About this Article

This material was included with the downloadable supplemental content accompanying the *ARRL Antenna Book*.

You may print a copy of this material for personal use. Any other use of the information requires permission from the ARRL.

Copyright/Reprint Notice

In general, all ARRL content is copyrighted. ARRL articles, pages, or documents – printed and online – are not in the public domain. Therefore, they may not be freely distributed or copied. Additionally, no part of this document may be copied, sold to third parties, or otherwise commercially exploited without the explicit prior written consent of the ARRL. You cannot post this document to a website or otherwise distribute it to other through any electronic medium.

For permission to quote or reprint material from ARRL, send a request including the issue date, a description of the material requested, and a description of where you intend to use the reprinted material to the ARRL Editorial and Production staff at: **permission@arrl.org**.

10.8 HF DISCONE ANTENNAS

The material in this section is adapted from an article by Daniel A. Krupp, W8NWF, in *The ARRL Antenna Compendium, Vol 5*. (Additional articles on discone antennas are referenced in the Bibliography or included on this book's CD-ROM.) The name "discone" is a contraction of the words "disc" and "cone." Although people often describe a discone by its design-center frequency (for example, a "20 meter discone"), discones work very well over a wide frequency range, as much as several octaves. **Figure 10.57** shows a typical discone, constructed of sheet metal for UHF use. On lower frequencies, the sheet metal may be replaced with closely spaced wires and/or aluminum tubing.

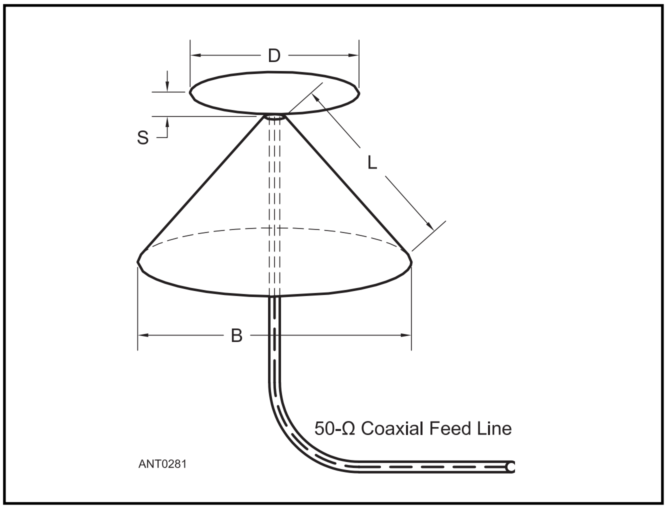

Figure 10.57 — Diagram of VHF/UHF discone, using a sheet-metal disc and cone. It is fed directly with 50-Ω coax line. The dimensions L and D, together with the spacing S between the disc and cone, determine the frequency characteristics of the antenna. L = 246 / f_{MHz} for the lowest frequency to be used. Diameter D should be from 0.67 to 0.70 of dimension L. The diameter at the bottom of the cone B is equal to L. The space S between disc and cone can be 2 to 12 inches, with the wider spacing appropriate for larger antennas.

10.8.1 DISCONE BASICS

The dimensions of a discone are determined by the lowest frequency of use. The antenna produces a vertically polarized signal at a low-elevation angle and it presents a good match for 50-Ω coax over its operating range. One advantage of the discone is that its maximum current area is near the top of the antenna, where it can radiate away from ground clutter, reducing losses. The cone-like skirt of the discone radiates the signal — radiation from the disc on top is minimal. This is because the currents flowing in the skirt wires essentially all go in the same direction, while the currents in the disc elements oppose each other and cancel out. The discone's omnidirectional characteristics make it ideal for roundtable QSOs or for a net control station.

Electrical operation of this antenna is very stable, with no changes due to rain or accumulated ice. It is a self-contained antenna — unlike a traditional ground-mounted vertical radiator, the discone does not rely on a ground-radial system for efficient operation. However, just like any other vertical antenna, the quality of the ground in the Fresnel area will affect the discone's far-field pattern.

Both the disc and cone are inherently balanced for wind loading, so torque caused by the wind is minimal. The entire cone and metal mast or tower can be connected directly to ground for lightning protection.

Unlike a trap vertical or a triband beam, discone antennas are not adjusted to resonate at a particular frequency in a ham band or a group of ham bands. Instead, a discone functions as a sort of high-pass filter, efficiently radiating RF all the way from the low-frequency design cutoff to the high-frequency limits imposed by the physical design.

History of the Discone

The July 1949 and July 1950 issues of *CQ* magazine both contained excellent articles on discones. The first article, by Joseph M. Boyer, W6UYH, said that the discone was developed and used by the military during World War II. (See Bibliography.) The exact configuration of the top disc and cone was the brainchild of Armig G. Kandonian. Boyer described three VHF models, plus information on how to build them, radiation patterns, and most importantly, a detailed description of how they work. He referred to the discone as a type of "coaxial taper transformer."

The July 1950 article was by Mack Seybold, W2RYI. He described an 11-MHz version he built on his garage roof. The mast actually fit through the roof to allow lowering the antenna for service. Seybold stated that his 11-MHz discone would load up on 2 meters but that performance was down 10 dB compared to his 100-MHz Birdcage discone. He commented that this was caused by the relatively large spacing between the disc and cone. Actually, the performance degradation he found was caused by the wave angle lifting upward at high frequencies. The cone wires were electrically long, causing them to act like long wire antennas.

10.8.2 A-FRAME 20-10 METER DISCONE

W8NWF's first discone was designed to cover 20 through 10 meters without requiring an antenna tuner. The cone assembly uses 18-foot long wires, with a 60° included apex angle and a 12-foot diameter disc assembly. See **Figure 10.58**. The antenna was assembled on the ground, with the feed coax and all guys attached. Then with the aid of some friends, it was pulled up into position.

The author used a 40-foot tall wooden "A-frame" mast, made of three 22-foot-long 2×4s. He primed the mast with sealer and then gave it two coats of red barn paint to make it look nice and last a long time. The disc hub was a 12-inch length of 3-inch schedule-40 PVC plumbing pipe. The PVC is very tough, slightly ductile, and easy to drill and cut. PVC is well suited for RF power at the feed point of the antenna.

Three 12-foot by 0.375-inch OD pieces of 6061

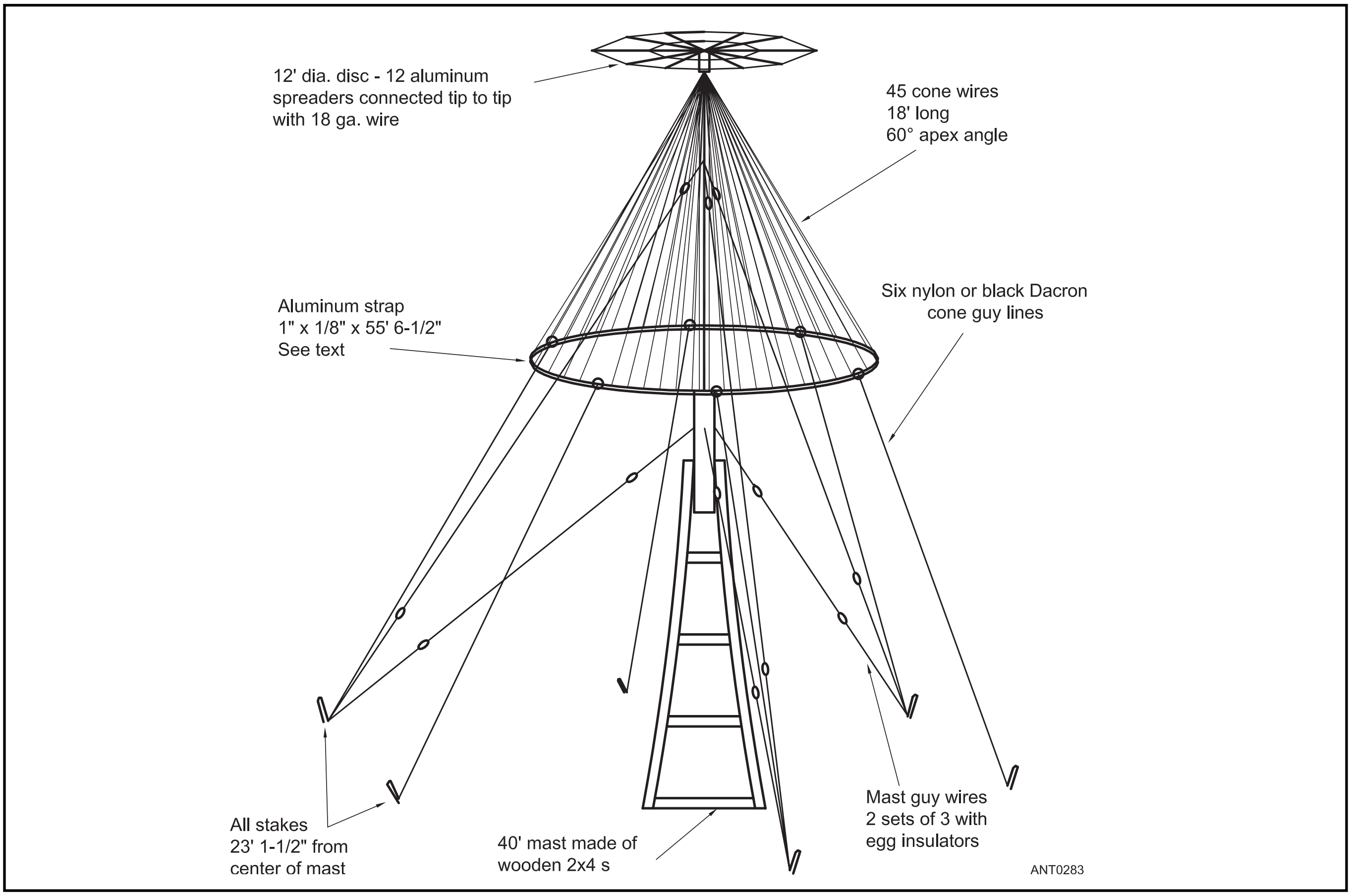

Figure 10.58 — Detailed drawing of the A-frame discone for 14 to 30 MHz. The disc assembly at the top of the A-frame is 12 feet in diameter. There are 45 cone wires, each 18 feet long, making a 60° included angle of the cone.

aluminum, with 0.058-inch wall thickness, were used for the 12-foot diameter top disc. These were cut in half to make the center portions of the six telescoping spreaders. Four twelve foot by 0.250-inch OD (0.035-inch wall thickness) tubes were cut into 12 pieces, each 40 inches long. This gave extension tips for each end of the six spreaders.

10.8.3 40-10 METER DISCONE

When an opportunity arose to buy a 64-foot self-supporting TV tower, W8NWF jumped at the chance to implement a full 7 to 30-MHz discone. His new tower had eight sections, each eight feet long. Counting the overlap between sections, the cone wires would come off the tower at about the 61.5-foot mark. See **Figure 10.59**.

W8NWF took some liberties with the design of this larger discone compared to the first one, which he had done strictly "by the book." The first change was to make the cone wires 70 feet long, even though the formula said they should be 38 feet long. Further, the cone wires would not be connected together at the bottom. With the longer cone wires, he felt that 75 and 80-meter operation might be a possibility.

The second major change was to widen the apex angle out from 60° to about 78°. Modeling said this should produce a flatter SWR over the frequency spectrum and would also give a better guy system for the tower.

The topside disc assembly would be 27 feet in diameter and have 16 radial spreaders, using telescoping aluminum tubing tapering from ⅝ to ½ to ⅜ inches OD. All spreaders were made from 0.058-inch wall thickness 6063-T832 aluminum tubing, available from Texas Towers and other suppliers. A section of 10-inch PVC plumbing pipe would be used as the hub for construction of the disc assembly.

On the air tests proved to be very satisfying. Loading up on 40 meters was easy — the SWR was 1:1 across the entire band. W8NWF can work all directions very well and receives excellent signal reports from DX stations. When he switches to his long (333 foot) center-fed dipole for comparison, he finds the dipole is much noisier and that received signals are weaker. During the daytime, nearby stations (less than about 300 to 500 miles) can be louder with the dipole, but the discone can work them just fine also.

The author happily reports that this antenna even works well on 75 meters. As you might expect, it doesn't present a 1:1 match. However, the SWR is between 3.5:1 and 5.5:1 across the band. W8NWF uses an antenna tuner to operate the discone on 75. It seems to get out as well on 75 as it does on 40 meters.

The SWR on 30 meters is about 1.1:1. On 20 meters the

SWR runs from 1.05:1 at 14.0 MHz to 1.4:1 at 14.3 MHz. The SWR on the 17, 15, 12 and 10-meter bands varies, going up to a high of 3.5:1 on 12 meters.

From modeling using *NEC/Wires* by K6STI, W8NWF verified that the low-angle performance for the bigger antenna is worse than that for the smaller discone on the upper frequencies. See **Figure 10.60** for an elevation-pattern comparison on 10 meters for both antennas, with average ground constants. The azimuth patterns are simply circles. Radiation patterns produced by antenna modeling programs are very helpful to determine what to expect from an antenna.

The smaller discone, which was built by the book, displays good, low-angle lobes on 20 through 10 meters. The frequency range of 14 through 28 MHz is an octave's worth of coverage. It met his expectations in every way by covering this frequency span with low SWR and a low angle of radiation.

The bigger discone, with a modified cone suitable for use on 75 meters, presents a little different story. The low-angle lobe on 40 meters works well, and 75-meter performance also

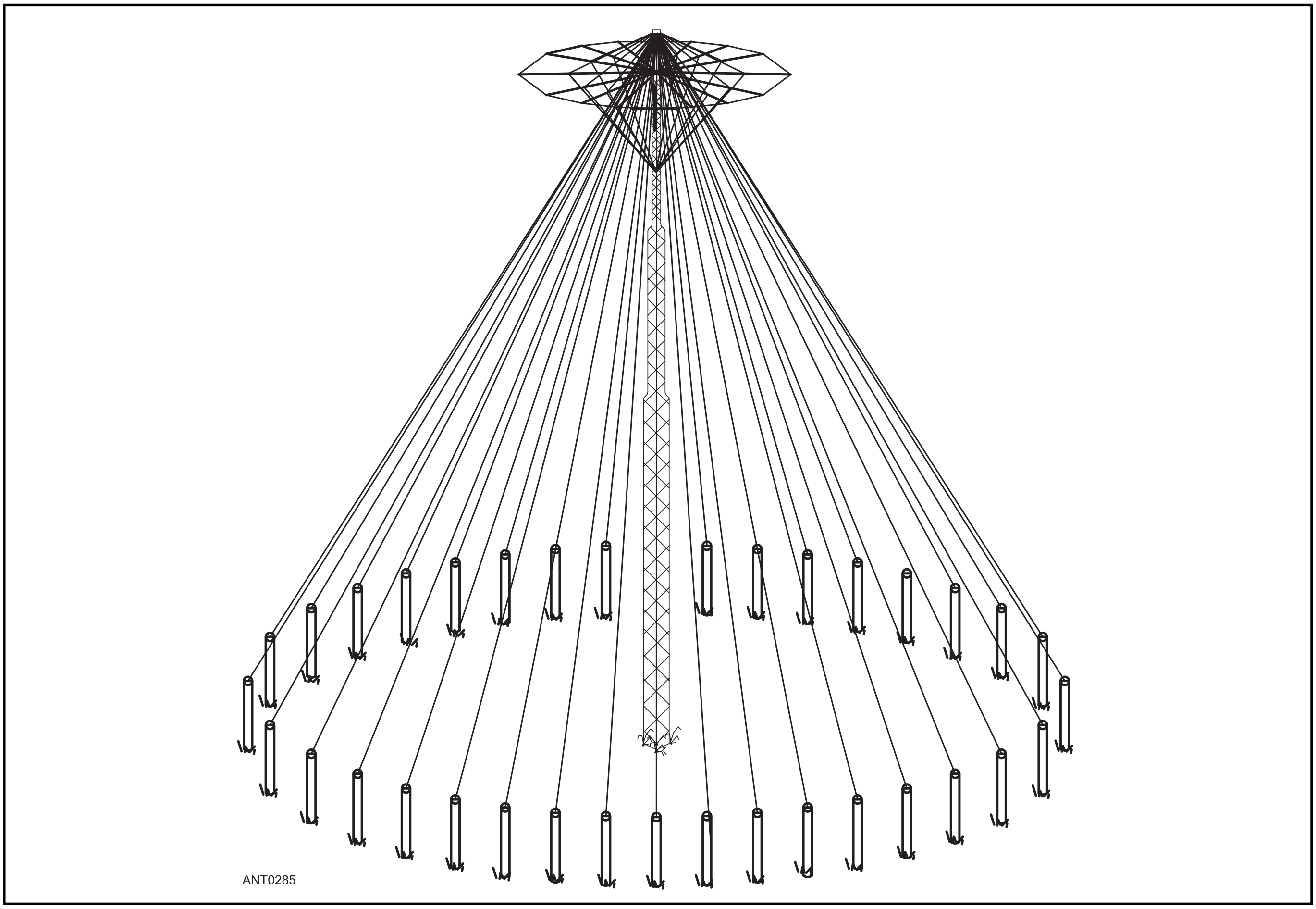

Figure 10.59 — The large W8NWF discone, designed for operation from 7 to 14 MHz, but useable with a tuning network in the shack for 3.8 MHz.

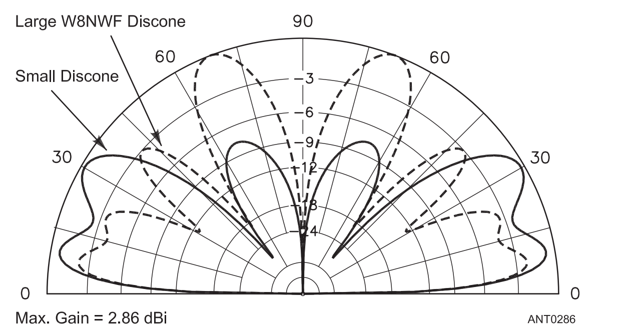

Figure 10.60 — Computed patterns showing elevation response of small discone at 28.5 MHz compared to that of the larger discone at 28.5 MHz. The cone wires are clearly too long for efficient operation on 10 meters, producing unwanted high-angle lobes that rob power from the desirable low-elevation angles.

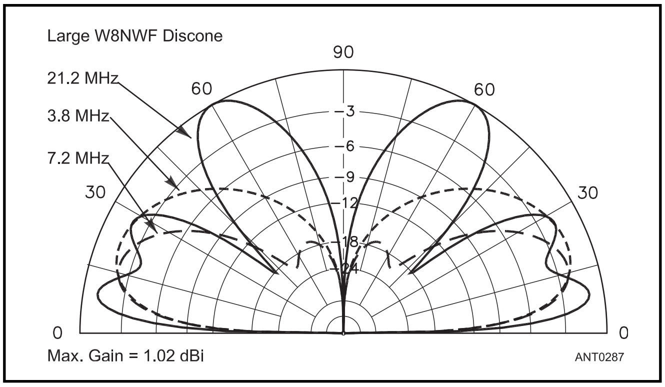

Figure 10.61 — Computed elevation-response patterns for the larger W8NWF discone for 3.8, 7.2 and 21.2 MHz operation. Again, as in Figure 10.60, the pattern degrades at 21.2 MHz, although it is still reasonably efficient, if not optimal.

is good, although an antenna tuner is necessary on this band. The 30-meter band has a good low-angle lobe but secondary high-angle lobes are starting to hurt performance. Note that 30 meters is roughly three times the design frequency of the cone. On 20 and 17 meters there still are good low-angle lobes but more and more power is wasted in high-angle lobes.

The operation on 15, 12, and 10 meters continues to worsen for the larger discone. The message here is that although a discone may have a decent SWR as high as 10 times the design frequency, its radiation pattern is not necessarily good for low-angle communications. See **Figure 10.61** for a comparison of elevation patterns for 3.8, 7.2 and 21.2 MHz on the larger discone.

A discone antenna built according to formula will work predictably and without any adjustments. One can modify the antenna's cone length and apex angle without fear of rendering it useless. The broadband feature of the discone makes it attractive to use on the HF bands. The low angle of radiation makes DX a real possibility and the discone is also much less noisy on receive than a dipole.

10.9 BIBLIOGRAPHY

Source material and more extended discussion of topics covered in this chapter can be found in the references given below and in the textbooks listed at the end of Chapter 2, **Antenna Fundamentals**.

B. Austin, "An HF Multiband Wire Antenna for Single-Hop Point-to-Point Applications," *Journal of the Institution of Electronics and Radio Engineers*, 57, 1987, pp 167-173.

H. B. Barkley, *The Open-Sleeve As A Broadband Antenna*, Technical Report No. 14, U.S. Naval Postgraduate School, Monterey, CA, Jun 1955.

W. M. Bell, "A Trap Collinear Antenna," *QST*, Aug 1963, pp 30-31.

J. S. Belrose, "The HF Discone Antenna," *QST*, Jul 1975, pp 11-14, 56.

J. Belrose and P. Bouliane, "The Off-Center-Fed Dipole Revisited: A Broadband, Multiband Antenna," *QST*, Aug 1990, pp 28-34.

J. Belrose, "Technical Correspondence: Terminated Folded Dipole," *QST,* May 1994, pp 88-89.

H. J. Berg, "Multiband Operation with Paralleled Dipoles," *QST*, Jul 1956, pp 42-43.

E. L. Bock, J. A. Nelson and A. Dorne, "Sleeve Antennas," *Very High Frequency Techniques*, H. J. Reich, ed. (New York: McGraw-Hill, 1947), Chap 5.

J. T. Bolljahn and J. V. N. Granger, "Omnidirectional VHF and UHF Antennas," *Antenna Engineering Handbook* , H. Jasik, ed. (New York: McGraw-Hill, 1961) pp 27-32 through 27-34.

J. M. Boyer, "Discone — 40 to 500 Mc Skywire," *CQ*, July 1949, p 11.

G. A. Breed, "Multi-Frequency Antenna Technique Uses Closely-Coupled Resonators," *RF Design*, November 1994. US Patent 5,489,914, "Method of Constructing Multiple-Frequency Dipole or Monopole Antenna Elements Using Closely-Coupled Resonators," Gary A. Breed, Feb 6, 1996.

G. H. Brown, "The Phase and Magnitude of Earth Currents Near Radio Transmitting Antennas," *Proc. IRE*, Vol 23, No. 2, Feb 1935, pp 168-182.

G. H. Brown, R. F. Lewis and J. Epstein, "Ground Systems as a Factor in Antenna Efficiency," *Proc. IRE*, Vol 25, No. 6, Jun 1937, pp 753-787.

C. L. Buchanan, "The Multimatch Antenna System," *QST*, Mar 1955. pp 22-23, 155.

L.B. Cebik, "Modeling the T2FD," *Antennex*, Jan 2015.

R. A. Cox, "The Open-Sleeve Antenna," *CQ*, Aug 1983, pp 13-19.

G. Countryman, "An Experimental All-Band Nondirectional Transmitting Antenna," *QST*, Jun 1949, pp 54-55.

D. DeMaw, "Lightweight Trap Antennas — Some Thoughts," *QST*, Jun 1983, pp 15-18.

W. C. Gann, "A Center-Fed 'Zepp' for 80 and 40," *QST*, May 1966, pp 15-17.

D. Geiser, "An Inexpensive Multiband VHF Antenna," *QST*, Dec 1978, pp 28-29.

A. Greenberg, "Simple Trap Construction for the Multiband Antenna," *QST*, Oct 1956, pp 18-19, 120.

G. L. Hall, "Trap Antennas," Technical Correspondence, *QST*, Nov 1981, pp 49-50.

J. Hallas, "Getting On the Air: The Terminated Folded Dipole," *QST*, Sep 2010, pp 51-52.

W. Hayward, "Designing Trap Antennas," Technical Correspondence, *QST*, Aug 1976, p 38.

D. Hollander, "A Big Signal from a Small Lot," *QST*, Apr 1979, pp 32-34.

R. H. Johns, "Dual-Frequency Antenna Traps," *QST*, Nov 1983, pp 27-30.

W. Jones, "Practical High Performance HF Log Periodic Antennas," *QST*, Sep 2002, pp 31-37.

A. G. Kandoian, "Three New Antenna Types and Their Applications," *Proc IRE*, Vol 34, Feb 1946, pp 70W-75W.

R. W. P. King, *Theory of Linear Antennas* (Cambridge, MA: