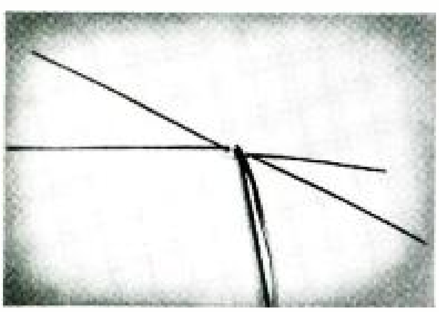
Antennas For Television*

Part VI—Construction information and performance reports on several variations of the common half-wave dipole

By
EDWARD M. NOLL
and
MATT MANDL†

A NUMBER of antennas, which can be considered half-wave dipole types, have different characteristics because of their shape. The basic modifications are the short-V, conical, and circular types. These antennas have a higher resistance and generally a broader bandwidth than the dipole. Gain is a bit higher because of somewhat narrower directivity, particularly in the vertical plane, and because of greater surface area presented to the arriving wavefront.



Short-V antenna is usable with 300-ohm line.

The short-V (Fig. 1) consists of two V-shaped sections fed at the apex of each section. Each rod forming the V is an electrical quarter-wave; the separation between the rods of each section forms an angle (which is noncritical) of 30 to 45 degrees. Antenna resistance is 150 to 200 ohms and matches a 300-ohm line with insignificant loss for the usual length of line used for TV installations.

The short-V and other modified types find application in the fringe areas because they lend themselves to stacking and use of parasitic elements without too much reduction of antenna resistance. If antenna resistance is too low, matching problems are more difficult and leakage losses become higher because of the higher current which flows in the antenna system.

* From a forthcoming book: *Reference Guide For Television Antennas.*

† Television Instructors—Technical Institute, Temple University.

The improved performance of the expanded types of dipoles is due to the ease with which the transfer is made from propagated wave to antenna current feeding into the transmission line. Perhaps this is best understood if we consider that at the ends of the antenna we have minimum current but maximum voltage. If an end is expanded, it will intercept a greater cross section of the arriving signal wavefront. Energy, if it has a choice, will flow along a conductor. If a substantial part of the wavefront is intercepted, its energy (in the form of antenna current) will flow along the antenna elements, grouping at the apex, the maximum-current point of the antenna. At this point the transmission line is attached.

The conical antenna

The conical antenna (Fig. 2) is a further expansion of the V, each antenna element spanning out in the form of a cone from the apex. The recommended element length for symmetrical bandwidth on each side of a chosen center frequency is 0.365 wavelength from the apex along the conical surface to the rim. Of the modified types the conical has the greatest bandwidth—approximately 30% of center frequency.

For example, a cone cut for a strategic frequency in the low band (depending on local station frequencies) can be made to have peak response to two or three channels and a somewhat reduced sensitivity to other channels, depending on frequency separations. In addition the third-harmonic sensitivity of the cone permits substantial pickup on the high-band channels. A cone cut for 70 mc has a bandwidth of 21 mc and, therefore, would have peak sensitivity to channels 3, 4, and 5. Third-harmonic sensitivity would cover channels 9 through 13.

The cone can be constructed of sheet metal, although (better from the standpoints of wind resistance and economy) it can be formed of 12 equidistant radial wires or of copper screening, with an insignificant change in characteristics. The cone is versatile so far as impedance match is concerned because its resistance depends on its shape. For example, with an angle of 15 degrees between the sidewall and axis, the antenna resistance is 300 ohms. If two cones are to be stacked, an angle of 10 degrees can be used to obtain a resistance of 600 ohms per unit, again matching a 300-ohm line. Some typical angles and corresponding antenna resistances are:

Angle (degrees)	*Resistance* (ohms)
5	950
8	750
10	600
13	400
15	300

Reflectors and directors can be used with the various dipole modifications. The parasitic elements, for best performance, should have the same general shape as the driven antenna. Thus a V-shaped reflector is used for a V antenna, while a cone can be used for the conical antenna.

The circular antenna

A circular antenna constructed by the authors was found to have a number of unusual features which make its performance outstanding for television. It has somewhat higher gain than a V or folded dipole, and it is much less sensitive to high-angle radiation. Horizontal directivity is also sharp, and orientation rather critical. This is, of course, advantageous for the suppression of multipath reflections which would produce ghosts.

The manner in which this circular antenna receives signals differs from that of an ordinary radio or a direc-

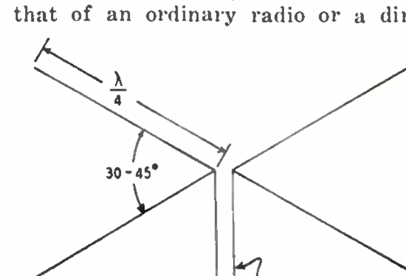
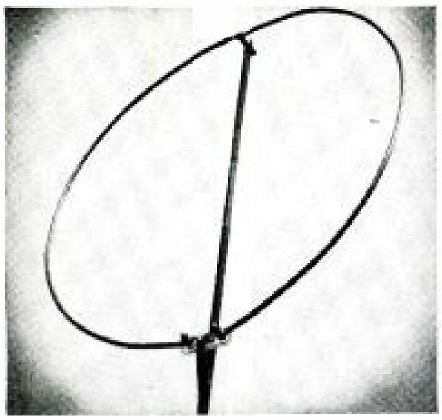


Fig. 1—Short-V uses four quarter-wave rods.


Mast supports the loop at exact center of top.

tion-finding loop antenna with which maximum pick-up is obtained when the edge of the loop points toward the station. In direction finding, a minimum or null is obtained with the loop broadside to the station. Of course, the loop itself is smaller in diameter than the wavelength of the received signals. Inasmuch as the signal phase, therefore, is about the same on both sides of such an antenna, similarly phased voltages are induced in both sides and cancel at the receiver feed point.

The circular antenna illustrated in Fig. 3, however, although in the form of a loop, is just slightly less than a half-wave in diameter; therefore, out-of phase voltages are present on the sides when the antenna is broadside to the television station. It is this position which feeds maximum signal to the transmission line.

Orientation is critical because the pattern of this antenna is elongated, extending in narrow-beam formation forward and backward. Position of the antenna in its vertical plane is also sharp. A tilt of a few degrees makes a considerable difference in signal pick-up. Because of the electric and magnetic fields of the antenna, rotation about its circumference is also critical, and the transmission line feed point must be either at the exact bottom or top.

The more nearly perfect the circle, the better the reception and noise-reduction characteristics for television. The tubing from which the antenna is constructed can be either ¼ or ½ inch. Too large a surface area may increase signal pickup from ground levels and harm the exceptional noise-reduction characteristics of this circular antenna.

For peak performance, then, the following summarized factors must be closely observed: The antenna must be absolutely circular; it must be mounted vertically; the plane of the antenna must be broadside to the station direction; and the transmission-line feed point must be attached so that it is exactly at bottom or top. The antenna conveniently matches a 300-ohm, ribbon transmission line.

The poor performance of a circular antenna in other than the correct position indicates its ability to reject noise and spurious-signal interference. This improvement is evident when we consider that, for signals arriving from beneath the antenna, the voltages induced in opposite sides of the antenna would be in phase because of the added half-wave of travel necessary to reach the top of the antenna. Noise signal would therefore cancel at the transmission-line feed point. Multipath and other signals which arrive at an angle other than perpendicular to the plane of the antenna encounter the same canceling effects. The directivity pattern of the circular antenna instead of being doughnut-shaped as is that of the more conventional type of dipole, is narrowed and pulled out horizontally toward the station as is the pattern of a stacked system.

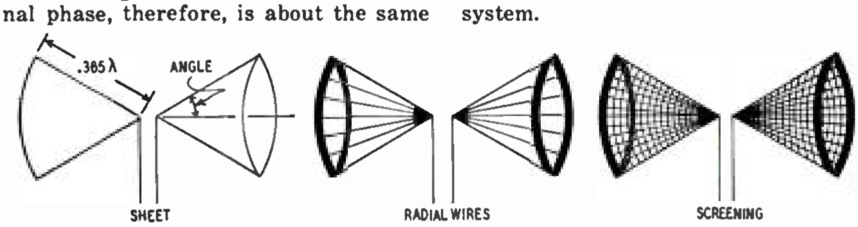


Fig. 2—Conical antennas may be made in a number of ways, as these drawings illustrate.

The circular antenna is a full wavelength *in circumference*, and this dimension must *not* be corrected for end effect. It was found that peak sensitivity was obtained with the antenna cut to a free-space wavelength. Apparent absence of end effects also indicates less end loss due to capacitive leakage. Dimensions for the various channels (in inches) are as follows:

Channel	*Circum.*	*Channel*	*Circum.*
2	202 inches	8	63 inches
3	183 inches	9	61 inches
4	167 inches	10	59 inches
5	145.5 inches	11	57 inches
6	135.5 inches	12	55.5 inches
7	65 inches	13	54 inches

Perhaps another reason for the increase in sensitivity of the circular antenna is its responsiveness to other than horizontally polarized components of the arriving signal. With the usual turnstile transmitting antenna used by television broadcast stations, there is present a vertically polarized component which is 25 to 30% as strong as the horizontally polarized component. A substantial level of circularly polarized component has also been observed. The circular antenna has some sensitivity to these components also. In fact, the circular antenna can be converted into one with peak sensitivity to a vertically polarized wave simply by positioning the transmission line feed point at the right or left instead of at top or bottom.

A circular antenna constructed for channel 10 is shown in the photo. Note that the antenna can be attached to the mast at the top, which is a ground or maximum-current point. Feed point is at the bottom where the antenna is insulated from the mast. The antenna is comparatively small, symmetrical, not top-heavy, and has very little wind resistance.

Summary

1. Antenna placement is of primary importance. It can do more to bring up a stubborn signal than a multi-element array or a booster. Place the antenna in space loops of weak stations.

2. Use directional antennas where needed in fringe areas or multipath localities. To obtain the utmost from a directive system, both impedance matching with stubs at the antenna and proper over-all length of transmission line are important.

3. Choose antenna type and dimensions with an eye to your local allocations. Design antennas for peak sensitivity on frequencies to be received and minimum sensitivity to other frequencies from which interference might come. Broad-band insensitive antennas are not recommended.

4. Use ribbon transmission line to match standard receiver inputs and cut down attenuation on spans of line. Only at the very high TV channels does the loss in twin-lead approach the loss of a very-good-quality co-axial line. Co-axial line is helpful in some noisy localities, but make certain the greater attenuation does not cancel the benefits of shielding.

5. Antennas perform better on frequencies higher rather than lower than those for which they are cut. Choose antenna dimensions to favor the lower frequencies, particularly if one of these stations is weak. Separate high- and low-band antennas are not necessary in most localities. A low-band antenna properly cut will perform just as well on the high band because of harmonic relationship. If stations are not in the same direction, a separate high-band antenna may be helpful in some localities if it can be separately oriented.

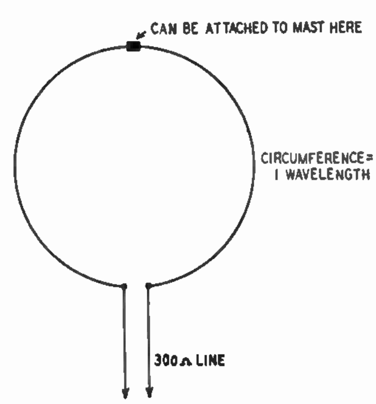


Fig. 3—Loop is a simple 1-wavelength circle.

6. The advantage of stacked antennas, so far as signal strength is concerned, is questionable, the maximum possible increase under the most ideal conditions being 40%. Stacked systems reduce noise pickup from below.