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Measurements of Selective Near-In Sidelobe Reduction of a Pyramidal, Horn-Reflector Antenna

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This paper describes measurements of a simple but effective means for reducing selective near-in sidelobe levels of a pyramidal horn-reflector antenna by using microwave absorber to modify the electric field across the reflector surface of the horn-reflector antenna. Examples of several modifications (made in the transverse plane for transverse polarization) are discussed and compared with data obtained before modification. Good reductions are achieved in the region of 2 to 6 degrees from the main beam. For example, an improvement was obtained on the order of 4 dB in the first sidelobe level with corresponding improvements of 8 and 10 dB in the angular region of the second and third sidelobe levels. One would expect some of the far-out sidelobe regions to increase; however, the reductions obtained in the levels of the near-in sidelobes could warrant a trade-off.

I. INTRODUCTION

It is well known that radio interference from adjacent paths limits the number of converging routes of a common carrier microwave radio system, and in recent years demands have been made to improve the sidelobe performance of the pyramidal, horn-reflector antenna. The use of blinders[1] (stepped extensions to the side walls of the antenna aperture) provide a degree of far sidelobe reduction, i.e., lobes beyond

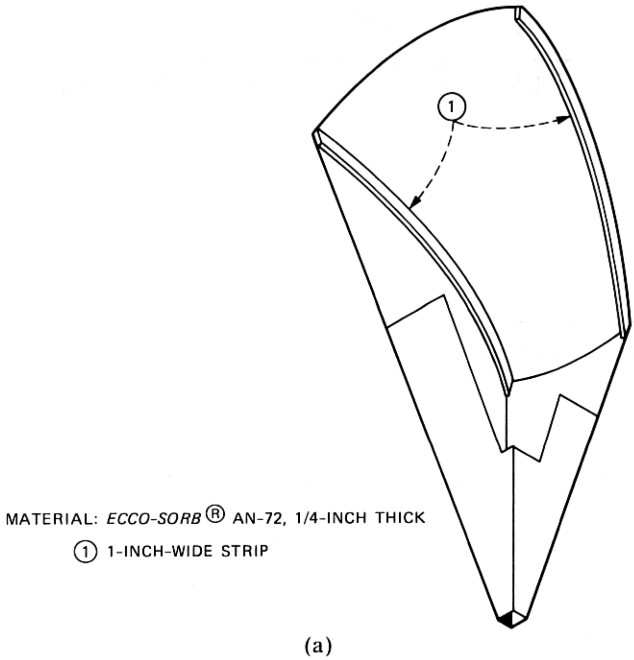


Fig. 1a—A cutaway view of the pyramidal, horn-reflector antenna showing the placement of the 1-inch strips of microwave-absorbing material.

35 degrees from the axis of the main beam. Two methods now exist for dealing with the troublesome reflections from the flat weather cover of the horn-reflector antenna. One eliminates the reflections by using a focused weather cover.[2] The other uses a bottom-edge blinder to direct the reflections upward. An experimental investigation by C. A. Siller of Bell Laboratories showed that lining the sidewalls of the horn-reflector antenna with microwave absorber would reduce the sidelobe levels for angles greater than 40 degrees from the axis of the main beam, but this degraded the near-in sidelobes. A proposal by D. C. Hogg of Bell Laboratories for apodizing the horn-reflector antenna by applying a graded microwave absorber on the weather cover of the antenna might accomplish the desired sidelobe reduction. However, to achieve reduction in the sidelobe level by this technique one would have to suffer not only a reduction in antenna gain of at least 3 dB, but also an increase in the 3-dB beamwidth of the antenna. Such an increase in the beamwidth of the main beam could further degrade system performance. An analysis of available data on path interference, conducted by R. H. Turrin of Bell Laboratories, indicates that the most severe levels of interference occur at small angles (i.e., within ten degrees of the main beam), where the antenna discrimination is less than at large angles.

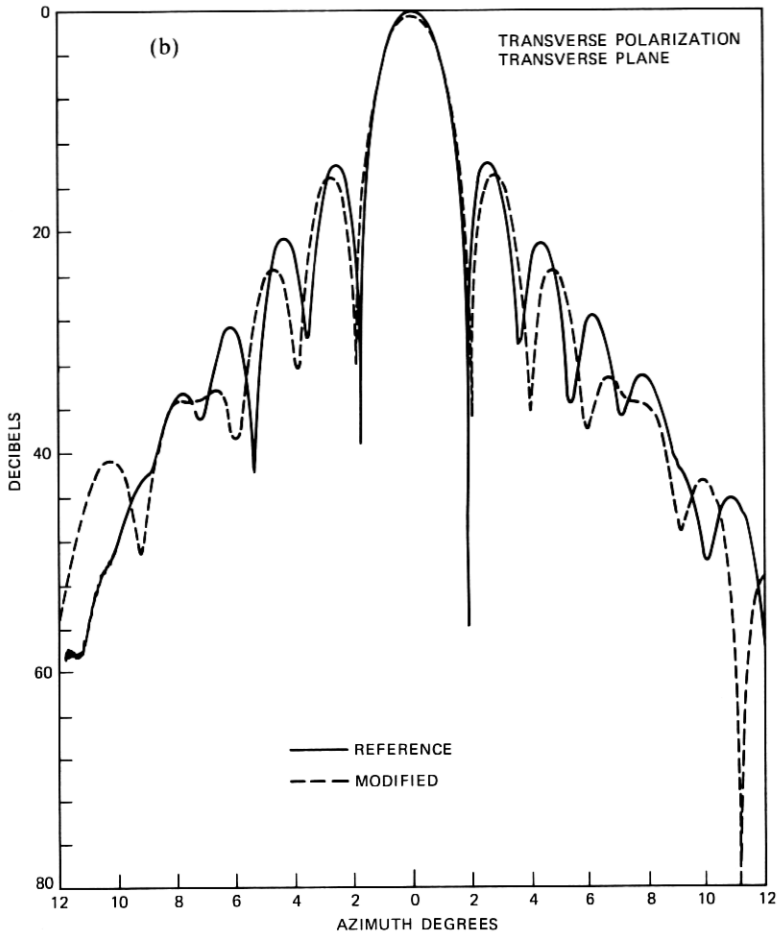
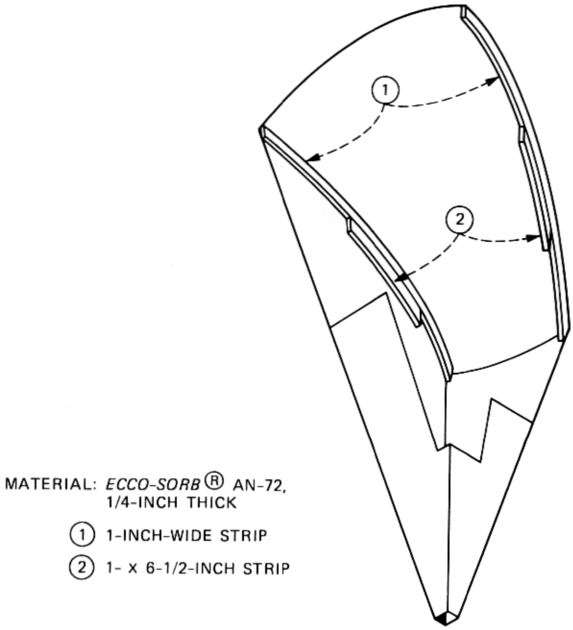


Fig. 1b—Comparison of the radiation patterns for transverse polarization of the modified (with absorber) antenna, the dashed curve, and the solid curve of the unmodified antenna. The gain loss owing to the absorber is on the order of 0.6 dB.

To continue the investigation for ways of reducing the near-in sidelobe levels of the horn-reflector antenna, a scale-model was built. The model has a numerically machined, precision reflector, and the scaling factor is 7.5, which means that measurements made at a frequency of 30 GHz will represent the performance of a full-size antenna measured at a frequency of 4 GHz. The discussion of the measurements made on the scaled model at a frequency of 30 GHz and the comparisons with data obtained by others on full-sized antennas are presented elsewhere.[3]

Inherent in the design of the pyramidal, horn-reflector antenna is a problem that results from illuminating the aperture with a dominant



(a)

Fig. 2a—A cutaway view of the pyramidal, horn-reflector antenna showing an additional strip of absorbing material added to the sidewall of the horn.

waveguide mode.[4] The theoretically obtainable off-axis radiation levels in the transverse plane for transverse polarization are therefore considerably higher than one would like, i.e., they are essentially the equivalent of an aperture with constant illumination.

It should be remembered that longitudinal polarization and longitudinal plane of antenna rotation, for radiation measurements, are aligned with the pyramidal horn axis, i.e., vertically polarized in a terrestrial radio system. Transverse polarization and transverse plane indicate that the electric field and the plane of antenna rotation are perpendicular to the horn axis, i.e., horizontally polarized in a terrestrial radio system.

In view of the information obtained from Siller and Hogg, it appeared that a more fruitful approach to the reduction of the near-in sidelobes would be to take advantage of the reflection occurring at the surface of the paraboloidal section and attempt to modify the electric-field distribution across the surface of the reflector. This could be accomplished by introducing a microwave-absorbing material directly on the surface of the reflector.

In the discussion that follows, the microwave absorbing material* is

* *ECCOSORB* AN-72, a product of Emerson and Cuming, Inc.

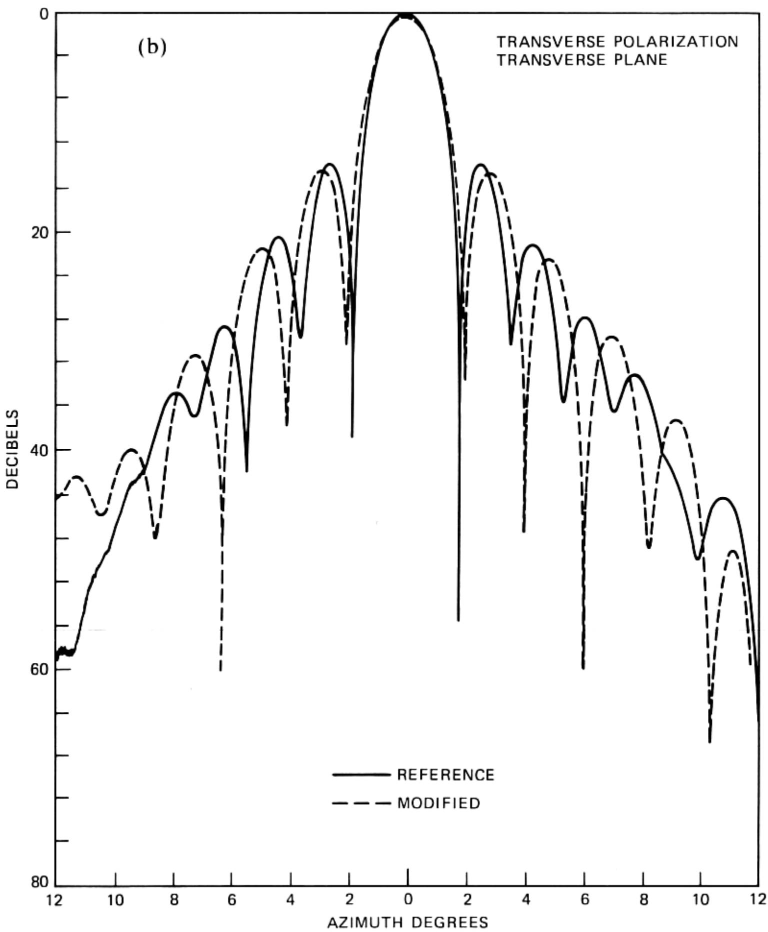


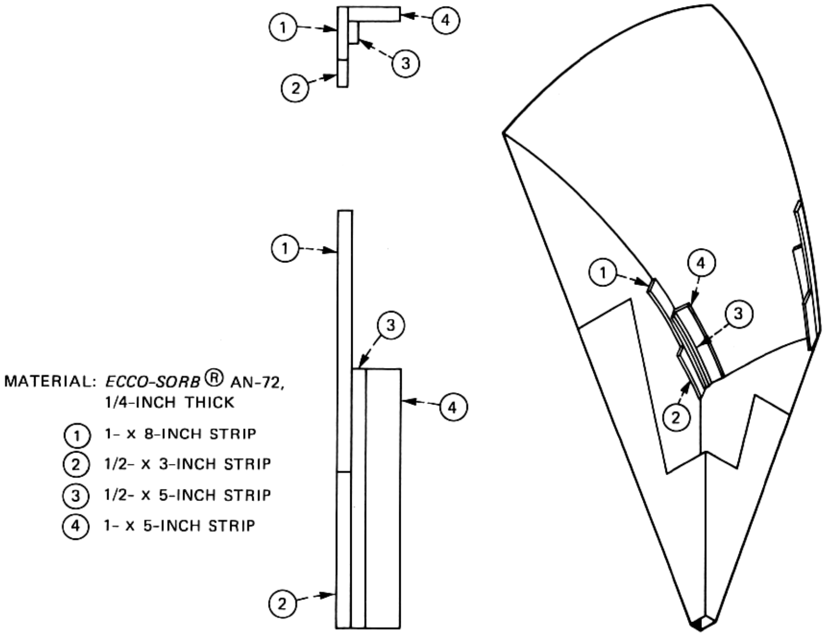
Fig. 2b—Comparison of the radiation patterns for transverse polarization of the modified (with absorber) antenna, the dashed curve, and the solid curve of the unmodified antenna.

attached to the surface of the reflector with a soluble floor-tile cement. The radiation patterns were made at a frequency of 30 GHz in the transverse plane for transverse polarization.

II. DISCUSSION

From the many combinations (of absorbing-material configuration and placement on the surface of the reflector) that were measured, several were selected for discussion here.* For example in Fig. 1a, the

* The examples in the order cited serve to illustrate the evolution of these combinations.



(a)

Fig. 3a—A cutaway view of the pyramidal, horn-reflector antenna showing the placement of strips of microwave absorber in the rear corners on the reflector.

placement of the absorbing material on the reflector is shown in the cutaway view of the horn-reflector antenna. Here, the 1/4-inch-thick edge of the absorbing material is fastened to the reflector surface with the one-inch width of the material fastened to the sidewall of the horn. The absorbing material extends from the back wall to the edge of the aperture. The radiation pattern for this combination is shown by the dashed curve of Fig. 1b; the solid curve is the reference radiation pattern of the horn-reflector antenna, i.e., with nothing introduced into the antenna. In spite of the obvious lowering of the near-in sidelobes, which in this instance were 0.6, 3.0, and 6.0 dB for the first, second, and third sidelobes, respectively, there was no measurable increase in the 3-dB beamwidth. Although there is a gain reduction of 0.5 dB, this has been accounted for when stating the sidelobe reductions. One should note that the modified radiation pattern has very good symmetry and the angular displacements of the maxima for the sidelobes of the modified antenna have increased.

One might say that the observed results are typical of what would be expected when the aperture area is reduced. But consider Fig. 2a.

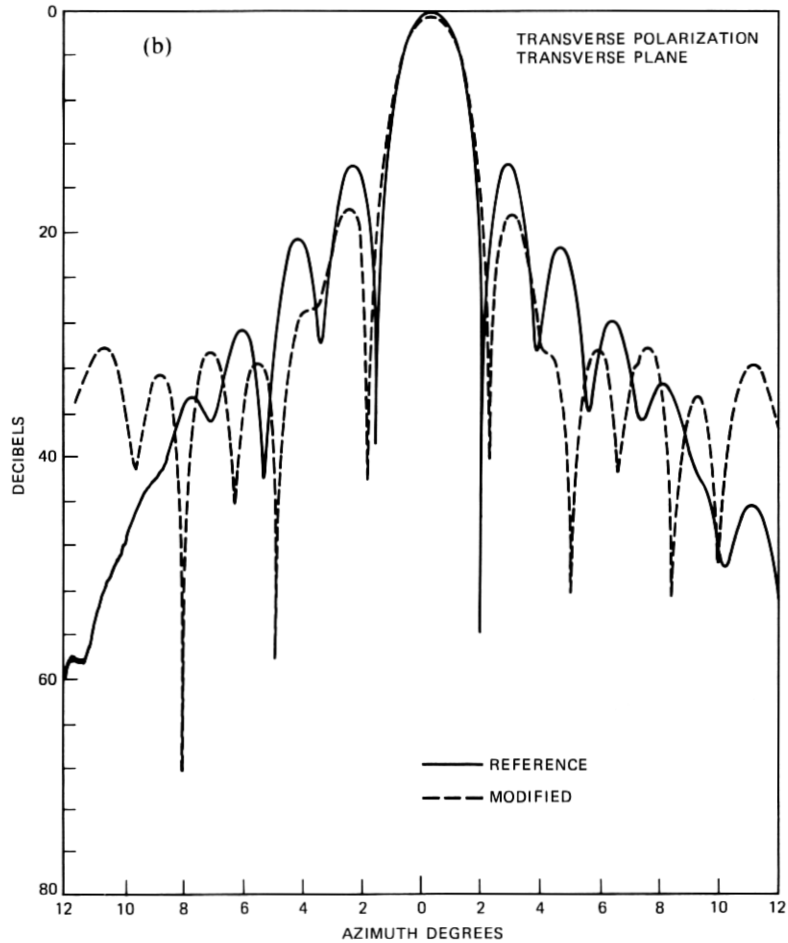
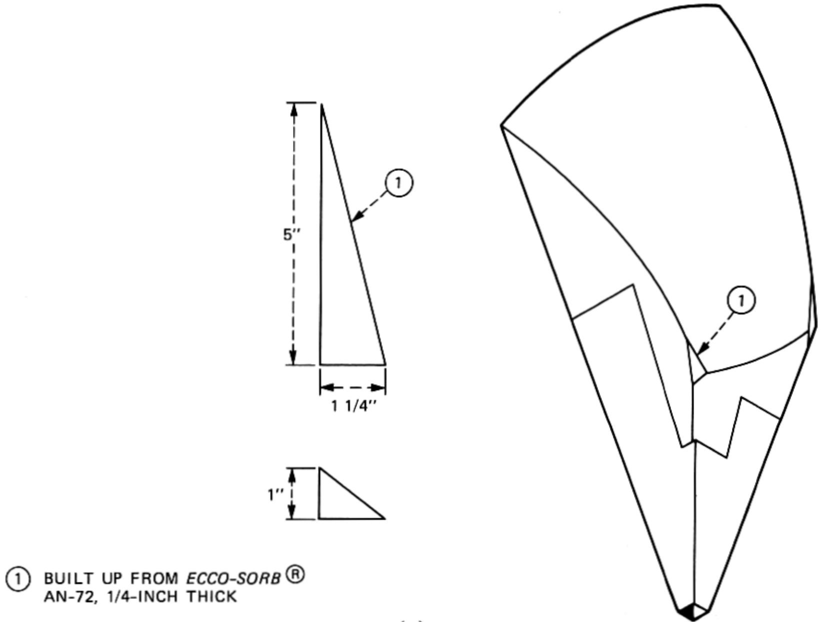


Fig. 3b—Comparison of the radiation patterns for transverse polarization of the modified (with absorber) antenna, the dashed curve, and the solid curve of the unmodified antenna. For this configuration the gain loss is 0.5 dB.

Here, an additional piece of absorber was placed on the sidewalls of the horn. No further reduction in the effective aperture area has taken place. However, the electric field distribution has again been modified. This is clearly seen by the dashed curve Fig. 2b, which shows a slight decrease in the near-in sidelobe levels of the modified antenna. The gain loss is essentially the same, but now there is a just discernible increase in the 3-dB beamwidth of the main beam. There is a further displacement on the sidelobe maxima for the modified antenna. Again the modified radiation pattern shows good symmetry. This configura-



(a)

Fig. 4a—A cutaway view of the pyramidal, horn-reflector antenna showing the placement of a triangular wedge of absorbing material in the rear corners of the reflector.

tion could reduce specific interferences (i.e., at about 6 degrees), but the pattern envelope is slightly degraded.

It soon became apparent that one could achieve very good results by working in areas on the reflector that have the highest electric fields. The cutaway view of Fig. 3a shows the absorbing material confined to the rear corners of the reflector. The rather dramatic effects for this combination are shown by the dashed curve of Fig. 3b. Here, the first sidelobes are reduced by 4 dB, and the reduction out to about 5 degrees is remarkable. Again, the radiation pattern of the modified antenna shows good symmetry. The disconcerting feature of the radiation pattern for this configuration is the increase in the sidelobe levels beyond 8 degrees. In view of the number of edges that were introduced by the absorber, it seems that the increase in the sidelobe level beyond 8 degrees was due in part to scattering from these multiple edges.

An example, for another configuration, where an attempt was made to minimize the number of edges is shown in the cutaway view of Fig. 4a. Indeed, as one can see in Fig. 4b (when compared to Fig. 3b), there is an improvement in the region beyond 8 degrees. Here the loss in gain was of the order 0.2 dB and one can easily see the reduction in

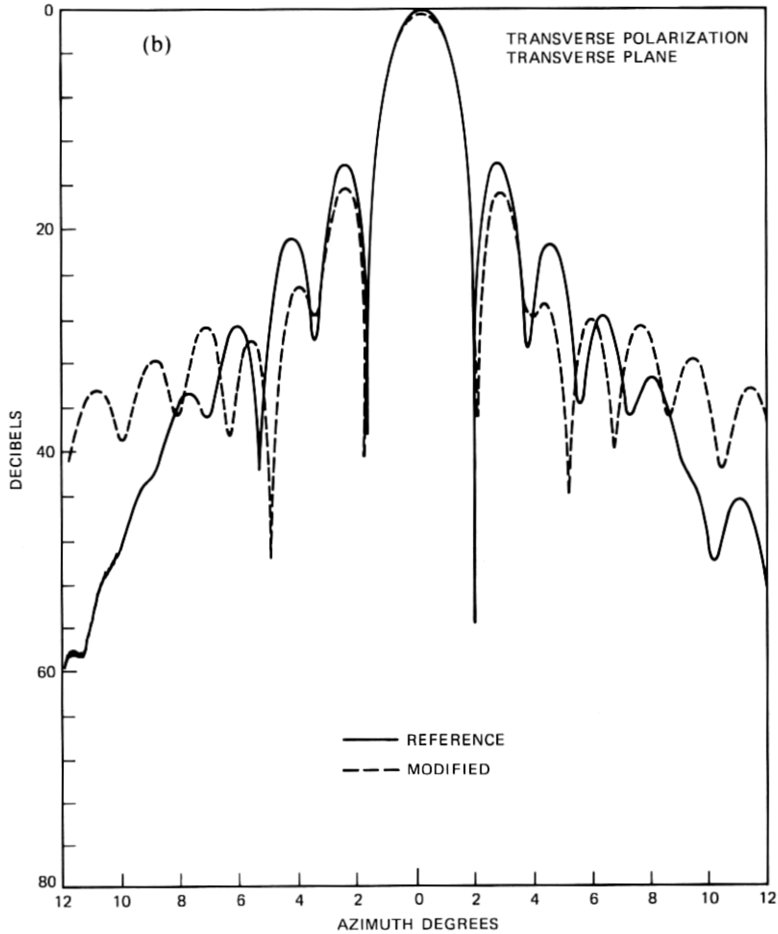
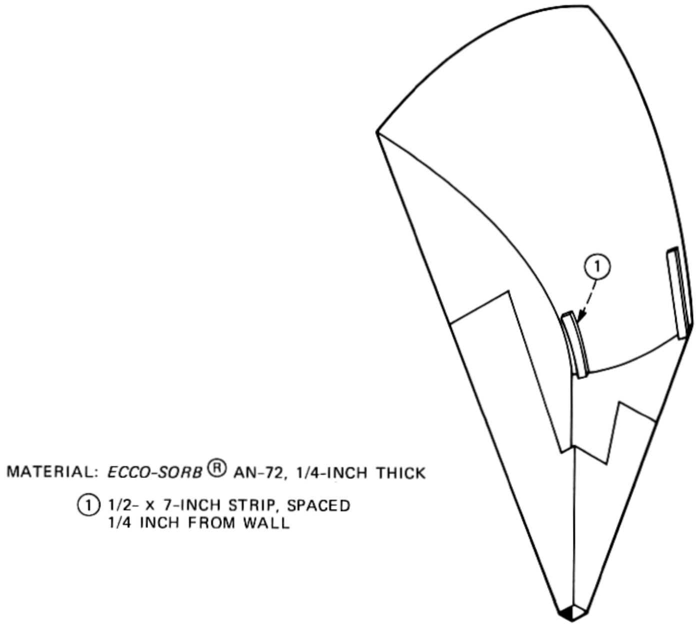


Fig. 4b—Comparison of the radiation patterns for transverse polarization of the modified (with absorber) antenna, the dashed curve, and the solid curve of the unmodified antenna. The gain loss is 0.3 dB.

the first and second sidelobe levels. Again, the symmetry of the pattern is preserved.

The last configuration to be discussed is shown by the cutaway view of Fig. 5a. In this configuration, a simple strip of absorbing material is placed on the reflector and spaced one-quarter inch from the sidewall. As shown by the dashed curve of Fig. 5b, the loss in gain is of the order 0.2 dB, and there is an appreciable reduction in the second and third sidelobe levels. Note the improvement obtained by this configuration in the region beyond 8 degrees when compared with the previously discussed modifications.



(a)

Fig. 5a—A cutaway view of the pyramidal, horn-reflector antenna showing the placement of a strip of absorbing material on the reflector surface.

Radiation patterns made for longitudinal polarization (in the transverse plane) indicate that the modifications introduced on the reflector were transparent for this polarization. Therefore, these patterns are not included here. Measurements in the longitudinal plane were not made, but one would expect to obtain similar performance. Further, the effects on far-out sidelobes were not evaluated.

III. CONCLUSIONS

A simple but effective means for reducing selected near-in sidelobe levels has been developed and the measurements are presented and discussed. For example, if an interferer were located at the maxima of a third sidelobe, then by modifying the electric field distribution on the reflector one could reduce the amplitude at the angle of the third sidelobe at least 10 dB (as shown in Figs. 3b and 5b). Better results can be obtained for reduction in the angular region of the second sidelobe. Even the first sidelobe can be reduced by more than 4 dB. One would expect some of the far-out sidelobe regions to increase; however, the reductions obtained in the levels of the near-in sidelobes could warrant a trade-off.

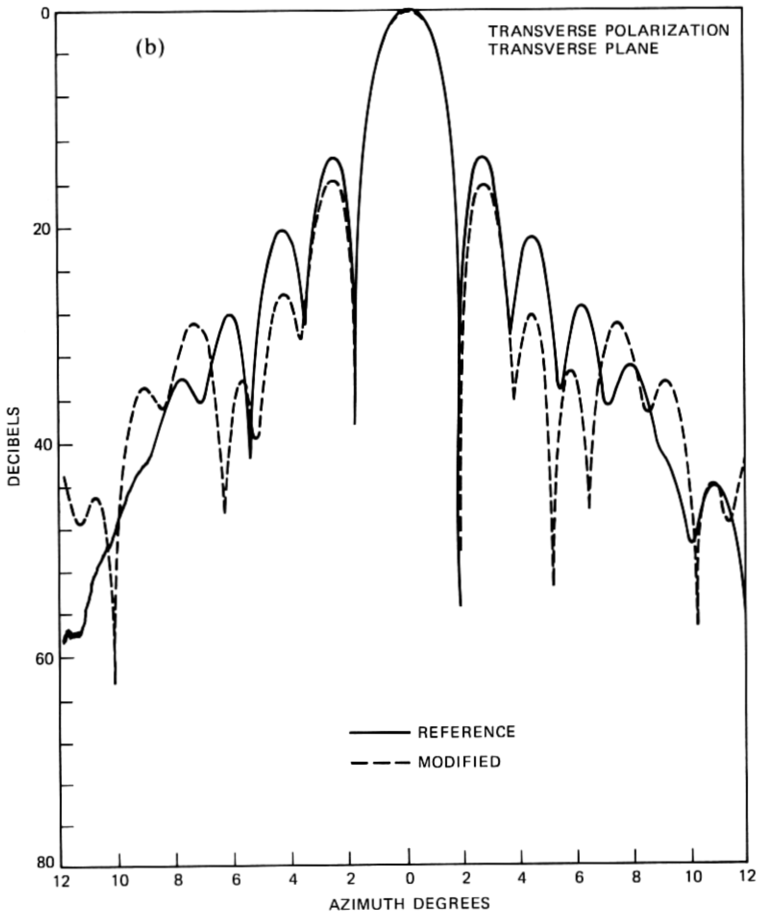


Fig. 5b—Comparison of the radiation patterns for transverse polarization of the modified (with absorber) antenna, the dashed curve, and the solid curve of the unmodified antenna. The gain loss is 0.3 dB.

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