ALL-CHANNEL ALL-WAVE ANTENNA

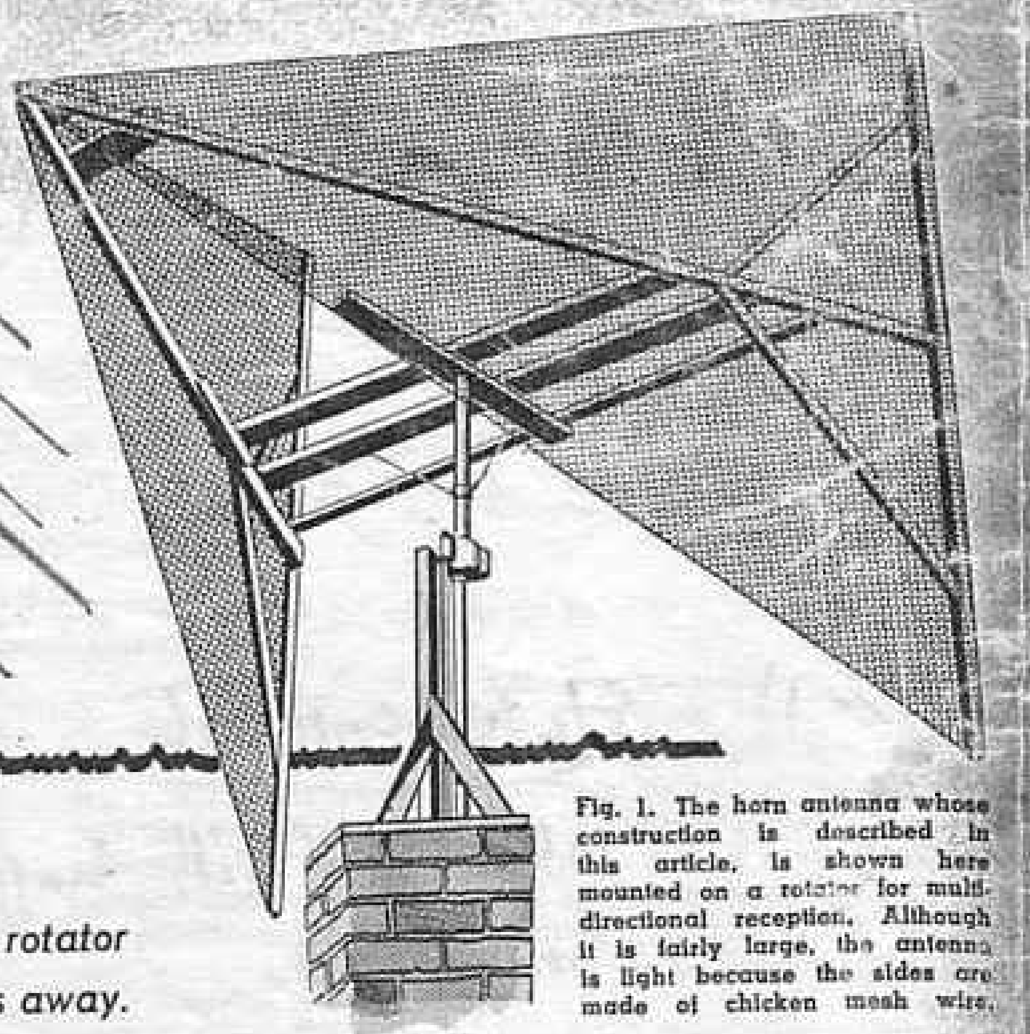


Fig. 1. The horn antenna whose construction is described in this article, is shown here mounted on a rotator for multi-directional reception. Although it is fairly large, the antenna is light because the sides are made of chicken mesh wire.

By **JOSEPH MARSHALL**

Use this antenna with or without a rotator to pull-in TV channels over 200 miles away.

ONE of the most vexing problems in fringe area TV reception is that of obtaining multi-channel reception. Where only one or two stations are within reliable range, separate antennas for each channel is the ideal solution. However, where a location is within range of a number of stations both on the high and the low band, separate antennas become impractical.

It is true that there are a number of antennas which provide fair multi-channel or all-channel reception. Among these are the stacked conicals, modified yagis, and colinear arrays with reflectors. The trouble is that, being resonant, most of these arrays provide optimum pickup on only a few channels and optimum impedance match on even fewer and, unless some form of tunable matching network is used, they fail to deliver optimum gain. Moreover, their directional characteristics vary from channel to channel. They work well in the near-fringe areas but seldom live up to expectations in the far fringe.

The nonresonant, transmission-line rhombic antenna provides excellent gain on most of the channels and, being nonresonant, does not suffer mismatch losses from channel to channel. However, for appreciable gain on the low bands, a rhombic needs to be at least 40 feet long. Where all the stations lie in the same direction, a fixed rhombic provides an excellent solution; but since it is virtually impossible to rotate a rhombic 40 feet long, it is not suitable for reception from several directions.

Horn antennas have found great use in the microwave bands, notably in radio-relay systems, but they are not easily applicable to the v.h.f. TV frequencies because of their bulk, weight, wind resistance, and the problem of transferring the signal from horn to feedline. However, some modifications on the conventional horn antenna, introduced by Dean O. Morgan of *G-E*, makes this antenna practicable for use on the TV frequencies. The first and most obvious was that of using wire instead of solid metal for the horn sides. The second was that of eliminating two sides of the horn. Since TV signals are horizontally polarized, only the two vertical sides of the horn are necessary. Finally, for a two-sided horn, the feedline could be connected to the two apexes. The result is an antenna which, although bulky, has extremely high gain, broad bandwidth, is capable of being rotated, and presents a nearly uniform impedance over a great frequency range.

Although the location at which the antenna shown in Fig. 1 is erected is 140 airline miles from Atlanta, Georgia —some 20 calculated miles beyond line of sight—phenomenally good reception is obtained on channels 2 and 5 in Atlanta. Channel 8, which could not be received with any degree of dependability despite considerable effort, has been brought in by the horn antenna where all others failed. Unlike most antennas, the horn apparently delivers in practice the theoretically determined performance. Moreover, it proved to be completely non-critical in construction, adjustment, and erection. Its performance is really phenomenal and very much worth the small trouble involved in its construction.

Fig. 2. Graph of relative gain of the horn antenna over its frequency range.

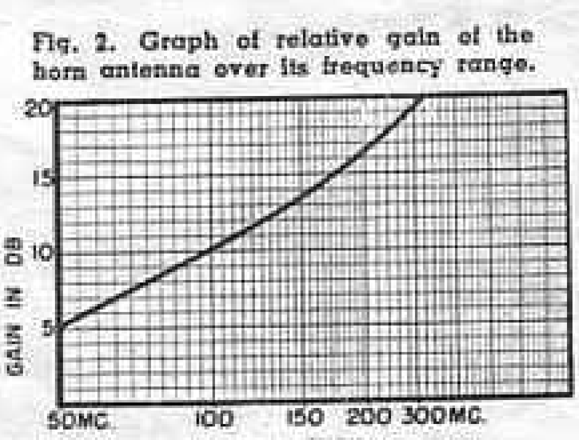


Fig. 2 gives the calculated gain of an 11-foot horn (mouth size) over that of a resonant folded dipole at each frequency. It will be seen that it provides almost 6 db gain on channel 2, over 9 db on channel 6, and between 15 and 17 db on the high v.h.f. band channels, as well as 10 db in the FM band. The impedance is 450 ohms on channel 2 and 400 ohms above that. Experience indicates that the theoretical gain is actually achieved in practice. In other words, the horn provides a gain equal to or exceeding that of most stacked commercial yagis on channels 4, 5, and 6; equal to that of a single commercial yagi on channels 2 and 3; and twice the *voltage* gain (or 4 times the power gain) of stacked yagis on channels 7 to 13.

Where channel 5 suffers from interference from an FM station, as it does in the author's neighborhood, use of a narrow-band yagi for that channel alone will reduce the interference. Channel 4 in Birmingham, Alabama 200 airline miles distant, can be received almost constantly, and so can channel 3 in Charlotte, North Carolina, 225 miles away over the mountains. Sporadic reception of other stations has been experienced on almost every channel.

When the FM receiver was connected to the antenna, stations began to pop out of the noise all over the dial. Every FM station in Atlanta, even th low-powered ones, is now received with full quieting almost 100 per-cent of the time. The receiver is extremely sensitive, to be sure, but nevertheless, only the three most powerful stations had ever been logged previously.

Finally, the antenna works more than adequately on the short-wave and broadcast bands with an "SX32" receiver. This, despite the fact that the antenna ceases to operate efficiently as a horn when its sides are smaller than one-half wavelength at the signal frequency received. Under these conditions, it becomes a very large, broad-band conical dipole. The 11-foot antenna shown in Fig. 1 is resonant at about 20 mc. and gives good performance from about 13 to 40 mc. Below this, and especially at broadcast frequencies, it operates simply as a large pick-up sheet, and because of its area, absorbs a considerable amount of energy. It is not, of course, very directional below 30 mc. The antenna is, in effect, a single all-wave, all-channel radio and TV antenna, which is simply switched from TV to FM and AM receivers.

The results are all the more striking because the cost is very low and the construction simple. Fig. 3 gives the dimensions of an 11-foot horn. This is about 1 wavelength on channel 6 and was chosen because the necessary wood strips can be cut from a single 12-foot board, whereas longer boards are hard to find.

The four main wood strips are 1½ inches wide and ¾ or ⅞ inch thick. The various braces can be 1 inch wide, and the horizontal joining pieces should be about 4 inches wide. The two wire-covered triangles which form the sides are assembled first. Joints are made with 2½- and 3½-inch carriage bolts. The long cross pieces are drilled to take the horizontal boards, so that the horn can be assembled easily by setting and tightening bolts.

The wire for each triangular side can be cut from one 14-foot length of chicken wire, 5 feet high. The two triangles are assembled into the horn by bolting the cross pieces in place. Two vertical braces can be nailed at the mouth to keep the horn from twisting. The mast is mounted at the point of balance, which can be determined experimentally by moving the mount back and forth between or under the cross pieces until the point is found at which the antenna will balance itself horizontally. If a broad-based mast mount is used, no strutting or bracing is necessary.

Fig. 5 is a universal design chart for horns of various mouth sizes with a flare angle of 50 degrees. This is an excellent compromise angle; narrow enough to give sharp directivity and not so broad as to offer maximum resistance to the wind. Fig. 4 is a universal gain chart for a 50-degree horn. It will be noted that, whereas in ordinary antenna arrays the power gain doubles as the antenna size is doubled, in the horn antenna, the power gain is quadrupled as the antenna size doubles. The chart shows that a gain of 20 db can be achieved with a horn 3½ wavelengths wide at the mouth.

For vertically polarized signals, the horn can be turned so that the sides lie in the horizontal plane.

To use the design chart in Fig. 5, hold a straightedge joining the equal numbers on the lines *AA* and *A'A'*, which represent the desired mouth width and height. The point where the straightedge intersects the diagonal line *B* gives the length of the strip *B* in each side of the triangular sides. Thus, for instance, for a horn with a mouth 11 feet wide, the strip *B* is just a little over 12 feet long.

The antenna dimensions to suit your particular situation depend, of course, on the stations you desire to receive. It is best to cut the antenna for the center of the frequency range you are interested in. For TV, for example, channels 2 to 4 cover the frequencies from 54 to 72 mc.; channels 5 to 6, 76 through 88 mc.; channels 7 through 13, 174 to 216 mc., and channels 14 through 83 cover 470 to 890 mc. For channel 10, therefore, the lower frequency limit is 174 plus 18, or 192 mc. (Each channel is 6 mc. wide.) The wavelength you need is that of the video carrier, which is 1.25 mc. added to the lower frequency limit of the channel. For channel 10, the wavelength is 984 divided by (192 + 1.25) or 5 feet.

There is plenty of room for improved mechanical engineering, although the model shown here has withstood winds of about 40 miles per hour. For instance, the booms could be made of aluminum tubing and the sides of wire or small-diameter tubing splines, as is done in corner reflectors. An all-metal design, however, would require that the horizontal cross pieces which form the two sides into a horn be insulated from each side.

The transmission line to the receiver is connected at the apex of the horn, one wire to the end of each triangle. Any good low-loss transmission line can be used. -30-

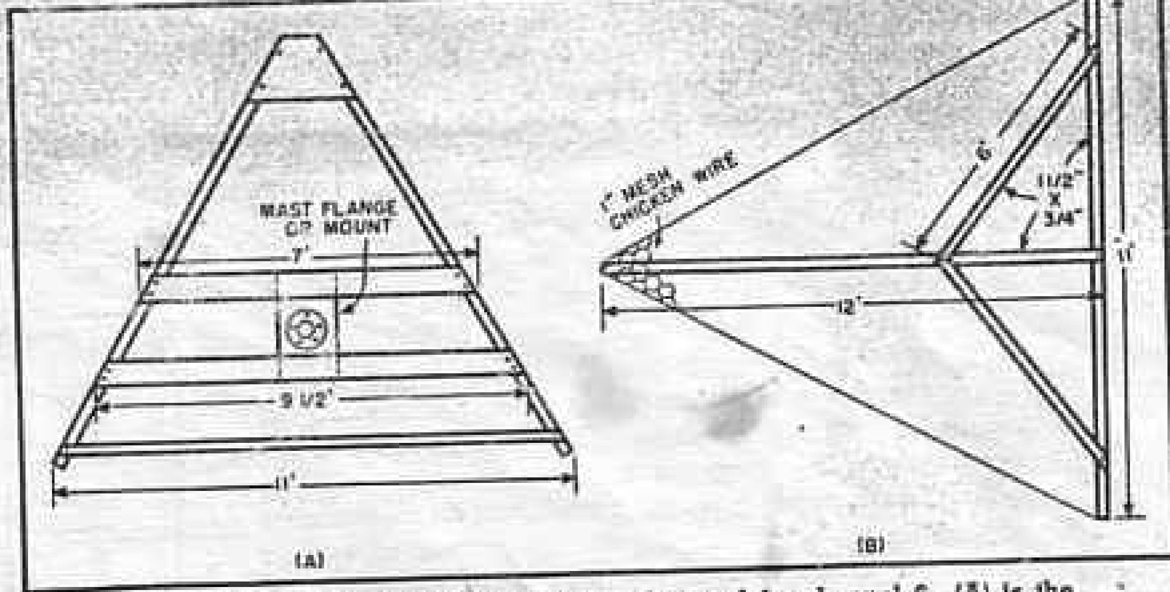


Fig. 3. Dimensions of the horn antenna designed for channel 6. (A) is the top view of the antenna structure. (B) is the side view for one of its sides.

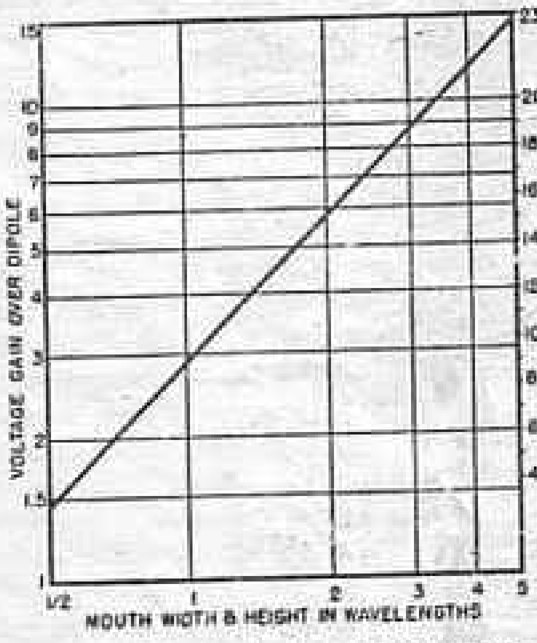
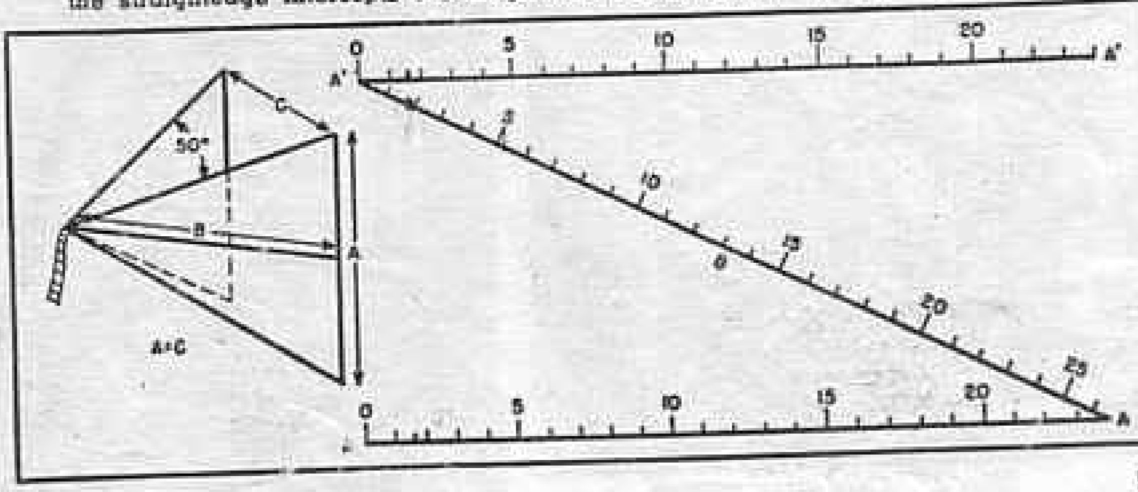


Fig. 4. Graph of antenna voltage gain for various horn antenna mouth widths.

Fig. 5. Nomograph for determining the length of the horn antenna sides. Knowing the height and width (which are the same). To use, place a straightedge from the top line to the bottom line at the dimension chosen for the height, where the straightedge intercepts the diagonal line read off the length, shown as "B."



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