Simplicity of construction and flexibility of use are the key ingredients of Gary Price's two-band vertical antenna.

Base Loading a Simple Vertical Antenna for Two-Band Use

BY GARY H. PRICE*, W6IRA

Operation here has remained low-key over the years. The station is modest by most any standards, until recently consisting of only a 25 year old ARC-5 transmitter running some sixty watts input on forty meters. A ground-plane vertical antenna graces the roof and an FET regenerative receiver completes the essentials. Awards have (perhaps understandably in light of the above) not stood high on the list of station goals, although a gradual approach to WAS has not gone completely unnoticed. Recently, however, the snagging (after a month's effort) of a ZS during their semiannual equinoctal influx produced, in addition to much celebration, the realization that only Europe remained for completion of WAC. Unfortunately, Europe (for the information of those inhabiting the eastern seaboard) is not noted in these parts for its cooperation on forty meters, and a period of patient listening confirmed the recollection of past experience: hearing them is still considered by some to be good form when working them. I wasn't!

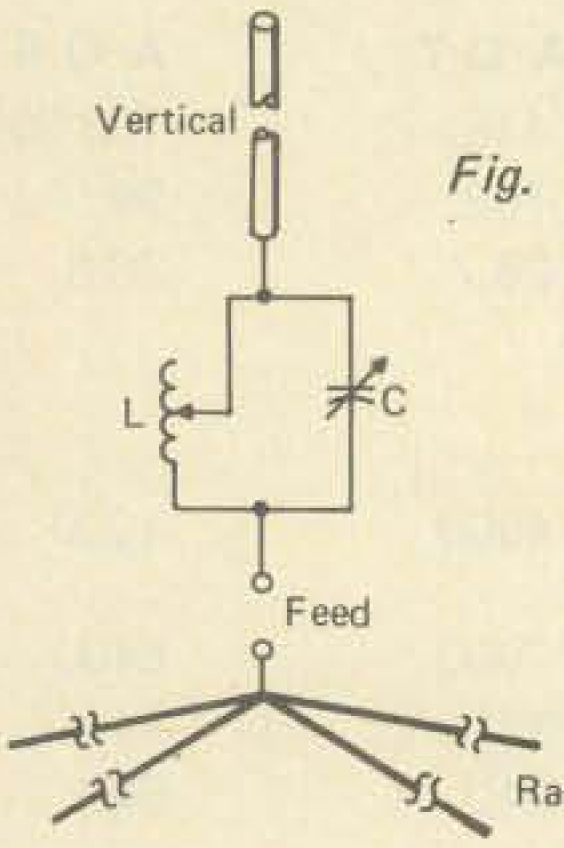

Fig. 1—Two-band base loading network.

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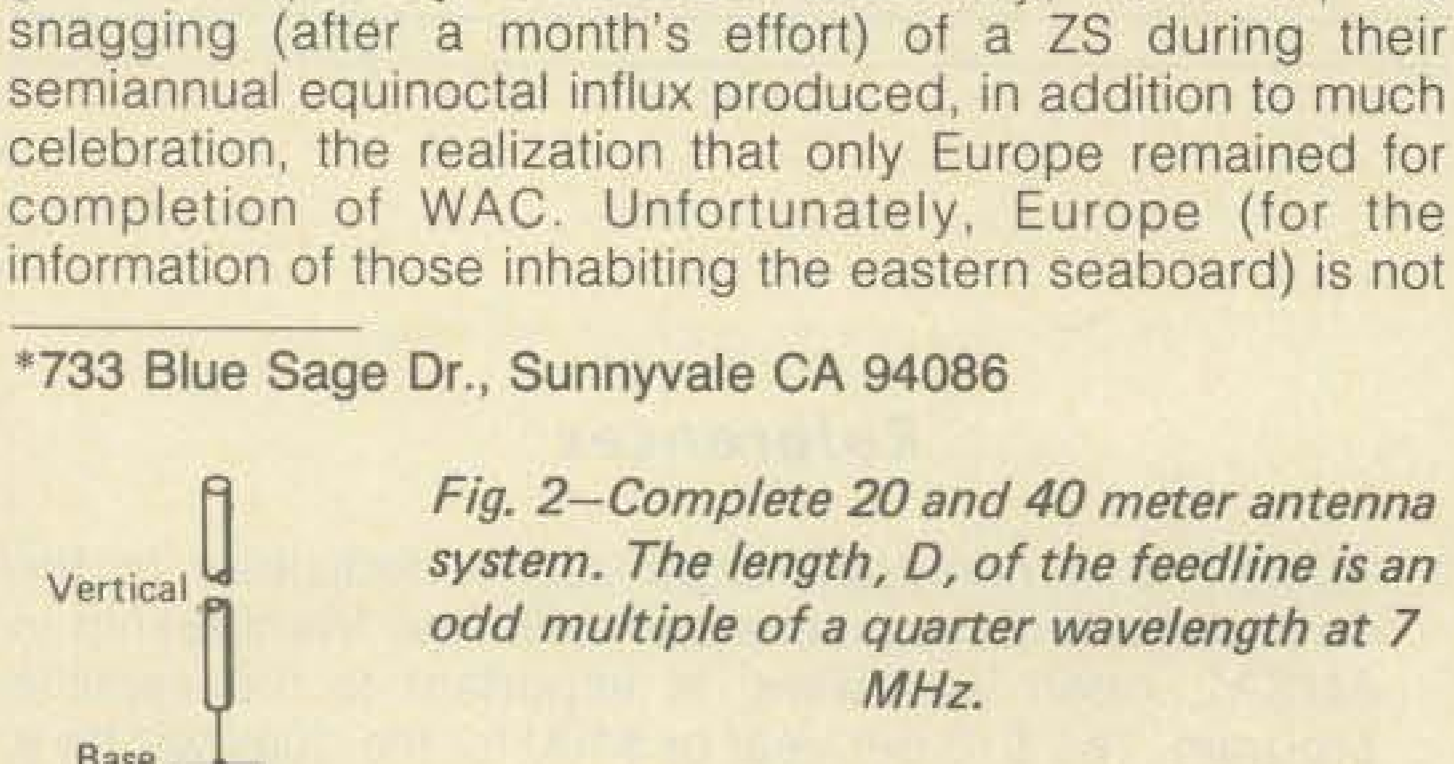

Fig. 2—Complete 20 and 40 meter antenna system. The length, D, of the feedline is an odd multiple of a quarter wavelength at 7 MHz.

It had become evident by this time that a crisis had finally arisen of sufficient magnitude to prompt serious consideration of station improvements. But what? Transmitter and receiver were fairly well matched in their capabilities, so increased transmitter power was not, in itself, the answer—I still wouldn't be able to hear them. Furthermore, I had been publically committed too long to the proposition that anything worth doing could be done, and with more satisfaction, using less than 100 watts. Installation of a sufficient antenna to make the grade on forty with the existing equipment was, although intriguing, also out of the question.

I had heard rumors for years that twenty meters was the DXer's fantasyland; perhaps multiband operation was the answer. Getting the gear on twenty seemed straightforward enough. The receiver was general coverage, and doubling the transmitter up to twenty would be, at least according to old articles found in the station archives, pretty simple. There remained the question of antennas. A beam, of course, would be the natural choice for one unfettered by other considerations. Not all agree, however, that beams are beautiful (I'm not so sure myself). The installation of a retractable tower was an option, but such a choice seemed, in addition to being more elaborate a project than had been intended, not altogether in keeping with the station image. The search for alternatives led to the conclusion that a vertical on twenty was not a completely hopeless proposition, albeit one not exactly enthused over by the club experts. Thought thus turned to how best to use the resources already perched on the roof.

Past experience suggested a number of guidelines. First, remote r.f. switching and/or antenna loading adjustments were best avoided. They could be counted on, oh yes, counted on to act up just when that rare one finally emerged from the pileup sending my call. My agility at erecting and ascending ladders, although considerable, would be sorely tried by such a challenge, to say nothing of my temper.

It also seemed worthwhile to eke out whatever gain possible from the antenna on twenty. Although not a great improvement, the use of the full length of the antenna would maximize to the extent possible its twenty-meter radiation at low angles. Finally, confusion when changing bands would be minimized if the tune-up procedure were similar for both the twenty and forty meter bands.

These characteristics were found to be attainable by modest elaboration of the forty-meter base loading network used with the existing antenna and a judicious selection of feedline characteristics. The antenna length, 7 meters (23 feet), suited it well to multiband loading for a resistive termination on both bands. This length is short of a quarter wavelength on forty meters, and the antenna had always been operated with inductive base loading. On twenty meters, the antenna would be long relative to a quarter wavelength, and capacative base loading would be appropriate. These requirements could be met by a fixed network consisting of an inductor and a capacitor in parallel, as indicated in fig. 1. The lower-reactance component of the combination would always dominate in the parallel arrangement, making the pair inductive for frequencies below its resonent frequency and capacitive for frequencies above this frequency. By suitable choice of values for the inductance and the capacitance, with their resonant frequency between 7 and 14 MHz, the reactance at these frequencies should be adjustable to provide the desired reisitive load on both bands without the need for any switching or tuning at the antenna.

Detailed calculation confirmed the initial analysis. The antenna reactance was estimated to be about -200 ohms at 7 MHz and about +200 ohms at 14 MHz.[1] Solution (see Appendix) for the network L and C gave 2.27μH for L and 113 pF for C, and coil and capacitor were installed at the antenna base accordingly.

The reader should, however, not be lulled by the algebra of the Appendix into the conclusion that the job had been completed at this point. The paper analysis had provided a method and a starting point, but a working antenna remained to be produced. The actual reactance values of the antenna no doubt departed somewhat from those used in the calculation, and the L and C values were expected to require adjustment accordingly. A procedure for this adjustment was therefore devised.

Since two variables (L and C) were to be adjusted, some systematic approach was desirable. Unorganized trial and error could easily yield mostly error, a trial that seemed worth avoiding. It was reasoned further that the two components could best be adjusted alternately, while the antenna was switched back and forth between the two bands. On each band, the adjustment of one component should affect the antenna characteristics much more than would that of the other component. On forty meters, the net reactance of the loading network would be primarily that of the coil, and this reactance would be relatively weakly affected by changes in the higher-impedance capacitance in parallel with the coil. The converse would hold for twenty meters; the net reactance would be primarily that of the capacitor, and a relatively large change in the inductance would have only a secondary effect. Thus, adjustment for minimum s.w.r. on each band of the component whose effect was secondary *on the other band* should home in smoothly to the appropriate L and C values. This was indeed found to be the case.

The resistive component of the antenna impedance also varies with its length; a second reference to *The A.R.R.L. Antenna Book* provided values of 13 ohms at 7 MHz and 95 ohms at 14 MHz. The base loading network compensates only for the antenna reactance, and after optimization the minimum standing-wave ratio into a 50-ohm line was found to be about 3:1 on both bands, roughly consistent with the book resistance values. The matching network could have been elaborated to provide an impedance transformation as well, but the desire for two-band operation with a fixed network at the antenna complicates such an approach excessively.

The alternative to this procedure that was adopted is to complete the matching at the transmitter end of the feedline, which then operates with some standing wave on it. Although coaxial line is less immune to breakdown problems with high standing-wave ratios than is open-wire line, the relatively low power levels used here suggested that such an approach was feasible. Further consideration of the situation revealed a bonus. The impedance to be matched at the transmitter could be made nearly the same for both twenty and forty meters if the feedline were made an odd multiple of one quarter wavelength for forty meters. This length would provide a quarter-wave step-up transformer on this band. On twenty meters, the line would be a multiple of a half wavelength, thus presenting the antenna impedance unchanged at the transmitter end of the line. Moreover, a standard 25-foot length of RG-8/U coax, as was already in place, comes very close to an electrical quarter wavelength on forty meters. Clearly, further exploration of alternatives at this point would have been ignoring fate.

Although 50 ohms was not a necessary value for the impedance to be presented to my transmitter, it did offer certain advantages of standardization and also simplified the monitoring of antenna performance with an available s.w.r. meter. A matching network, using coupled series-tuned LC circuits, as befitted the estimated 100 or 200-to-50 ohm impedance transformation desired, was therefore built along standard lines[2] to join line and transmitter.

The completed antenna system is illustrated schematically in fig. 2. Adjustment of the final coupling network at the transmitter achieves s.w.r.'s of 1:1 on forty meters and 1.1:1 on twenty meters. Wet weather requires some readjustment of the tuning network, particularily on twenty meters, where the minimum s.w.r. deteriorates appreciably during downpours (not a problem of late) even with retuning. Ground radials on shingle substrate evidently possess electrical

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[1] *The A.R.R.L. Antenna Book*, 10th Edition (1964), p. 61.

[2] *The Radio Amateur's Handbook*, 53rd Edition (1976), p. 583.

Antennas *(from page 60)*

"Well, I saw a fine article in *CQ-ham radio*, the Japanese amateur magazine a few months ago. It described a mini-loop antenna that is tunable to either 20 or 15 meters (fig. 4). What do you think of this?"

Pendergast gulped. "Well, my Japanese isn't very good. What's it all about?"

"All the dimensions are in millimeters", I replied. "It is a loop about half-wavelength in circumference for 15 meters. It is 1000 millimeters on a side, or one meter. That corresponds to 40 inches on a side. The antenna is voltage-fed at the bottom with the tuned circuit which can be adjusted from 15 to 20 meters.

"The diagonal dimensions of the loop are 60 inches. The loop is made up of four pieces of aluminum tubing about ⅜-inch in diameter. The ends of the tubing are flattened and bolted together. At the bottom feedpoint, the sections of tubing are attached to an insulating block. The cross-support arm is bamboo and the vertical support arm is wood.

"The tuning network is placed in a small box at the bottom of the loop, which is supported in a vertical position. The tuning capacitor is a split-stator job having an effective capacity of 75 pF. The three coils are made of one section of coil stock about 1¼ inches in diameter. L1 and L2 have 3 turns and L3 has 2 turns. The photo of fig. 5 should give you an idea of the network assembly.

"The capacitor is tuned for resonance either at 15 meters or 20 meters. For the 15 meter band, the operating bandwidth of the loop is about 200 kHz. and on 20 meters the bandwidth is about 100 kHz. So the little antenna should be peaked at the center of the portion of the band that you wish to use".

"What is the radiation pattern of the loop?", asked Pendergast.

"The pattern is at right angles to the plane of the loop. That is, a figure-8 pattern (similar to a dipole) in and out of the page. The builder of the antenna, JG1UEA, reports that it is better than a ground plane on 15 meters by two S-units. He has no comparison antenna for 20 meters, but has worked plenty of DX on that band".

"Looks good", said Pendergast. He paused, and then said, "Any information about treating bamboo to make it waterproof?"

"I'm glad you asked", I said. "I just got a note from VE2TH about that. Mike says that you can get an epoxy compound made by CIBA (and possibly others) called *Epoxy 502, Araldite 825 polyamide*. This resists weathering and protects the bamboo from the ultra-violet rays of the sun which tend to break down carbohydrates. He coats his bamboo with this, and while still wet, wraps the bamboo arm with fiberglass tape. He follows this up with a coat of liquid fiberglass. This makes an exceptionally strong bamboo pole for Quad construction. Finally, he puts on a final coat of fiberglass liquid with a bit of paraffin in it. This gives a glossy surface to the bamboo so that rain and ice don't tend to stick to it.

"He doesn't drill the bamboo pole for Quad wires. No, no. He makes up a sleeve which he passes over the wire at the point it crosses the bamboo. The sleeve is about six inches of polyethylene inner dielectric from a hunk of RG-8/U cable. He slips the sleeve over the Quad wire then attaches the sleeve to the bamboo pole with a wire wrap. He claims this construction has withstood the Canadian winters and winds of over 80 miles per hour!"

"Well, I doubt if you have to go into that detail with the little Japanese loop, but nothing is too sturdy for a full size Quad antenna. I hear that plenty of Quads came down this spring because of the bad weather in the east and mid-west. Perhaps the VE2TH bamboo arm treatment will help this vexing problem".

Pendergast gathered up his car keys and half-empty wine bottle.

"I must be on my way", he said. "Ten meters will open to Japan shortly and I want to be around for all the DX that will be booming in".

"*Sayonara*", I replied. "See you next month."