When an idea germinates, it's still theory until you actually get to try it out. WB0DGF took the idea and went with it through research, modeling, and testing.

The Open-Sleeve Antenna

Development of the Open-Sleeve Dipole and Open-Sleeve Monopole for H.F. and V.H.F. Amateur Applications

BY ROGER A. COX*, WB0DGF

A broadband antenna for 80 meters tugged at my curiosity after the 1982 Dayton Hamvention. It was a dipole antenna sold by Snyder Antenna Corp. that exhibited a v.s.w.r. curve with two dips—a double resonance within the same band. Upon returning home and leafing through the pages of the just-arrived April '82 IEEE *Antennas and Propagation Newsletter*, I spotted a familiar v.s.w.r. curve. An antenna for military satellite communications had the same double-resonance v.s.w.r. curve as the 80 meter dipole. After closer examination of the article,[1] which explained various types of v.h.f. and u.h.f. antennas developed by the Aerospace Corporation, I told myself that the antenna with the double resonance may not use the same method in obtaining its broadband performance, but it was certainly worth further investigation. The v.h.f. antenna was an open-sleeve dipole in front of a plane reflector.

I sent for the report listed as a reference in the article. Interestingly, this report was dated January 15, 1973. That would mean that this antenna had been around for awhile, yet I had never read anything about an open-sleeve dipole.

The first thing that came to my mind when I saw the term *open-sleeve dipole* was the conventional sleeve dipole where you strip the insulation off the end of a length of coaxial cable. Then you fold a ¼ wavelength of braid back upon the cable to form a center-fed ½-wavelength dipole. I knew that this antenna doesn't work well unless the ratio between the folded-back shield and the coaxial shield is increased. This is the basis for the sleeve decoupling system used on many v.h.f. antennas. I thought that this was probably not the same as the open-sleeve dipole.

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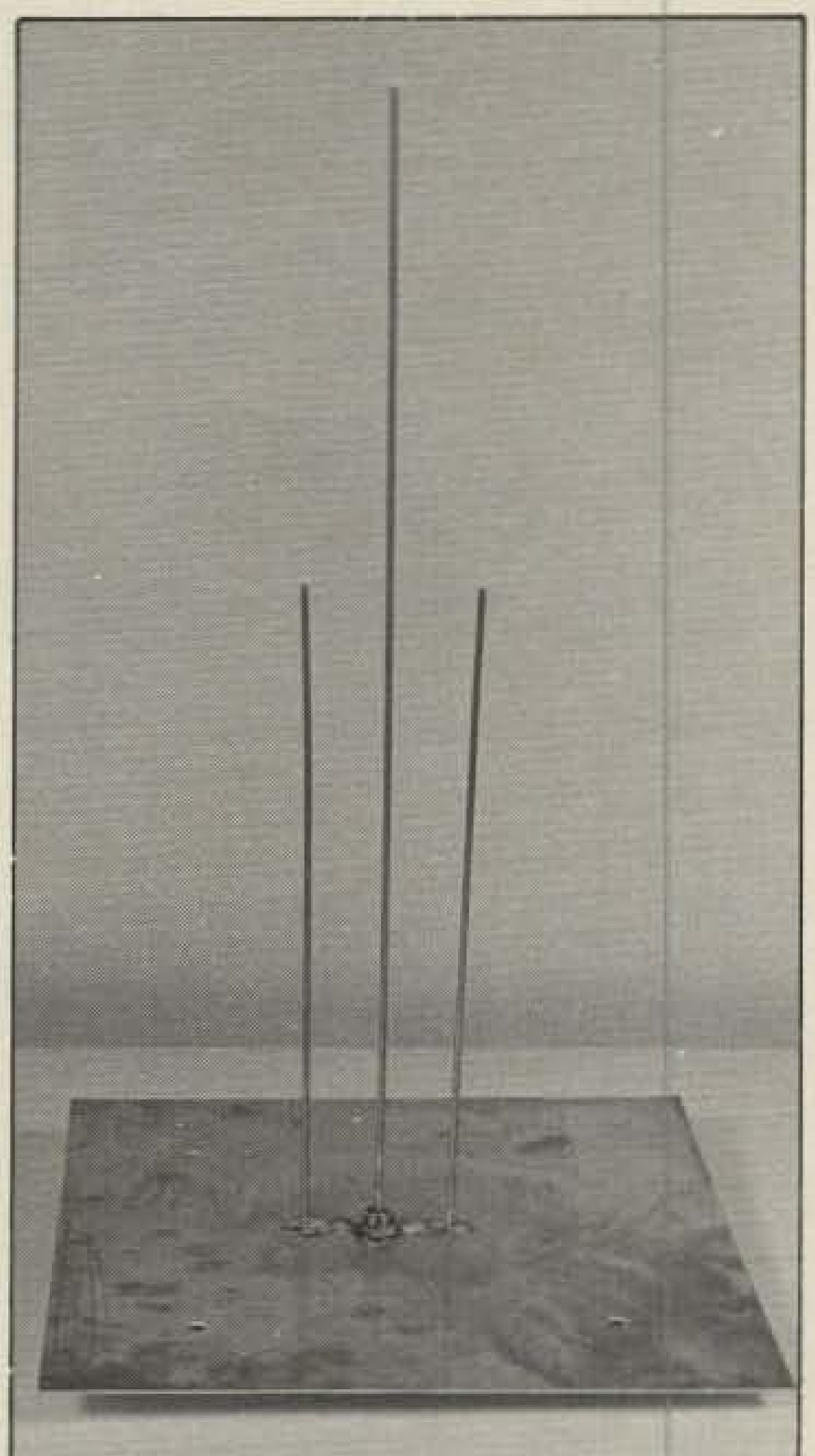

Modeling antennas need not be all that complicated. Here is a version of the open-sleeve antenna as modeled by the author, WB0DGF.

Upon inquiry, I was told that a sleeve antenna can take another form. I was also told to go look in a book entitled *VHF Techniques*.[2] This was a fairly old book, being published in 1947. Consequently, it was not in my collection of antenna books. Luckily I was able to borrow it from a colleague so that I could find out what a sleeve antenna was.

The book's definition of a sleeve antenna is as follows:

> "An electromagnetic radiator is termed a sleeve antenna when it incorporates a tubular conductor, i.e., sleeve, of which the exterior is used as a radiating element and the interior as the outer conductor of the coaxial transmission line that feeds the antenna."

So far this sounds like the familiar sleeve decoupler. Reading on: "The length of the sleeve may be any portion of the total length of the antenna." This seemed totally different from the ¼-wavelength sleeve decoupler. The book went on to describe various forms of the sleeve monopole as shown in figs. 1 and 2.

Continuing from the book:

> "It will be noticed that each of these has been shown to possess a sleeve with the inner diameter substantially less than the outer. In each case a crosshatched region between the walls of the sleeve is shown. It is evident, from consideration of the structures, that the performance of the antennas will in no way depend upon whether the crosshatched regions are empty or are filled with metal, since they are separated from all fields by continuous metal surfaces. This matter has been brought out to distinguish the sleeve antenna as defined here from the type of antenna shown in figure 3, which also involves a "sleeve" element but which differs in that the sleeve is used as a choke and the space corresponding to the crosshatched regions of figure 2 must be empty in order that the choking effect take place. Antennas of this latter type are usually forms of center-fed cylindrical dipoles, and the purpose of the sleeve is merely to permit feeding them with coaxial transmission line."

Now I knew the difference between the two types of sleeve antennas. The book also went on to describe how the sleeve dipole evolved from the sleeve monopole. Some of these are shown in fig. 4.

The impedance of the sleeve dipole (or

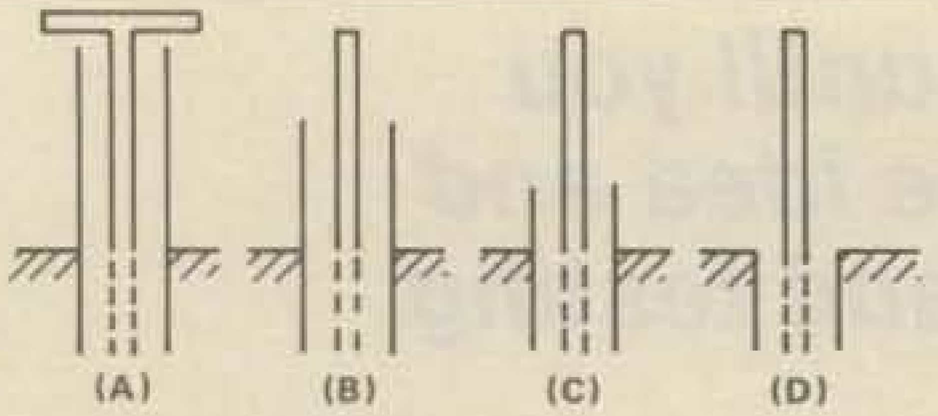

Fig. 1– Sleeve-stub antennas with uniform cross section.

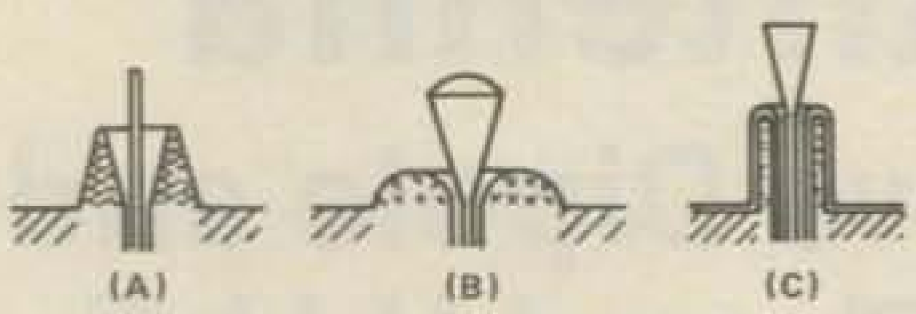

Fig. 2– Sleeve-stub antennas with non-uniform cross section.

sleeve monopole) can be optimized with the use of tapered elements, as shown in fig. 4 (C), (D), and (E). Also, the radiation pattern can be controlled by the maximum length of the dipole. As shown in fig. 5, I could not allow the maximum length (2L) to exceed 1.0 wavelength at a given frequency without introducing major sidelobes into the radiation pattern.

Although the book made a very good argument for an antenna that exhibits rugged mechanical construction and favorable broadband characteristics, I could not justify to myself using this type of antenna in anything other than certain v.h.f. or u.h.f. antennas. It would be a very bulky antenna on any frequency less than 100 MHz, and tuning the antenna by changing the sleeve taper or diameter ratio would be a very time-consuming process.

The Open-Sleeve Antenna

Luckily the Aerospace Corporation report[3] arrived before I lost interest in the design; and upon reading it, I was amazed at the simplicity and flexibility of the construction.

The basic design of an open-sleeve dipole consists of a conventional center-fed dipole with two shorter parasitic sleeve elements *closely* spaced on both sides and parallel to the center-fed dipole. The length of the center-fed dipole corresponds to a half wavelength at a frequency f1, and the lengths of the sleeves correspond to half wavelengths at a higher frequency, f2. As shown before in the conventional coaxial sleeve dipole, the ratio of f2 to f1 cannot exceed 2:1 without creating significant sidelobes. Typical spacing between the sleeve elements and the central dipole is on the order of 4–12 times the diameter of the elements. A comparison of the v.s.w.r. response of a typical open-sleeve dipole with that of a conventional cylindrical dipole of the same dimension is given in fig. 6.

I could easily see the noticeable increase in bandwidth obtained by this design. The report states that an open-sleeve dipole can be operated over a bandwidth of *1.8:1* as compared with an operating bandwidth of 1.25:1 for a conventional cylindrical dipole.

What this means is that a cylindrical dipole that was constructed to cover 100 to 125 MHz could, with the addition of the appropriate sleeve elements, be made to cover 100 to 180 MHz instead. Pattern, gain, and impedance variations would be similar to those of the cylindrical dipole alone, but only over a much wider frequency range.

The possibilities of various broadband v.h.f. and u.h.f. antennas were tremendous. I could now cover 88–158 MHz, 138–248 MHz, 225–405 MHz, and 450–810 MHz, each as a separate broadband antenna. But these incredible bandwidths could also be achieved by very large diameter cylindrical monopoles and structures such as discones. What I needed to do was to take a look at the physical size of the antenna structures and compare them.

Size vs Bandwidth

Various open-sleeve dipole arrangements have been described by H.E. King and J.L. Wong.[4] From the information presented in their article, I could see that I would need dipole element diameters of at least 1.125 inches in order to cover 225–400 MHz under 2.5:1 v.s.w.r. Overall dimensions of the antenna would be 5.125 inches wide, 1.125 inches thick, and 20.375 inches long. Scaling this an-

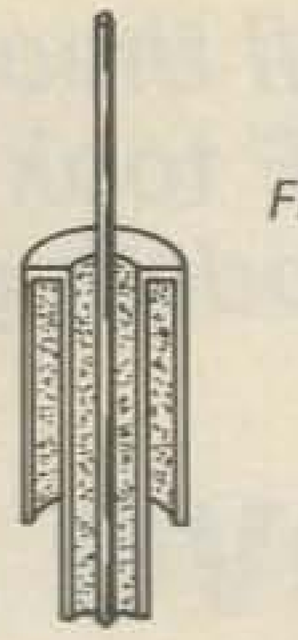

Fig. 3– Center-fed coaxial dipole.

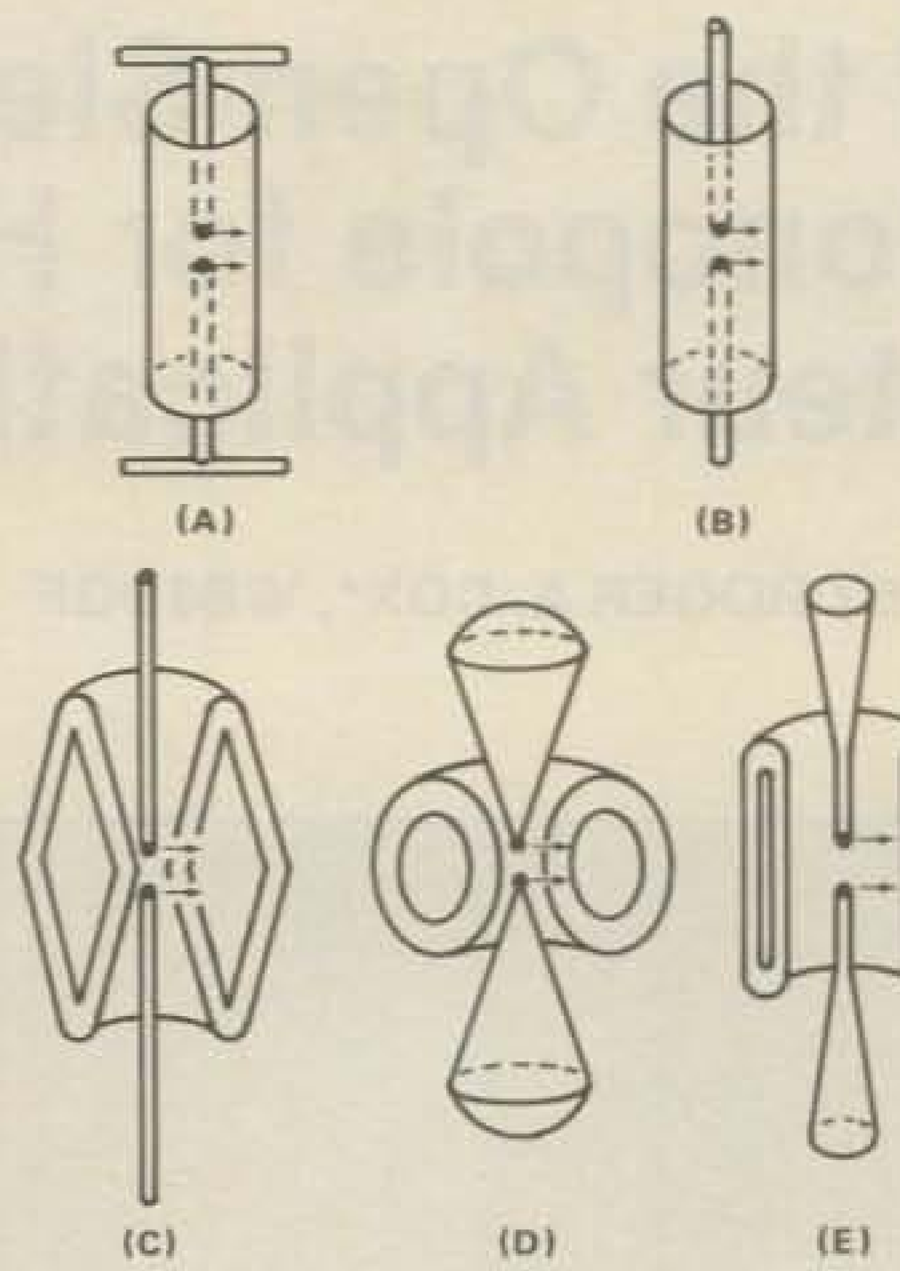

Fig. 4– Evolution of sleeve-dipole antennas from sleeve-monopole antennas.

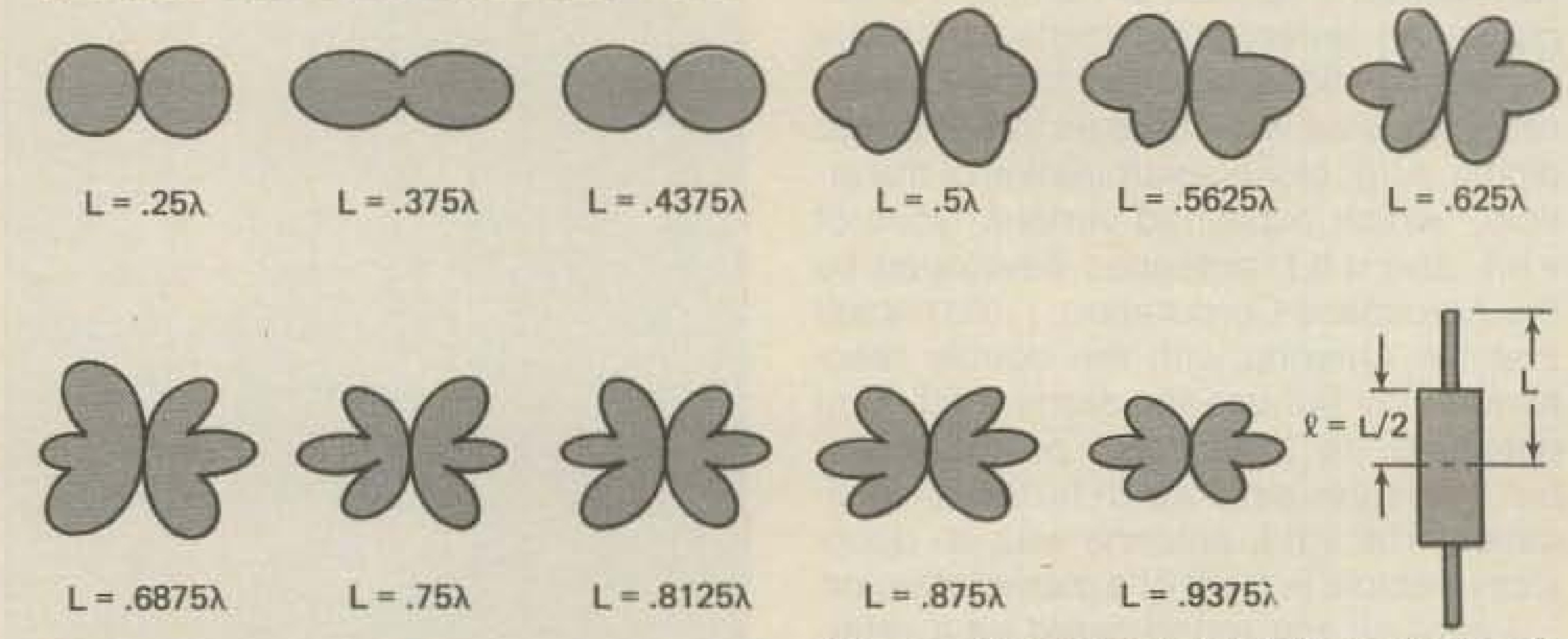

Fig. 5– The measured field patterns of a sleeve dipole. (Note: $1 = 0.5L$, $D = 0.25L$, $d = 0.5D$.)

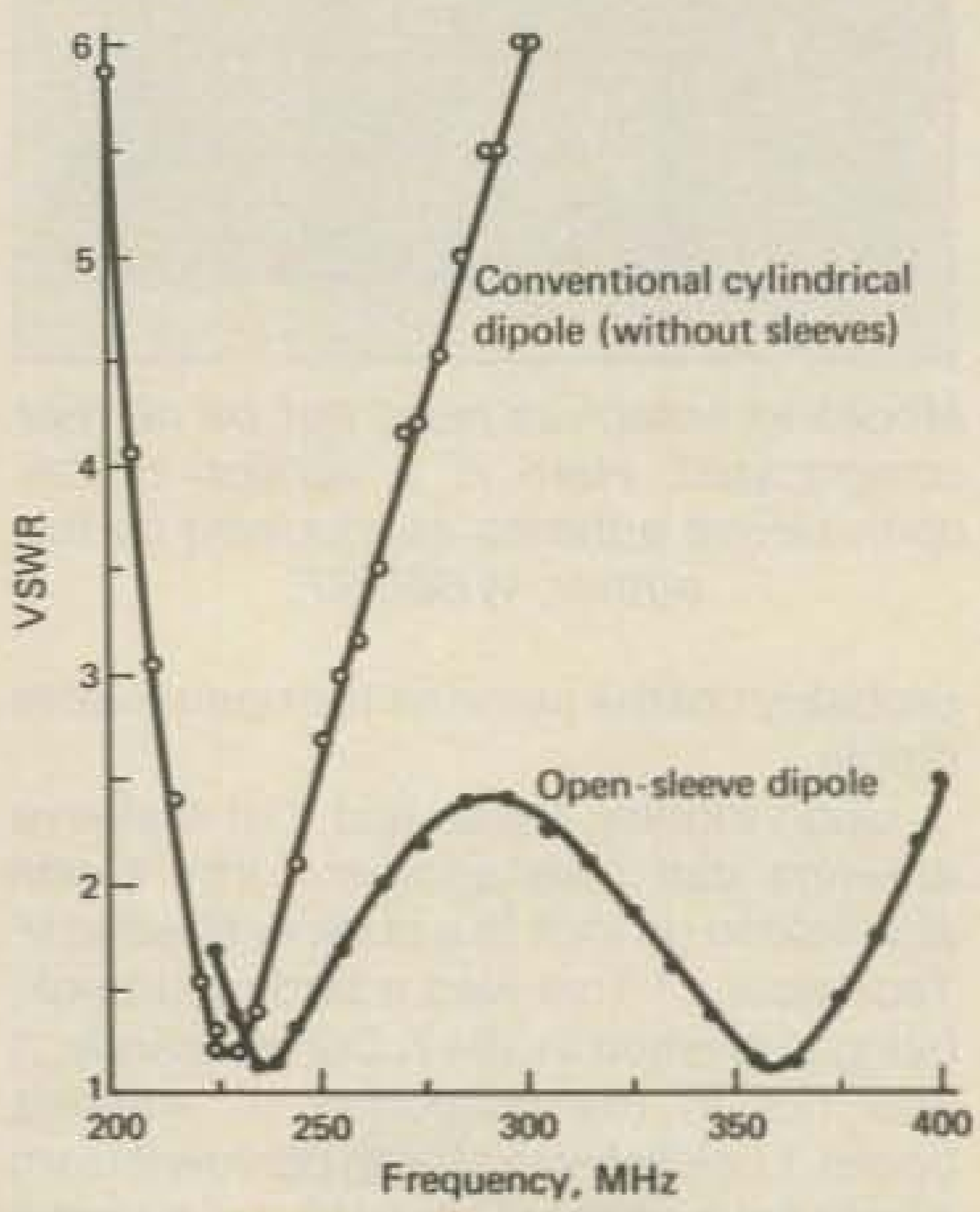

Fig. 6– V.s.w.r. response of an open-sleeve dipole and a conventional dipole.

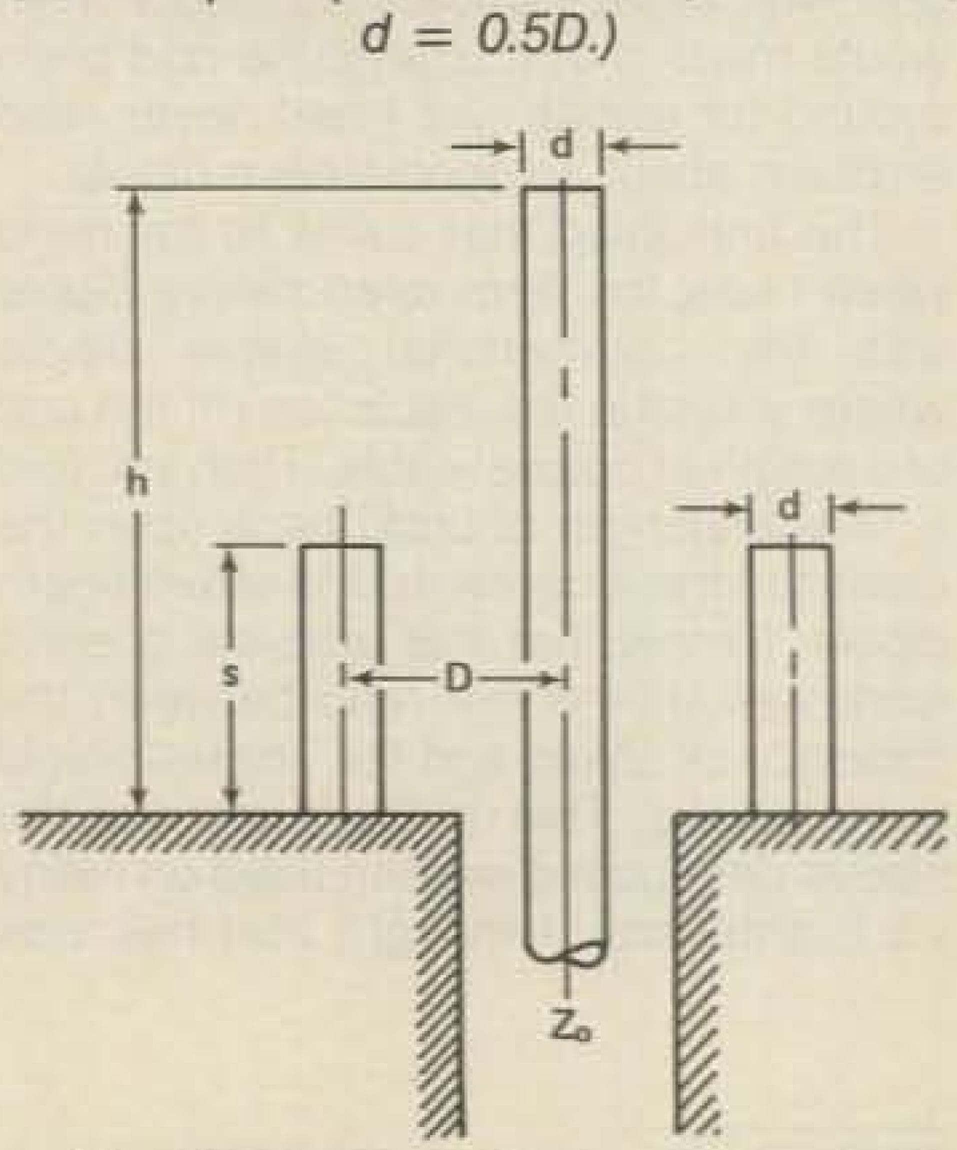

Fig. 7– An open-sleeve monopole.

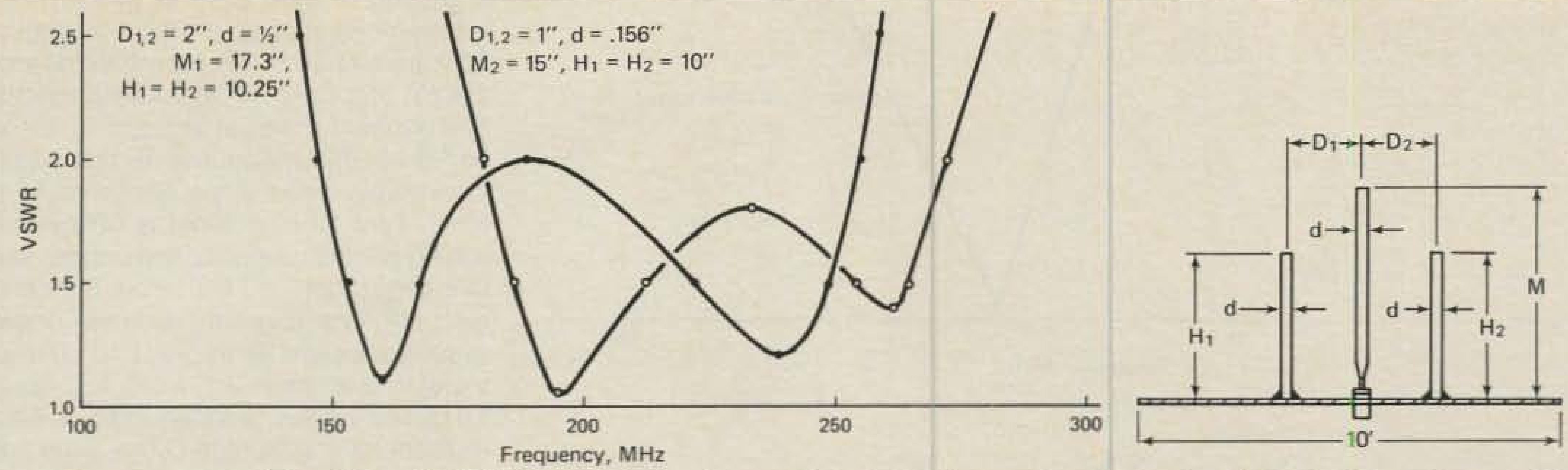

Fig. 8– V.s.w.r. curve of the 195 and 260 MHz modeled antenna. A variation in construction using ½ inch O.D. tubing and 2 inch separation is also shown.

tenna structure by 1.6 so that the lowest frequency is 140 MHz gives overall dimensions of 8.2 inches wide, 1.8 inches thick, and 32.6 inches long. This would permit coverage from 140 MHz to 249 MHz under 2.5:1 v.s.w.r.

A broadband antenna presented by Dave Geiser, WA2ANU, in December 1978 *QST* and the ARRL *Antenna Book*[5] is the discone for 144, 220, and 420 MHz. Although it has a higher cutoff frequency, the lowest frequency, which determines the maximum dimensions, is 140 MHz. For comparison, its overall dimensions are 22.563 inches in diameter by 20 inches tall. Although the discone covers a much broader frequency range, the open-sleeve dipole, because of its long, slender geometry, should lend itself more readily as a driven element in more complex antenna structures such as Yagis and corner reflectors. In fact, Telex Communications, Inc. has applied for a patent on the use of open-sleeve dipole elements in Yagi-Uda arrays. They also have a product called the Explorer 14, which utilizes this application in a triband Yagi beam.

The Open-Sleeve Monopole

Although the studies of the open-sleeve antenna by King and Wong concentrated on applications of the open-sleeve dipole at v.h.f. and u.h.f., the earliest studies of the open sleeve by H.B. Barkley in June 1955 dealt with the open-sleeve monopole.[6] Barkley's MSEE thesis for the U.S. Naval Postgraduate School contains the results of an investigation into the properties of the open-sleeve monopole.

The open-sleeve monopole had previously been patented by Dr. J.T. Bolljahn of Stanford Research Institute and was issued patent no. 2,505,751 in May of 1950. During the fall of 1954 it was suggested to Mr. Barkley that the open-sleeve antenna would be a possible subject of investigation for an 11-week industrial tour with Stanford Research Institute from January through March 1955. Barkley's paper contains the results of this investigation.

The basic principles of the open-sleeve monopole are the same as those of the open-sleeve dipole. The form of the open-sleeve monopole is shown in fig. 7.

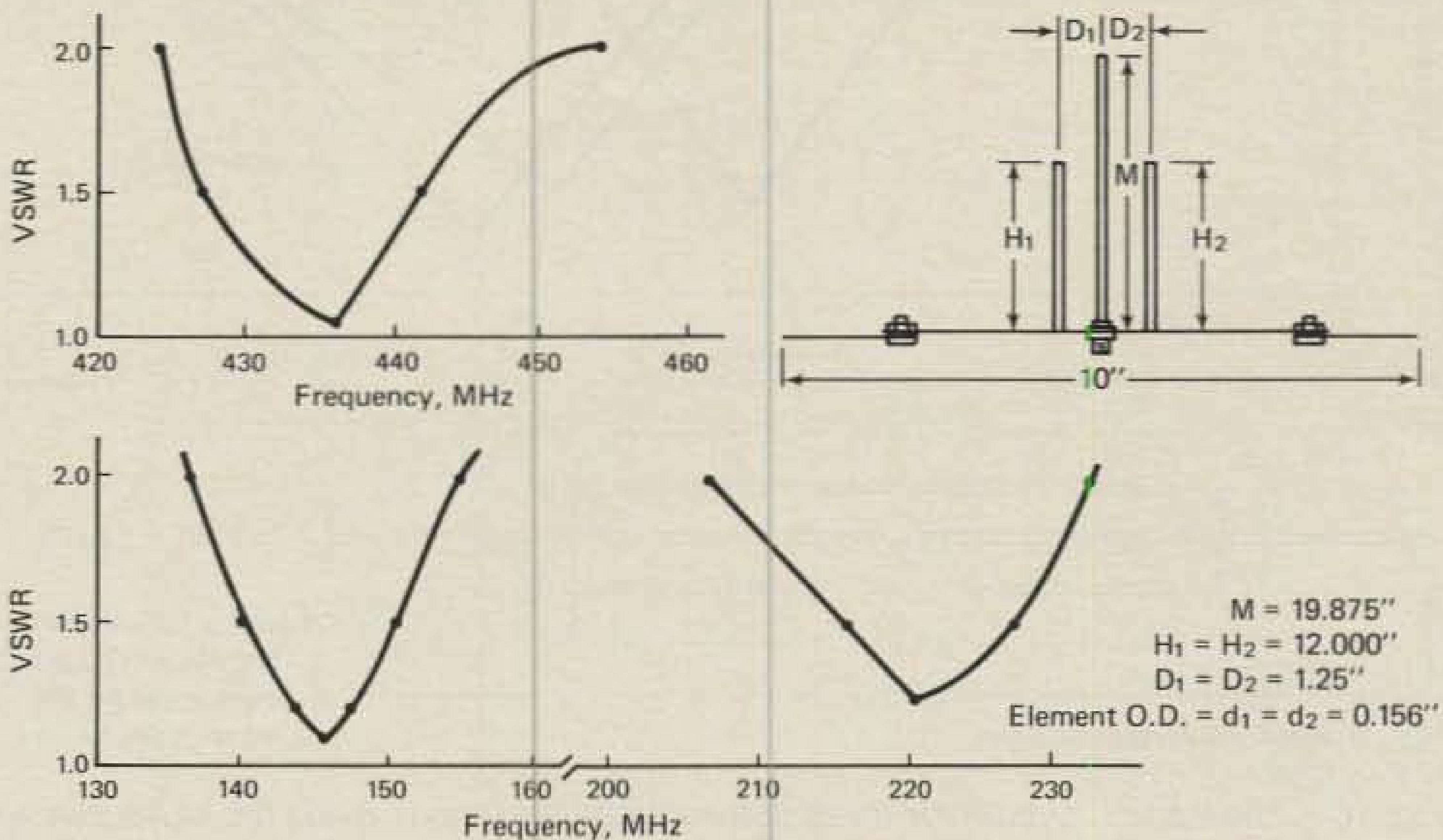

Fig. 9– A third variation of the test antenna. This version tunes 2, 1 ¼, and ¾ meters.

The longer central driven element controls the low-frequency resonance, and the shorter sleeve elements control the high-frequency resonance. The diameter of the elements controls the maximum v.s.w.r. between the two resonances. In all cases sleeve elements are grounded.

Tests on the V.H.F. Open-Sleeve Monopole

I constructed three v.h.f. models of the

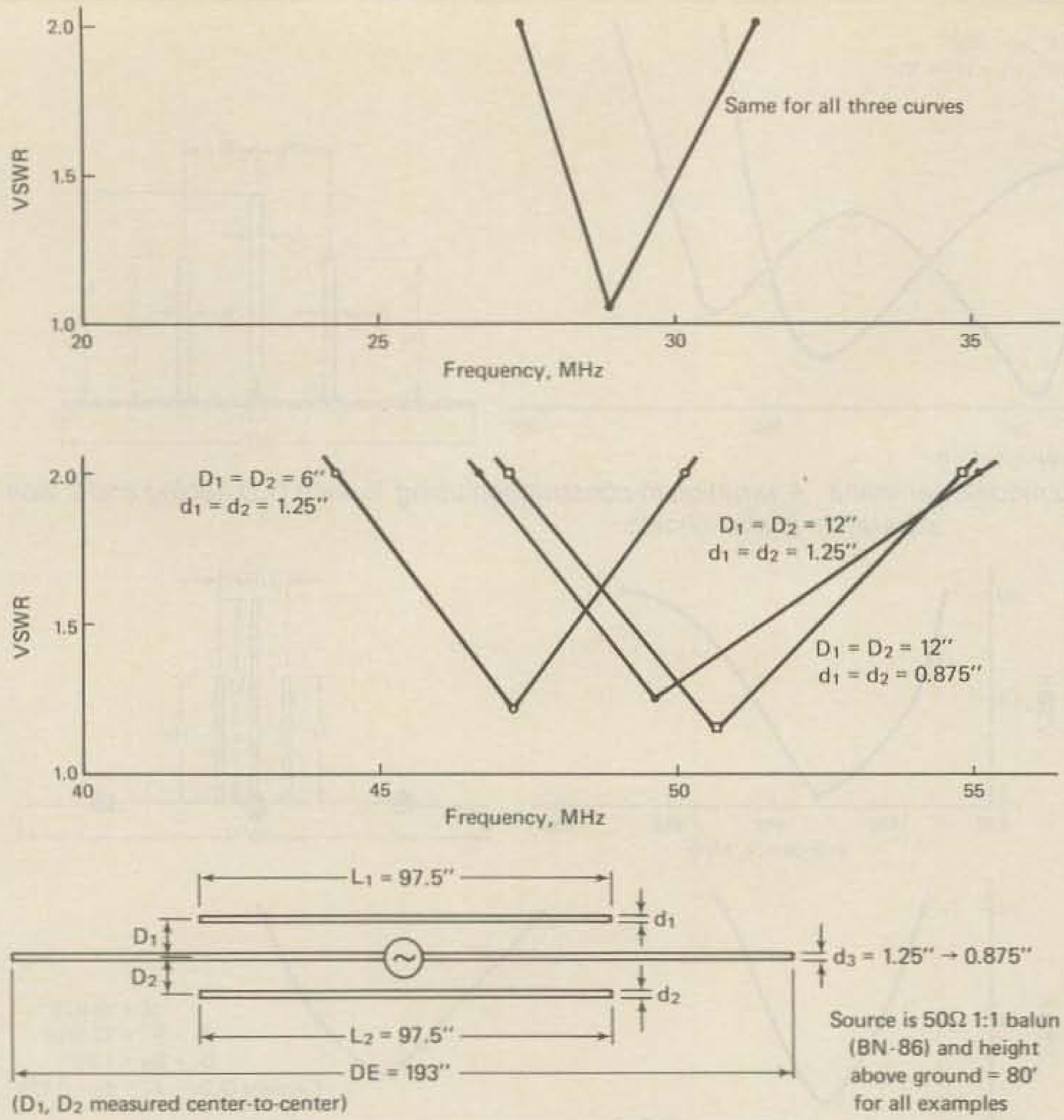

Fig. 10– The v.s.w.r. curves for three different configurations using the same sleeve length of 97.5 inches.

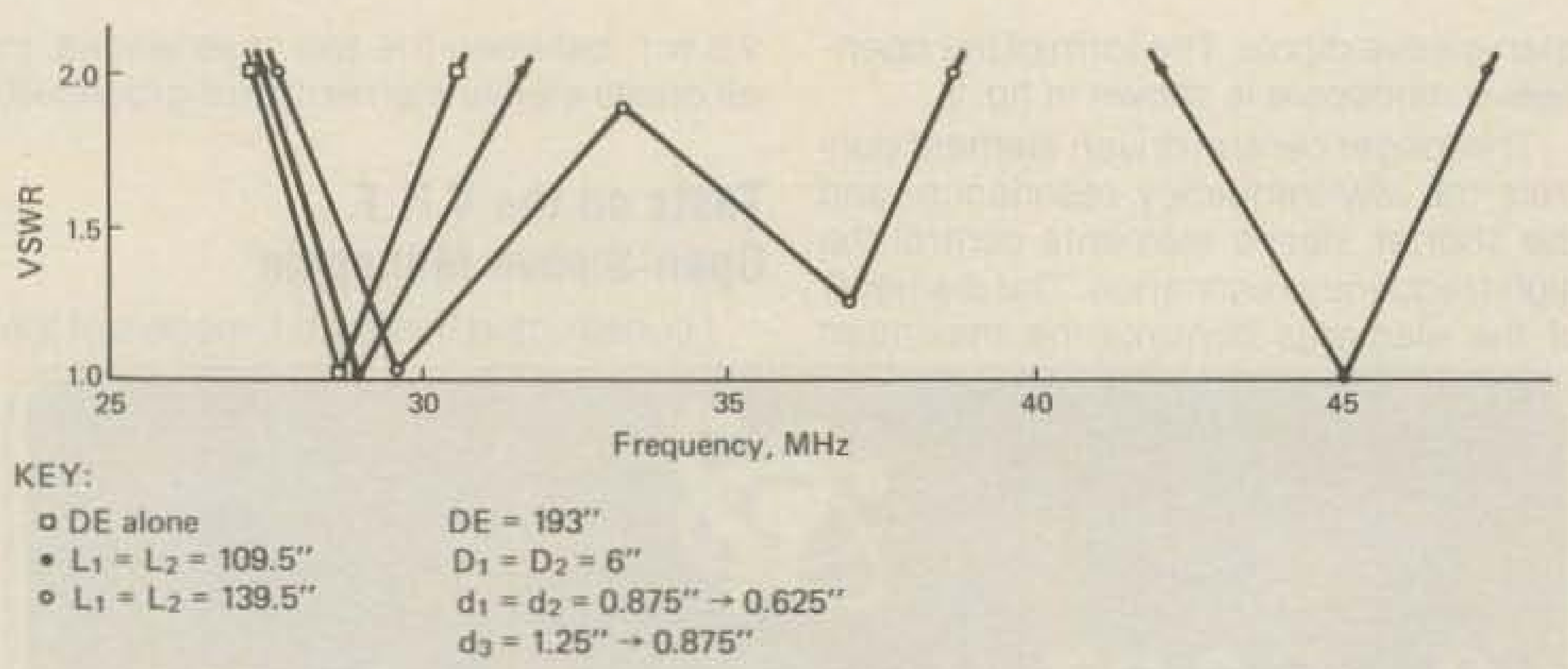

Fig. 11– The effect of lengthening the sleeve elements while maintaining a constant spacing and relatively constant element diameter.

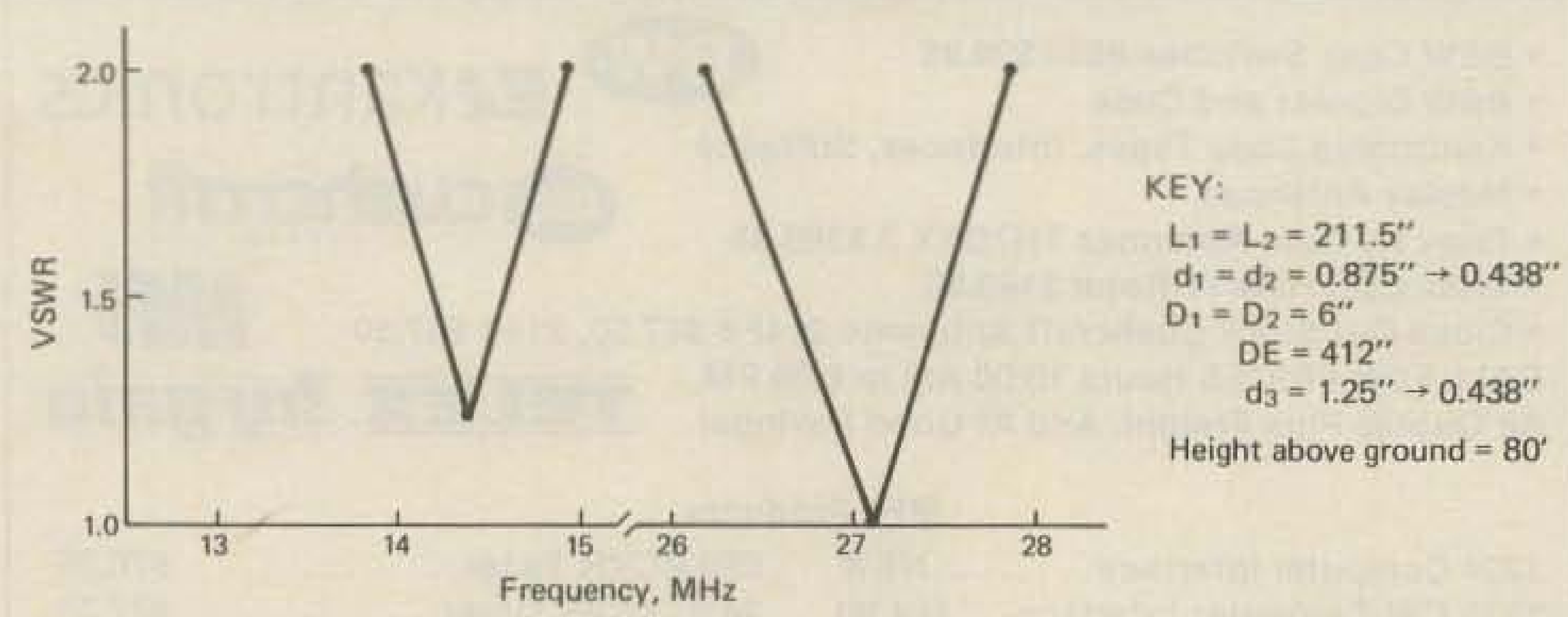

Fig. 12– The results of a model using a central dipole resonant near 14.3 MHz.

open-sleeve monopole to test. The first model consisted of a 15 inch length of 5/32 inch O.D. brass tubing soldered to the pin of a type "N" chassis connector. The connector was attached to a flat copper sheet that measured 10 feet square. Its ¼-wave resonance occurred at 195 MHz. Two 10 inch lengths of the same tubing were soldered to the copper sheet at a separation of 1 inch from the central element. The resultant antenna showed resonances at 195 and at 260 MHz with v.s.w.r. less than 2:1 from 180 to 272 MHz. The v.s.w.r. is shown in fig. 8. Another model using ½ inch O.D. tubing and 2 inch separation is also shown in fig. 8. A third model tuned for the 2, 1¼, and ¾ meter amateur bands is shown in fig. 9. The antenna behaves as a quarter-wave with low-angle radiation on 2 and 1¼ meters. However, the ¾-wave resonance is used at 436 MHz with resulting high-angle radiation. If the central monopole is tuned higher in the 2 meter band, the ¾ meter v.s.w.r. will be better within the 440–450 MHz region.

H.F. Open-Sleeve Applications

The broadband potentials of the v.h.f. or u.h.f. open-sleeve antenna are obvious. Not so obvious is its potential for broadband or multiband use at h.f. (3–30 MHz).

In the investigation by King and Wong it was found that larger diameter elements enhanced the broadband characteristics of the open sleeve by lowering the maximum v.s.w.r. between the resonance of the longer driven element and the resonance of the shorter sleeve elements. With a ratio of the element diameter to the maximum length of the dipole (d/l) at 0.055, the maximum v.s.w.r. between resonances was 2.5:1. With a ratio of d/l at 0.017, the maximum v.s.w.r. between resonances was 4:1. I assumed that even smaller ratios would give even higher values of midband v.s.w.r. I also assumed that the two separate resonances would remain intact, each with a bandwidth typical of the element diameter used.

My first h.f. models of the open-sleeve antenna were open-sleeve dipoles in the transition region between h.f. and v.h.f. My central dipole was a center-fed dipole element mounted on a metallic boom, fed with a BN-86 balun, and resonant near 29 MHz. The sleeve elements were chosen so that the 2:1 frequency range would not be exceeded.

Fig. 10 shows curves of three different configurations using the same sleeve length of 97.5 inches. The sleeve elements were of a constant diameter, whereas the driven central element used tubing which tapered from 1.25 inches at the center to 0.875 inches at the tips. The different configurations of the sleeves did not have a noticeable effect on the v.s.w.r. at 29 MHz.

Fig. 11 shows the effect of lengthening

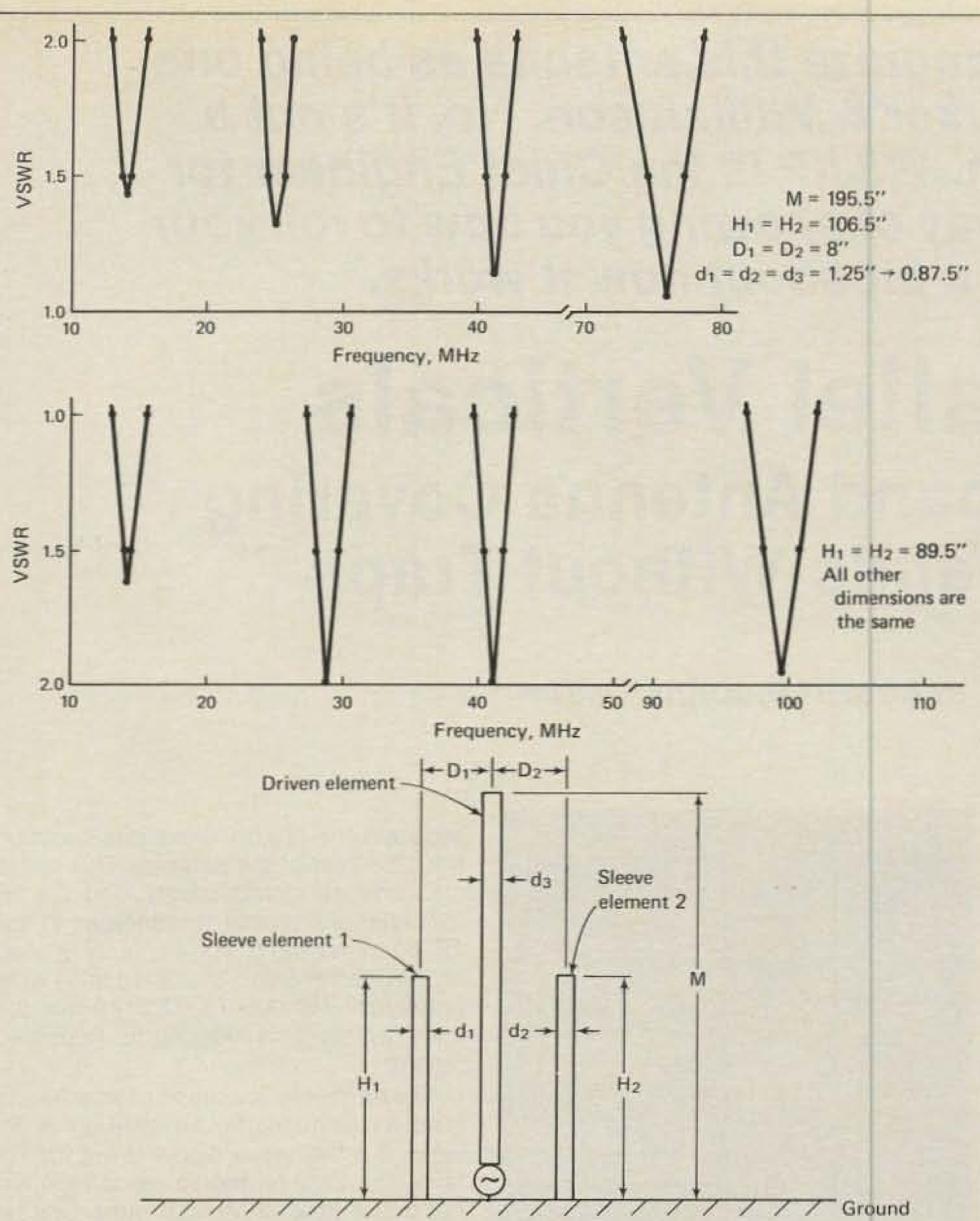

Fig. 13– Diagram of an open-sleeve monopole. The plot shows the v.s.w.r. of two configurations using a central monopole resonant near 14 MHz.

the sleeve elements while maintaining a constant spacing and relatively constant sleeve-element diameter. As one can easily see, the v.s.w.r. curves merge together as the sleeve lengths approach that of the central element. This could allow multibanding of frequencies too closely spaced for conventional traps. This could also be used to broadband h.f. antennas where low v.s.w.r. is required over a frequency range too broad for conventional dipole elements.

Fig. 12 shows the results of a model using a central dipole resonant near 14.3 MHz. The sleeve lengths were chosen at random using the 2:1 criteria established earlier. A slightly shorter sleeve length should make a perfect 20 and 10 meter antenna, whereas longer sleeve elements could make 20/12, 20/15, or 20/17 meter multiband antennas.

Although I have not tried lower frequencies, it should be possible to make open-sleeve antennas for the 40/20, 40/30, 30/20, 30/15, 30/17, 80/40, and 160/80 meter bands. Unique triband configurations should work on 40/30/15, 40/20/15, or 40/17/15 using the central dipole as 3 half waves on 15 meters.

The open-sleeve monopole was also modeled on h.f. Fig. 13 shows the v.s.w.r. of 2 configurations using a central monopole resonant near 14 MHz. One configuration used sleeve elements resonant at 25 MHz (12 meters). It also had ¼-wave resonances near 41 and 76 MHz. The other model used sleeve elements resonant at 29 MHz, with corresponding ¼-wave resonances near 41 and 100 MHz. The h.f. open-sleeve monopoles were ground mounted with 8 radials, each 12 feet long, buried slightly below ground level.

Summary

Even though the open-sleeve antenna has been in existence since the early 50s, I feel as though I have discovered an entirely new and exciting antenna. In a way it is new to the amateur community. Why, in over 30 years of existence, no amateur has put its simplicity and broadband capabilities to work, I do not know. But I do know that with the current popularity of broadband no-tune transceivers, a new broadband antenna will not be overlooked for long.

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