

## ANTENNA

### *Four-to-One Frequency Coverage with a Vertical*

Commercial version of the conical monopole used by the U. S. Navy and other government services.

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**I**t is important to concentrate your transmitter power into the proper beam if you wish to deliver the best signal to the other fellow's receiving antenna. This has logically led to the popularity of the Yagi beam antenna on the higher-frequency amateur bands. A beam antenna for the 80-meter band should have a 140-foot reflector and a 77-foot boom on a 250-foot tower. This makes the beam antenna impractical for the 80-meter band, and even for 40-meter operation a full-size Yagi is a forbidding structure to the neighbor's narrow-minded view — even a well-trained XYL might view such a monster beam with alarm. There is no easy solution to the need for a good DX antenna at low frequency, but the conical monopole antenna may be of interest to the more eager radio amateur as a more practical solution. The conical monopole antenna is a base-fed vertical antenna that has an omni-directional pattern in azimuth but with an elevation (vertical plane) pattern that keeps most of the energy down close to the horizon, where it belongs for long-distance transmission. This is important as will be shown in the follow-

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*News releases on the new WWV mention the use of "conical monopole" antennas, and the same antenna has been seen at many military installations. While the antenna is possibly a bit "rich" for the blood of most hams, it is still interesting to know how it is constructed. The antenna was developed and is sold by Granger Associates.*

ing table, giving the one-hop distances for an assumed radio ray at various angles above the horizon.

<i>Distance (Statute Miles)</i>	<i>Elevation Angle (Degrees)</i>
100	75
200	60
300	49
400	40
600	28
1000	16
1500	8
2000	3

The above distances are based upon an assumed height of the virtual reflection point in the ionosphere at 180 miles. It is evident from the table that it is important to concentrate the radiated energy from the transmitter at low angles. Even when two-hop transmission paths are assumed, the maximum of the elevation plane beam should be held down "near the deck." For a path between New York and London, it is desirable to radiate most of the energy below 8 degrees for a good two-hop path. The *Handbook*<sup>1</sup> shows that both horizontal dipoles and beams should be about one wavelength above ground for low-angle radiation, and even with this height, the maximum radiation is at 15 degrees with essentially zero right along the earth. The above discussion of vertical plane patterns shows why a vertical antenna may frequently out-perform a horizontal beam antenna. Another important consideration of Yagi and dipole antennas is their very narrow-band characteristic. It is usually hard to cover even one amateur band effectively without high v.s.w.r. using these antennas.

<sup>1</sup> *The Radio Amateur's Handbook*, 42nd edition, Fig. 14-1

How would you like a good low-angle antenna that would cover not just one, but three bands and that is only about 0.17 wavelength high? The conical monopole is such an antenna. It is big compared with a dipole but then it is unfair to compare a sailboat with an ocean liner, since the performance is much improved with the big one. The conical monopole antenna consists of two hexagonal cones joined at the bases. The lower cone, including an impedance-matching stub to improve the impedance over the operating frequency range, is fed from the 50-ohm transmission line. To simplify construction, the cones are simulated with wire elements to form a cage. In commercial versions, the central tower, supporting the cages, is a metal tower connected to ground, but the antenna described here uses a telephone pole with six wires running down the pole connecting to the ground system. A pole is used because no guying is needed and an old pole may be easier to find than a metal tower. Thus, the antenna is at d.c. ground and this protects the station from lightning damage.

Fig. 1 shows the overall dimensions for a conical monopole antenna that will cover the 80-, 40-, and 20-meter bands with a v.s.w.r. of less than 2.5 to 1. Unfortunately, the best impedance match to 50 ohms is in the range of 10 to 12 Mc., which is of no interest to the ham. The base of the cones is 31 feet across the diagonal. The antenna is supported by a telephone pole about 48 feet long (five feet of it in the ground) so no guying is needed. A guyed metal tower or wood 4 × 4 could be used if desired. The top cone is made up of 12 wires, 2 at each corner. The bottom cone has 3 additional wires added to each face of the cone to better simulate a solid cone. The sectional view of Fig. 1 shows the outside wires, two of the six radial wires *a*, grounding stubs *b*, and pole wires *c*. The radial wires and grounding shunt wires make up a shorting stub connected across the transmission line that feeds the outside cage at the bottom of the lower cone. A ground radial system consisting of 60 ground radials 62 feet long connects to the sheath of the transmission line, to the six matching stub down-leads and the six wires running down the pole.

A small flat-top (see Fig. 2) at the top of the upper cone is supported by 2 × 4s screwed to the pole with lag screws. A galvanized steel 16-gauge plate at the top stabilizes the top hat and provides an easy termination for the cage wires and the pole wires. All antenna wire is 10-gauge soft copper or Copperweld wire. The Copperweld wire is hard to bend and keep straight, but it is much stronger than copper and the cost is much less. A staple can be used to fasten the two cage wires to each of the spokes, preferably on top near the end of each spoke so the peripheral wire *d* can be soldered to the two cage wires at each spoke. The top-hat assembly should be done on the ground before the pole is erected. However, climbing lugs on the pole will permit assembly and soldering in the air, if desired. A propane torch is very handy for soldering the wire.

The central spoke assembly supports the widest part of the antenna at a height of 17 feet 3 inches above the ground. Select straight and clear 16-foot 2 × 4s for the spokes. These are cut off to extend 15 feet 6 inches from the center of the pole. Gate hinges fastened to the under sides of the spokes and to the pole with wood screws support the spokes at the center; the outer ends are held up by the upper cage wires. Cage wires spread to four inches apart at the end of the spokes where they are soldered to the peri-

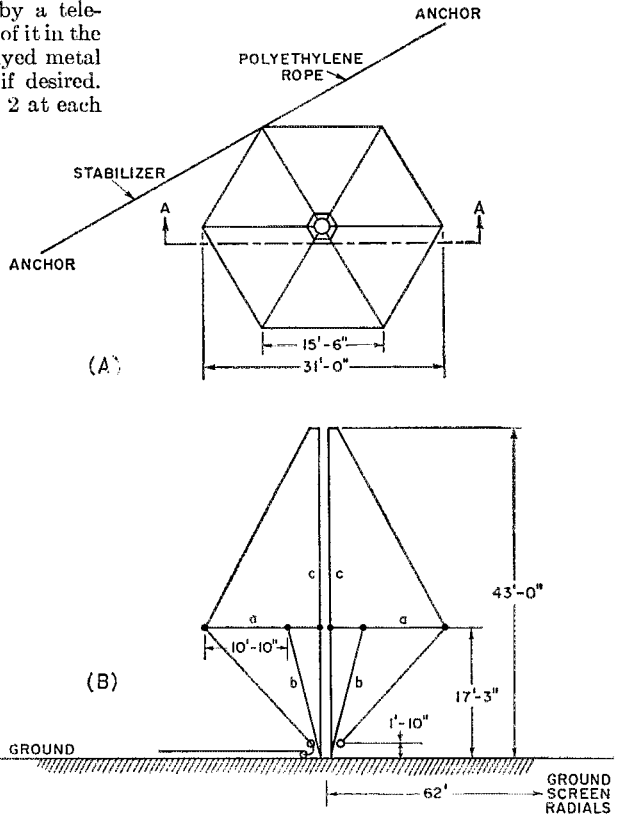
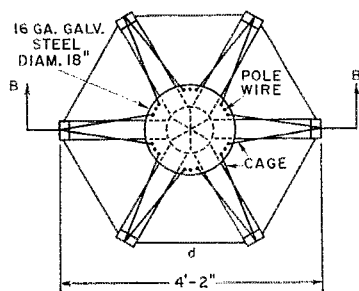
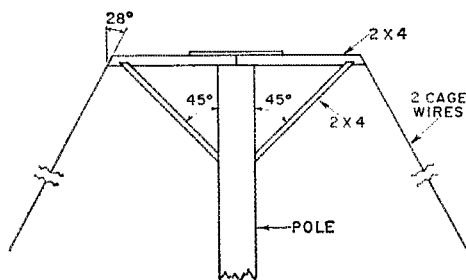


Fig. 1—(A) Top view of the conical monopole antenna for 3.5 through 14 Mc. (B) Side view of conical monopole at section A-A. Note that grounding stubs, *b*, connect to short radial wires, *a*. Wires *c* run up the sides of the supporting pole.



(A)



(B)

Fig. 2—(A) Top view of the antenna top hat. The steel plate is held to the 2 X 4 spokes by wood screws.  
(B) Side view through section B-B.

pheral wire. A copper plate is cut as shown in the detail of Fig. 3 to hold the cage and peripheral wires. The copper plate is cut out of sheet copper with tabs similar to the kind found on solder lugs. These tabs are bent over the cage wires and soldered in place. The plate is fastened to the spoke and then the peripheral wire is soldered in place. It should have some slack so that when the lower cage wires are soldered in place, there will not be excessive tension on the peripheral wire and the spokes. In addition, spoke wires (*a* in Fig. 1) must be soldered to the peripheral wire and to the pole wires at the pole. The stub wires (*b* in Fig. 1) should also be soldered in place. At the conclusion of all of the soldering and screw-fastening to the spokes, the top cone should be nicely aligned and tensioned. If it is not symmetrical at this time, it should be adjusted. This would also be a good time to check the dimensions—an accuracy of  $\pm$  one inch should be suffi-

cient. The three additional wires on each face of the bottom cone are soldered to the peripheral wire spaced equally from spokes.

At the bottom of the lower cone (Fig. 4) six one-inch diameter copper pipes with ends flattened form a ring to which the 30 wires of the lower cone are attached. Heating the tube ends will make it easier to flatten and bend them. Bronze bolts  $3/8$  inch in diameter are ideal for holding the lower ring together. Before bolting the ring together, fasten the insulators to the ring using loops of wire going around the bronze bolts and placed between the flattened sections of the pipe. Similar loops of wire connect the insulators to the turnbuckles and  $1/4$ -inch hooks screwed to the pole complete the tensioning arrangement at the base of the antenna. It might be simpler to drill all of the holes after the pipes are bolted together. Now is the last chance to adjust the tension of the wires so it is important to carefully position the feed ring by blocking it up from the ground and carefully tightening the turnbuckles. The wires are then fed through the holes in the copper pipes, wrapped back around the pipe and twisted back on themselves preparatory to soldering. The blocks are then removed and the turnbuckles are tightened to make the whole structure rigid. If all wire lengths are okay, solder the wires to the feed ring. Two one-inch copper straps connect from the feedline to the feed ring. Both ends of the strap are carefully soldered to make good electrical connections to the coax and to feed ring, respectively. If solid coaxial cable is used, the end must be carefully wrapped with electrical tape to prevent the entry of moisture.

Two guy lines of polyethylene (water-ski rope) stabilize the antenna and keep it from twisting (see Fig. 1.).

About 4200 feet of wire is used in the ground system. Luckily, it does not have to be copper. Galvanized No. 10 steel wire is almost as efficient and much cheaper to use. If desired, the ground wires can be laid along the surface rather than being buried. If burial is desired, a small

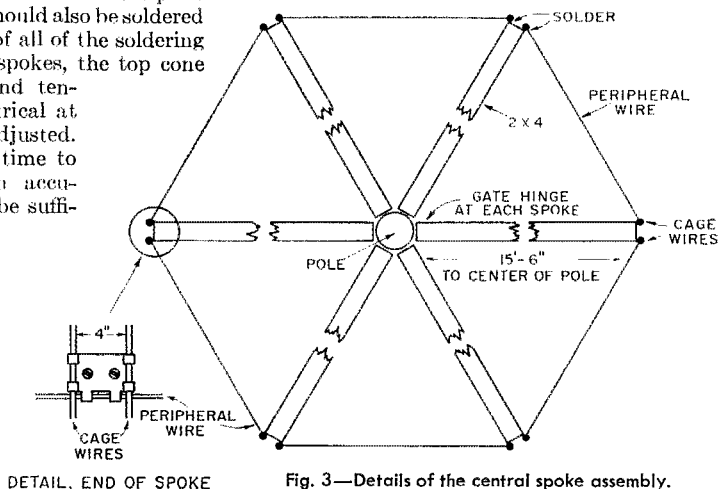


Fig. 3—Details of the central spoke assembly.

garden plow will reduce the amount of coolie labor.

Each ground radial is stretched out from the pole and anchored to a temporary stake. The grass and underbrush should be cleared away so the wire will be flat on the ground. It can be held down with large staples driven into the ground which will hold the ground wire in place until the growth of vegetation binds the wires in place. Five foot by 3/8 inch diameter galvanized rods are driven into the ground at the end of every third radial where the radial is soldered or clamped to the rod. A circular wire ties all of the ground rods and remaining radials together as shown in Fig. 4.

After all of that work, what do you have? The performance can best be shown in the elevation plane patterns given in Fig. 5. The dotted curves are typical for average soil conditions. The specified ground screen will improve the patterns by about 1 db. at low angles. It is easy to see how effectively the antenna concentrates energy at low angles for long one-hop paths. It is not very effective for 100 miles but for this local work, any old horizontal antenna is adequate, and v.h.f. is a better answer. The radiation pattern is not too good on the 20-meter band where radiation is too high above the horizon, but the 40-meter pattern is almost as good as on 80.

If it is desired to use this antenna for 40-, 20-, and 10-meter operation, then all dimensions should be multiplied by 0.543. However, a horizontal beam is usually a better choice. Only a few amateurs will have the space and the ambition for building this antenna, but for those who do, it will greatly improve communication.

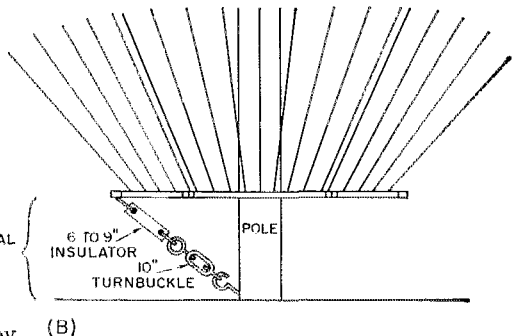
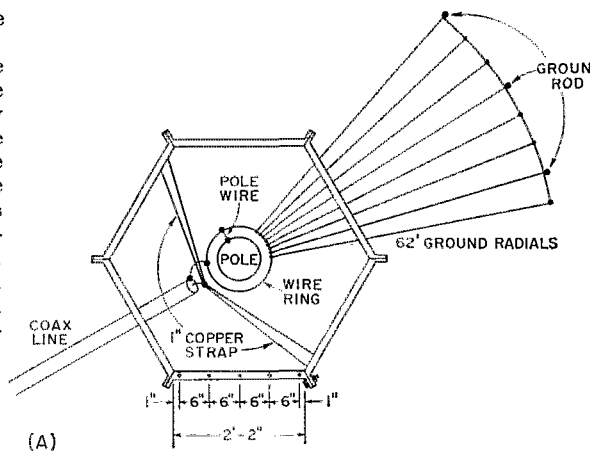


Fig. 4—Top and side views of the bottom feed ring. For clarity, not all of the pole wires and grounding details are shown.

#### Parts List of Major Items

- |          |  |
|----------|--|
| 1        | 48-foot pole   |
| 4200 ft. | No. 10 galvanized wire                               |
| 900 ft.  | No. 10 copper or Copperweld wire                     |
| 6        | 10-inch turnbuckles                                  |
| 6        | 3/8 inch bronze bolts and nuts                       |
| 6        | insulators, 6 to 9 inches long                       |
| 15 ft.   | one-inch copper pipe                                 |
| 6        | screw hooks, 1/4 x 6 inches                          |
| 2        | copper straps, 1 x 26 inches                         |
| 3        | 2 x 4s, 5 feet long                                  |
| 6        | 2 x 4s, 16 feet long                                 |
| 1        | polyethylene rope, as needed                         |
| 6        | gate hinges  |
| 1        | 16-gauge galvanized steel, 18-inch diameter          |
| 20       | galvanized or copper-plated ground rods, 5-foot long |

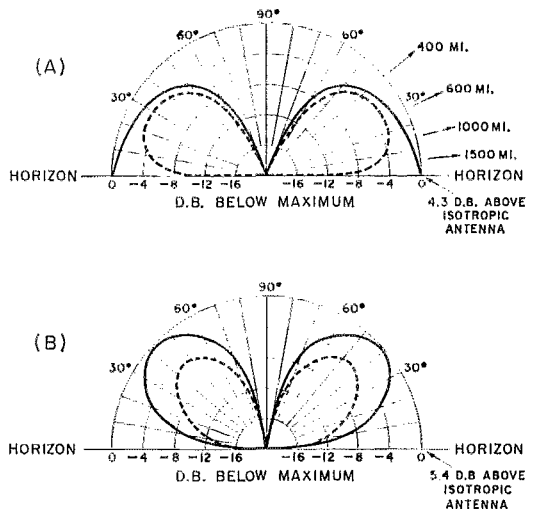


Fig. 5—Radiation pattern for (A) 80 meters and (B) 20 meters. Solid patterns are for conical monopole over perfectly conducting ground; dashed, for average soil.