BY KENT BRITAIN,* WA5VJB

Circular Polarization— Putting the Right "Spin" on Radio Signals

Some day I may devote an entire column to circular polarization. Explaining how circular polarization is generated can be a bit math intensive and keeping it simple is quite a challenge.

Circular polarization has a variety of advantages and disadvantages depending on how it's used. If you are on 146 MHz, then a signal from a circularly polarized antenna appears to spin 146 million times a second. (I'll need to really crank up the voltage on my drill!) Half the time the antenna is vertically polarized, and half the time the antenna is horizontally polarized. If you are listening to a circularly polarized antenna with a linear, or whip antenna, then it is not taking advantage of the signal half, or 3 dB, of the time. In short, you are losing half of the signal.

There are three cases where circular polarization has an advantage:

First is a tumbling satellite. As the satellite rotates, the signal is never cross-polarized, so there is far less fading. Fading is still possible when the satellite antennas are edge on to the Earth station, but in general fading is greatly reduced.

Second is multipath. With high-speed digital signals, multipath can cause all kinds of decoding problems. First you have the direct signal. Then another signal bounces off a water tower or building and arrives a few millionths of a second later. The digital receiver is now hearing two signals with different symbols and can get pretty confused.

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Photo A– The ring-stub circularly polarized antenna.

If you're not familiar with cross-polarization, a vertically polarized signal is reduced 20 to 30 dB when the receive antenna is horizontal. The same thing happens with circular polarization. If the transmitter signal is spinning to the right, and the

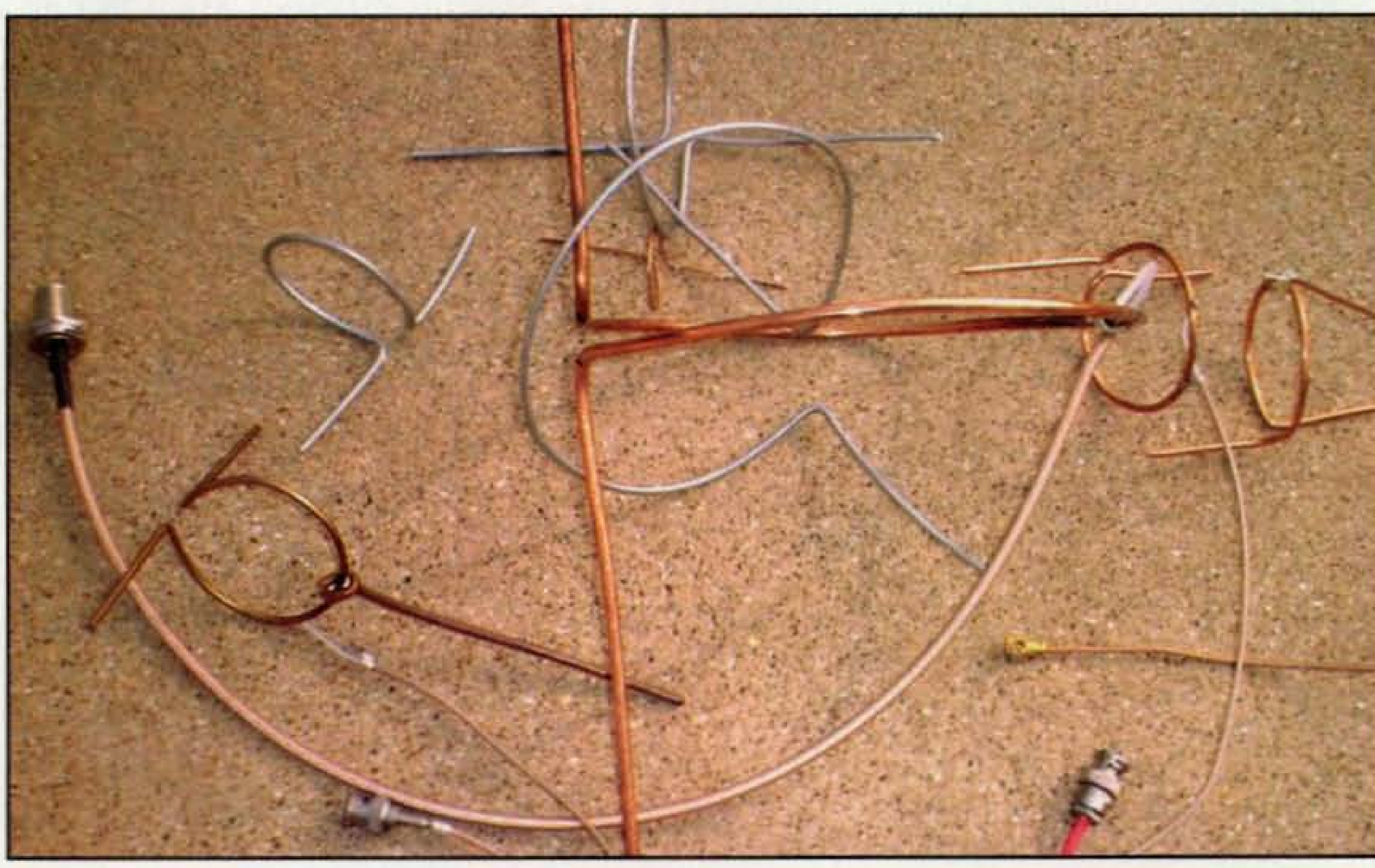

Photo B– A collection of ring stubs.

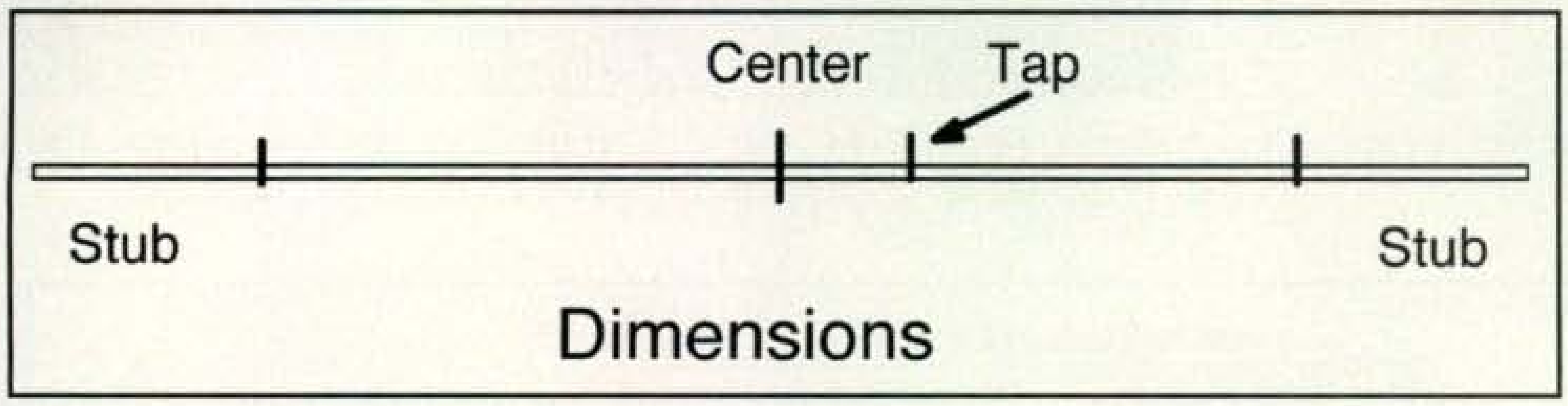

Fig. 1– Laying out the dimensions for a ring-stub antenna.

Band (MHz)	Length (in.)	Stubs (in.)	Tap Point (in.)	Gap (in.)
147	39.5	8.0	3.0	3/4
223	26.0	5.25	2.0	1/2
445	13.0	2.6	1.0	3/8

Table I– Dimensions for some popular frequencies.

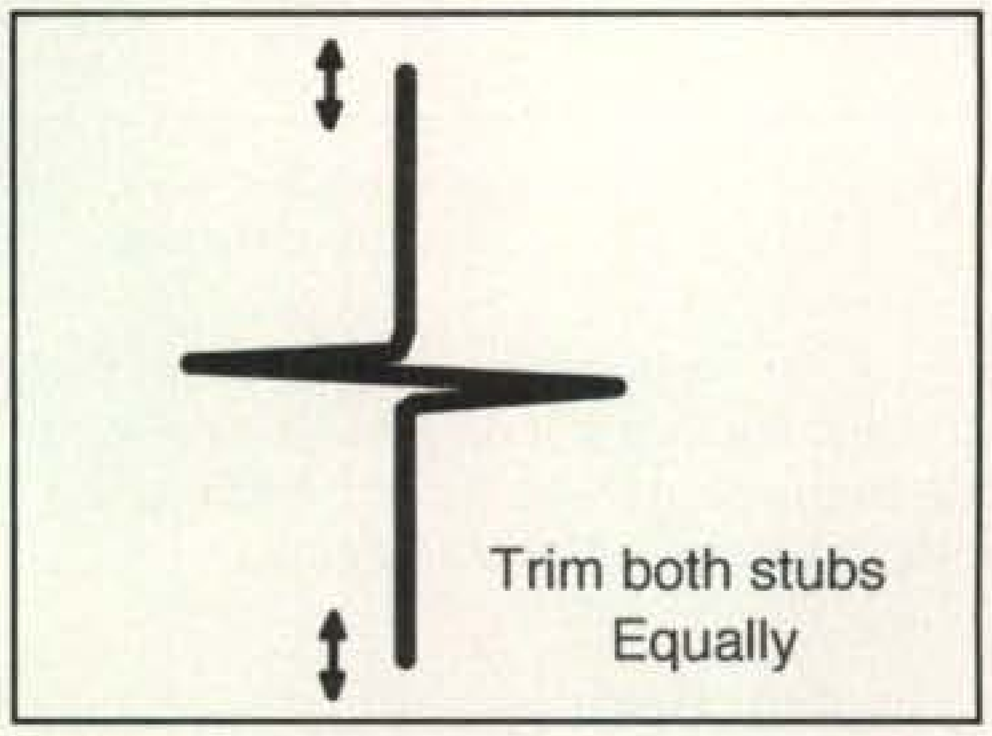

Fig. 2– Tweaking the frequency after forming the ring and the stubs.

receive antenna is looking for a signal spinning to the right, then a signal spinning to the left is reduced 20–30 dB. This means that any reflected signals are now mirror-imaged and the opposite polarization. This cancels out most of the reflected signals. Therefore, circular polarization is popular with many RF data links.

The third advantage of circular polarization goes back to multipath, but this time for linearly polarized signals. In the mobile environment, the signal may have started out as vertically polarized, but after bouncing off two buildings, squeezing under an overpass, and reflecting off a stop sign, the polarization is probably not vertical anymore. This can be a problem for FM broadcast stations that cater to people in their cars, so most FM broadcast transmitters utilize circular polarization.

While not always an advantage, if the other radio is something like a walkie-talkie or a cell phone that might be held at any position, a circularly polarized antenna will hear it about the same whether the antenna is held in a vertical or horizontal position.

In a proper circularly polarized antenna, signal levels to a vertical receive antenna and to a horizontal receive antenna should be the same.

Photo A is a circularly polarized antenna made for low-power FM broadcast use. I had been asked to make several measurements on the antenna, and as usual, it got me started on several ideas for construction projects.

The antenna is often called a "ring stub," but one of you actually sent me the patents for the "dual cycloid" anten-

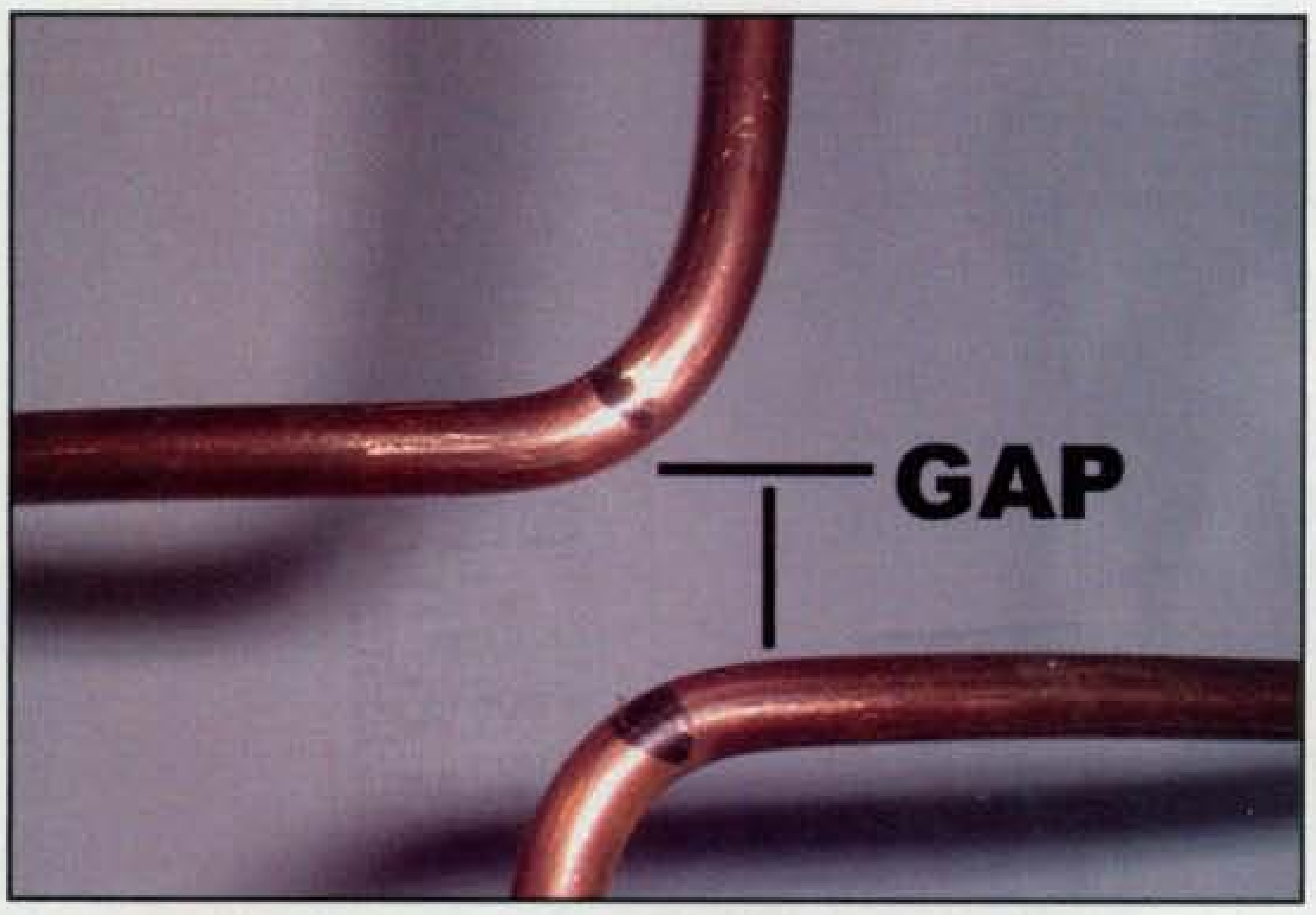

Photo C– Measuring and tweaking the gap where the ends of the ring turn up and down 90 degrees to make the stubs.

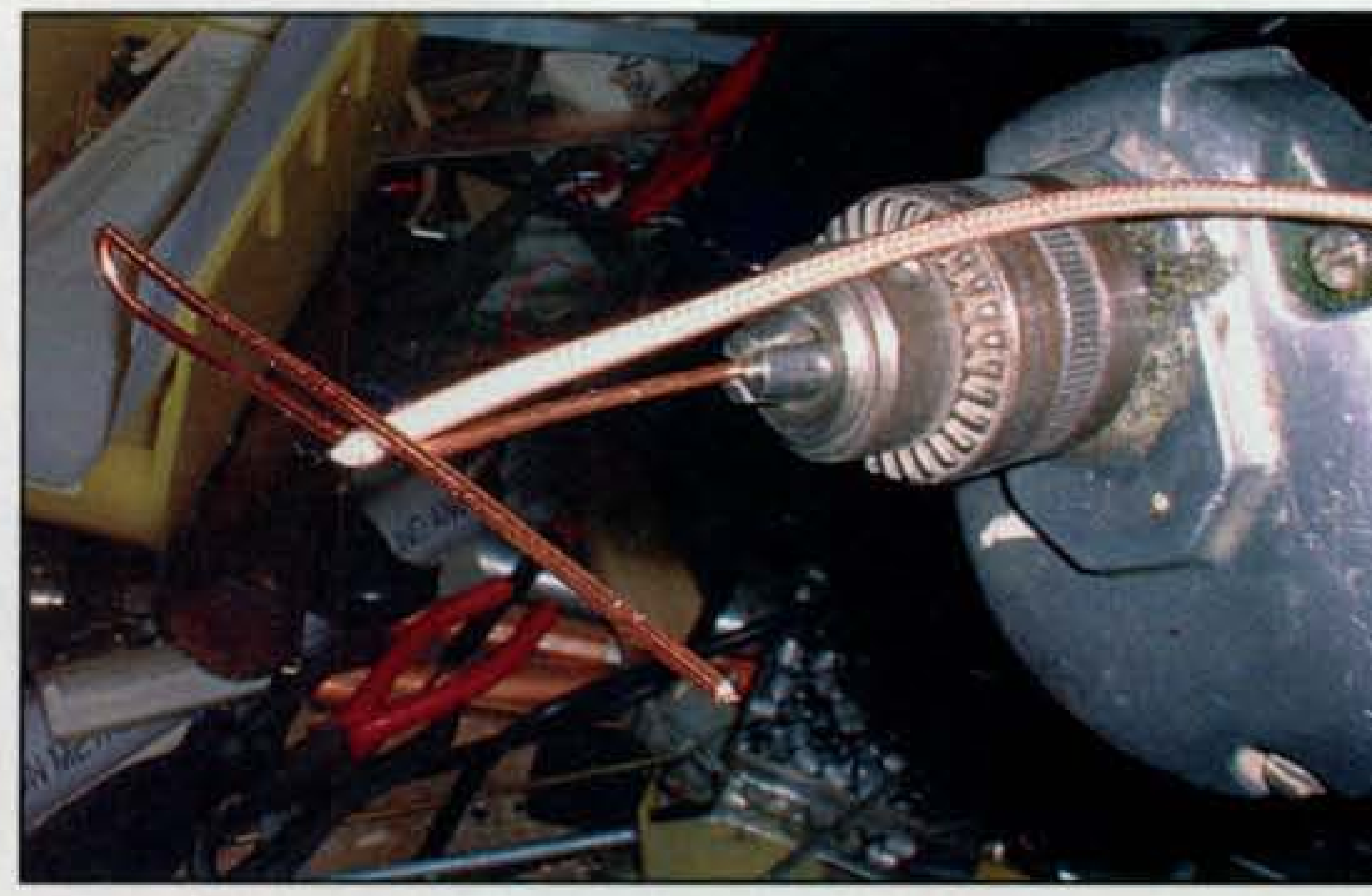

Photo D– One way to get circular polarization, but the drill would have to spin awfully fast at 146 MHz (146 million times per second)!

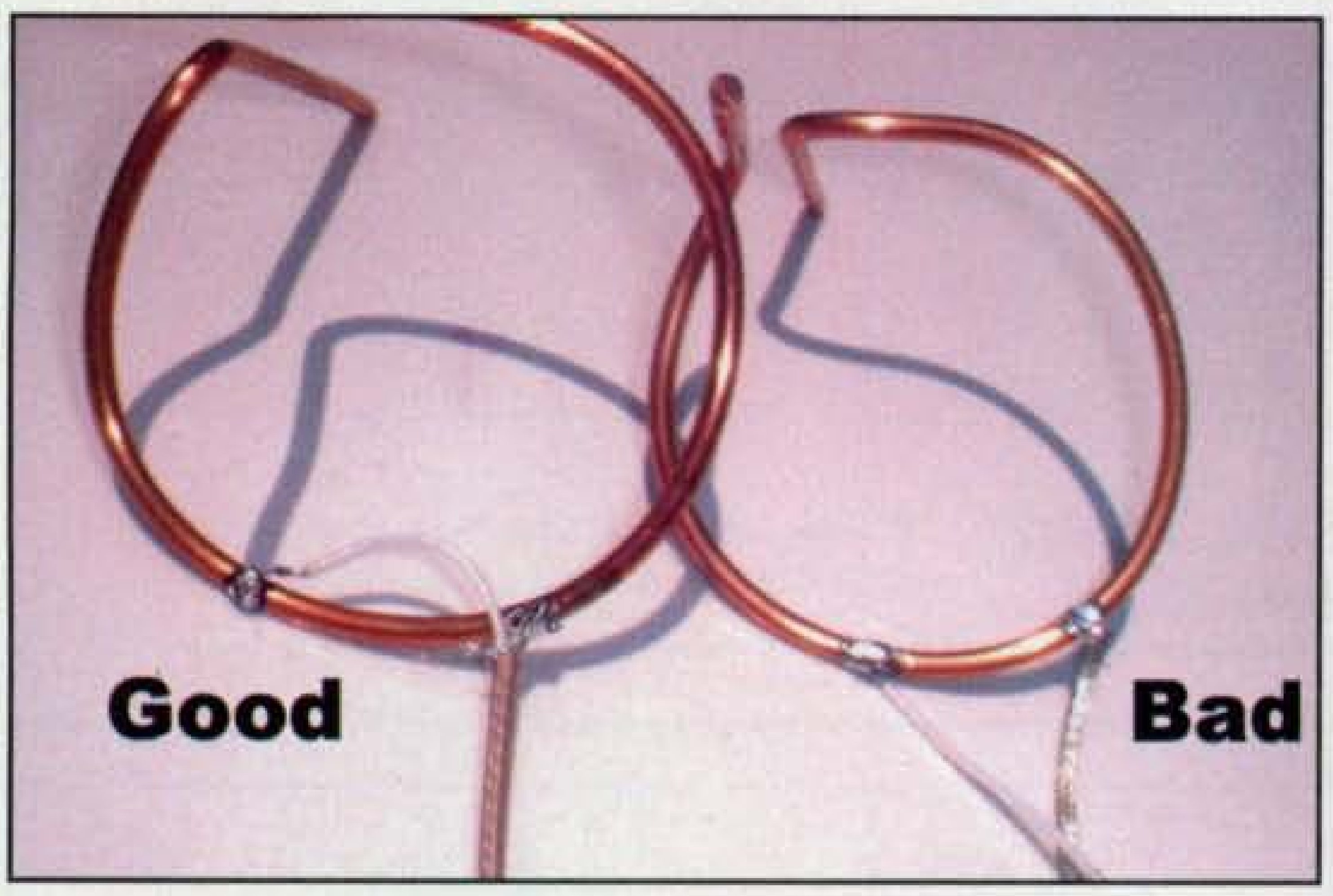

Photo E– The right and wrong way to attach coax to a ring-stub antenna.

Photo F– 435/145-MHz Cheap Yagi for low-Earth-orbit satellites. Watch for details in an upcoming column.

na. The matching section for the dual cycloid is a bit complex and beyond the average garage work bench, but a simple tap match worked well.

Construction

While I built the loop in a circle, it just as easily could be built as a square. If you're really into using plumbing fittings, the antenna could be built using six 90-degree elbows and a T.

The very center of the loop is a voltage null. At this voltage null we want to put the attachment point for a mast or other support. The attachment can be a metal tube or something non-conductive such as plastic or wood. Personally, I like my outside antennas to be hard grounded whenever practical, but wood or plastic would work fine as a support.

There are several ways to feed the antenna, but I found a simple tap worked best. The coax shield goes back to the voltage null at the very center of the loop. The coax center conductor goes a few inches away along the loop.

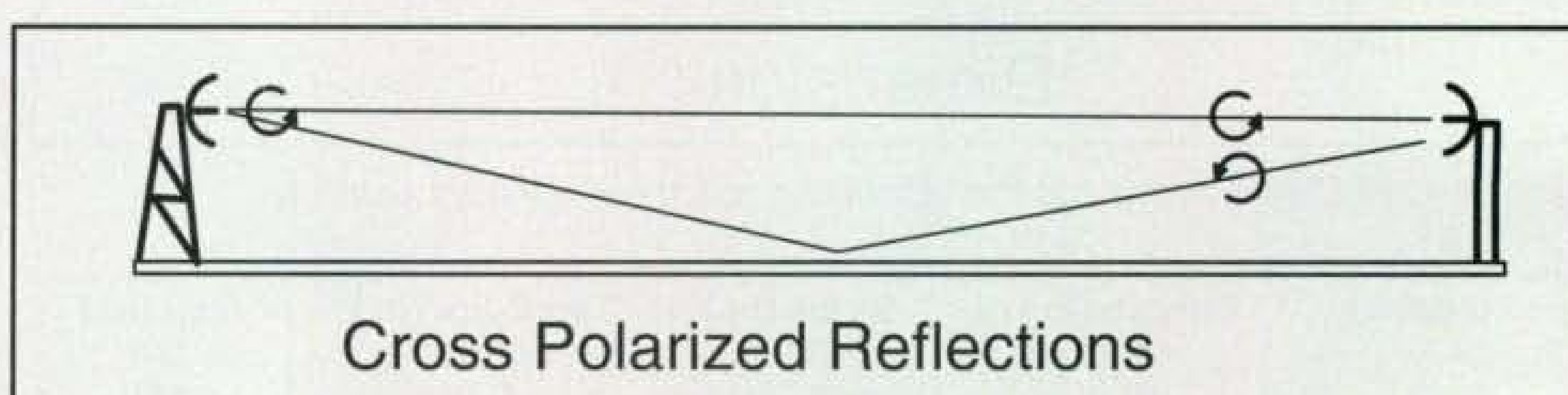

Fig. 3– A circularly polarized signal bouncing off the ground may reverse polarity, resulting in multipath distortion caused by –20 to –30 dB cross-polarization losses.

Dimensions

The first measurement you need to make is for the overall length of the loop.

tip to tip length in inches = 5800/frequency in MHz

For 445 MHz you would start with 5800/445, or 13.0 inches of wire. While you're at it, mark the exact center of the wire, 6.5 inches from each end.

Next you want to mark where to make the bends for the stubs.

stub length measured from the tip in inches = 1175/frequency in MHz

Again for our 445-MHz version, this would be 1175/445, or 2.6 inches. While you're at it, go ahead and mark the tap point. This is measured from the very center of your element.

tap distance in inches = 445/frequency in MHz

For 445 MHz the tap distance works out to 1.0 inches.

See Table I for dimensions for other popular frequencies.

Precision vs. Accuracy

Now I know someone is going to run the numbers and say, "147 MHz is really 39.45578231 inches, not 37.5 inches." Before I threaten to slap ya up side of the head and take away your HP-45, you need to know where the numbers for the formulas came from. I built about a dozen ring-stub antennas (see photo B), and those formulas are taken from those antennas. I can assure you the frequencies and dimensions were not taken to that many decimal places. Heck, I didn't even measure with a micrometer. Wire diameter also affects the final resonant frequency, and I haven't come up with a compensation factor if you want to make a 147-MHz version out of #28 wire, or 2-inch water pipe. For typical materials, the values in Table I will get you very close.

The 90-degree bends form a capacitor tuning the ring. Just bending the ends of the ring in and out will change the frequency ±5%, or about 10 MHz on 2 meters (see photo C). That's another reason not to get too carried away with your calculations. You can bend it onto frequency.

Tweaking your Ring-Stub on Frequency

I like to start with the stubs just a little long. The tips of the stubs can be trimmed quite a bit before you mess up the circular polarization. Next the coax tap point can be moved in and out a bit for best SWR (see fig. 1).

VE3SQB has written a program that calculates the dimensions for a true dual cycloid with a capacitance matching network. His program can be downloaded from my site, <http://www.wa5vjb.com>. Look for "Circular Polarization Calculator" in the "downloads" section (see photo D).

Caveats

The coax shield needs to be very short or you can get RF going back down the outside of the coax. The antenna also likes a solid connection to the coax shield (see photo E). I recommend a solder connection whenever possible.

The diameter of your element will make a slight difference in the length of the antenna.

Questions

Now some questions for you:

At the moment, I don't know which side you feed for right-hand or left-hand circular polarization (RHCP or LHCP). Thus, if you know whether to feed the side that goes to the up stub or the down stub to get right-hand circular polarization, let me know and we can cover it in a future column.

It was easy to just solder a wire to the small antennas for support. If you come up with a good way of mounting larger ring-stub antennas, we can again share this with readers.

Future Topics

Ring-stub antennas can be stacked, so if there is enough interest, I can work up a stacking harness for them. I am also curious how they work when mounted sideways over a ground plane. This will have more gain than just a ring stub by itself, and the ring stub might be easier to build than a turnstile over a ground plane for working those tumbling satellites.

Speaking of satellites, by next time I hope to finish tweaking a combined 435/145-MHz Cheap Yagi with integral diplexer. This will let you work the LEO (low earth orbit) satellites for about $10.

Keep those questions coming and get some more antennas in the air!

73, Kent, WA5VJB