Fig. 1. Commercially-built fan type antenna designed and constructed by Channel Master Corp. engineers.

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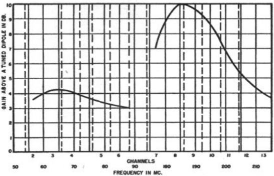
DEVELOPMENT of FAN TYPE TV ANTENNA

Design of an antenna which maintains the good broadband performance of conical antennas yet provides better high-band gain characteristics.

THE past year has seen the phenomenal emergence of the conical type as the predominant suburban and fringe area antenna. Its characteristics are superior to the folded or straight dipole type of antenna from the standpoint of gain and of bandwidth. The use of separate high and low sections can be eliminated in most cases. However, this antenna does have several drawbacks. The first is the poor response brought about by its drooping gain characteristic on the high end of the high band from Channels 10 to 13. (See Fig. 2.) This is accompanied by a splitting of the major lobe into two large side lobes in the horizontal polar pattern. (See Figs. 3A and 3B.) This means that there is both loss in gain on these channels and a high susceptivity to ghosts due to the splitting lobe. The sharp slopes in the gain curve indicate that in a channel having a 6 megacycle bandwidth, there can be differences in gain in an antenna of 2 to 3 db. These sharp slopes and non-uniform gains introduce distortion to video components of the telecast signal.

Fig. 2. A typical curve showing the gain of a conventional conical antenna.



About six months ago work was undertaken at the *Channel Master Laboratories* on the design of an antenna which would match or improve the broadband and gain characteristics of the conical antenna without the deterioration of the horizontal polar pattern on the high end of the high band and the resultant drooping gain characteristic.

A brief discussion of field strength standards would help to clarify some of the points which will follow. Field strength contours from transmitters are generally plotted in microvolts-per-meter. Contours are generally shown for 5000 μv., 1000 μv., 500 μv. and 100 μv. This means specifically that on the 100 μv. contours, a wire one meter long will intercept that number of microvolts. Fig. 4 shows three contours for a theoretical telecasting setup. For the purpose of this illustration, both Channel 2 and Channel 13 are telecasting from the same point with exactly the same amount of power. A tuned dipole for Channel 2 is roughly two meters long and a tuned dipole for Channel 13 is about half a meter long. This means that at the 100 μv. contour where the one meter wire reference is placed, the Channel 2 dipole will give approximately 200 μv. since it is twice as long as the reference and the Channel 13 dipole will give 50 μv. since it is only half as long as the reference wire. It can be seen that although both tuned dipoles are placed on the same field strength contour, one will give four times as much signal as the other.

In other words, in areas of equal signal strength, tuned dipoles for low band channels will supply stronger signals to the set than tuned dipoles *for high band channels.* Moreover, transmission line losses are greater on the high band, and in general, receiver front ends are less efficient on the high band. The chief problem then is to design antennas which can supply more energy on high band channels than the conventional half-wave dipole or dipole and reflector combinations.

Since this is the problem, more energy must be intercepted by the antenna. This means that the high band dipole must be longer than a half-wave. On the average, a half-wave dipole for the low band is three times as long as the half-wave dipole for the high band. This means that three times as much signal would be intercepted on the high band with this dipole. However, since on the high band this low band dipole is three half-waves long, it is operating on the third harmonic at high band frequencies and the resultant lobe pattern is a clover leaf somewhat similar to Fig. 3B. This split lobe means that the antenna is insensitive to "head on" reception and that if one major lobe is pointed toward the station, the other is highly receptive to ghosts and stray pickup. (It is assumed that rear lobes will be reduced by the use of reflectors.) The problem then is to keep the antenna length but to "focus" the energy into one lobe. This is accomplished by arranging the antenna so that it forms a "V" (Fig. 3C). The "V" type antenna gains efficiency as the legs of the "V" become a greater number of wavelengths. The higher the channel, the greater the gain and the narrower the lobe.

However, when this is done, low band efficiency decreases. The reason for this is that veeing forward of the elements reduces the space aperture or area of interception. In addition to this, the nulls at 90 degrees are not complete. (Fig. 3D.)

At this point in the discussion, it is necessary to deviate slightly to consider the evolution and theory of a conical element. What is ultimately accomplished is the incorporation of these two principles, the "V" type element and the conical element into one broadband antenna. The conical element was developed out of the need to create a dipole antenna which would operate efficiently over a wide range of frequencies and also present a relatively uniform impedance over this range of frequencies. A dipole can be considered a special case of the parallel wire transmission line. As is commonly known, the characteristic impedance of such a line depends upon the diameter of the conductors and the spacing between them and is independent of frequency. If such a line is opened and bent so that the two conductors are formed into right angles opposite to each other and each conductor is cut a quarter-wavelength from the bend, a half-wave dipole is obtained. Before the bend, while the wires are still parallel to each other, voltages and currents in each conductor are equal and opposite as are the fields surrounding these conductors

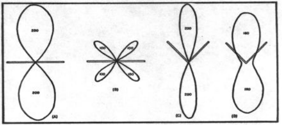


Fig. 3. (A) Horizontal pattern of half-wave dipole cut for Channel 2. (B) Pattern of same antenna when operated on its fourth harmonic or Channel 13. (C) Pattern of antenna shown in B when the elements are bent into the form of a "V". (D) pattern of this same "V" antenna when it is used on Channel 2.

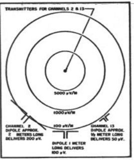


Fig. 4. Reduction in gain of a Channel 13 dipole due to its shorter physical length.

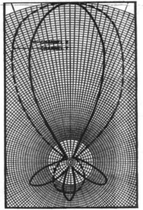


Fig. 5. Polar pattern of fan antenna.

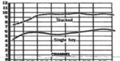
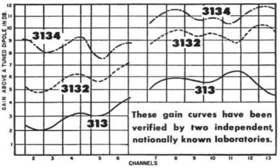


Fig. 6. Gain curves for VHF and UHF



and therefore, all radiation is cancelled. However, when the conductors are bent out to form a dipole, the cancellation can no longer take place and the dipole antenna will either radiate or receive.

This dipole has an impedance of approximately 73 ohms. Now if the diameter of the dipole is increased after a right angle bend so that it constantly increases as we get farther from the point of the bend, a three dimensional cone is formed. This cone will still radiate or receive energy. However, its impedance characteristics are different. In this case, as the transmission line has been fanned out, the diameter of the conductors has been increased. The result is that the impedance remains constant over a wide band of frequencies. In other words, by the use of conical elements, a broadband antenna has been secured. In summarizing the previous two paragraphs, it can be seen that by veeing an antenna forward very narrow horizontal lobes and patterns can be obtained over a relatively wide band of frequencies.

In the case of the conical antenna, by the use of this uniform impedance conical element, it will work over a wide band of frequencies with a low standing wave ratio.

It must be borne in mind that the above description pertains only to driven or receiving elements and does not pertain to reflectors. The requirements of a reflector are such that it must re-radiate energy to the driven element in such a relationship that reinforcement or addition occurs. To fulfill these requirements, a straight reflector is as effective as a conical reflector or a fan shaped reflector provided that it is cut and spaced properly. In the laboratories, the above considerations were given careful thought. It was obviously not feasible to make a three dimensional sheet metal cone or even a wire cage type cone element. Previous conical antennas had simulated this cone by running two dipoles from a common apex producing a cone in two dimensions. It was further observed that in the case of a "V" antenna as the diameter of the legs of the "V" was increased, the antenna would become increasingly uni-directional in the direction of the enclosed part of the "V." It was then reasoned that if the conical element which operated effectively over the entire low band were bent forward so that it formed a "V" on the high band, it would provide an efficient all channel antenna. However, two shortcomings were observed. Veeing forward the antenna reduced the amount of energy intercepted on the low band because the distance across the front was decreased and secondly the two element conical antenna did not have an effective diameter large enough to produce a workable front-to-back ratio on the high band. A third element was added. This element overcame these two shortcomings. On the low band, the third element meant that more energy was being intercepted and therefore the narrowing of the space aperture was overcome. On the high band, the effective diameter of the legs of the "V" was increased so that a high front-to-back ratio was realized. As a matter of fact the same front-to-back ratio was realized on the high band after the inclusion of the third element, with or without reflectors. In addition, to these two improvements, it was found that the third rod made the elements more closely resemble a three dimensional cone and a more uniform impedance was realized. Therefore, a better match was made to the transmission line over the entire range of frequencies. The impedance was found to lie in the neighborhood of 150 ohms so that good matches were available at 72 ohms and at 300 ohms. The finished antenna is shown in Fig. 1. Horizontal polar diagrams at Channels 2 and 7 are shown on Fig. 5. Gain curves for the single, double, and four-bay arrays are shown graphically and tabularly in Fig. 6.

313

713

SUPER FAN

The uniform impedance brought about by the use of fan type elements and the high gain on the high band achieved by the expedient of veeing forward these fan elements provides this antenna with extremely fine broad band characteristics. The impedance is approximately 150 ohms and this antenna can be used with either 72 or 300 ohm. The deciding factor should be the imput impedance of the set. On the high band, the directivity of this antenna increased from the conventional patterns of a two element array to the narrow lobe pattern of a vee type antenna. Gains from 2 to 4 db. on low band and 5 to 6½ db. on high band.

3132

7132

STACKED SUPER FAN

This STACKED SUPER-FAN is superior to all conventional conical types. ½ wave spacing at low band mid frequency. Aluminum elements and cross arm, completely pre-assembled. Narrow lobe makes use excellent in conjunction with rotator. Gains from 5 db. to 7 db. on low band and 8 to 11 db. on high band.

3134

7134

DOUBLE STACKED SUPER FAN

The DOUBLE STACKED SUPER-FAN is the most sensitive broad band antenna developed to date. Carefully engineered matching sections give full advantage of stacking arrangement. This completely pre-assembled ultra fringe antenna provides gains of 7½ to 9 db. on the low band and 10½ to 11¾ db. on the high band.

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414 **ULTRA-DAPTER**

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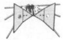

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*all VHF, all UHF

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