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B. S. T. J. BRIEF

A Finline Radiator

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I. INTRODUCTION

Tapered finline might constitute a radiating element compatible with planar technology and therefore be suitable for antenna arrays fed by integrated circuitry. We have constructed such an element, not by photoetching a substrate but by mounting a tapered fin in a circular waveguide such that it is fed in Robertson's traditional way,[1] and then applying a dielectric "substrate" to the fin. Measurements of radiation patterns at 18.5 GHz are given for the prototype element using various "substrate" thicknesses. It is found that the element has considerable gain, and that performance improves with the thickness of the simulated substrate.

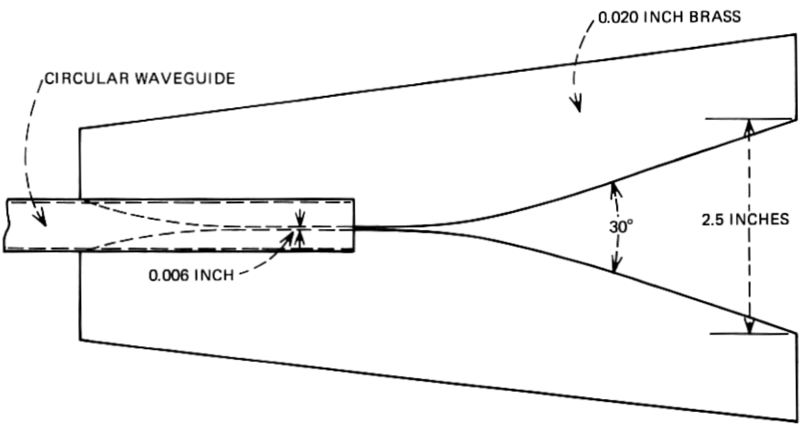

Fig. 1—Finline radiator.

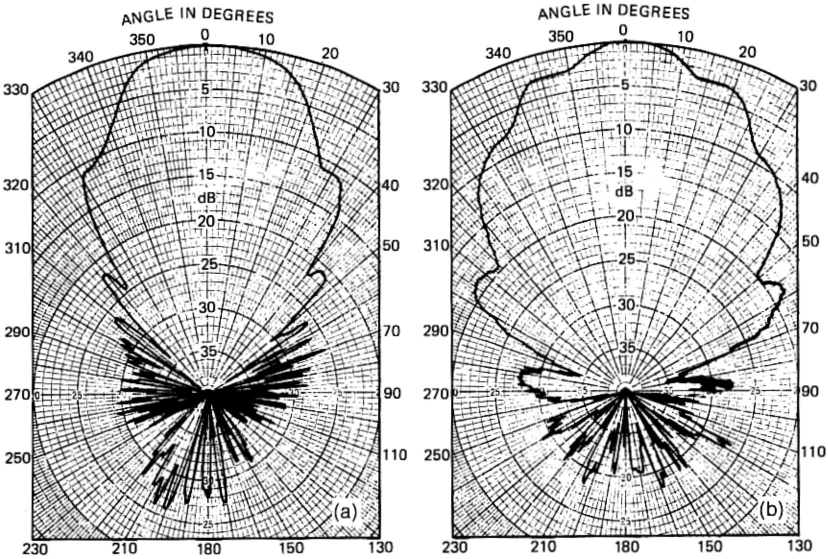

Fig. 2—Radiation patterns at 18.5 GHz with no dielectric applied. (a) H-plane pattern. (b) E-plane pattern.

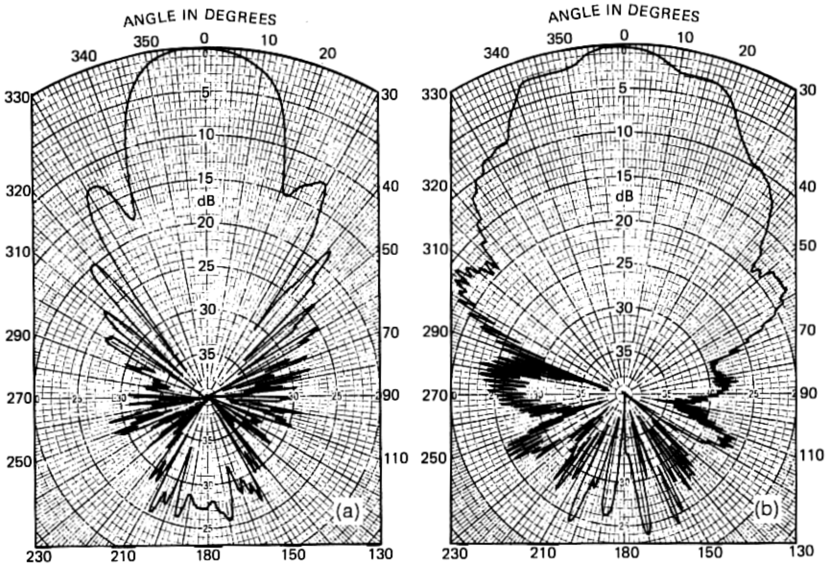

Fig. 3—Radiation patterns at 18.5 GHz with dielectric thickness of 10 mils. (a) H-plane pattern. (b) E-plane pattern.

II. DESIGN

The impedance and power flow along a fin in circular waveguide has been calculated by S. P. Morgan[2] but, to the author's knowledge, no information is available regarding radiation properties. Therefore, the simple device shown in Fig. 1 was built for initial tests. The dominant-mode circular waveguide is matched into the finline gap via a taper. After exit from the waveguide the finline is gently expanded to a $2\frac{1}{2}$ inch "aperture" which amounts to about four wavelengths at 18.5 GHz. The fin is 20 mils thick and the finline *per se* has a gap of 6 mils, resulting in an impedance of about 70 ohms. The taper is such that the phase error over the aperture, in the plane of the fin, is about $\pi/2$; the flare angle is 30 degrees. The return loss exceeds 20 dB over, at least, a ten-percent band.

III. RADIATION PATTERNS

Figure 2 shows the H- and E-plane radiation patterns (orthogonal to and in the plane of the fin, respectively); in this case no dielectric (substrate) is applied.

The E-plane pattern (in the plane of the fin) has several shoulders; but these are not unexpected[3] for phase errors of the order $\pi/2$. Figures 3, 4, and 5 show patterns where polyethylene substrates of thickness 10, 15, and 27 mils, respectively, were applied over an entire side of the fin structure, i.e., also within the waveguide. Note that the E-plane patterns remain essentially constant with increasing substrate thickness.

The H-plane patterns (in the plane orthogonal to the fin) are interesting. In the first place, the pattern of Fig. 2a is more well-behaved and somewhat narrower than the E-plane pattern, Fig. 2b. This means that the field spreads considerably in the transverse plane resulting in a sizeable effective aperture dimension. Moreover, as shown in Figs. 3a, 4a, and 5a, the addition of substrate material narrows the beamwidth of the H-plane pattern. Table I lists the 3- and 10-dB beamwidths of the H-plane pattern as a function of substrate thickness.

The gain of the 27-mil version is about 15 dB.

IV. CONCLUSION

The tapered finline radiator appears to be a reasonable candidate for an array element where planar technology is involved. Element beamwidths appropriate for certain tasks (such as illumination of the contiguous United States from synchronous orbit where beamwidths of the order of 10 degrees are desirable) appear feasible by suitable choice

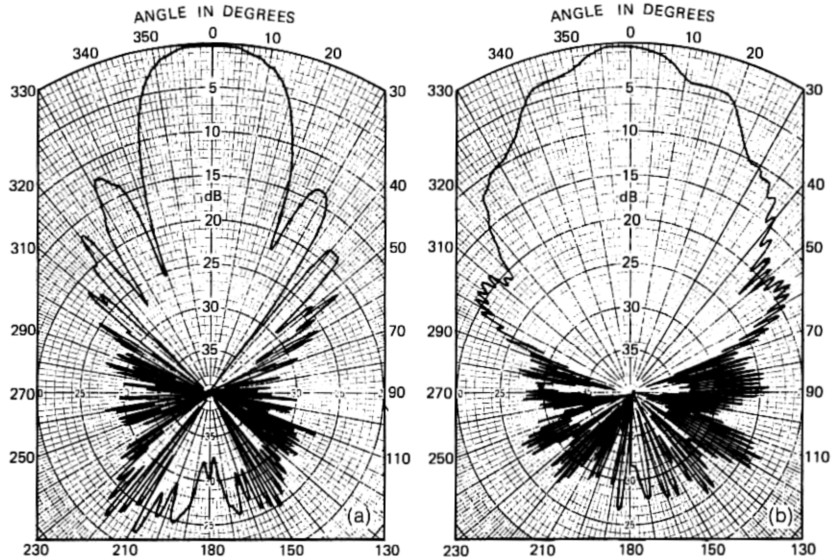

Fig. 4—Radiation patterns at 18.5 GHz with dielectric thickness of 15 mils. (a) H-plane pattern. (b) E-plane pattern.

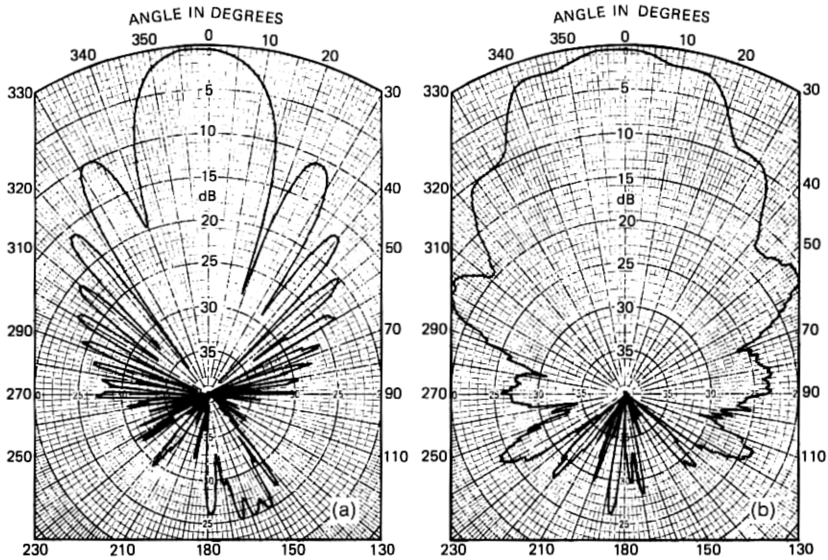

Fig. 5—Radiation patterns at 18.5 GHz with dielectric thickness of 27 mils. (a) H-plane pattern. (b) E-plane pattern.

TABLE I—BEAMWIDTHS OF H-PLANE PATTERN

Substrate (Polyethylene) Thickness-Mils	H-Plane Beamwidths Degrees	
	3 dB	10 dB
0	30	48
10	23	36
15	20	34
27	20	32

of flare angle and aperture. Of course, an objective of the design is that the radiator be integrable with microstrip circuitry; this requires a microstrip-to-finline (slotline) coupler, perhaps of the type described by S. B. Cohn.[4]

V. ACKNOWLEDGMENTS

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REFERENCES

1. Robertson, S. D., "Ultra-Bandwidth Finline Coupler," Proc. IRE, *43*, June 1955, pp. 739–741.
2. Morgan, S. P., "Theoretical Properties of Fin Waveguide," unpublished work, 1954.
3. See for example Fig. 10-3 of *Antenna Engineering Handbook*, Henry Jasik, ed., New York: McGraw-Hill.
4. Cohn, S. B., "Slot Line on a Dielectric Substrate," IEEE Trans. Microwave Theory and Techniques, *MTT-17*, No. 10 (October 1969), p. 768.