A High Performance 20- 40- and 80-Meter Vertical System

BY J. SEVICK,* W2FMI

IN A PREVIOUS ARTICLE on vertical antennas,[1] we have tried to point out some fundamental characteristics of ground-mounted verticals, namely: (1) a good image plane is necessary for efficient operation, (2) a vertical over a good image plane compares favorably with a dipole at an elevation of one-half to one wavelength, (3) a short vertical compromises little in the way of performance.

This paper describes a highly efficient three-band vertical system for 20, 40 and 80 meters using elements of the order of an eighth wavelength. The system consists of an 80-meter vertical in parallel with a 20/40-meter trap vertical. Actually, either the 80-meter or the 20/40-meter vertical can be constructed and used alone if one is not interested in triband operation. The input impedances of both antennas are 12-1/2 ohms and they use the same 4:1 matching transformer.[2] The antennas also use the same radial system consisting of 100 radials of No. 15 aluminum wire 50 feet (15.2 m) in length (a lesser number of radials can be used as is discussed later in the article). Because of expected lower sunspot activity and, hence, poorer propagation conditions on the higher bands, the 40- and 80-meter portions of this antenna system, in particular, should prove very effective in DX communication over the next few years.

* Bell Laboratories, 600 Mountain Ave., Murray Hill, NJ 07974.

[1] Sevick, "The W2FMI Ground-Mounted Short Vertical," *QST*, March, 1973.

The first part of this paper deals with the design and tune-up considerations of the 80-meter element; the second part with the 20/40-meter element and the way it is used with the 80-meter vertical forming an efficient triband system. This is followed by reports on performance. Reference is also made to other alternatives for a multiband vertical system.

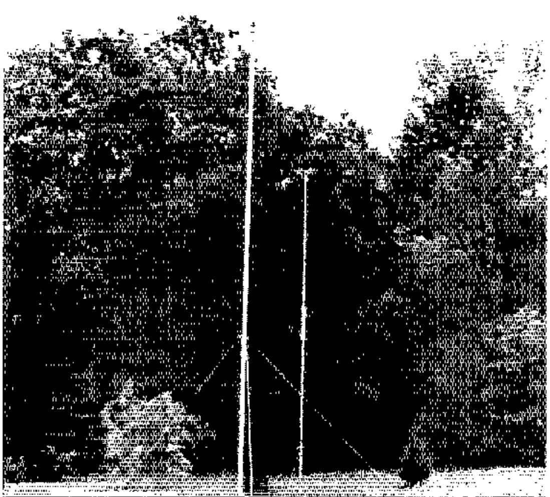
80-Meter Vertical

The two considerations in designing the 80-meter element of this vertical system were: (1) a good bandwidth for a reasonable height (a height one person can handle); and (2) proper spacing between the 80 and 20/40 portions such that coupling is negligible and both can be used over the same radial system.

Prior to building the shortened vertical described in this article, two others were constructed and tested on the air. One was a 22-foot (6.8 m) vertical[3] which had a 65-kHz bandwidth.

[2] Sevick, "The W2FMI 20-Meter Vertical Beam," *QST*, June, 1972.

[3] See footnote 1.



The triband vertical showing the polypropylene guys which provide an extra margin of support.

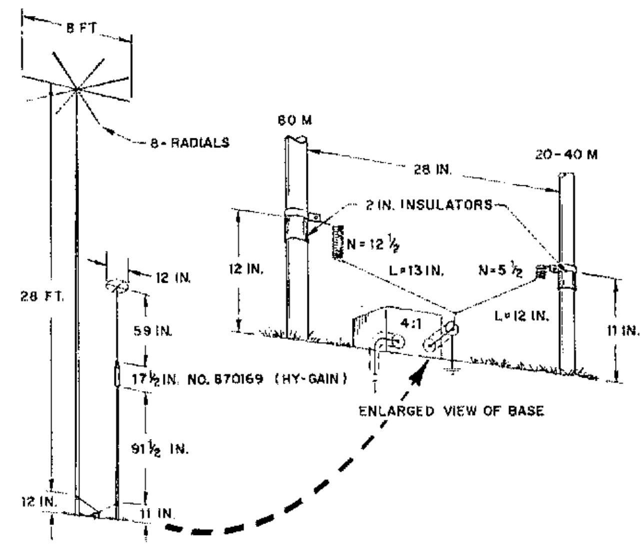


Fig. 1 — The 20-, 40- and 80-meter vertical antenna system. Tuning and construction details are given in the text.

The other was a trap vertical[4] with only a 20-kHz bandwidth. Both of these antennas were used separately over the same image plane of 100 radials and were efficient radiators. Therefore, the main reason in going to a slightly longer antenna was simply *to obtain a broader bandwidth.* The eighth-wavelength vertical on 40 meters from the previous work[5] promised considerable improvement by adding only a few feet. The results are shown in Figs. 1 and 2. The total height turned out to be 29 feet (8.8 m). This resulted in a bandwidth of about 140 kHz, a little more than twice the bandwidth of the 22 footer.

The vertical, in Fig. 1, uses a 20-foot (6.1 m) section of thick-wall aluminum tubing. (It was used some years ago as a ginpole for erecting a beam on a 40-foot (12.2 m) tower.) An 8-foot (2.44 m) extension was constructed with 1-inch (2.54 cm) tubing bolted in place using spacers for centering. The insulator at the bottom is phenolic tubing with a canvas base.[6] It has a 1/2-inch (1.27 cm) thick wall, is 9 inches (22.86 cm) long and has an ID of 1 inch (2.54 cm). The bottom aluminum tubing supporting the antenna is 3-1/2 feet (106.68 cm) long with 2-1/2 feet (76.2 cm) of it placed in cement. The diameter of the hole in the ground is about 1 foot (30.48 cm). Even though this construction could probably be self-supporting, three simple polypropylene guys at about the 7 foot (2.13 m) level are used for extra margin of support. The radials at the top use 1/2 inch (1.27 cm) aluminum tubing.[7] The base loading consists of 12-1/2 turns of a B&W 3029 coil.[8] Actually, 14 turns are on the coil. A shorting stub, as shown in the close-up picture of the base of the two antennas, is used for adjustment. To place the minimum SWR near the low end of the phone band, where much of the DX is worked, 1-1/2 turns were shorted out. The final number of turns employed depends, to some extent, on the number of radials used in the image plane. A simple check is to set the shorting tap at some convenient point, like 12 or 13 turns, and plot the SWR. If the minimum value appears too high in frequency, then add about a half a turn of coil. This half turn should change the position of the minimum SWR value by about 50 kHz. As can be seen in Fig. 2, the minimum value of SWR is practically 1:1 and occurs at 3.840 MHz. This also verifies the input impedance value of 12-1/2 ohms, as expected from the previous work on short verticals.

[4] To be published later.

[5] See footnote 1.

[6] Cadillac Plastic and Chemical Co., Post Office Box 810, Detroit, MI 48232.

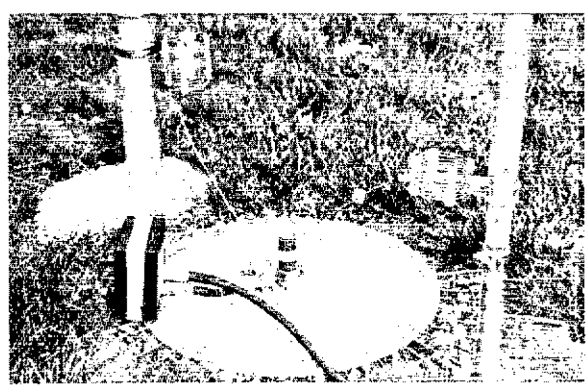
[7] Construction details on the top hat are also given in the reference in footnote 1.

[8] 2-1/2 inch diameter, 6 tpi, No. 12 wire.

20/40-Meter Vertical

In extending the operation of a vertical system over other bands, many alternatives are available. A trap vertical with a 12-1/2-ohm input impedance

Close-up of the base of the triband vertical antenna.



can be connected in parallel with the 80-meter vertical. Alternatively, the trap vertical can be designed to present an impedance of 50 ohms and thus be connected to the input side of the 4:1 transformer.[9] If broad-band operation is desired on only 80 and 40 meters, then one-eighth wavelength verticals on both bands can be used.[10]

For this work, a 20/40-meter trapped vertical having an input impedance of 12-1/2 ohms was used. It offered a rather simple mechanical form of parallel operation as is shown in Fig. 1 and the close-up picture. The bandwidth on 40 meters of 155 kHz appeared acceptable. As will be seen in a subsequent article, this bandwidth can be extended by about 50 percent by using the 50-ohm design of a trap vertical.

In the first attempt of parallel operation, the 20/40-meter vertical was placed only 14 inches (35.56 cm) away from the 80-meter vertical. The coupling appeared excessive. The 80-meter vertical was detuned by approximately 50 kHz. The 20/40-meter vertical also required excessive base loading in order to present an acceptable input impedance. By doubling the spacing between the verticals to 28 inches (71.12 cm), the interaction between them became negligible. The final values of heights and loadings were practically the same as if the elements were operating alone.

[9] The characterization and design of these trap verticals will be published later.

[10] See footnote 1 for details on the 40-meter vertical.

The adjustment of the 20/40-meter vertical is somewhat more complicated than the 80-meter vertical. An impedance bridge, as described in the *ARRL Handbook*, is of considerable help. In this case, there are two degrees of freedom: (1) varying the number of turns at the base, and (2) adjusting the lengths of the vertical sections.

Basically, the tuning is as follows: The tap is set at about 5-1/2 turns and the 20-meter section adjusted to give an acceptable value of SWR, both in position in the band and in magnitude. If the impedance is too high, it can be lowered by increasing the number of turns and lowering the height of the 20-meter section for resonance. After this, the 40-meter portion is then tuned. A plot of the SWR vs. frequency can immediately give an indication of the necessary adjustment of the section above the 20-meter trap. If the minimum value appears too low in frequency, a shortening of the top section is required. In no case should large adjustments be made. A change of a few inches has considerable effect. If the input impedance on 40 meters appears too low, then the 20-meter section has to be lengthened. This requires that the whole procedure be repeated. In any case, the initial adjustment should be started on the highest band of the trap vertical.

Results

Short verticals have been used by the author during the past year with considerable success. Many DX contacts were made on 40 meters with

Table I — Some Results With Triband Vertical

Date	*Station Contacted*	*W2FMI Signal Report*	*Freq. MHz*	*Input Power SSB (Peak)*	*Comments*
3/13	K5LWL/YV6	59 + 10 dB	7	2 kW	very, very strong signal, only one signal stronger — he used a Yagi at 120 feet
4/3	WB5HJY	59 + 40 dB	7	2 kW	superior to anything on band
4/4	ZF1SP	59 +	14	2 kW	very, very nice signal
4/4	WA4MUR/4	59 + 40 dB	14	2 kW	best signal on whole band
4/18	KV4HW	59 + 10 dB	7	2 kW	loudest on band
5/9	K6YIY	59	4	2 kW	K1GZL and I are only ones they hear
5/9	W9LZX	59 + 30 dB	4	2 kW	strongest (very consistent signal)
5/12	W2DU	59 +	4	2 kW	tremendous signal
5/17	VK5PB	56-7	4	2 kW	remarkably strong
5/17	W4JNY	59 + 20 dB	4	2 kW	outstanding, certainly one of best
5/22	VK5PB	59 + 10 dB	7	2 kW	really amazing
5/23	ZL3RJ	57-8	4	2 kW	one of the strongest he's heard for some time — pinned the S meter
5/27	WA2BQL	59 + 30 dB	4	200 W	very potent — Stronger than most locals — couldn't believe you were using 200 W

antennas varying in length from 6 (1.83 m) to 33 (10 m) feet. Since an extensive ground system was used, very little difference in effectiveness was noticed between the antennas.[11] This even includes redesigned trap verticals. As was stated before, the objective of the present investigation was to design a three-band vertical system which not only yielded competitive antennas on the lower bands, but one that was capable of covering a considerable portion of 80 meters. As was seen, a separate one-eighth wavelength antenna connected in parallel with a trap vertical not only gave a bandwidth on 80 meters of 140 kHz where the SWR was less than 2:1, but was short enough to not require considerable help in erection.

During all this time of operation of short verticals on 40 meters, and as of this writing, including several months on 80 meters, very few signal reports were received which did not indicate one of the best signals on the band. Table I gives some of the reports and comments received. In only three specific cases on 40 meters have the short verticals been bested by other antenna systems. One is shown in Table I where K5LWL/YV6 reported a stronger stateside signal by an amateur using a Yagi at 120 feet (36.6 m). The other cases include a comparison with W2GO of Linden, New Jersey. On 40 meters, VK5PB reported 6 dB and VK2WC 10 dB in favor of W2GO's signals. He was using a 2-element Yagi at 60 feet (18.3 m). The elements were 44-1/2 feet (13.6 m) in length and the boom, 20 feet (6.1 m). On 80 meters, only one other station received a stronger report on direct comparison. This was by W2HCW, when comparing my signals with VK5PB. The difference was 2 to 3 S units. His antenna was an 80-meter Yagi at 120 feet (36.6 m).

Invariably, most amateurs were surprised by the performance of these verticals. In many instances, questions were asked regarding the minimum number and length of radials required for efficient operation of ground-mounted verticals. As was noted in previous articles,[12] the answer depends to some extent on the conductivity of the soil at the respective locations. Poorer soils not only require more radials, but ones that are also considerably longer. Although more experimental work is required in this area, it appears that about 50 radials, 0.2 wavelength long, should generally give good operation. The loss in this case will be approximately 1 to 2 ohms. Doubling the number to 100 radials should reduce the loss to less than 1 ohm. It should be noted that even 1 to 2 ohms of loss are appreciable with these short antennas since their radiation resistances are only 12-1/2 ohms.

[11] See footnote 1.
[12] See footnote 1.

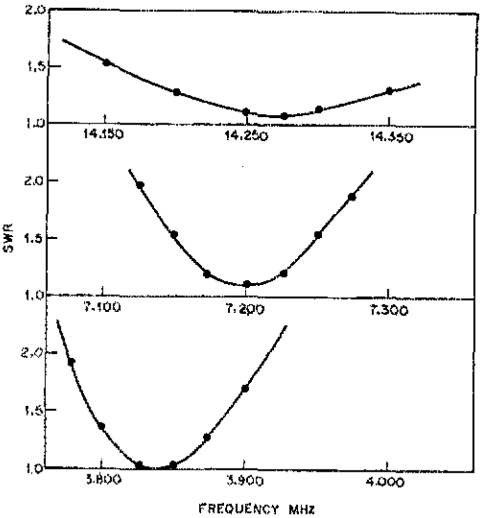


Fig. 2 -- Standing wave ratio vs. frequency for the 20-, 40- and 80-meter vertical antenna system.

Again, I would like to acknowledge the help, encouragement, and interest shown by the many amateurs during our experimental studies on verticals. Very few antenna laboratories can boast of a greater number of willing and competent field stations. In particular, we would like to thank Al Jones, W2GO, for his considerable help in obtaining comparative reports in Australia and New Zealand. QST

Strays

After years of complaining about Field Day interfering with her wedding anniversary, Bede Gooch, XYL of W9YRV, was surprised by the Twin City ARC members with a 23rd anniversary cake and second honeymoon tent at the club's Field Day site this year.