The RASER Revisited

How this superior HF dipole antenna can be improved.

by James E. Taylor W2OZH

The original article on the RASER ("The RASER: A Novel Wire Antenna System," by James E. Taylor W2OZH, *73 Amateur Radio Today*, September 1992) showed how a dipole can be extended to provide enhanced gain with a length much less than the normal two half waves in phase. This was accomplished without the need for either a high-impedance feedline or an external antenna tuner. Both end-fed and center-fed options were described. This article will show how I increased the gain of the RASER appreciably while using an improved coupler circuit, which also provides decreased feedline radiation.

The RASER Concept

The center-fed RASER for 75 meters is comprised of a dipole lengthened by self-resonant Divided Coherent Radiator (DCR) sections on either side of the center feed point. Since the RF currents in the adjacent DCR sections are essentially equal and in-phase, the antenna shown gives a power gain of roughly a factor of two over the normal figure-eight pattern of a classical dipole. Such a 20-section RASER is shown in Figure 1. Each DCR section is comprised of a chosen length of wire, which acts as an inductor, and a capacitor which, together with the inductor, forms a series resonant circuit. The wire length was chosen to be 57 inches and the corresponding capacitance was 750 picofarads. Figure 2 shows the scheme for mounting the capacitors, which were potted in insulating foam. I adjusted the antenna to resonance by changing the lengths of the two terminator wires and by selecting the capacitance in the coupler unit, shown schematically in Figure 3. The coupler unit used a bifilar-wound powdered-iron toroidal transformer for impedance matching. This 20-section RASER was used at W2OZH for over a year with outstanding results.

How Can the RASER be Improved?

Critical review of the above design gives rise to three constructive questions:

1. Could the common-mode shield radiation be decreased by placing the shield connection at the tap on the transformer, to bring it closer to the electrical center of the balanced radiator?

2. Could the capacitor in the coupler unit be eliminated by direct connection to the feedline?

3. Could the inductive component then remaining at the feed point be counteracted by increasing the capacitive reactance of the terminators, i.e. by shortening them? If so, can the number of DCR sections then be increased to improve the gain, without a net increase in the overall length of the antenna?

I investigated each of these possibilities, and made the following improvements in the design.

The Balanced Coupler Circuit

The previous coupler circuit, shown in Figure 3, which involves a simple autotransformer connection, can be redrawn as in Figure 4 to clarify ground relationships. Referring to Figure 4, the two halves of the RASER radiator naturally comprise a balanced symmetrical circuit with a virtual ground at the center. It is apparent that the shield connection is not isolated from RF ground and should ideally be placed at this center rather than at the right-hand side as shown. The unbalanced feed system shown does not discriminate against common mode coupling with its attendant feedline radiation. The circuit arrangement shown in Figure 5 would improve this situation by placing the shield connection electrically much closer to the natural virtual ground of the radiator.

I experimented with this change (Figure 5) and found that the RF current on the

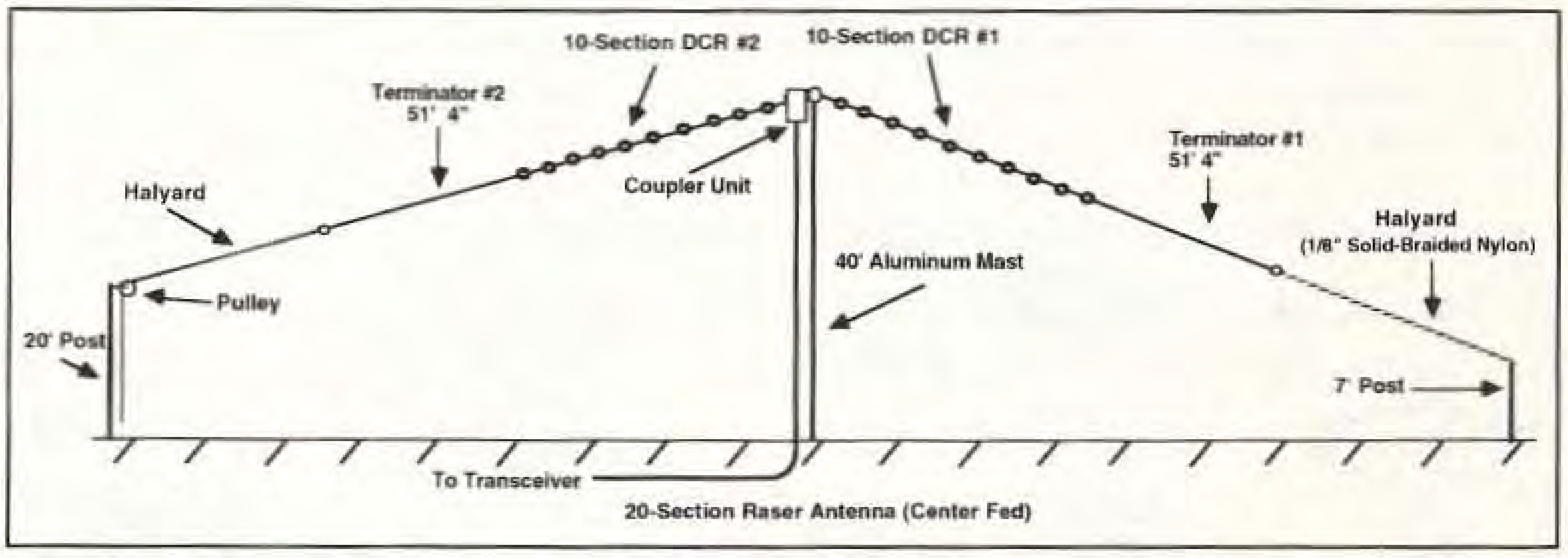

Figure 1. 20-section RASER antenna (center-fed).

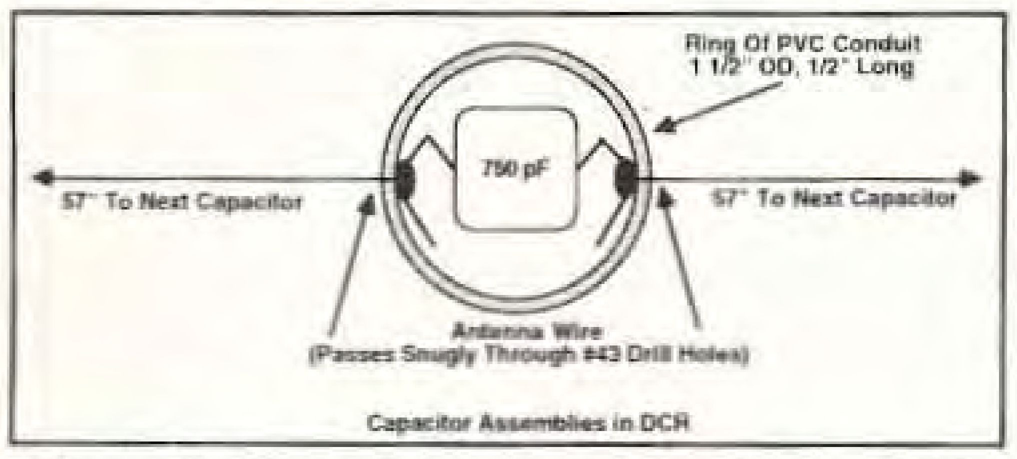

Figure 2. Capacitor assemblies in the DCR.

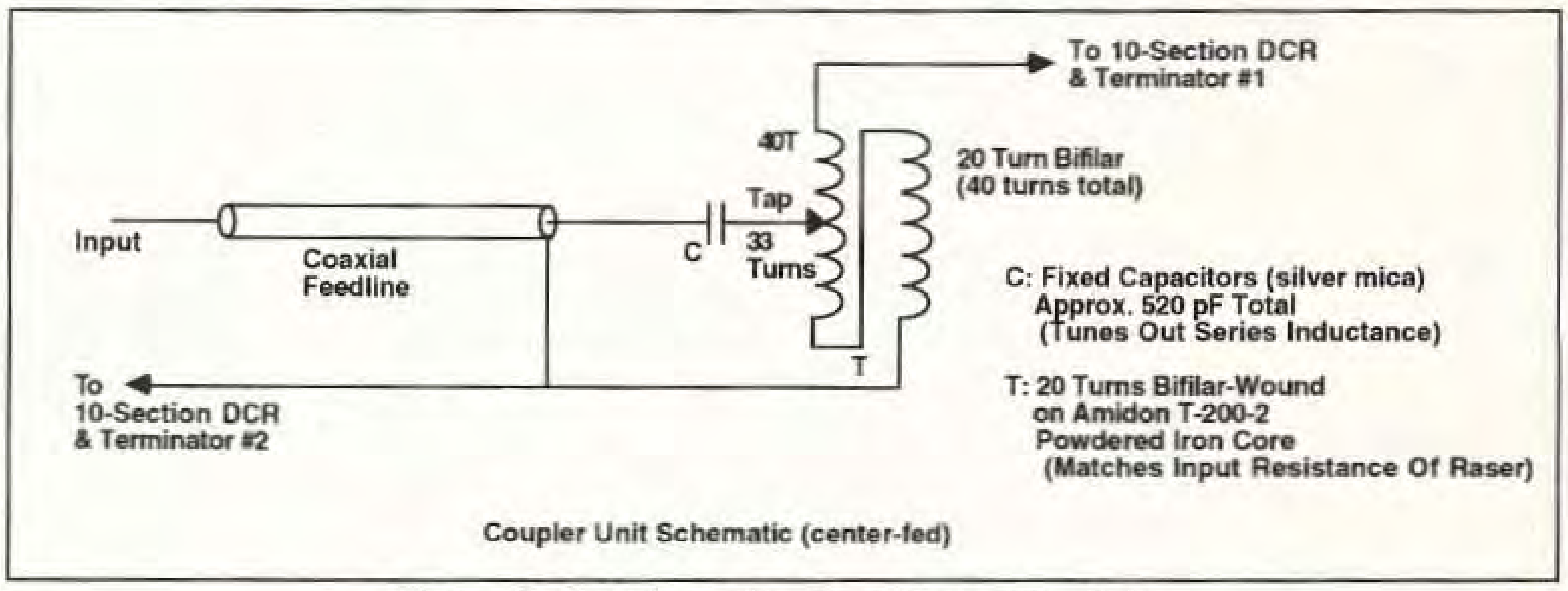

Figure 3. Coupler unit schematic (center-fed).

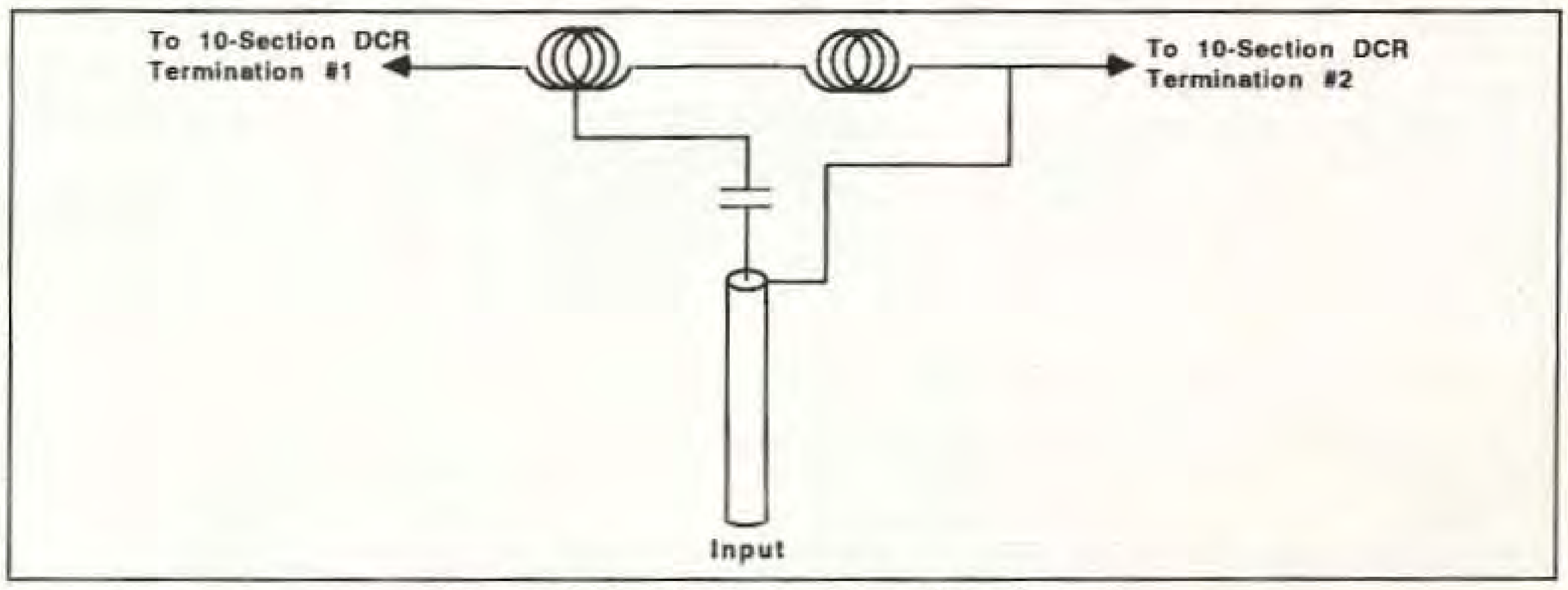

Figure 4. Original coupler unit (redrawn).

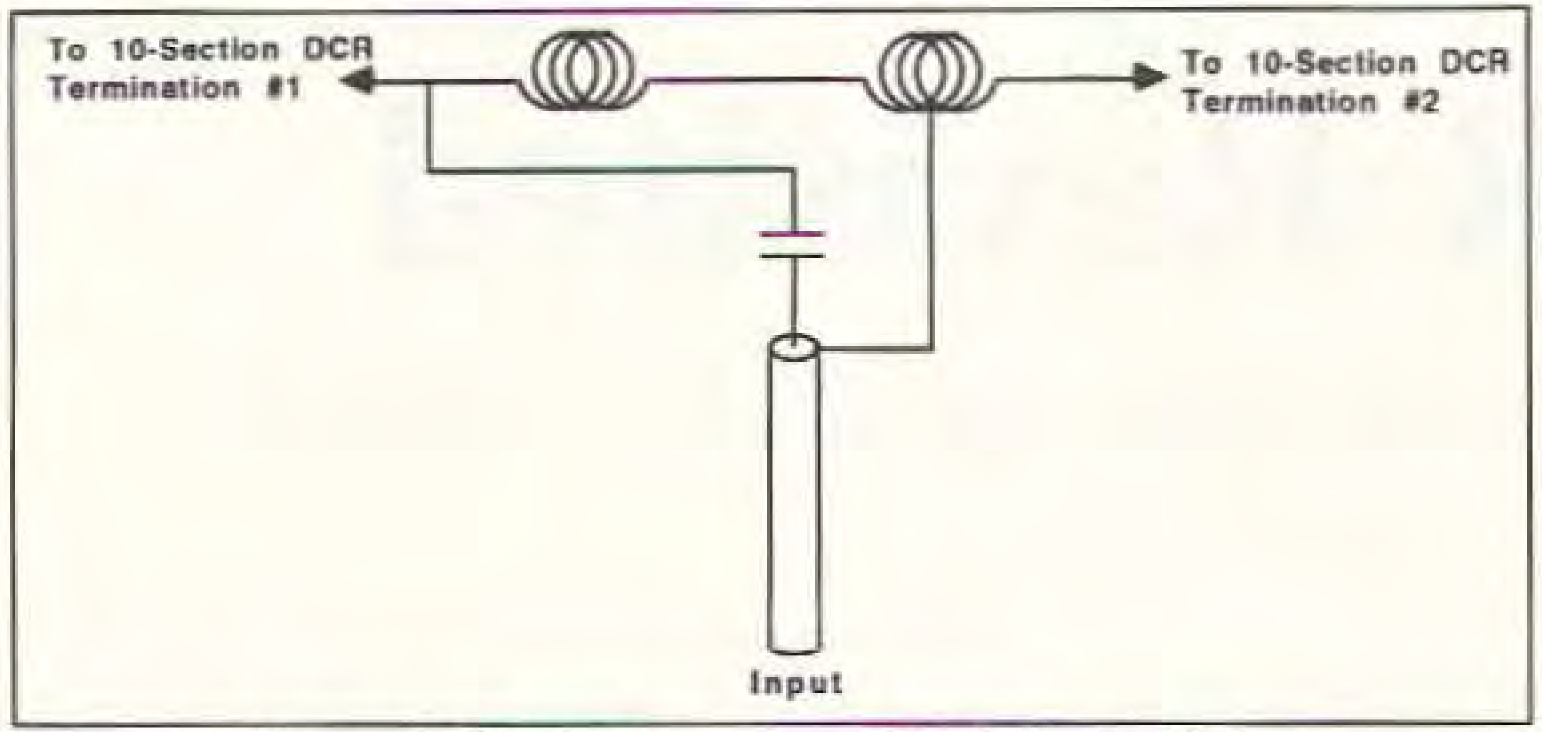

Figure 5. Original coupler unit—balanced input.

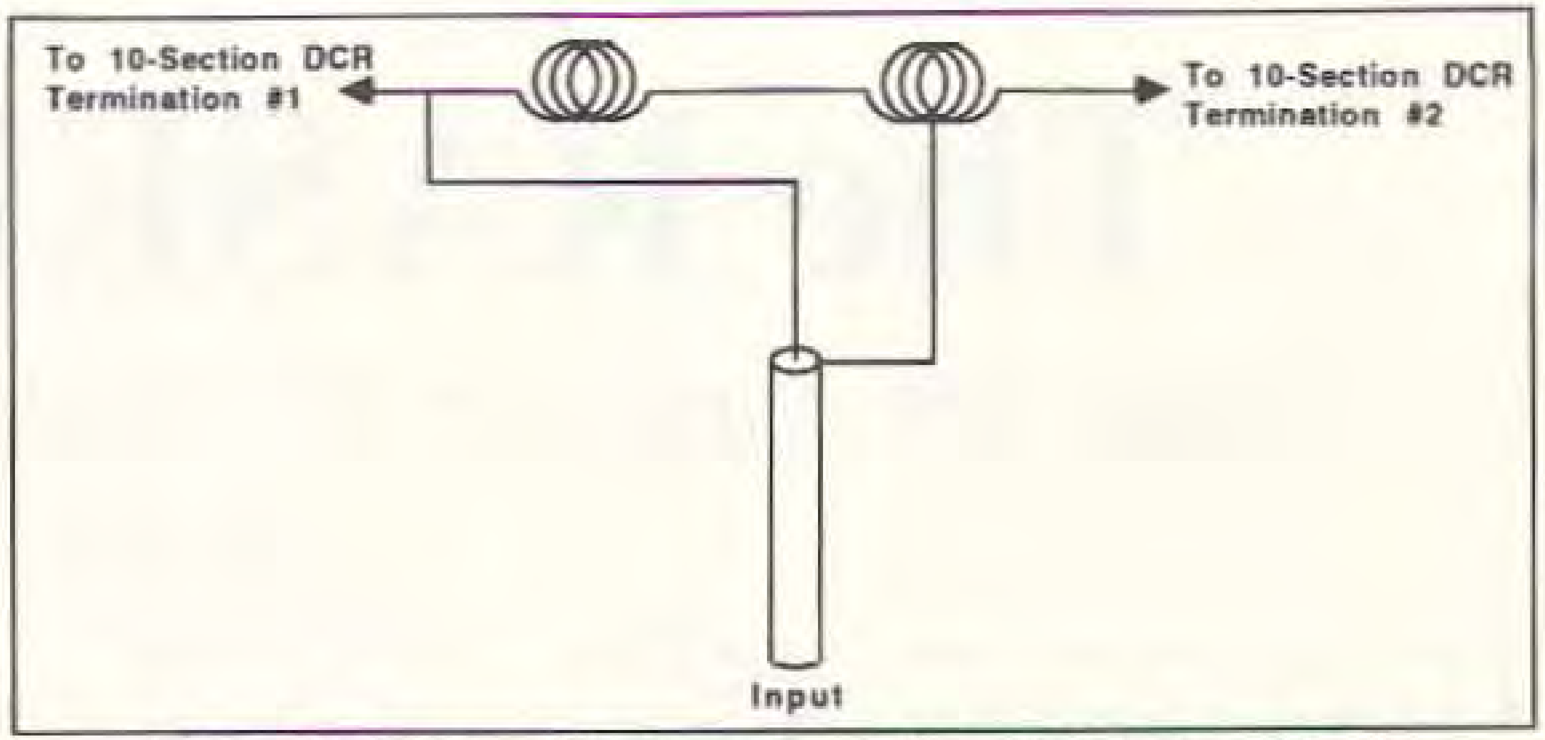

Figure 6. Improved balanced coupler unit (no capacitor).

shield of the coax, as measured by an MFJ H-field Antenna Probe, was decreased substantially. Resonance measurements using a noise bridge led to changes in the value of capacitance required for resonance. This is consistent with the measured reduction of common mode coupling, further confirming that the answer to question 1 above is "yes." During these experiments I noticed a prominent resonance point some 100 kHz below the desired frequency of 3.953 kHz. This led to experiments answering questions 2 and 3 above.

Elimination of the Coupling Capacitor

As an experiment, I replaced the coupling capacitor by a direct connection, as shown in Figure 6. This leaves a substantial uncompensated inductive reactance at the feed point, which lowers the resonant frequency of the system. The measured resonant frequency of the 20-section RASER with the terminator lengths of 51' 4" was lowered to below 3.7 MHz. Thus, the answer is "yes"—the capacitor can be eliminated.

Re-Resonating the Radiator

I then made the terminators incrementally shorter, which raised the measured resonant frequency of the radiator. Since the terminators had been made shorter I was able to add more DCR sections for greater gain without any increase of the overall space required. These experiments showed the desired deep resonance nulls on the noise bridge with very satisfactory bandwidth. Thus, the answer to question 3 above is also "yes"—the capacitor can be eliminated and the number of DCR sections can be increased.

Thus, the procedure which I followed was first to add DCR sections and then to adjust resonant frequency by changing the length of the terminators. I found that increasing the number of DCR sections to 12 on either side of center and changing the terminator length to 29 feet gave a deep resonance null (signifying a pure resistance) on the noise bridge at a frequency slightly above 4.0 MHz. This indicated that, for my available space of some 200', I could increase the number to 30 DCR sections (15' either side of center). The final RASER design is shown in Figure 7.

The Final Design Values for Two RASER Radiators

At W2OZH, a two-element phased array is used so it was necessary to optimize the

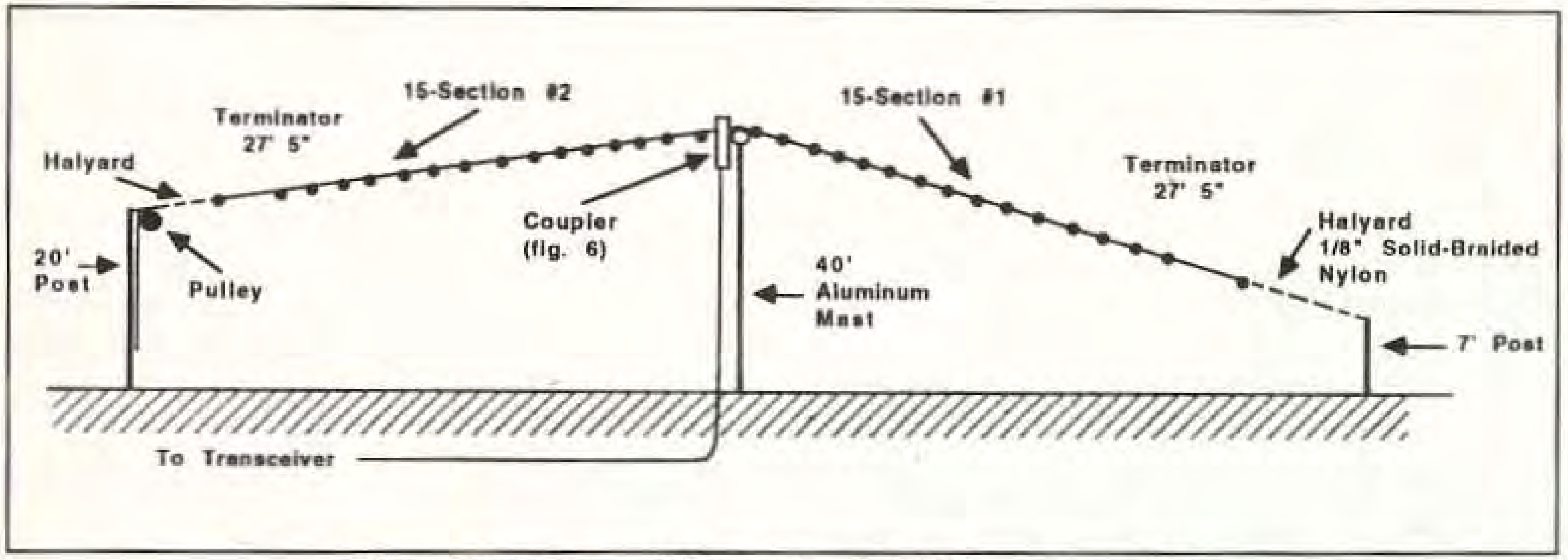

Figure 7. Balanced 30-section RASER—(center-fed).

Table 1.

Terminator Lengths	Tap Position	Resonant Frequency
27' 5" (east radiator)	25 turns	3.954 MHz
26' 2" (west radiator)	26 turns	3.948 MHz

lengths of two parallel RASERS. This simply involves adjusting the lengths of the two identical terminator wires until the desired frequency, in my case 3.9535 MHz, is approached. The final design values are shown in Table 1.

The differences between the two RASERs are probably due to the proximity of nearby buildings, trees, etc. However. these measurements indicate a level of variation to be expected in other installations of this outstandingly effective antenna.

Results

The experiments described produced the serendipitous results of a simplified design which yields improved performance. The use of a coupler connection which is balanced to ground measurably decreases the feedline radiation due to common mode coupling. The elimination of the coupling capacitor simplifies resonance adjustment and the attendant shortening of the terminator wires permits the insertion of 50 percent more DCR units to further increase the gain of the radiator.

The modifications of the RASER described above were confined to the center-fed version because this configuration is suitable for my site. However, similar changes can be made in the end-fed arrangement. The procedure would only involve reversal of the input connections to the transformer in the coupler, elimination of the capacitor by direct connection, and experimental adjustment of the single terminator wire. All other adjustments should remain as described in the original article. Although the parameters indicated above are for the 75 meter band, the design can be modified for any other band. This would involve using the steps of design described in the original RASER article, but scaled for the chosen frequency of operation. It would be interesting to see the performance of a RASER designed for, say, 20 meters, where a high gain, linear beam antenna could be realized for point-to-point DX communication.

I have now used the 30-section RASER design in a two-element phased array for several months with even better results than for the previous 20-section version. It is my perception that the directivity has been improved and the large capture area of the system for reception brings about a dramatic decrease in fading of the signals. Results experienced when I have occasionally worked QRP stations lead me to believe that this would be an outstanding antenna for that application.

I wish to acknowledge the patience of many hams who have given signal strength comparisons as I switched several available combinations of RASER elements.