BY KENT BRITAIN,* WA5VJB

Transmitting Loops

Last year (in the March and May 2007 "Antennas" columns) we covered using loop antennas for receiving and showed you how to build one. This time we will go over using loop antennas with your transmitter as well.

There has been quite a bit of work done with HF loop antennas in recent decades, primarily by European military organizations. They found that vertically polarized loops on field radios usually work better than short verticals, since a ground plane is not required. Also, horizontal antennas such as dipoles just do not work well when used by field units in the lower HF parts of the shortwave band when the dipole is just a few feet off the ground.

Loop Myths and Facts

I have heard some very interesting myths about loop antennas and their polarization. When the loop is fed from the top or the bottom, the antenna is horizontally polarized. Feed the loop from either side and then it is vertically polarized. For some reason, many people think that if the loop is fed between these points, the loop is somehow putting out both vertically and horizontally polarized signals. Not so. When you feed a loop at a 45-degree angle, you get a 45-degree polarized wave!

Fig. 1 shows a variety of loop shapes. In each case the loop is horizontally polarized when fed at the top or the bottom. The two most important factors for a loop antenna when transmitting are (1) the area inside the loop and (2) the resistance of the loop. You want the greatest area with the lowest resistance, so the circular loop is best. On the other hand, the hexagonal loop is easy to build and the square is the easiest to build. Again, it is *area inside your conductor* you want to maximize.

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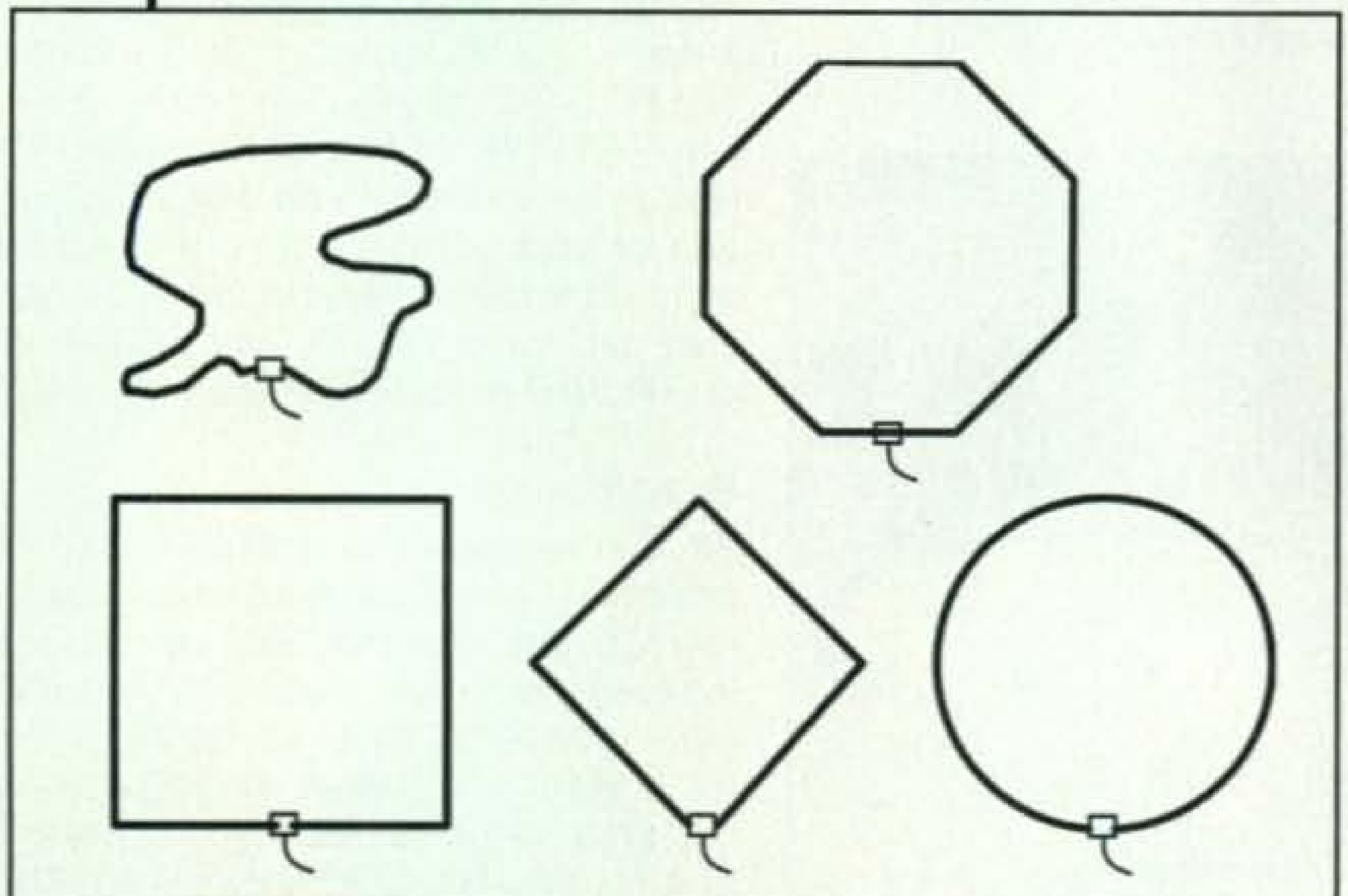

Fig. 1– Horizontally polarized loop antennas.

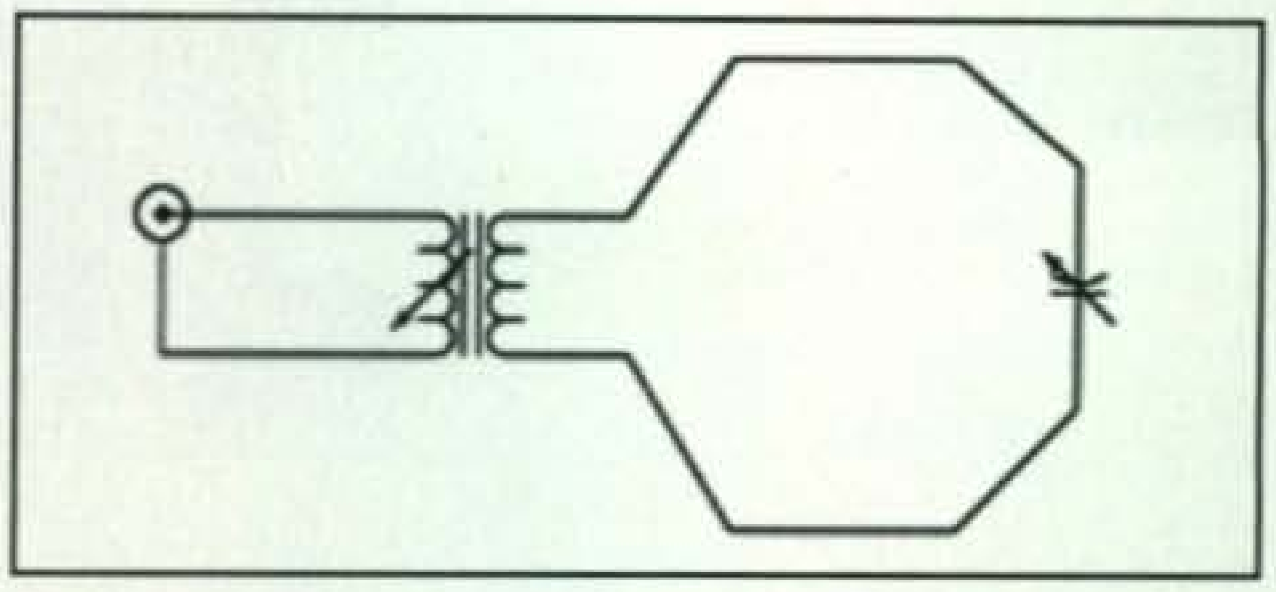

Fig. 2– Schematic of magnetically coupled loop antenna.

When the loop is one wavelength long, as used in quad antennas, the feedpoint impedance is around 100 to 120 ohms. However, as the antenna gets smaller and smaller, the radiation resistance becomes very low, in some cases just a fraction of an ohm. This means there are high currents when radiating even modest power levels. You need to keep the resistance losses in the loop extremely low. This is done by maximizing the surface area of your element. We are not talking about #10 copper wire here; you want to use something such as the outside of hardline coax, 1/2-inch to 1-inch copper water pipe, or a wide aluminum strip.

One aspect of loops that makes them attractive is they can be made just about any size, from large multi-wavelength versions to very small ones. You can make a 10-inch wide 80-meter loop and use it for transmitting. I said you *can*. I didn't say I would *suggest* such a small loop on 80 meters, but it would work. How well your loop antenna will get out is almost entirely a function of how big it is. A 2-foot loop has four times the field area of a 1-foot loop. As with so many other things, bigger is better for loop antennas. However, when it comes to radiation resistance, the formula is R_{rad} = 197 (length in wavelengths)^4 ohms. The 4th power is a pretty big factor, so efficiency of a loop antenna goes up very fast as you make it larger and goes down very fast as you make it smaller.

Next we show a commercial transmitting loop antenna designed for portable and backpacking-type operation. As you can see in photo A, the G4TPH QRP Mag-Loop breaks down nicely into 12-inch pieces for portable operation. For a small package, it expands quite a bit into a full-size loop antenna as seen in photo B. A length of string or rope is all you need to complete the portable installation.

The G4TPH is shown schematically in fig. 2. The antenna is much like an AC transformer with a magnetically coupled input. The ML40 tuning section contains a 15–440 pF variable capacitor, allowing the loop to have a pretty wide tuning range.

Photo A– Ready to go QRP on 40, 30, and 20 meters with G4TPH's collapsible loop antenna.

Photo B– Roughing it in the wilderness on 40-meter QRP.

In fig. 3 we show the 40-meter return loss of the loop antenna. Oh, I wish we could get the ham community to abandon SWR and go to return loss like the commercial folks use. There are so many advantages of return loss. Let's say you have an antenna where the reflected signal is 20 dB weaker than the outgoing signal. Then the antenna has a return loss of 20 dB. Improve the antenna such that it now has half as much reflected power, or 3 dB better, and then the return loss is 23 dB. However, going from 20 dB return loss, or 1.22:1 SWR, to 23 dB return loss, or 1.15:1 SWR, doesn't tell us very much about what is really happening in our antenna match except that the SWR is now a lower number.

We often run into some bad notation on return loss. While the return signal in this example is –20 dB from the strength of the forward signal, return loss is *loss*, sort of a negative of a negative number. Thus, return loss is a positive number, 20 dB.

I have digressed enough. The G4TPH is showing a better than 1.03:1 SWR on 40 meters, and as we change frequency, the loop is changing its size in wavelengths. Now the impedance of the loop is going from 100 ohms or so at 10 meters down to about 1 ohm at 160 meters. The 15–440-pF trimmer capacitor in the tuning unit limits the low end of the tuning range to 3.2 MHz, but if you put a 1000-pF leaded cap across the tuning cap, you can extend the tuning range down to 160 meters.

As you can see in fig. 4, the input coupling is a transformer from 50 ohms to the impedance of the loop. For a full-wavelength loop with its impedance of nearly 100 ohms, a 1:2 step-up transformer works out well. If the loop is much smaller and near 3 or 4 ohms, then a

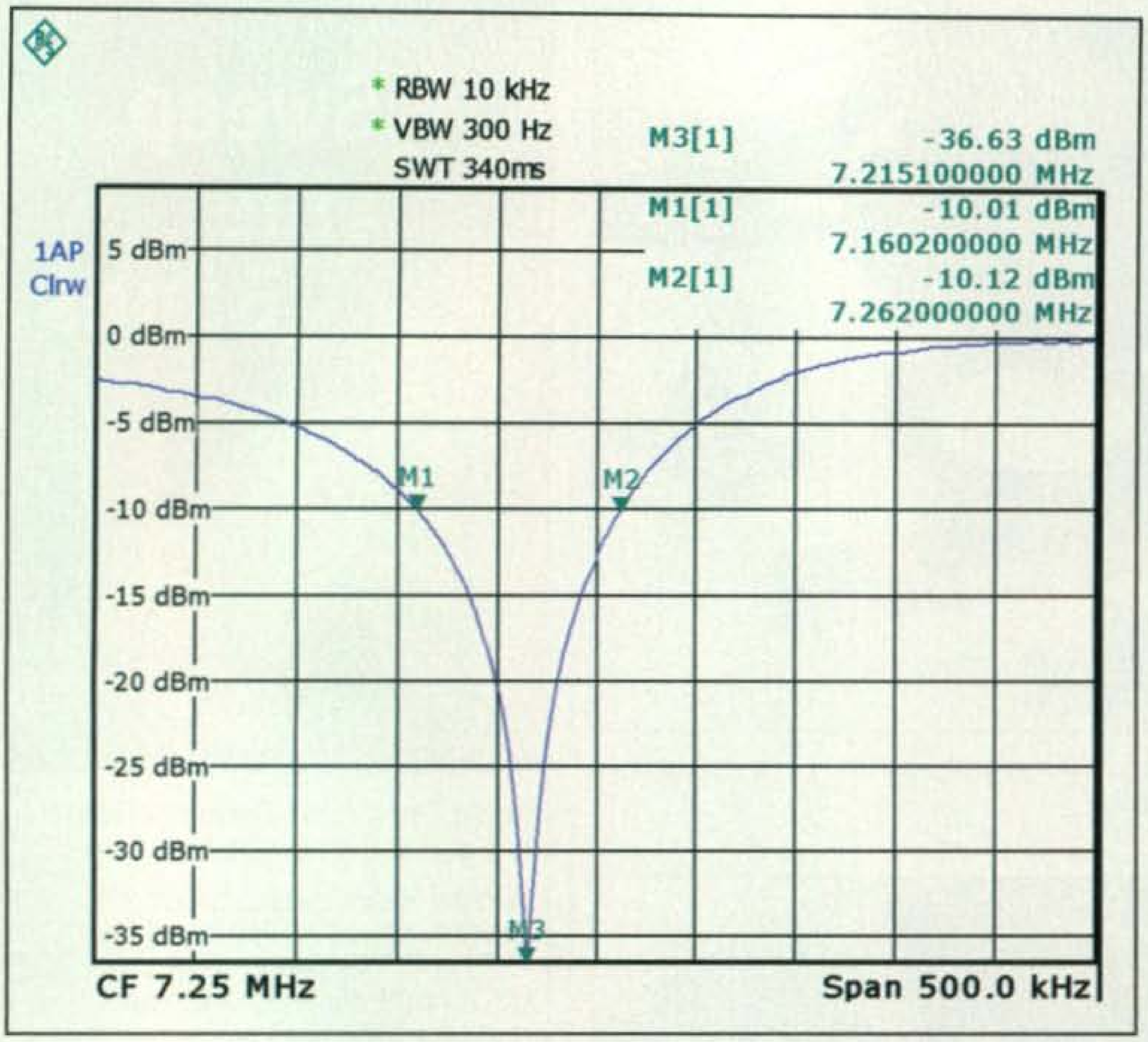

Fig. 3– The 7-MHz plot of the G4TPH loop.

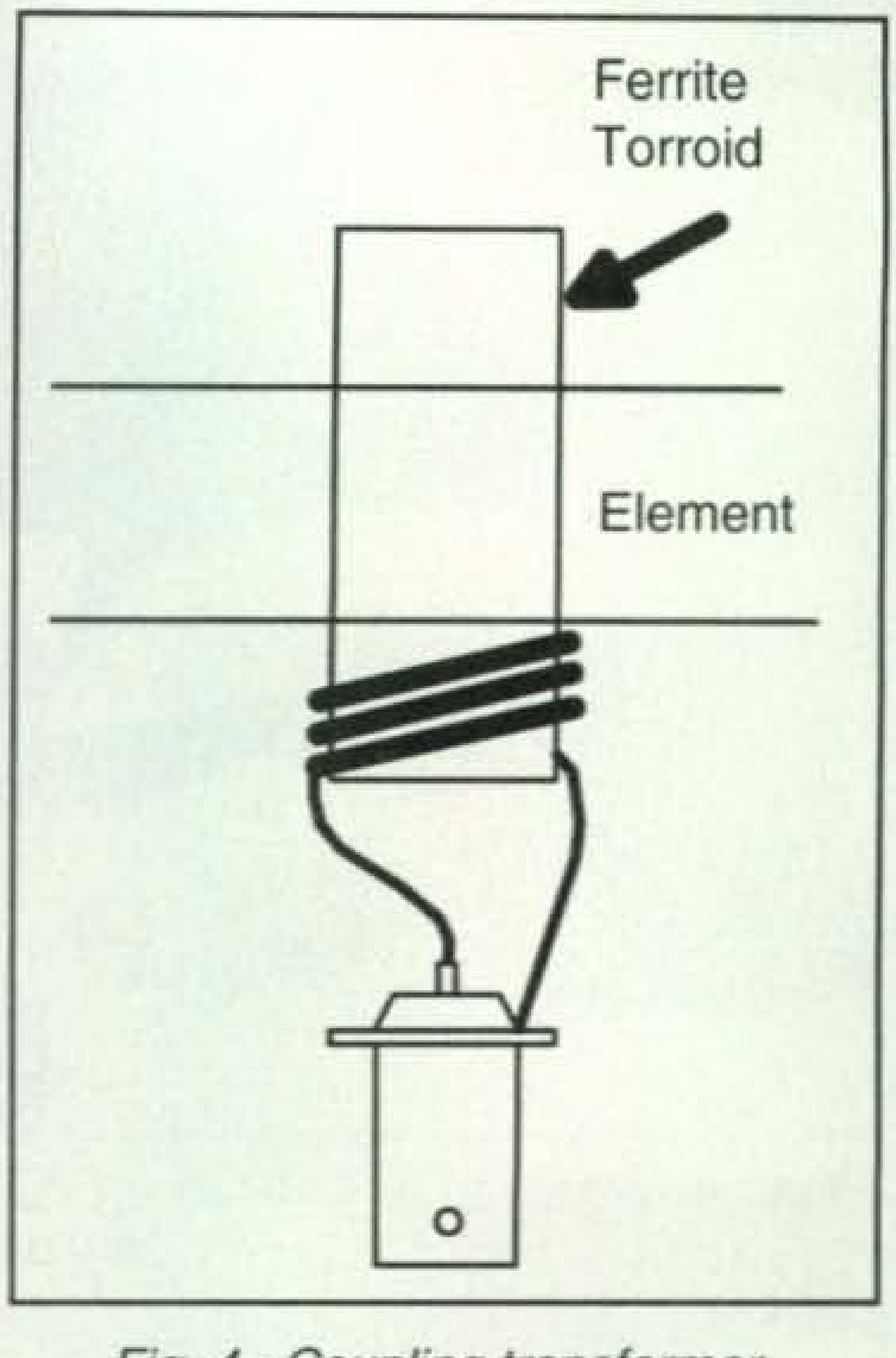

Fig. 4– Coupling transformer.

12:1 step-down transformer is what you want.

Therefore, to stay in the ballpark impedance wise, you have to change the transformer ratio as you change bands. At resonance there is quite a voltage across the tuning cap. This varies with frequency, but the antenna is limited to 15–20 watts before the tuning capacitor arcs. You really see the problems with this high voltage when you look at very small loops such as the MFJ-1786. MFJ solves this problem with some *very* large tuning capacitors and uses a wide aluminum strip on the loop to keep down losses.

Tom's ML-40 matching transformer in photos C and D works well on the 40-, 30-, and 20-meter bands. As I mentioned earlier, the antenna will tune down to 3.4 MHz, but the SWR is 3 or 4 to 1 over the 80-meter band. There is also a matching ML-20 transformer and tuning capacitor for the 20-, 17-, 15-, 12-, and 10-meter bands.

Of course I was not happy with just HF, and even with the 40-meter tuning coil I was able to reduce the loop to only five sections and tune 6 meters with a homebrew matching transformer shown in photo E. My next step will be to see if I can hit 70 MHz with four sections so I can use my new UK call on the 4-meter band the next time I'm in England: "CQ CQ 2EØVAA . . ." There is no reason why I can't make a 2-meter version, either. By the way, Tom has quite a bit of general QRP information on his website, <www.g4thp.com>.

In summary, a loop needs to be made of wide- and low-resistance materials such as aluminum or copper. Loops generate very high voltages, so use very-high-voltage trimmer caps.

Letters, Letters, We Get Letters

From Mat, we got a long letter about what kind of antenna he should use with his new software defined radio (SDR). Mat, it doesn't make any difference if your radio is a vintage super-regen, tube-type S-38, top-of-the-line HF contest rig, or one of the software defined radios. In each case you want the anten-

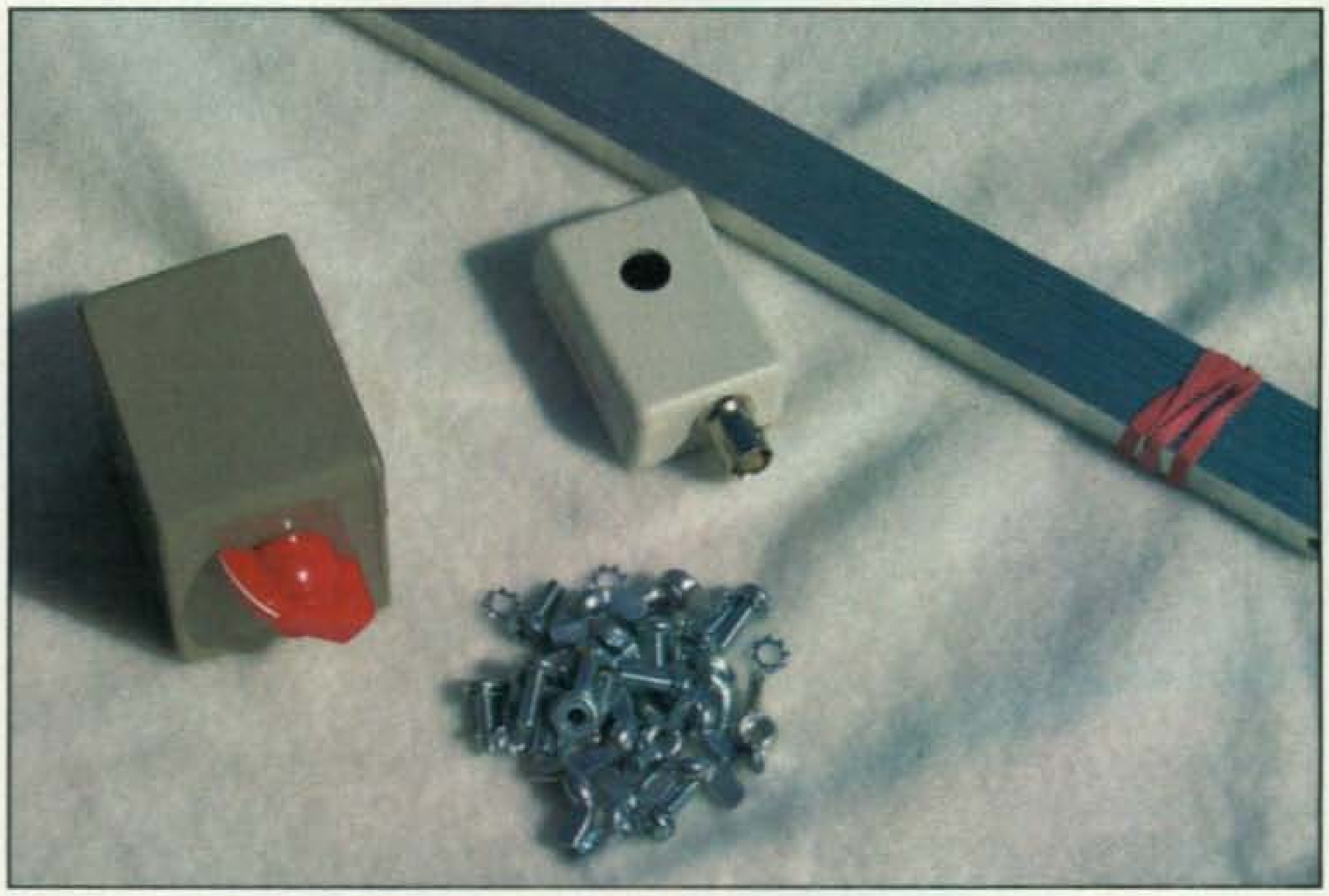

Photo C– Close-up of the tuning unit and coupler.

Photo D– Installed magnetic coupler.

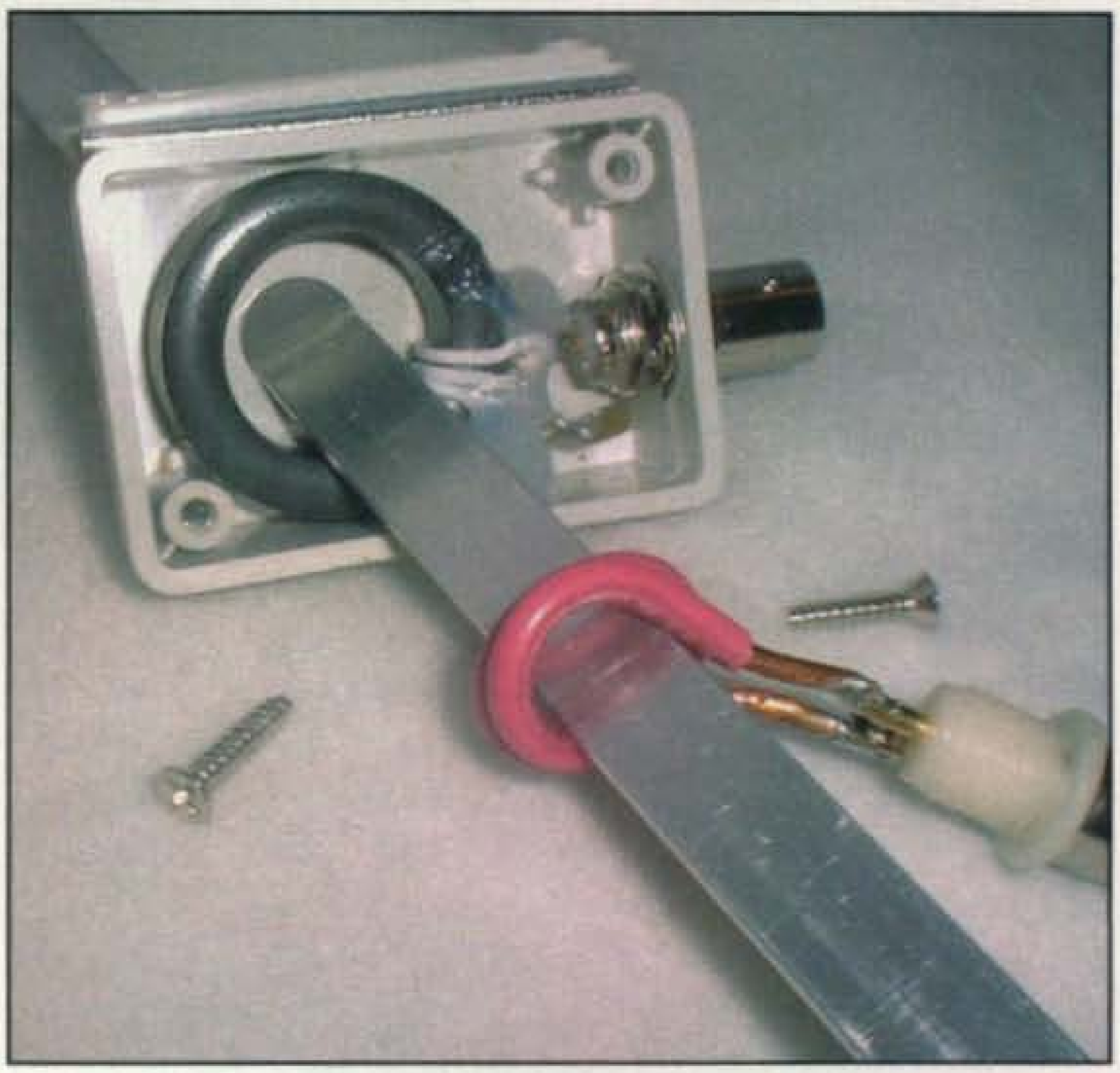

Photo E– Workings of the magnetic coupler and my 6-meter version.

na to be tuned to your frequency of interest. If the antenna works well with your Heathkit HW-101, it will work well with a radio using high-speed digital architecture.

Next Time . . .

By next time I will see if I can finish my ferrite rod antenna project, and, as always, I welcome your e-mails and suggestions for future projects. Just drop me a letter at my snail-mail address on the first page of this column address or send an e-mail to <wa5vjb@cq-amateur-radio.com>. Additional VHF/UHF projects can be found at <www.wa5vjb.com>. Now go get some more metal in the air before it gets too cold!

73, Kent, WA5VJB