for Field Day or at a contest rover site. ("Roving" is a popular activity in VHF contesting in which operators drive to and operate from more than one multiplier area during the course of a contest.)

For the 2- and 3-element versions, which are easily end mounted, I drill two sets of holes for the U-Bolt. This way the antennas can be mounted vertically or horizontally.

The Driven Element

A good hard-drawn copper wire or piece of hobby brass tubing can be used to build the driven element (see fig. 1 for dimensions). On the ones you see here, I used silicon bronze welding rod (see photo C). The welding rod is cheap, stiff, and easy to solder. If you look closely, you'll see where I used a few inches of 1/8-inch hobby tubing to splice two shorter pieces of welding rod. The shield of the feedline is attached near the center of the driven element. The coax center conductor is soldered to the free tip (see fig. 2 and photo D). Some hams have built these with an aluminum-rod driven element and attached the coax with various

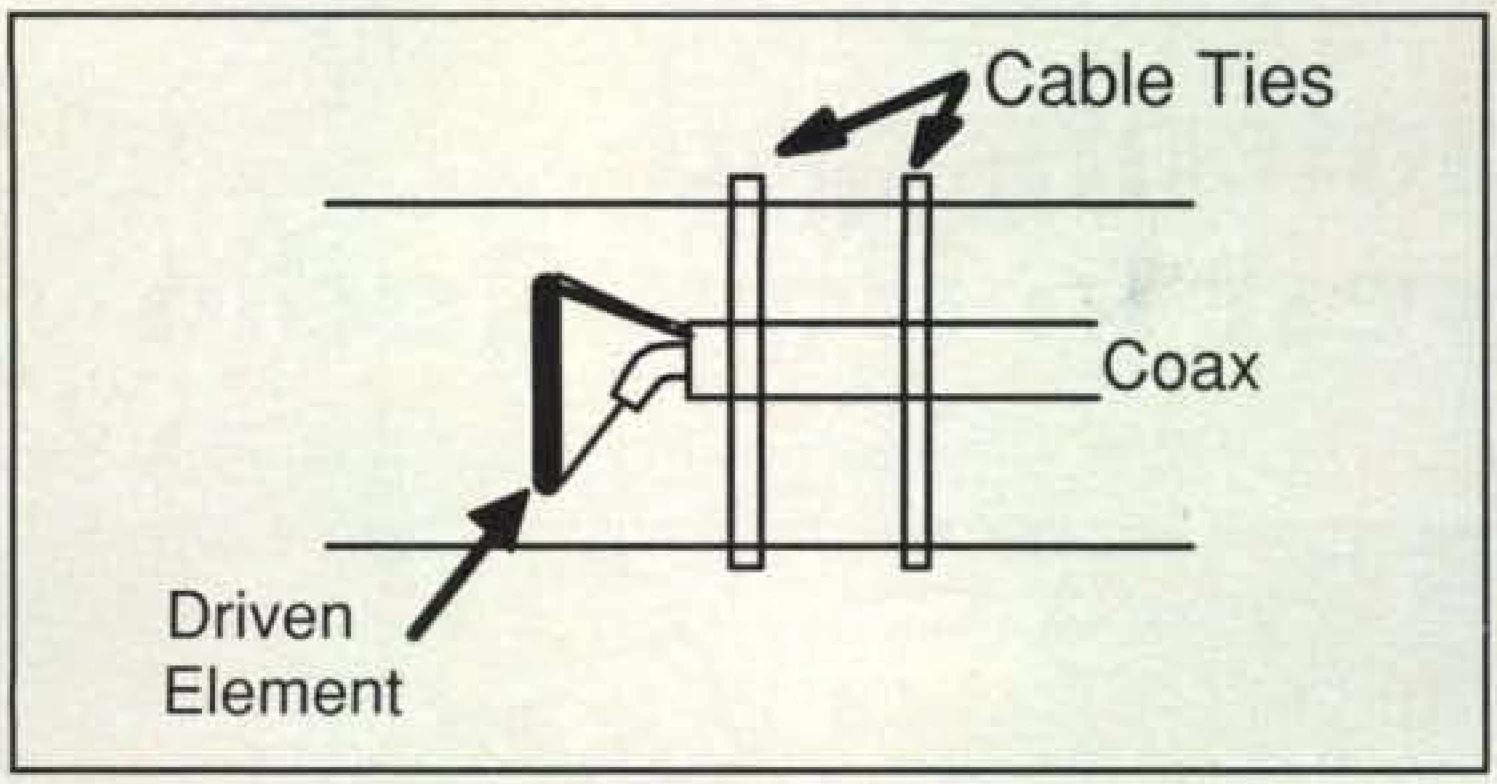

Fig. 2– Detail of how to attach coax to the driven element.

clips. However, if you can solder the coax directly to a brass or copper element, you'll be better off in the long run. The loop in the driven element is about an inch and a half wide, but this width is not critical. Computer programs just can't model this driven element well, so the best dimensions are determined on the antenna range. (See the sidebar, "Simulating the Cheap Yagi," for more on computer modeling of these antennas.)

Using Your Cheap Yagi

(Build it, Hook up the Radio, and Start Talking!)

Build it pretty close to the dimensions, and the SWR should be less than 2:1, and 1.5:1 is more typical of what you'll measure. That low an SWR is safe to use on the air without having to constantly check it. You're welcome to tweak it for lower SWR. I use a small section of copper or brass hobby tubing slipped over the end of the driven element (see photo E). Slide it in and out, and then solder it at the best point. The hobby tubing is also a quick fix if you trim the end a few too many times.

Just to see how low I could go, I played with it on my network analyzer. Got it right down to and below the uncertainty (margin of error) in my directional coupler, about 47 dB return loss. We will be talking more about return loss in subsequent columns. Return loss doesn't equate very well to SWR, but 47 dB RL would be an SWR of less than 1.009:1.

By the way, you don't have to mount these outside. I have a half dozen mounted in my attic space. If you just need a simple antenna for a local repeater, packet node, or ATV system, these antennas are something you can build in less than an hour for a few bucks.

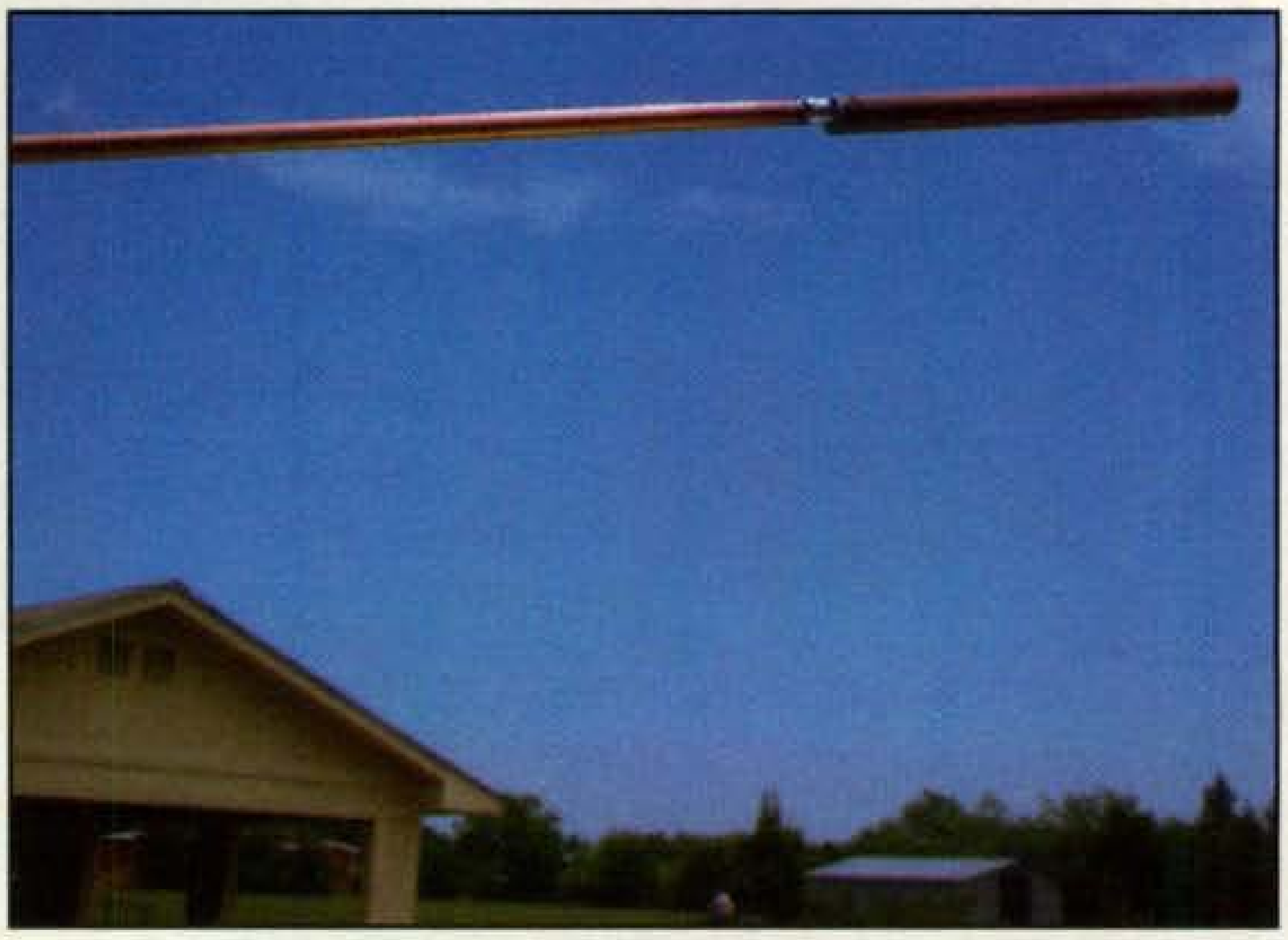

Photo E– Sliding tube on the driven element used in testing.

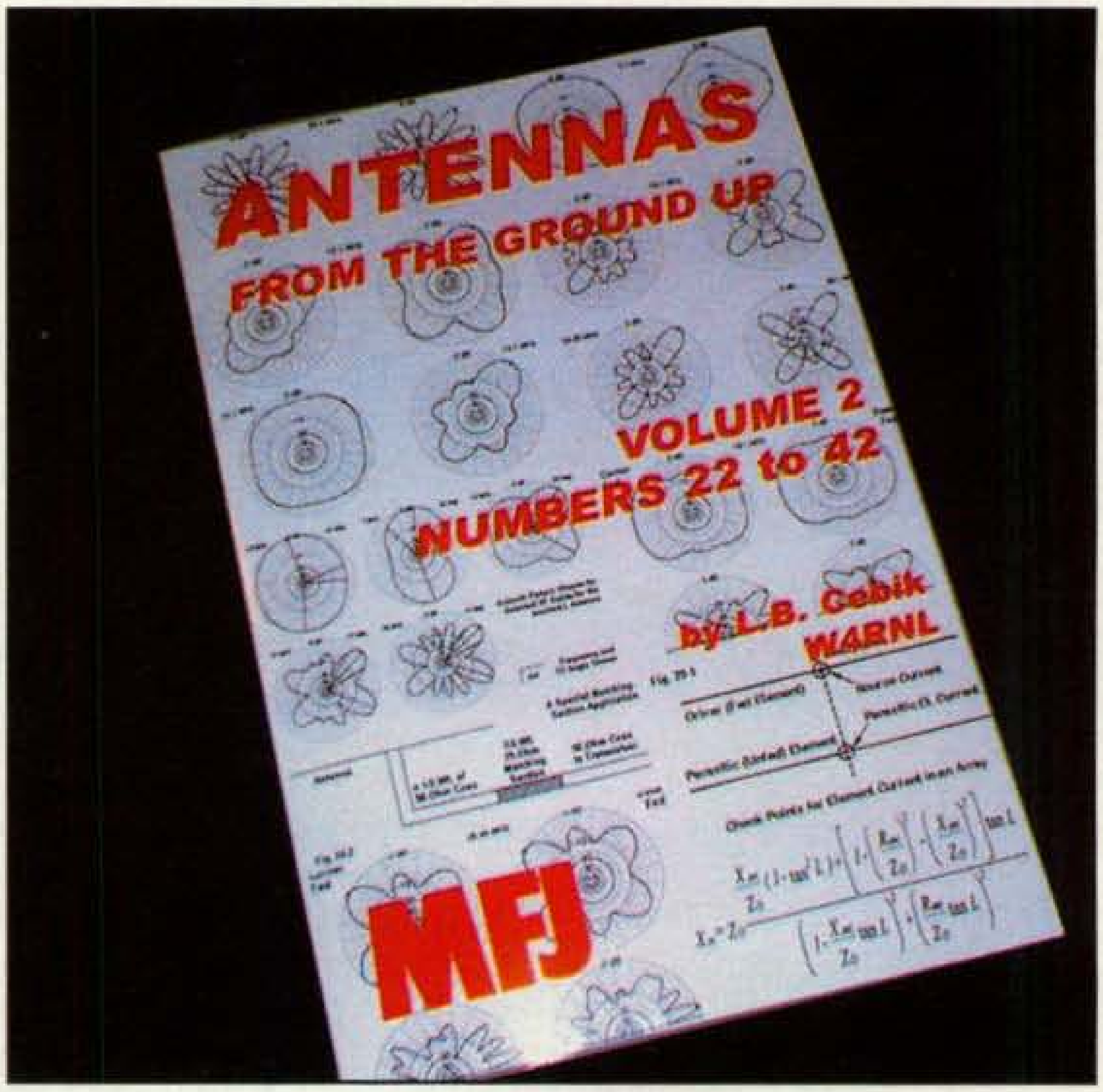

Photo F– W4RNL's new book, Antennas From the Ground Up. Vol. 2, *published by MFJ.*

Mini Book Review

We don't normally cover new books in this column, but this book by L. B. Cebik, published by MFJ, is particularly good. *Antennas From the Ground Up Vol. 2* (photo F) is a collection of 20 papers by W4RNL on HF antennas and related topics. Any one of these papers would made a good antenna column—uhh . . . they do say plagiarism is the most sincere form of flattery!

Again, an excellent book, *Antennas From the Ground Up Vol. 2,* by L. B. Cebik, MFJ-3307.

Letters, Letters...

From Tom, we had a comment about using room-temperature superconductors to build antennas. Yes, Tom, room-temperature superconductors are not yet available (and I'm not holding my breath until they are), but there is nothing in current superconductor theory that says they never can be. Several alloys will go superconducting in liquid nitrogen, which is far more practical than the older niobium ones that needed liquid helium.

Several years ago I visited Super Conducting Technologies in Golden, Colorado. They build several different RF filters out of superconductors for use in severe RF environments. The response of those filters was absolutely amazing, nearly vertical –80 dB skirts. Due to surface roughness and other losses, the loss in a superconducting filter or antenna would not be zero, but still very, very low. Thus, the 4-foot vertical on 160 meters that gets out like a quarter-wave with 120 radials isn't currently available ... but it's fun to dream.

Coming up...

In September we'll go over more of your letters and the 440-MHz versions of Cheap Yagis, but use the weeks in between to get more copper and aluminum in the air!

73, Kent, WA5VJB