Discover Ham Satellites with a Cheap Yagi

BY KENT BRITAIN,* WA5VJB

If ham radio satellites have always seemed out of reach for you because of cost or complexity, there's something you should know: If you own a dual-band handheld, you already have the most expensive and complicated part of an introductory satellite station. If you can hold a lightweight antenna, lift it over your head, and move it every couple of minutes, then you also have the getting-started rotator (you!). All that's left is the antenna, and this month's "Cheap Yagi" (photo A) will fill the bill—at a cost of about one $10 bill.

There are several low Earth orbit (LEO) FM satellites you can access with nothing more than a dual-band handheld (more about them later), and handheld dual-band antennas have become quite popular for making QSOs through them. Our version is a combined145-MHz/435-MHz antenna that's only 32 inches long, with two elements on 145 MHz and five elements on 435 MHz. At less than a pound, it's easy to hold up.

One popular commercial handheld satellite antenna mounts the elements for the different bands 90 degrees apart from each other. This is a mechanical, not really an electrical, decision. Crossed elements make the boom shorter, but mounting them flat (photo B) makes the antenna much easier to lay down in the back of a truck or store in the garage. If you mount all the elements in the same plane (which I find easiest), be aware that the last 145-MHz director and the 435-MHz reflector will interact if they're too close together. Space them three inches apart and everything should be fine.

*1626 Vineyard, Grand Prairie, TX 75052
e-mail: <wa5vjb@cq-amateur-radio.com>

Construction

For the boom, 5/8" × 5/8" or 3/4" × 3/4" wood works well. If you plan to mount the antenna outside for a long time, a coat of spar varnish, spray enamel, or some of that waterproofing stuff you use on wood decks will add years to its life.

For the elements, I used 1/8-inch material. The 435-MHz reflector and directors were from a roll of RadioShack aluminum ground-rod wire. Forty feet will run you about 5 bucks and make a lot of anten-

Photo A– "Cheap Yagi" for working FM "Easysat" satellites.

Photo B– Drew, KO4MA, using the Cheap LEO Yagi during a Dayton demonstration. In the background you can see CQ VHF Satellite Editor Keith Pugh, W5IU, using his Arrow commercial antenna. The Cheap LEO Yagi was at least as effective.

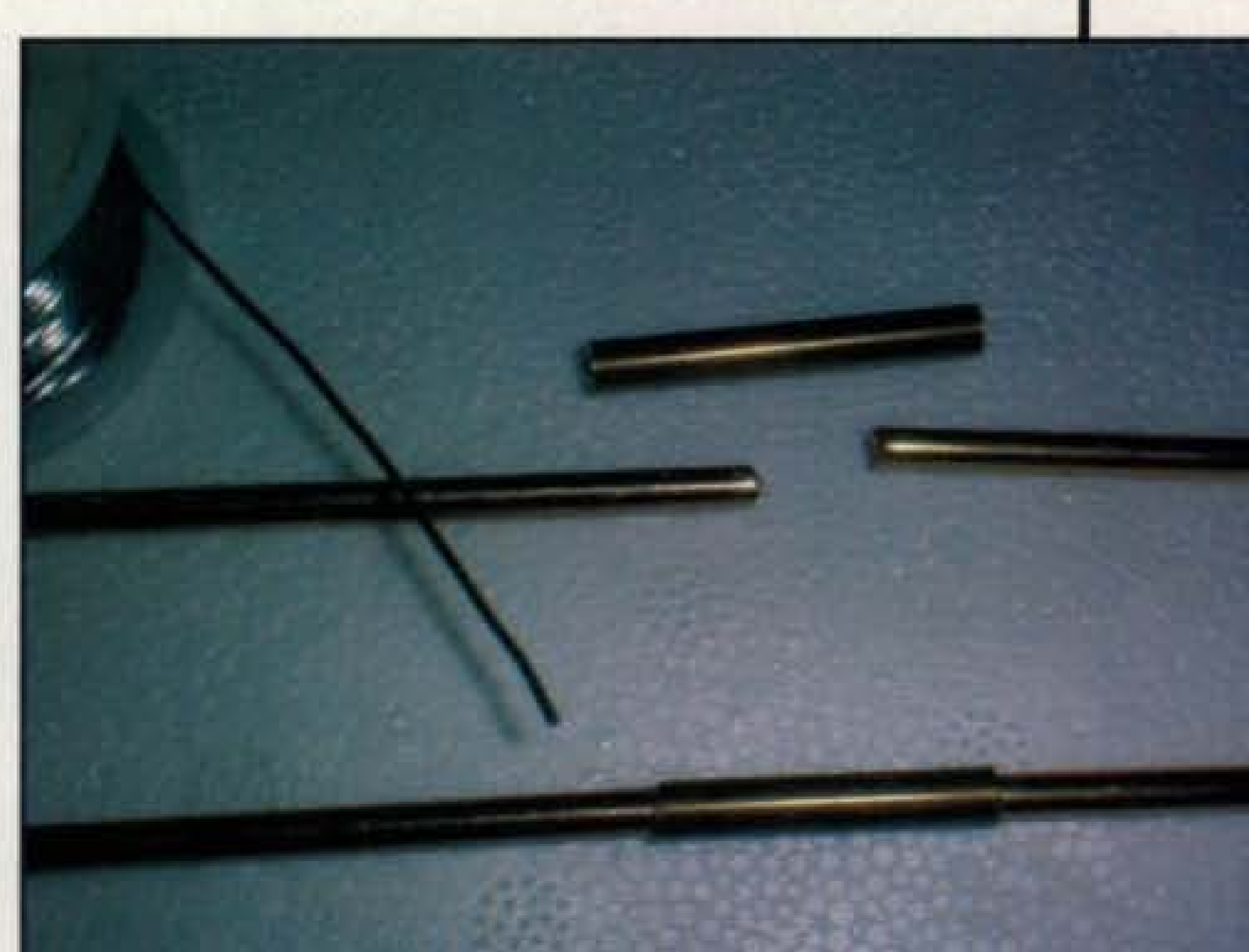

Photo C– Element splice using hobby tubing ... in case you trim off too much and need to lengthen an element.

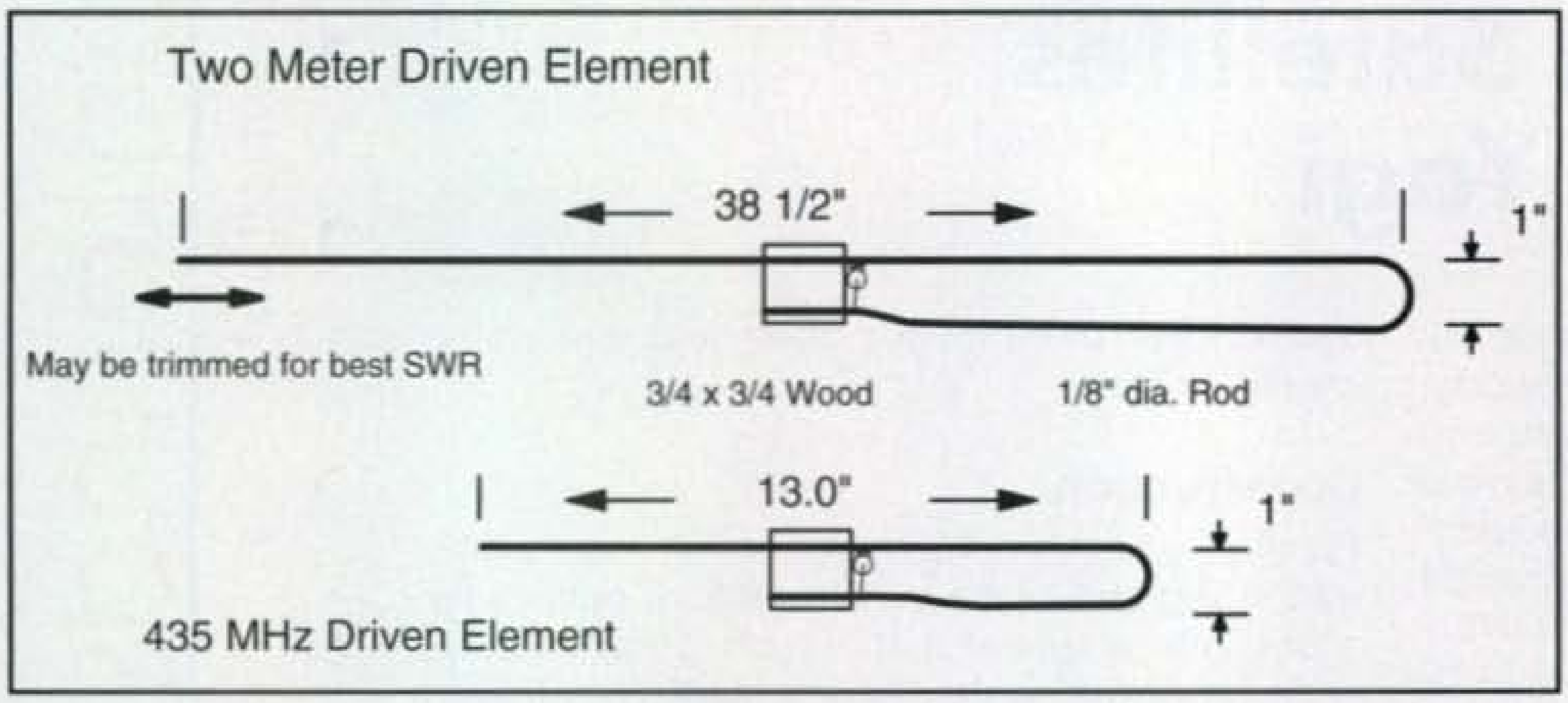

Fig. 1– Dimensions of the driven elements. Note that these dimensions do not include the additional wire needed for the lower portion of the "J."

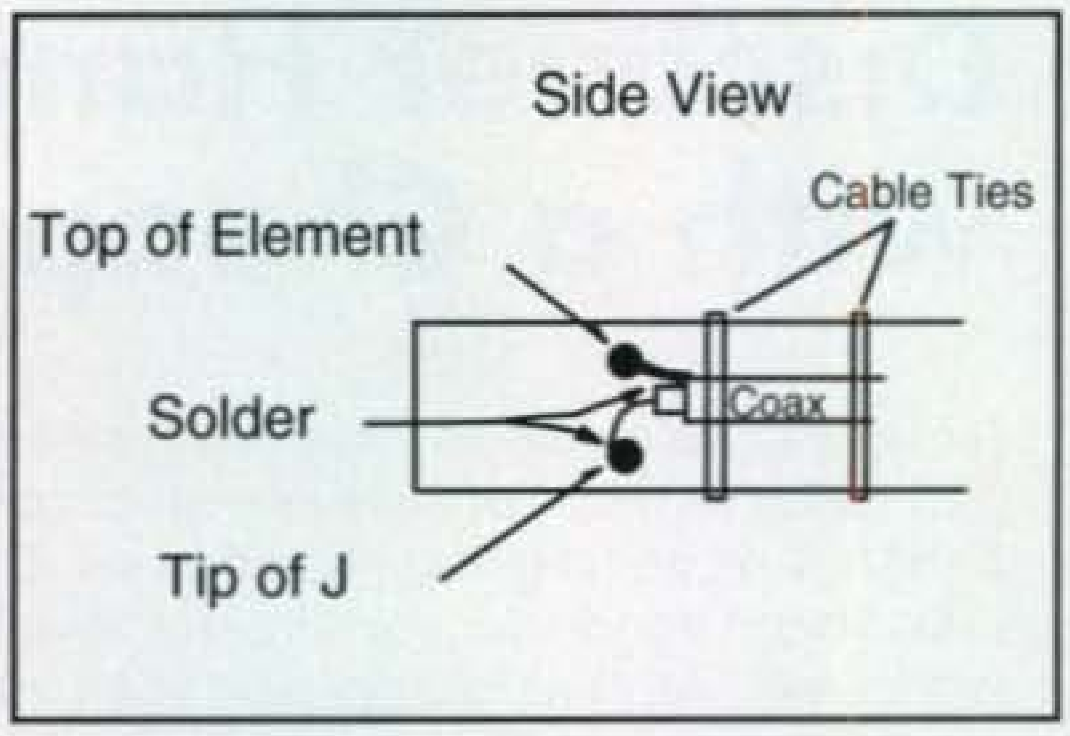

Fig. 2– Attaching the coax to the driven elements.

145 MHz Elements (2)

	Ref	DE*
Length	40.5	38.5
Spacing	0	7.0

435 MHz Elements (5)

	Ref	DE*	D1	D2	D3
Length	13.5	13.0	12.5	12.25	11.75
Spacing	0	2.5	5.25	12.0	18.5

Ref is the reflector, DE is the driven element, and D1, D2, etc., are the directors. All spacings are measured from the reflector element.
**The "J" driven elements extend the length of wire needed for each by approximately 50%. See fig. 1.*

Table I– Antenna dimensions (in inches).

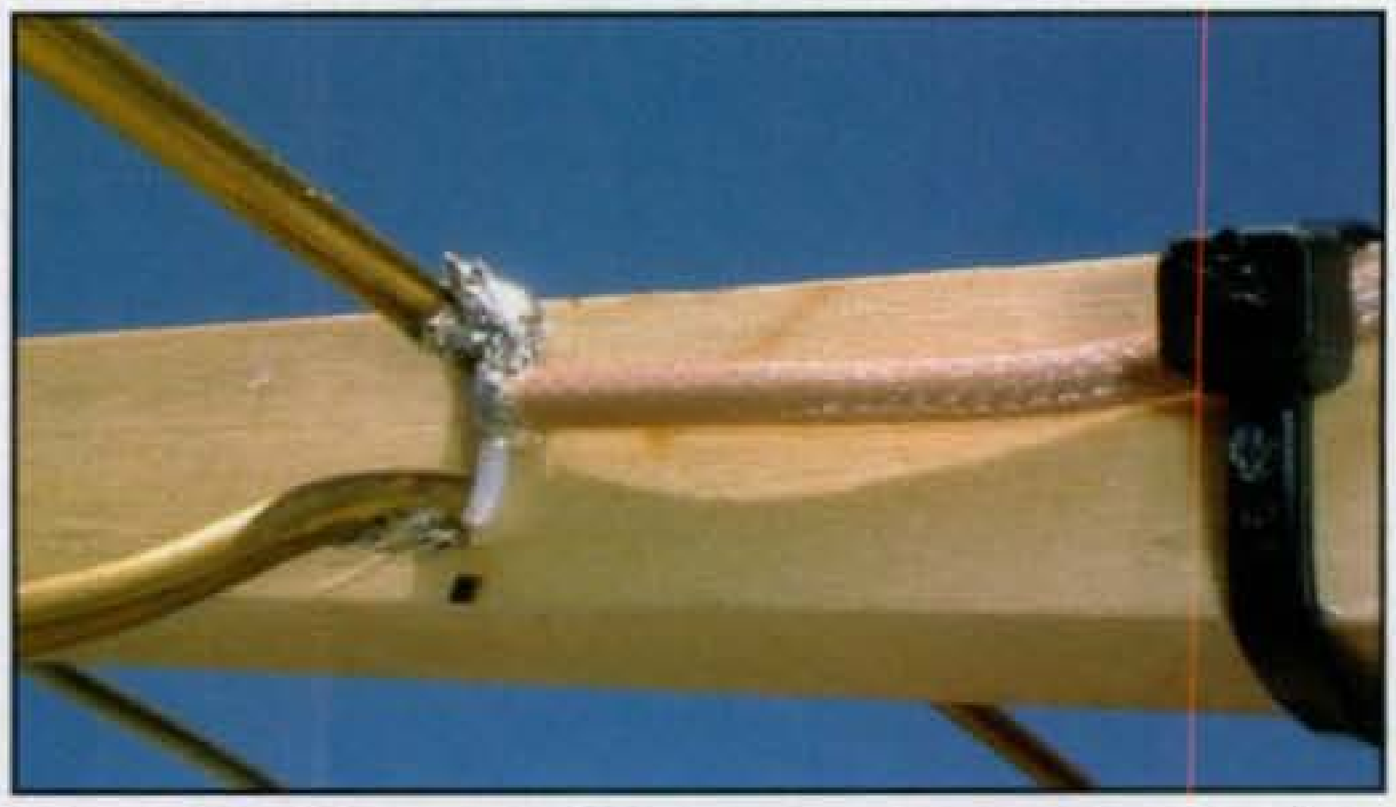

Photo D– Close-up of the coax connections to the driven element.

na elements. However, #10 bare copper wire, bronze welding rods, and hobby tubing all have been used to make elements. If you want to use 3/16-inch diameter elements, cut them .2 inches shorter than the dimensions in the tables to compensate for the thicker material. The 2-meter elements were all made from bronze welding rod. For the driven elements, I like to use something to which I can solder the coax directly, and the coppe- wire or welding rod solders well. See fig. 1 for driven0element dimensions; all other dimensions are in the table.

The welding rod is only 36 inches long. A section of 1/8-inch ID copper or brass hobby tubing makes a good splice. Just slip it on and solder them together. Save some of that hobby tubing. If the antenna ends up too short after trimming, you can solder a piece of tubing onto the end of the driven element and start over (photo C).

I usually hold the elements in place on the boom with a drop of super glue, but silicon glue and even paint have been used to hold the elements in place.

The driven elements are "J"s and they usually bring several comments from people new to "Cheap Yagis." The shield of the coax goes near the center of the *top* of the element (see fig. 2 and photo D). This is a voltage null and directly soldering the coax to the driven element has a lot of advantages. The center conductor of the coax goes to the tip of the J, so you can think of this driven element as three fourths of a folded dipole or a gamma match with no capacitor.

In free space, the J driven element has about a 150-ohm impedance. As other elements are added, they load down the impedance of the driven element. If the antenna has relatively wide element spacing, then a direct match to 75 ohms is possible. Bring in the reflector and directors a little closer, then you have a direct match to 50 ohms. Therefore, the impedance matching is the length and spacing of the other elements. Just build the antenna to the dimensions, solder on the coax, and start talking. No tuning required.

Band Splitter

The band splitter consists of a 250-MHz high-pass filter and a 250-MHz low-

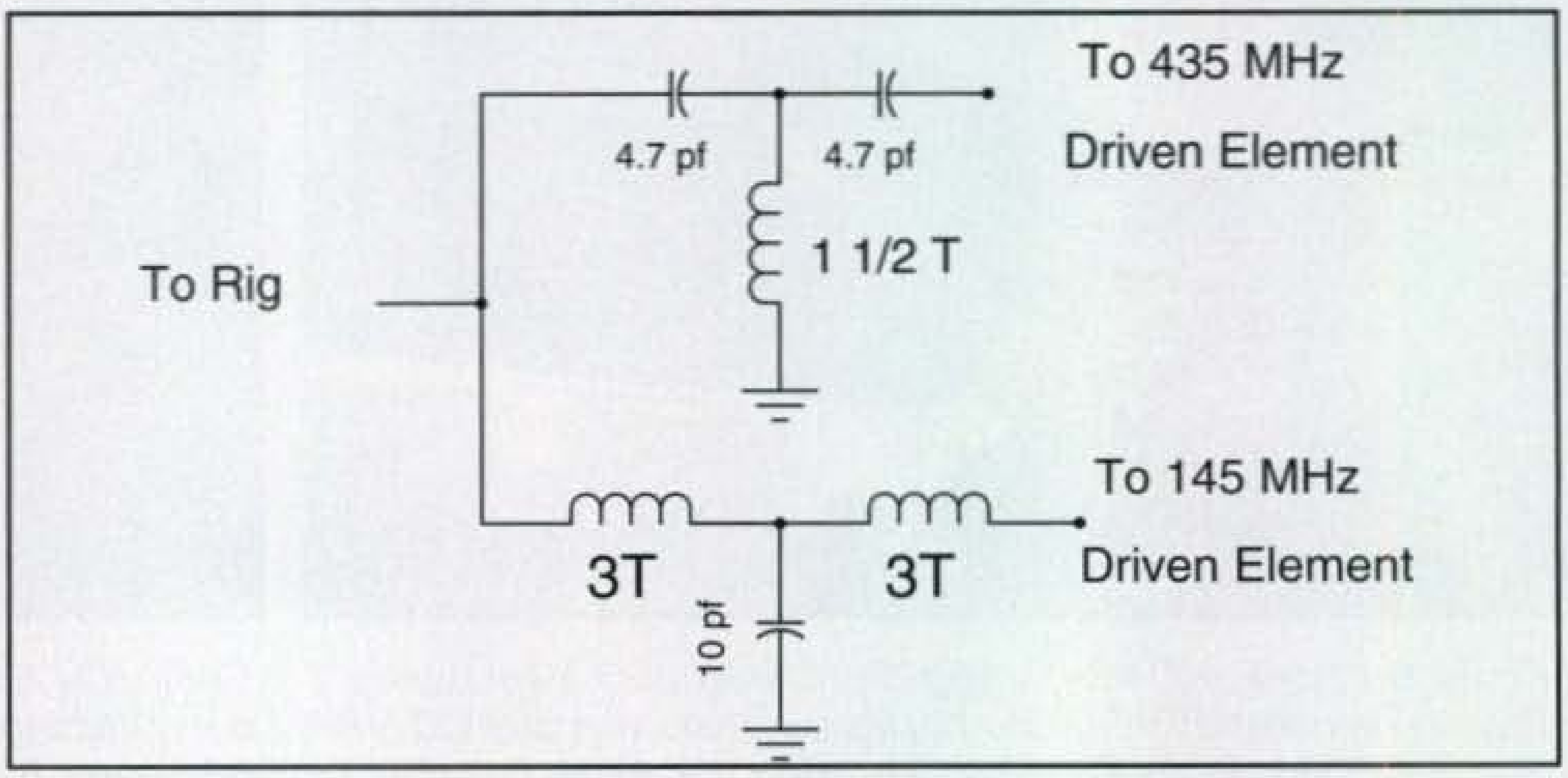

Fig. 3– Schematic of the band splitter.

Photo E– 145/435 MHz band splitter.

Photo F– Winding the band splitter coils.

pass filter connected together (see fig. 3 and photo E). This doesn't have to be very complex, or even very accurate. As long as the filters cut off somewhere between 200 and 400 MHz, they will work fine. If the coils get squished, just bend them kind of back in shape, and go for it. This one is built cheap, just out in the air on a piece of PC board. You can build the splitter into a box if you like, with connectors and all, but it's not going to change its performance. Remember, we are not trying to filter off harmonics, just make the 2-meter energy go to the 2-meter antenna, and the 435-MHz signals go to the 435-MHz antenna. This band splitter even makes a good project if you want to use two other 145/435-MHz antennas.

The parts list for the splitter is short and, of course, cheap:

435 high pass: Two 4.7-pF capacitors, one coil of $1^1/2$ turns #18 or #20 wire wound on a pencil (see photo F).

145-MHz low pass: One 10-pF capacitor, two (2) coils, each 3 turns #18 or #20 wire on a pencil.

(You're too late. I have already been asked if it needs to be a #2 or a #3 pencil. For the record, I wound my coils on a red grading pencil. For those of you with a more mature sense of humor, just about all wood pencils make a .3-inch coil form.)

The length of the coax between the splitter and the antenna is not critical. You want to keep the coax as short as practical, but its exact length is not important, nor are exact capacitor values. Got a box of 4.7-pF caps? You can use two of them (in parallel) instead of the 10 pF. Regardless, be sure to keep those leads very short. I used Teflon® coax on my splitter, by the way, because

it solders so much more easily than foam RG-58.

Power Handling

Power handling of this band splitter depends almost entirely on your caps. With 50-volt caps, 20 watts is about your limit. Dig up some 1-kV caps, and the coax will probably melt first as you warm up that 4CX250 amplifier. (Just kidding—*do not* use high power to operate these satellites!)

Tuning It Up

For the ultimate in performance connect your coax to just the 2-meter portion and trim the free end of the J for best SWR for your favorite LEO uplink frequency. Then connect the coax to just the 435-MHz portion and again trim the free end of the element for best SWR. Now install the band splitter and this time tweak the coil spacing for best SWR at your spot frequencies. You have now gotten the last .1 dB out of the antenna.

For everyone else, just build the antenna to the dimensions and the SWR will be under 2:1 on both frequencies. Just build it and talk. The design is pretty foolproof.

Taking Your New Antenna Outside

There are three ways the antenna can be used. If you have a rig that will operate crossband duplex, then you can transmit and listen to your return signal at the same time. (There's a little delay that can be a little disconcerting until you get used to it.) Rigs such as the ICOM W32A, the Yaesu FT-530, or the Kenwood D7 are great for working satellites this way. You can actually hear how well you're getting into the bird.

With rigs such as the Yaesu FT-817 or the ICOM 706 Mk II, you can work the birds in simplex mode. That is, you talk, then listen, as on most repeaters. Also, just about any dual-band talkie can be used. If you want to use two different rigs for 145 and 435 MHz, then eliminate the band splitter and solder on a separate piece of coax for each band. Now your transmitter can be most any 2-meter rig and the receiver can be most any 440-MHz rig or even a scanner.

The Birds

There are two satellites most commonly used with FM. AO-51 uses 145.92 MHz up with a 67-Hz tone, and 435.300 MHz back down (receive frequencies vary with Doppler shift; see resources below). SO-50 is a bit more complex with the control tones, but uses 145.85 MHz up and 436.795 MHz back down. Plus, even after all these years, AO-27 (launched in 1993) is often on as well. For more information on frequencies and times be sure to visit <www. amsat.org>. The Frequently Asked Questions at <http://www.amsat.org/amsat-new/information/faqs/ao27so50faq.php> are very good for newcomers to satellite operations. I know it's against ham tradition, but read them before trying to use one of the satellites.

Now you can have fun with these LEO satellites for less than $10. My column in the summer issue of *CQ VHF* is an expanded version of this one, and offers a variety of other options for different antenna configurations. You can also find more information and variations on my website at <www.wa5vjb.com/Reference>. Please keep those e-mails coming. I'm always looking for antenna topics.

73, Kent, WA5VJB

Neat Antennas

I am always a sucker for neat antennas at fleamarkets and surplus stores. The ones in photos G and H are external antennas for a cell phone. I don't know how old they are, but it has been a long time since I have seen a cell phone with a TNC connector!

Opening up the antenna was even more interesting. It's a J-pole etched on a PC board. First time I've seen that. I am sure there was a good reason for twisting the stub over to the side like that, but I haven't figured it out as yet. If you want to make your own PCB J-pole, start with the usual free-space calculations for the length of the element and the stub. Now multiply those dimensions by 60%. This allows for the effects of the fiberglas PCB and should get you pretty close to your design frequency. I think you'll find 800 MHz or so is the lowest practical frequency unless you have some very large pieces of PC board. It might work well on that 2.4-GHz project.

Photo G– A couple of really neat cell phone antennas. I have no idea how old they are…

Photo H– Close-up of the PCB J-pole antenna, the first time I've ever seen a J-pole etched onto a PC board.