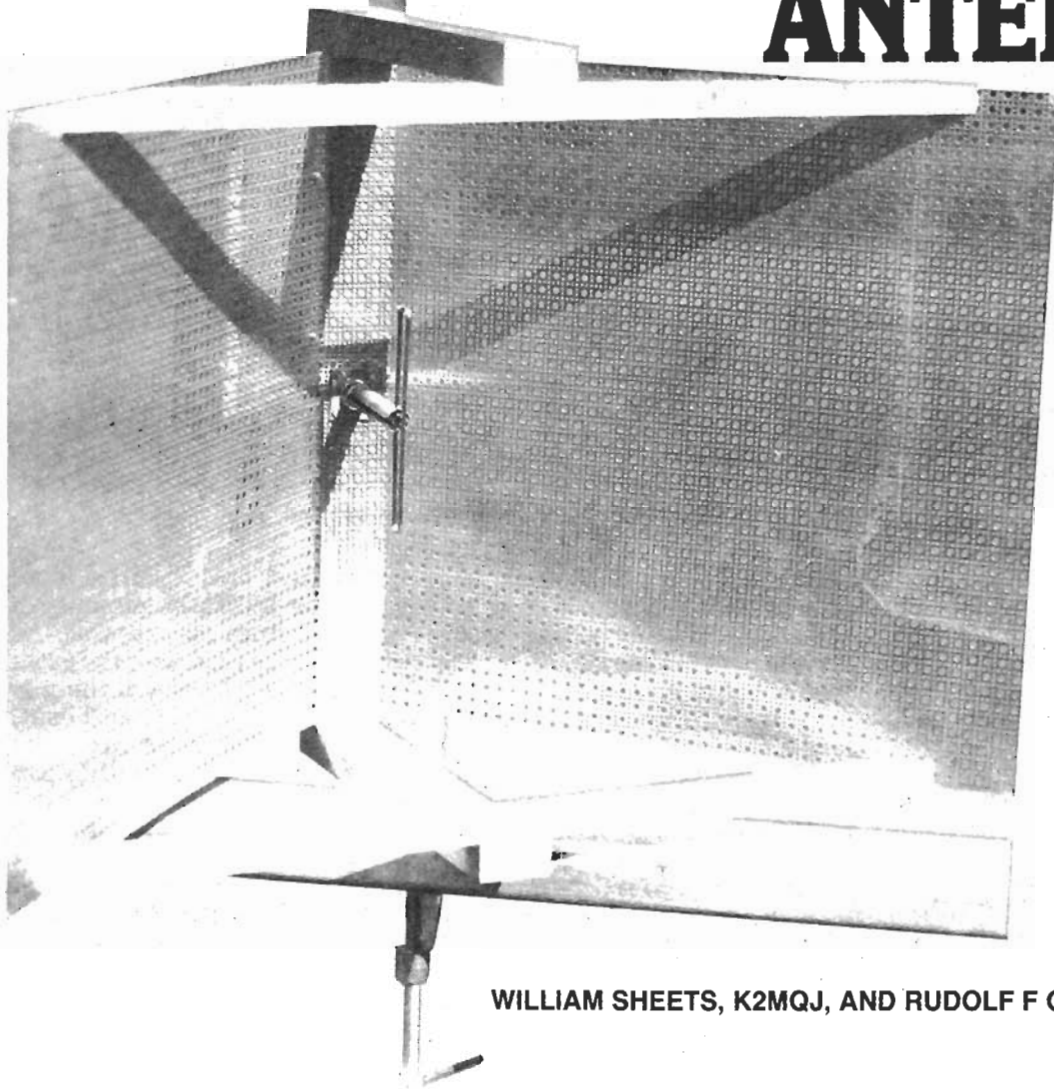


UHF Corner Reflector ANTENNA



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Obtain outstanding performance from a home-brew radiator built from readily-available parts and materials.

SCANNER ENTHUSIASTS, AMATEUR radio operators, and UHF experimenters are interested in simple antennas that are more effective than ground-planes and whips. You can build a high-performance UHF corner-reflector antenna that is compact and easy to tune using readily available materials.

A corner-reflector antenna provides good performance radiation for directional UHF work since it has 8 to 10 dB gain, is fairly easy to build, and

has reasonable bandwidth of 5% to 20%. Also, the corner-reflector antenna exhibits a good radiation pattern and front-to-back signal ratio.

The corner-reflector antenna consists of a balanced half-wave dipole placed in front of a conducting surface that is folded with an angle of 90 degrees or less. As the angle gets smaller, the gain tends to increase but the antenna structure tends to get larger and the dipole feed impedance becomes

lower. The dipole may be constructed with thick dipole elements to increase bandwidth. The spacing of the dipole from the reflector can be adjusted to optimize the feed impedance.

The gain of a corner-reflector antenna with a reflector surface of one to two wavelengths is typically 8 to 10 dB over an isotropic radiator. Antenna gain can be made 14 to 15 dB or more with a large reflector (greater than 5 wavelengths) and a narrow (45 degree or less) angle.

However this is mechanically impractical at frequencies below 1000 MHz.

Dipole operation

A dipole is a balanced antenna and should not be fed directly with coaxial cable. Doing so would cause the outer conductor of the coaxial line to act as part of the antenna, and a large amount of signal would be radiated or received by the outer conductor. For casual reception this may not matter much, but the directional radiation pattern of the antenna is destroyed and reception/transmission results are no longer predictable.

In order to derive a balanced feed for the dipole some sort of a transformer is necessary. For the corner reflector described here a slot-fed balun is used (see Fig. 1). This is accomplished by splitting the outer conductor (made from a brass tube) lengthwise for a quarter wavelength and connecting the inner conductor (a much smaller diameter tube or rod) to the end

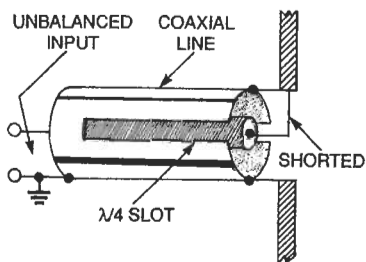


FIG. 1—METHOD FOR FEEDING a balanced dipole by a slot-fed balun.

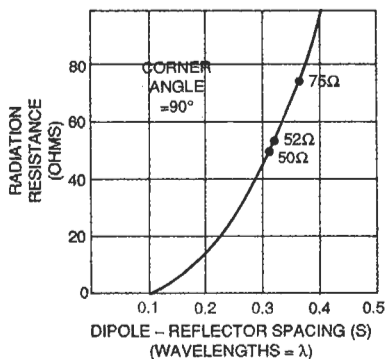


FIG. 2—PLOT OF RADIATION RESISTANCE in ohms vs. spacing of a dipole in wavelength from virtual apex of a 90° corner-reflector antenna.

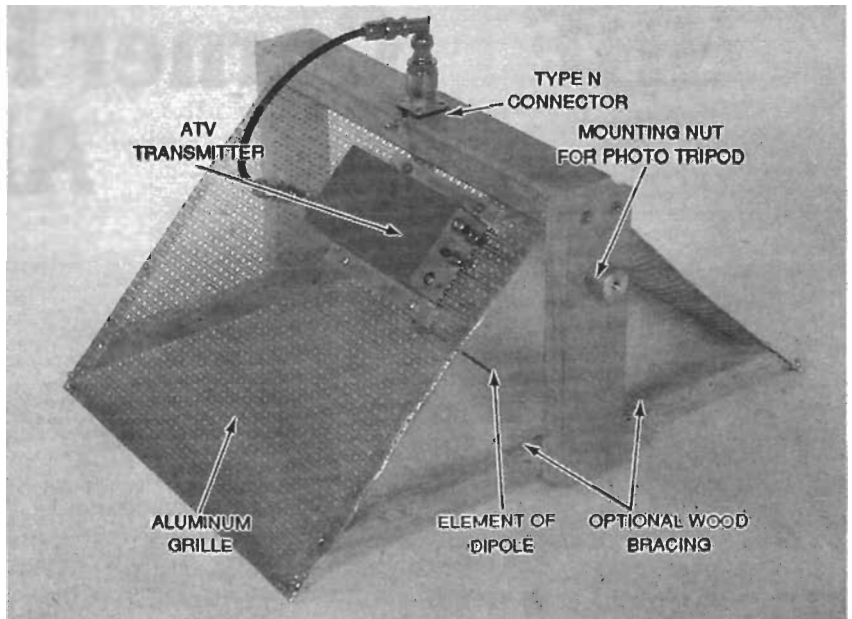


FIG. 3—THE BASIC PARTS of a corner-reflector antenna.

of one segment, and to one dipole element. The other segment is connected to the opposite half of the dipole. This type of balun gives a 4:1 impedance transformation and can feed a simple dipole. A satisfactory impedance match was achieved (1.5:1 or better VSWR) by adjusting slot length and trimming dipole length, and adjusting dipole-to-reflector spacing. Dipole-to-reflector spacing affects the dipole's impedance (see Fig. 2).

Construction

Fig. 3 shows some details of a corner-reflector antenna that you can build. Virtually all materials for the antenna are available at hobby shops and building supply centers. Total cost should be \$20 or less. The corner-reflector antenna described here was designed for operation at 900-MHz. For other frequencies, the dimensions can be scaled from the information given in Table 1 and inserted into Fig. 4. However, at lower frequencies, the antenna is larger so some compromises have to be made to keep within practical mechanical size, weight and structural stability. A good idea from a performance standpoint is to keep the reflector as large as you can, up to a few wavelengths. This becomes

impractical at 400 MHz, more so than at 1300 MHz, because of the antenna's overall size. As antenna size increases the extra gain may not be worth the mechanical difficulties and cost. Also, wind loading must be taken into account as this corner-reflector antenna presents a large wind surface area from all compass directions.

The antenna shown in Fig. 3 is fairly easy to construct with hand tools. Before you begin construction, review all the illustrations from Fig. 1 to Fig. 8, including Tables 1 and 2 to obtain a visual mechanical understanding of what is to follow.

Begin by cutting a 6.5-inch piece of 5/8-inch O.D. (outside diameter) brass tubing with a 0.015-inch wall thickness (available at well-stocked hobby shops). See Fig. 5. This length is the sum of half of a wavelength at the desired operating frequency, plus another 1 to 2 inches to allow for the connector and mounting flange as shown. Make sure the ends are squarely cut. A tubing or pipe cutter will provide a better cut than a hack saw. Cut a piece of 1/4-inch tubing to a length about 1/8 inch shorter than the length of the 5/8-inch tubing. These tubes will form the dipoles feed assembly and balun.

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CORNER REFLECTOR

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Cut two slots lengthwise along one end of the $\frac{5}{8}$ tubing, on opposite sides of tubing. Use a hacksaw or small saw and cut both slots at the same time with the saw passing through the center axis of the tube. The slot lengths should be $\frac{1}{4}$ wavelength at the operating frequency. For 923 MHz operation this cut should be approximately 3.2 inches. The slot width is not very critical.

Next, drill holes for the dipole elements as shown in Fig. 5. Leave about $\frac{1}{16}$ -inch space between the edge of the hole and the end of the tube. The dipole elements can be either $\frac{1}{16}$ or $\frac{1}{8}$ -inch diameter brass rods or $\frac{3}{32}$ -inch diameter brass welding rod. Use a drill that is the same diameter as the dipole elements for a snug fit. Cut a length of brass rod that is to be used for the dipole elements to 1.05 wavelengths long at the desired center frequency. See Table 2 for data on the dipole length.

Carefully clean up and deburr the cut edges on the $\frac{5}{8}$ -inch and $\frac{1}{4}$ -inch tubes. File the ends of the dipole element rods to remove burrs and sharp projections. Solder one end of the $\frac{1}{4}$ -inch tubing to the center pin of a type N connector so that the center line of the tube is aligned with the centerline of the center

pin on the type N connector. Allow $\frac{1}{8}$ -inch of space between the tube and the type N connectors flange as shown in Fig. 5. If necessary, build up the diameter of the center pin with some bare copper wire for a snug fit to ensure concentricity. Place the $\frac{5}{8}$ -inch tube over the $\frac{1}{4}$ -inch tube, and check to see that the end of the center tube is flush with or is slightly shorter than the outer tube by approximately $\frac{1}{16}$ inch, or less. Trim the center tube as needed. Clean the square flange on the connector with fine steel wool for soldering later.

Slip a $\frac{1}{2}$ -inch copper pipe coupling (use the kind that has no internal pipe stop) over the outer $\frac{5}{8}$ -inch tube. The com-

**TABLE 2
COAXIAL LINE IMPEDANCE
WITH AIR DIELECTRIC**

I.D./O.D.	Antenna Impedance (Ω)
2.0	41.5
2.1	44.5
2.2	47.25
2.25	48.6
2.3	49.9
23.33	50.7
2.5	54.9
2.67	58.8
2.75	60.6
3.0	65.8
3.5	75.1
4.0	83.1

Note: Shaded area indicates coaxial line impedances are within 10% of 50 ohms.

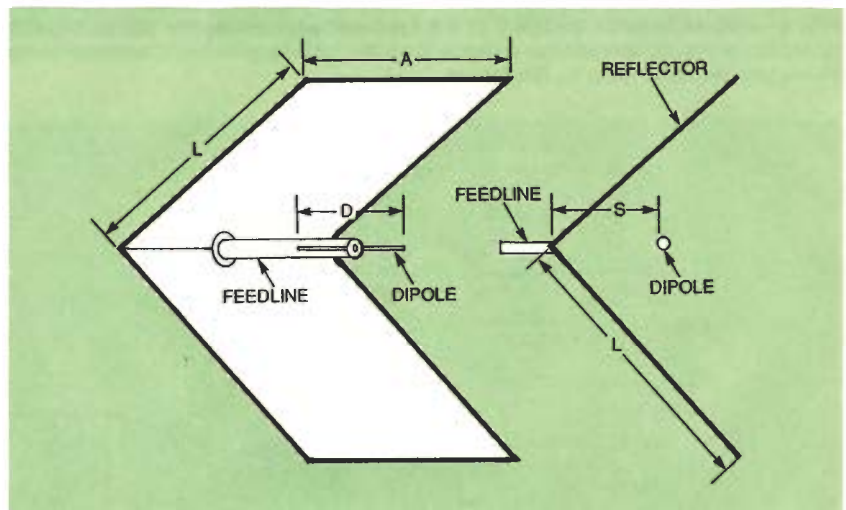


FIG 4—CORNER-REFLECTOR ANTENNA dimensions are determined by the frequencies used. Refer to Table 1 values.

**TABLE 1—SUGGESTED CORNER-REFLECTOR
DIMENSIONS FOR ELEMENTS IDENTIFIED IN FIG. AAA**

CENTER FREQ. (MHz)	Dipole Spacing S (inches)	SIDE LENGTH L (inches)	CORNER LENGTH A (inches)	DIPOLE LENGTH D (inches)
420-450 (70 cm Amateur)	8.5	≥24	≥15	13.6
450-470 (2-way Commercial)	8	≥22	≥14	12.7
850-870 (2-way Commercial)	4.25	12	10	6.8
902-928 (33 cm Amateur)	4	12	10	6.4
928-960 (Commercial)	3.9	12	10	6.2
1240-1300 (23 cm Amateur)	2.9	12	10	4.6

Note: Dimensions are suggested starting points for minimum 8-dB antenna gain and are not exact value. The values are for practical sizes and are a compromise value given where necessary for mechanical construction reasons.

monly used $\frac{1}{2}$ -inch copper water pipe has a $\frac{5}{8}$ -inch outside diameter so a smooth slip fit should result. If OK, remove and drill a hole at one end to pass a #4 machine screw. See Figs. 6 and 7. A #33 drill is large enough, but a #28 drill was used to allow extra clearance. Polish the copper pipe coupling with fine steel wool to a bright finish. Using rosin core solder, solder a #4 brass nut to the coupling centered over the hole. Use a stainless steel #4 screw about 1-inch long to hold the brass nut in place while soldering. Solder will not stick to stainless steel.

Remove the screw after the solder joint cools.

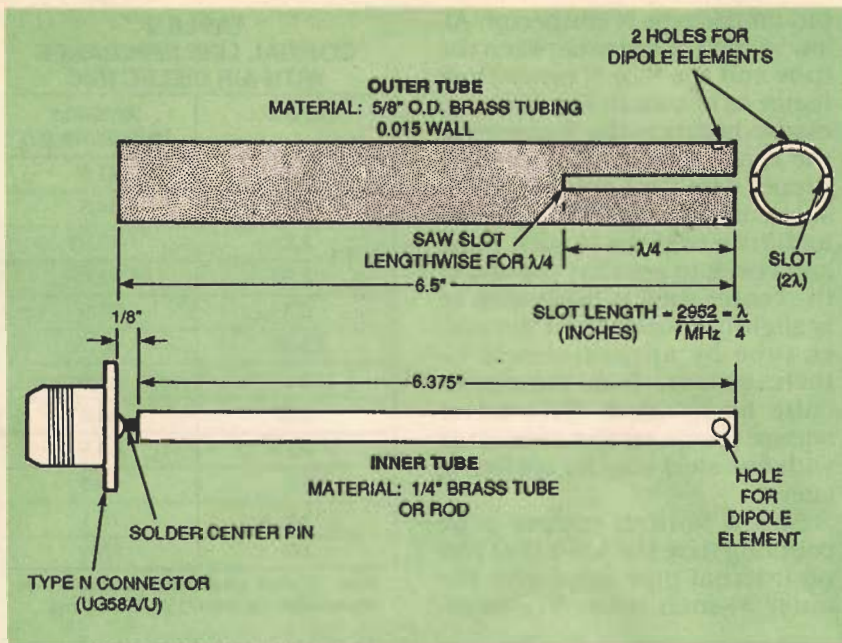


FIG. 5—PRE-ASSEMBLY DETAILS of the feedline/balun tubes. For 400 to 470-MHz operation of the corner-reflector antenna the outer tube length should be increased to 14 inches; the inner tube, 13.785 inches.

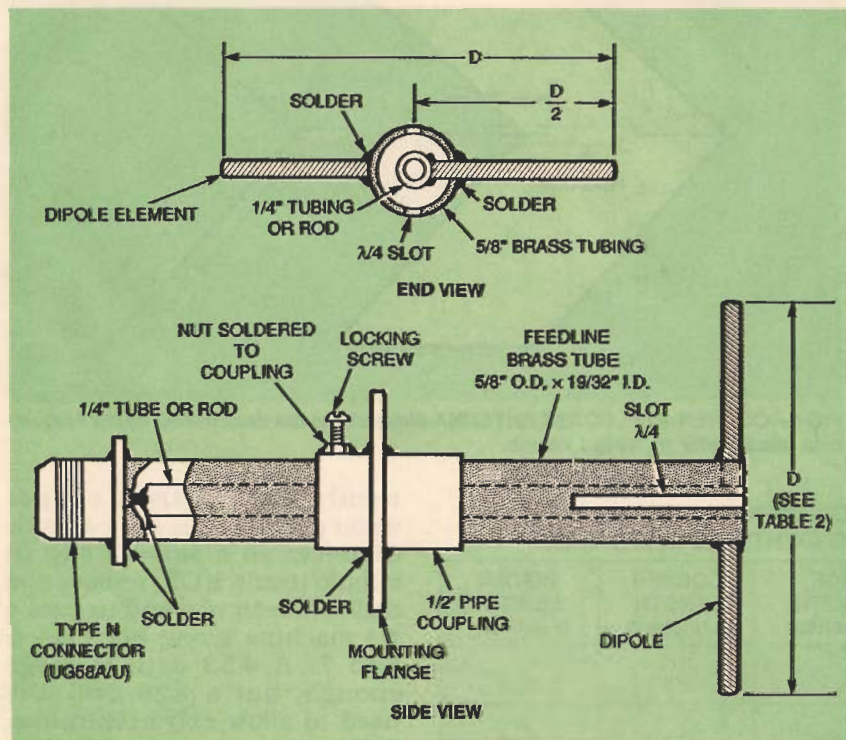


FIG. 6—TWO VIEWS OF THE DIPOLE AND FEEDLINE construction details. In the end view drawing note that the right dipole element connects to the inner and outer tubes and shorts them together. The left dipole element connects just to the outside tube. The ends of both dipole elements are equi-distant from the center of the inner tube.

Prepare a mounting flange from a 2 × 2-inch square plate made of copper, brass, or surplus PC board G-10 material. See Fig. 7. At its center, punch a hole in the flange to the outside diameter of the pipe coupling.

Solder the coupling in place about the entire circumference. Make sure coupling is perpendicular to the plate. Slip the flange assembly over the 5/8-inch tube, the slit end opposite the nut as shown. Clean both ends

LIST OF MATERIALS

Parts specified for 800-1300-Mhz range. Lengths given in brackets are for 400-470-MHz range.

- 1—5/8-in. O.D. × 19/32-in. I.D. brass tubing, 0.015 nominal wall thickness, 6.5-in. long (14-in. long)
- 1—1/4-in. O.D. brass tubing or rod, I.D. not critical, 6-3/8-in. long (13 7/8-in. long)
- 1—1/16-in. to 1/8-in. O.D. brass rod, or 3/32-in. brass welding rod, 15-in. long
- 1—Type N UG58A/U UHF connector, flange mount, or BNC UG290A/U RF connector, flange mount (either item preferably silver plated)
- 1—3-in. sq. ft material for reflector, 0.019-inch thick, perforated or grille aluminum recommended (see text)
- 1—4-40 brass hex nut
- 1—4-40 × 1/2-in. brass screw
- 1—4-40 × 1-in. stainless-steel screw
- 1—0.032 brass or copper plate, 2 × 2-in. square, or double sided G-10 material, 2 × 2-in. × 0.062-in. thick
- 1—1/2-in. stop-less copper pipe coupling, sweat type
- 1—Wood, 1- × 2- × 12-in.
- 8—#6 × 1/2-in. sheet metal or wood screws

Also: Solder (both resin core and solid), fine steel wool, hardware as needed, miscellaneous wood blocks, 1/2 × 1/2-in. wood lengths for bracing as required, suitable plastic container for optional cover.

A catalog describing kits for ATV transmitters, ATV receiving converters and other projects useable with the antennas described in this article is available from North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804. Please include a #10 SASE and \$1.00 to cover handling and postage.

E-mail: Ncradio200@aol.com
CompuServe 102033,1572

Note: Materials illustrated and listed are for a corner-reflector antenna operating at about 900 MHz. Antennas for lower frequencies are larger and will require correspondingly larger or more materials. Brass tubing for inner and outer conductors can also be any other reasonable dimensions as long as they have approximately a 2.3 to 1 ratio of ID (outer) to OD (center). See Table 2 for other suitable sizes and corresponding impedances.

of the outer tube with fine steel wool to facilitate soldering in the following steps.

Insert the 1/4-inch tube and type N connector assembly into the outer 5/8-inch tube placing type N connectors flange flush against outer tube (see Fig. 6). Check to see that pre-drilled holes for dipoles are aligned. You can insert the dipole elements and fasten them in place with tape to check for correct alignment. When the tubes are concentric, solder connector flange to 5/8-inch tube all around the edge. Use as little solder as you can for a neat job, and if possible use a hot 100-watt iron with a 1/4-inch tip. A few wooden blocks drilled with 5/8 diameter holes will be useful for holding parts during assembly and soldering operations.

Clean all solder residues deposited in the previous step with isopropyl alcohol, flush with water and blow dry. Do this outdoors away from flame or sparks. Remove the dipole elements and make sure no electrical contact (short) between the outer and inner tubes exist.

Solder the dipole elements in place. The outer and inner conductor are shorted together by one dipole element. This is normal. Make sure they are aligned as shown in Fig. 6. Measuring from center of center tube, the dimensions of each side of the dipole should be equal in length and symmetrical.

You now have a half-wave, slot-fed dipole. Connect it to a receiver and check to see if it works as a receiving antenna. It should work as well as your whip antenna or better. Try orienting vertically and horizontally for best signal reception.

If you have the test equipment, use an RF source and a SWR or power meter to check the VSWR. It should be 2.0 or better. The dipole elements can be trimmed for lowest VSWR later. This will be affected by reflector spacing, slot length, and also presence of nearby reflecting objects. If the antenna pulls in no signals, check for shorts from burrs, solder drops, steel wool fragments, or other foreign material.

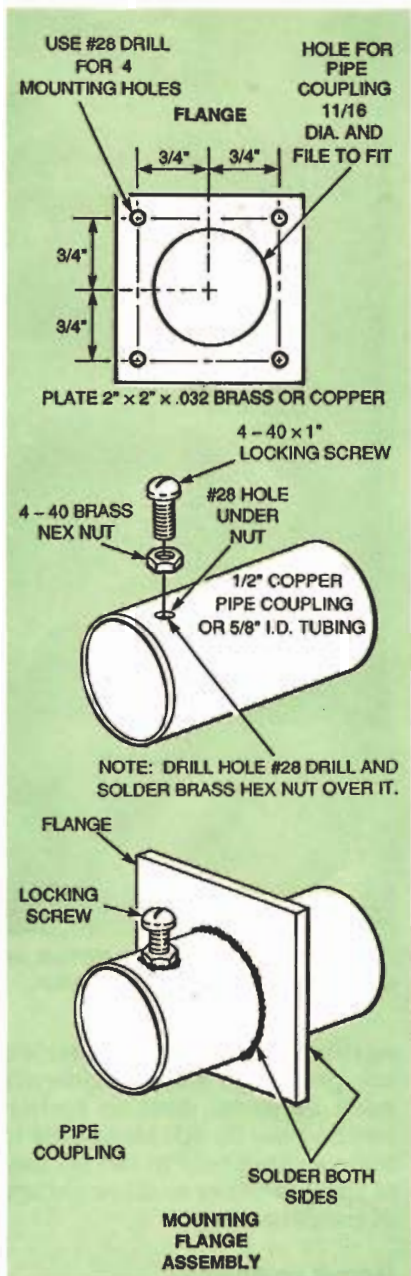


FIG. 7—DETAILS AND DIMENSIONS for the mounting flange assembly.

The reflector

Almost any perforated, stiff aluminum material can be used to make the reflector. A 0.019-inch thick perforated aluminum sheet was used. It is available in hardware stores for making grilles and covers for radiators, etc. The holes reduce the overall weight and wind resistance. Solid sheet aluminum, copper, wire mesh, or screening can be used since all you need is a conducting surface. Plywood or heavy cardboard covered with aluminum

foil can also be used, if weatherproofing is not needed, for experimental or temporary use. Hardware cloth (aluminum or copper screening material) is also useful but hard to handle.

Referring to Fig. 3, you see that the reflector is made by bending a 1 x 2-foot sheet of perforated aluminum sheet. The exact reflector dimensions are not critical, larger being better. Instead of one 90-degree bend, two 45-degree bends were used leaving a 1 5/8-inch valley that provides a surface for a good mechanical support. A piece of 1 7/8 x 3/4 x 12-inch wood is used to support the reflector and to mount the dipole in the center of the reflector. This piece of wood can also be used for mounting a bracket to hold the completed antenna to a mast or other support.

Bracing can be added to the reflector if desired as shown in the photo. Use wood, plastic, fiberglass, or other non-conducting material. Conductive materials in front of dipole will cause detuning and pattern distortion. If thin sheet metal is used alone for the reflector it is wise to cut the metal 1-inch larger in width and length and use this extra material to form a folded edge around the perimeter to stiffen the reflector surface. A block of wood can be used to form the bends, as the material is easily worked by hand. Make bends along perforated lines in the aluminum for sharp and true bends.

After the reflector is formed, cut a hole in the center of the valley fold as shown in Fig. 3 and fasten the flange on the dipole assembly to the reflector. The dipole should be parallel to the bend in the reflector. Initially set the dipole about 0.3 wavelengths from the reflector. Install a 4-40 screw in the nut previously soldered to the flange assembly to lock the dipole in place. Final adjustment can be made later by setting the dipole position for lowest VSWR, with an RF source and reflected power meter or SWR bridge. For receive only applications, no further adjustments are needed. You could try peaking

the adjustments on a weak signal if you are fussy, but you will find that they are very broad and have little noticeable effect.

Next, mount the antenna in its final location. Make sure to mount the antenna for correct polarization. Polarization is same as dipole (e.g. vertical for vertical polarization). Vertical polarization is generally used for amateur and commercial two way FM, but horizontal is used for SSB amateur work and some amateur TV. UHF TV is generally horizontal or circular. As a compromise, the antenna could be mounted at 45 degrees to vertical.

You will find that the antenna has pronounced directivity, maximum pickup occurring along a line bisecting the reflector angle, in the direction the dipole faces. The pattern is clean and well defined. Pickup towards the sides or rear is much less. Therefore, face the antenna in the direction of desired reception. Two or more of these antennas can be used if multi-directional reception is desired, or a rotator can be used. Bandwidth depends on the VSWR desired, but this antenna should work well over a range of 10 percent or so. An antenna made for 900 MHz will easily work well from 800 to 1000 MHz, and reception at 450 MHz and 1280 MHz will be adequate, but not optimum. You should find this antenna easy to make and quite effective and may even wish to build several for different frequency ranges. Simply scale the dipole element length and reflector size as needed.

For outdoor use, it would be a good idea to cover the dipole and slotted feedline assembly with a plastic cover to keep out water and insects. Use a clear, plastic-food container that is microwave safe. If it does not heat up in a microwave oven, it probably has low RF losses and will not affect the antenna. The container can be slit and placed over the dipole with the slit facing down. The lid can be used to cover the open end of the tubing. Clear silicone seal can be used to seal edges and joints

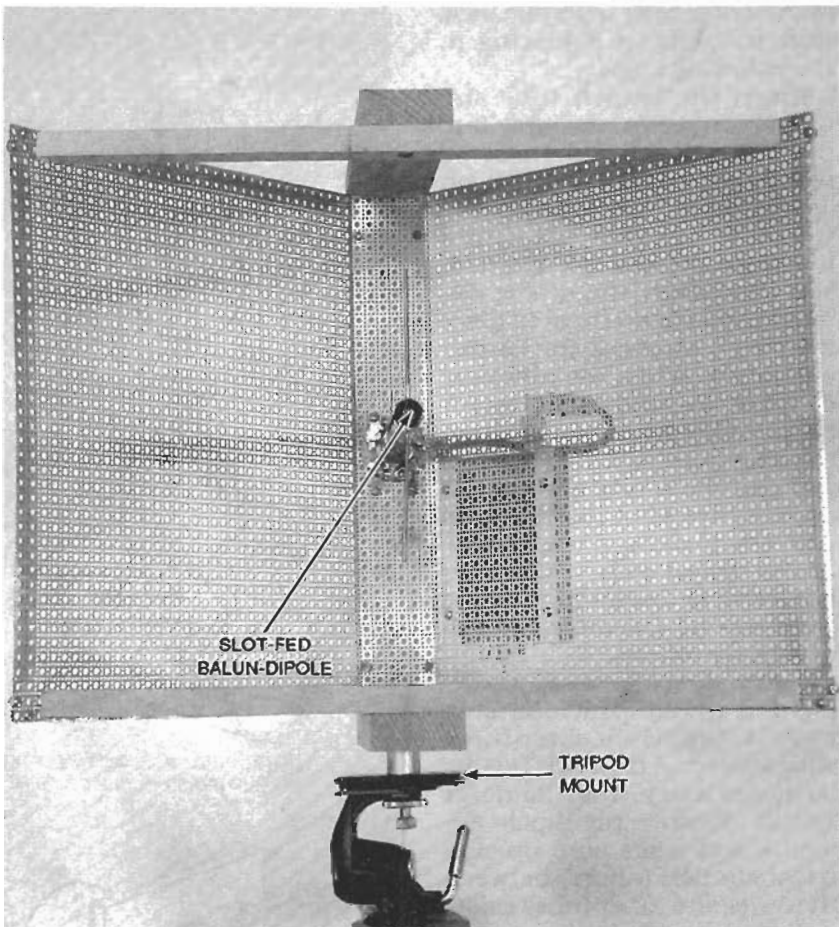


FIG. 8—THE CORNER-REFLECTOR ANTENNA fully assembled and mounted on a photographer's tripod for evaluation.

against leakage. Clear materials are preferred since pigments such as metal dust or carbon can be lossy for RF. Make sure to leave a small hole in the bottom of the container to allow escape of condensation.

How it performs

The corner-reflector antenna provides noticeable improvement over an omni-directional or ground-plane antenna. It can be used indoors as well. Fig. 8 shows the antenna mounted on a photographer's tripod for initial testing. The transmitter (or antenna) is mounted on the rear surface of the aluminum grille. This corner-reflector antenna is not intended for moon-bounce, weak-signal SSB, DX contests or other such exotic amateur radio uses but it will be a darn good antenna for much scanner listening and routine ham use, or as a temporary, cheap antenna to use before in-

vesting in a larger Yagi or other expensive setup. With a low-loss feedline, an 8 to 10 dB antenna will give very good results both in transmission and reception.

The author has used two of these antennas for amateur TV transmission at 923 MHz, one antenna at the home station about 30 feet above ground, the other in a vehicle with a portable TV set and a receiving down-converter to allow reception of the 923 MHz amateur TV signals on VHF channel 3. A 1-watt transmitter was used at the house. Excellent pictures were received 8 miles away and, although snowy, a picture was seen at 17 miles. The tests were repeated at 1289 MHz with a pair of corner-reflectors designed for this frequency and similar results were obtained. The transmitters and receiving downconverters were described in articles published in the April and May, 1996. Ω