RADANT ANALYSIS STUDIES

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C. T. Tai and E. S. Andrade

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FOREWORD

This report was prepared by the University of Michigan under USAF Contract No. AF 33(615)-2811, Task 416103, Project 4161. The work was administered under the direction of the Air Force Avionics Laboratory, Research and Technology Division, Air Force Systems Command, E.M. Turner, Technical Monitor, S. Pitts, Project Engineer.

This report covers work conducted from August through October 1965.

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ABSTRACT

The transmission characteristics of an anisotropic panel have been investigated experimentally and the initial results are presented. The anisotropic panel is formed from conducting strips being placed on a dielectric sheet. Three variations of the above panel have been considered during this reporting period. In addition, three antenna configurations have been considered as primary feeds for the anisotropic panel. Two of these feeds were inherently narrow banded (ferrite loaded slot and a $\lambda/2$ dipole) and the third was a broadbanded (10:1 frequency band ridged horn) antenna.

I
INTRODUCTION

This is the second interim report on an investigation of radant (combined radome and antenna) structures. The first report (Tai et al, 1965) was devoted largely to a theoretical analysis of the transmission characteristics of an anisotropic panel formed by conducting discs. In this report the emphasis is on experimental results obtained with a radant structure provided by the Air Force.

To obtain a better understanding of the electrical characteristics of the radant structure a detailed experimental study is being conducted.

Early impedance and pattern measurements were obtained for the following antenna types: (1) ferrite-loaded slot, (2) broadband (10:1 frequency band) ridged horn, and (3) $\lambda/2$ dipole. The ferrite-loaded slot was found to be a narrow band device as had been reported before (Adams, 1964). Therefore, to investigate the broadband characteristics of the radant structure, the ridged horn and $\lambda/2$ dipoles were used as feeds.

Ground plane effects were observed to affect the overall electrical characteristics of the radant system and, therefore, required further study. The ground plane effects were studied using both a ferrite-loaded slot antenna and a broadband ridged horn to excite the radant structure at several frequencies. Both the impedance and pattern characteristics were considered. During the impedance study, the VSWR was found to have unusual variations which were later shown to be caused by the loading effects of the radant structure of the antenna. The experimental work partially reported in the first interim report, for the ferrite-loaded slot antenna, has been completed and the results are in good agreement with the analytical data.

On the theoretical side, the computation of the transmission patterns of an anisotropic panel excited by a spherical source, reported in Interim Report No. 1, has not yet been completed. Work on this is continuing.

As a result of discussion in the recent meeting with the sponsor it appears that the scattering mechanism of a pair of dipoles linked by a transmission line merits a thorough study. The result of theoretical analysis of this problem is presented in Section IV.

II
RADANT STRUCTURE FED BY FERRITE-LOADED SLOT ANTENNA

The experimental study of the radant structure with the ferrite slot antenna as a primary feed included an investigation of both impedance (VSWR) and pattern characteristics. The results of these studies are presented below.

2.1 Impedance Study

The radant structure consists of two identical arrays of conductors attached to two 18" x 18" printed circuit fiberboard panels. The conductor elements, 3/32 inch wide by 1-5/8 inches long, form parallel rows spaced 1/2 inch apart with an end to end spacing of 1/2 inch. The elements are not aligned in the lateral direction, but are displaced as shown in Fig. 1.

In the radant assembly, one array is set above the other with each element facing the corresponding element on the opposite panel. The two arrays are converted into a single array of conducting loops by connecting both ends of each element with the corresponding ends of each facing element. Brass machine screws, size 0-80 by 1 inch are used for the connectors, thus allowing some adjustment in the thickness of the radant panel. For the purposes of this investigation, the loops of the radant structure were oriented parallel to the "E" field transmitted by the ferrite antenna. The ferrite slot feed was flush-mounted in an 18 inch square ground plane with the radant structure in front of and parallel to the plane of the radiating aperture of the antenna. Mechanically, the radant and antenna were assembled such that the spacing between the two could be varied in increments from 3/8 to 20 inches. The spacing between radant and antenna was varied in 1/2 inch increments from 3/8 inch to 2 inches and in 1 inch increments for the 2 to 20 inch range. The VSWR data obtained is shown in Fig. 2. Additional data is presented in Fig. 3 for the radant case and for the case where the radant is present with spacings of 3/8 and 2 inches. The results of the data can be summarized as follows:

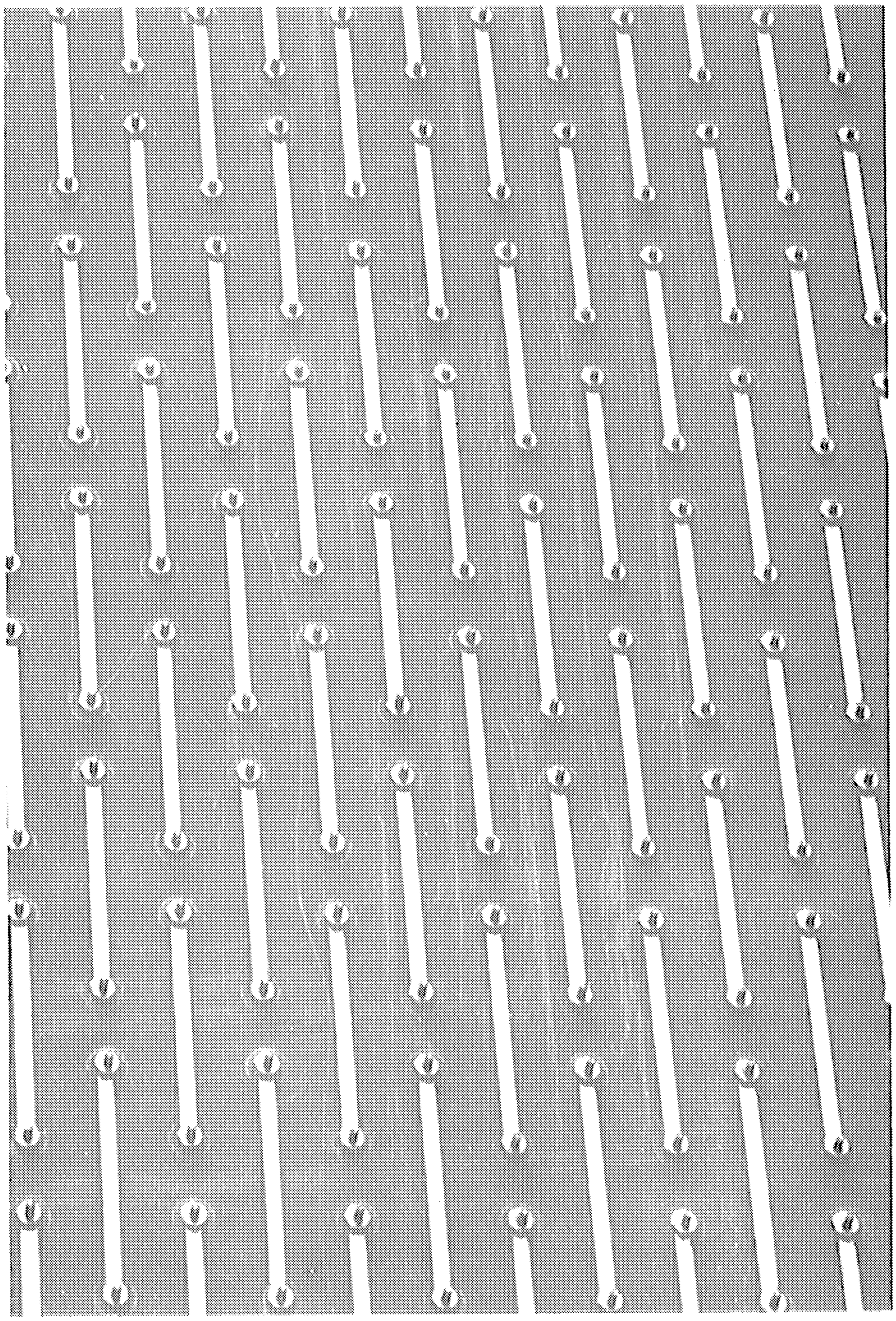

FIG. 1: PHOTOGRAPH OF SECTION OF RADANT STRUCTURE

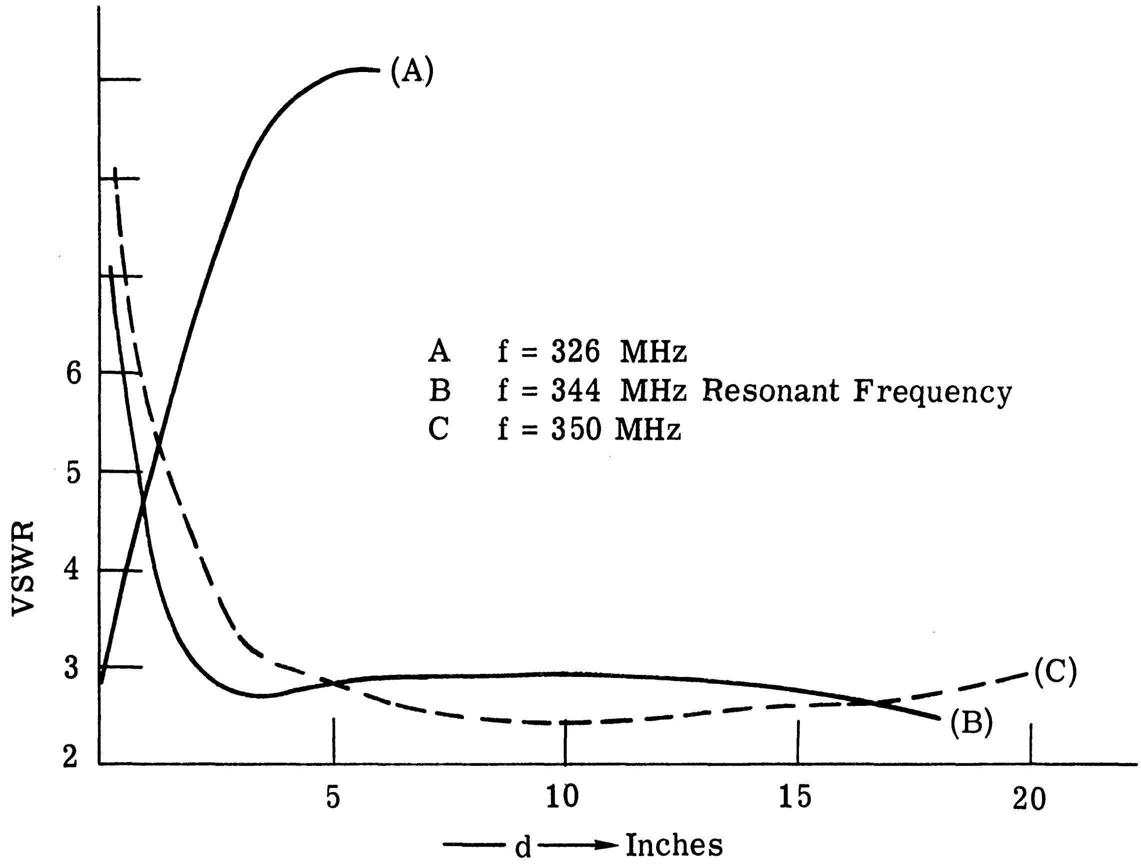

FIG. 2: VSWR VS. SPACING FOR FERRITE-LOADED SLOT ANTENNA

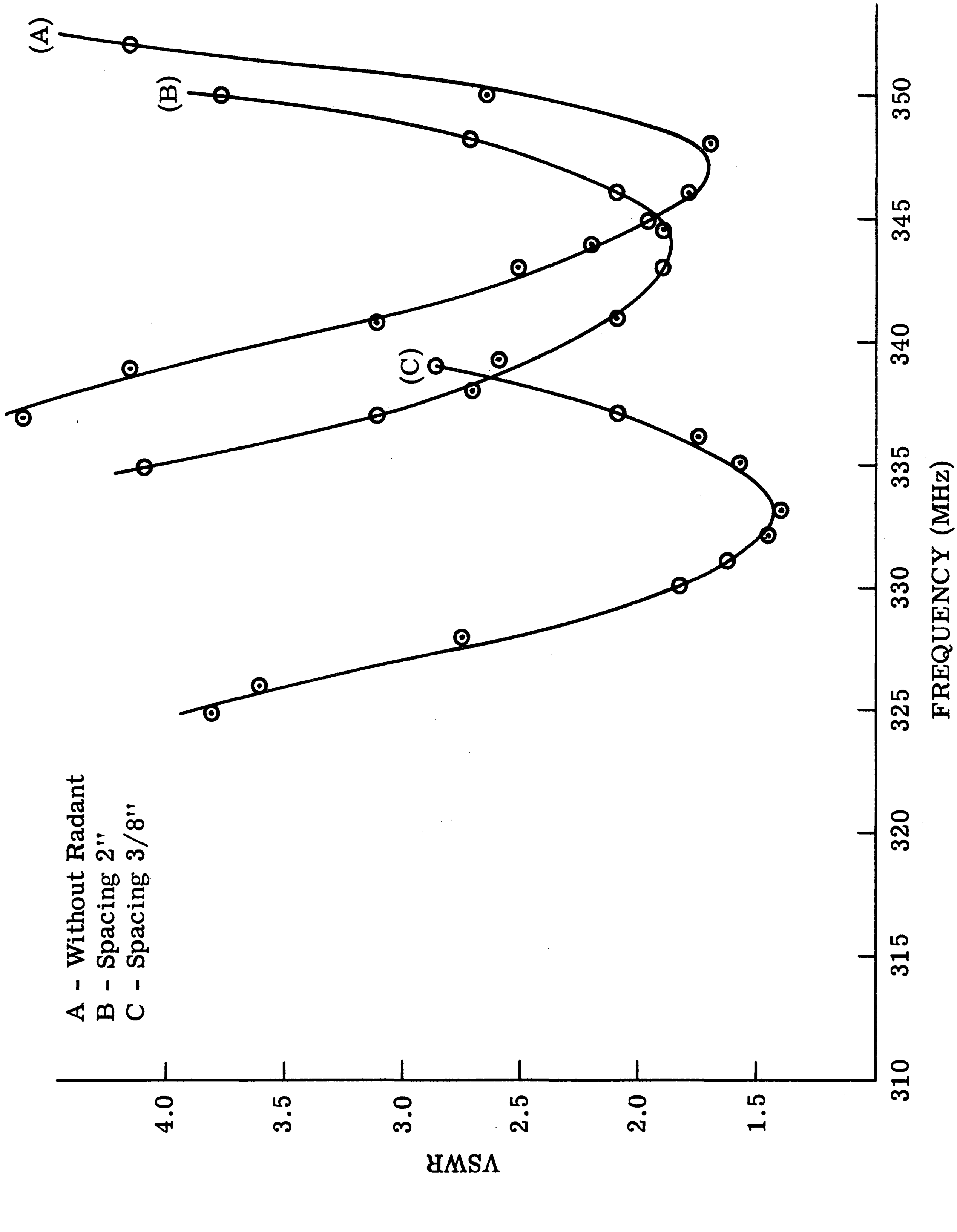

FIG. 3: VSWR VS. FREQUENCY FOR SMALL SPACINGS (FERRITE ANTENNA)

(1) At frequencies below the antenna resonant frequency, the minimum VSWR occurred with small spacings and increased as the spacing was increased. At frequencies equal to or greater than the resonant frequency, the VSWR minimum occurs with larger spacing and was observed to be less than 2 to 1 for most positions.

(2) For small spacings, between the radant system, the VSWR minimum was observed to occur at a frequency about 3 percent lower than that at which the minimum without the radant occurred (Fig. 3).

(3) For a fixed spacing between the radant and ferrite antenna, the frequency bandwidth is limited to narrow band applications, i.e., less than 5 percent (Fig. 3).

The impedance characteristics of the ferrite slot antenna without the radant strucg ture is shown in Fig. 4. In Figs. 5 and 6 impedance data is presented for spacings of 2 inches and 3/8 inches respectively. This data was obtained employing a Hewlett Packard 803A impedance bridge and 417A detector. It is interesting to note the strongly capacitive characteristic of the ferrite slot antenna in Fig. 4 and further that this characteristic is not affected by the radant structure, and, therefore, is inherent with the ferrite antenna. Further, the frequency shift noted in the previous section is present in the above figures.

2.2 Pattern Study

Pattern measurements of the radant structure fed by the ferrite antenna showed a narrowing of the pattern at 350 MHz. As a result of further study, the following characteristics were observed: (1) a narrow main lobe is formed in the E-plane rather than in the H-plane and (2) the directivity of the structure improved with larger spacings.

Additional data was collected at 550 and 595 MHz. A directional coupler was used at the transmitting site to monitor the input power to the transmitting antenna. The spacing between the radant structure and the ferrite antenna was also varied

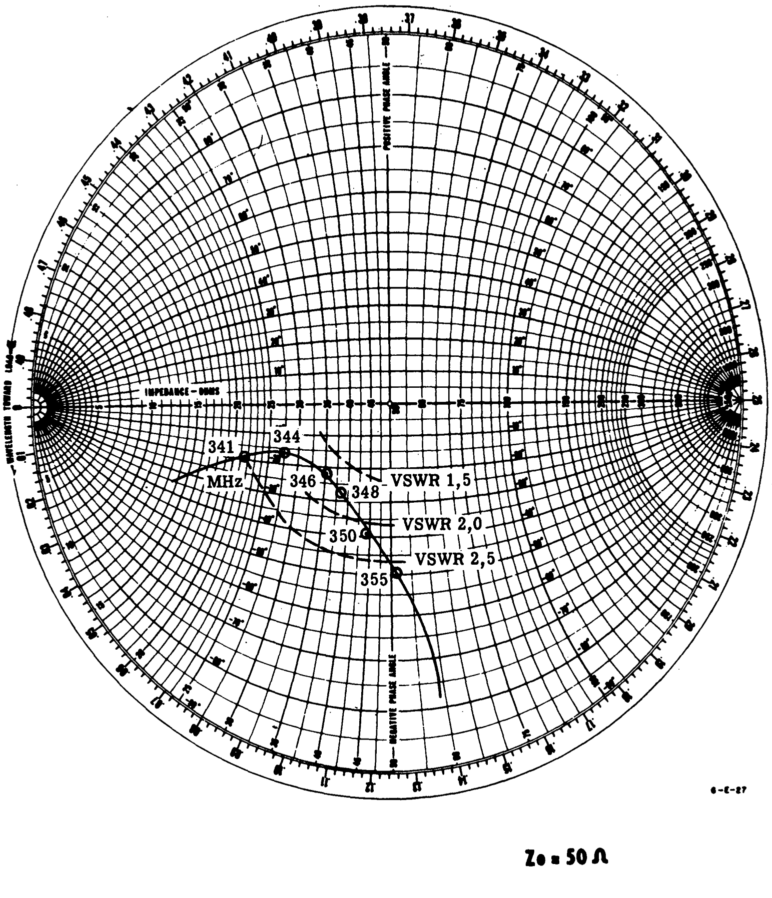

FIG. 4: IMPEDANCE CHARACTERISTIC OF THE FERRITE ANTENNA (NO RADANT)

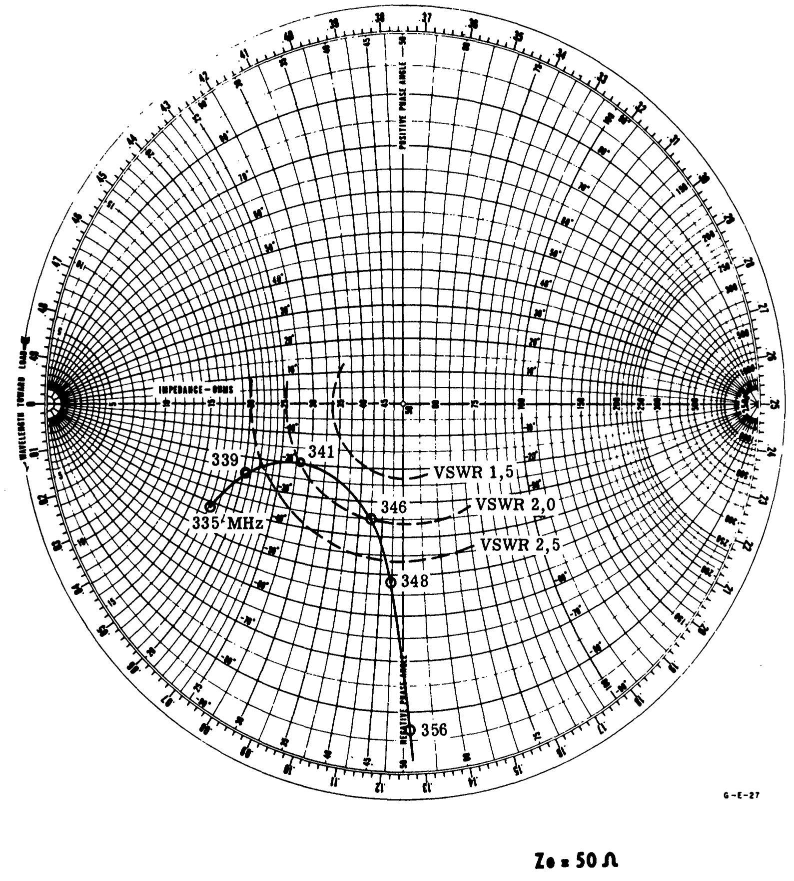

FIG. 5: IMPEDANCE CHARACTERISTIC OF THE FERRITE ANTENNA AND RADANT (SPACING d = 2")

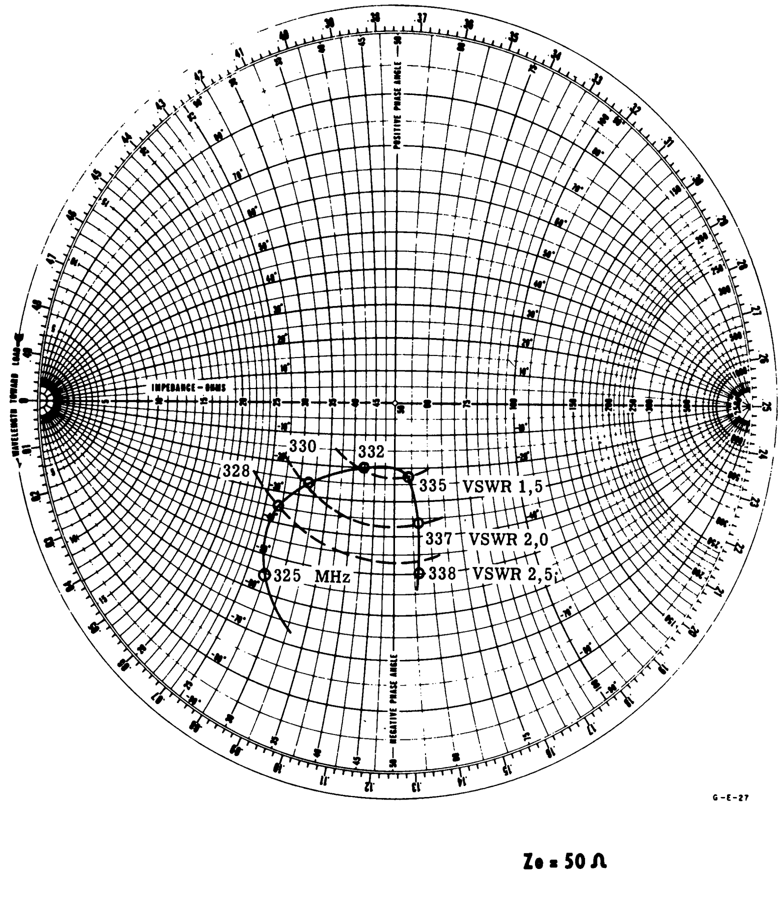

FIG. 6: IMPEDANCE CHARACTERISTIC OF THE FERRITE ANTENNA AND RADANT (SPACING d = 3/8")

during these tests and it was found that in general the half-power beamwidth decreased with spacing.

To obtain pattern data, two metal ground plane systems were employed; one was 18x18 inches and the second was 48x48 inches. Gain measurements were made of the ferrite antenna mounted in a 48x48 inch ground plane with no radant present and then with the radant present for five different spacings at a frequency of 595 MHz. Beamwidth and relative gain data is presented in Table I. Similar data for 550 MHz for both the 18x18 and 48x48 inch ground planes is given in Table II. With the 18x18 inch ground plane, the gain of the ferrite slot without the radant is -16 db with with respect to a $\lambda/2$ dipole at 595 MHz. At the resonant frequency of the ferrite slot antenna (348 MHz) its gain without the radant is -6 db with respect to a $\lambda/2$ dipole. Beamwidth as a function of frequency is plotted in Fig. 7. The results are seen to be comparable to those calculated by Pitts (1965).

It should be noted that the calculated beamwidth of Fig. 7 is based upon the array factor of isotropic sources in free space. If one takes into consideration the dipole pattern the beamwidth may be reduced considerably. The decrease of the beamwidth as a result of the presence of the radant structure, therefore, could be attributed to this effect. The image factor, of course, would also tend to reduce the beamwidth. The increase in gain for the 18x18 inch ground plane as compared with the 48x48 inch ground plane is due to the finite size of the ground plane since the pattern for the larger ground plane has a multilobe characteristic. The patterns shown in Figs. 8-13 further demonstrate the effects of the ground plane size on the pattern characteristics of the ferrite antenna.

2.3 Ground Plane Size Effects

If the ground plane is finite in the E-plane direction, its edges will form discontinuities which will generate reflecting waves that will interfere with the direct wave on the ferrite slot. As a consequence, the pattern will have a characteristic undulated shape whose magnitude depends on the size of the ground plane. According

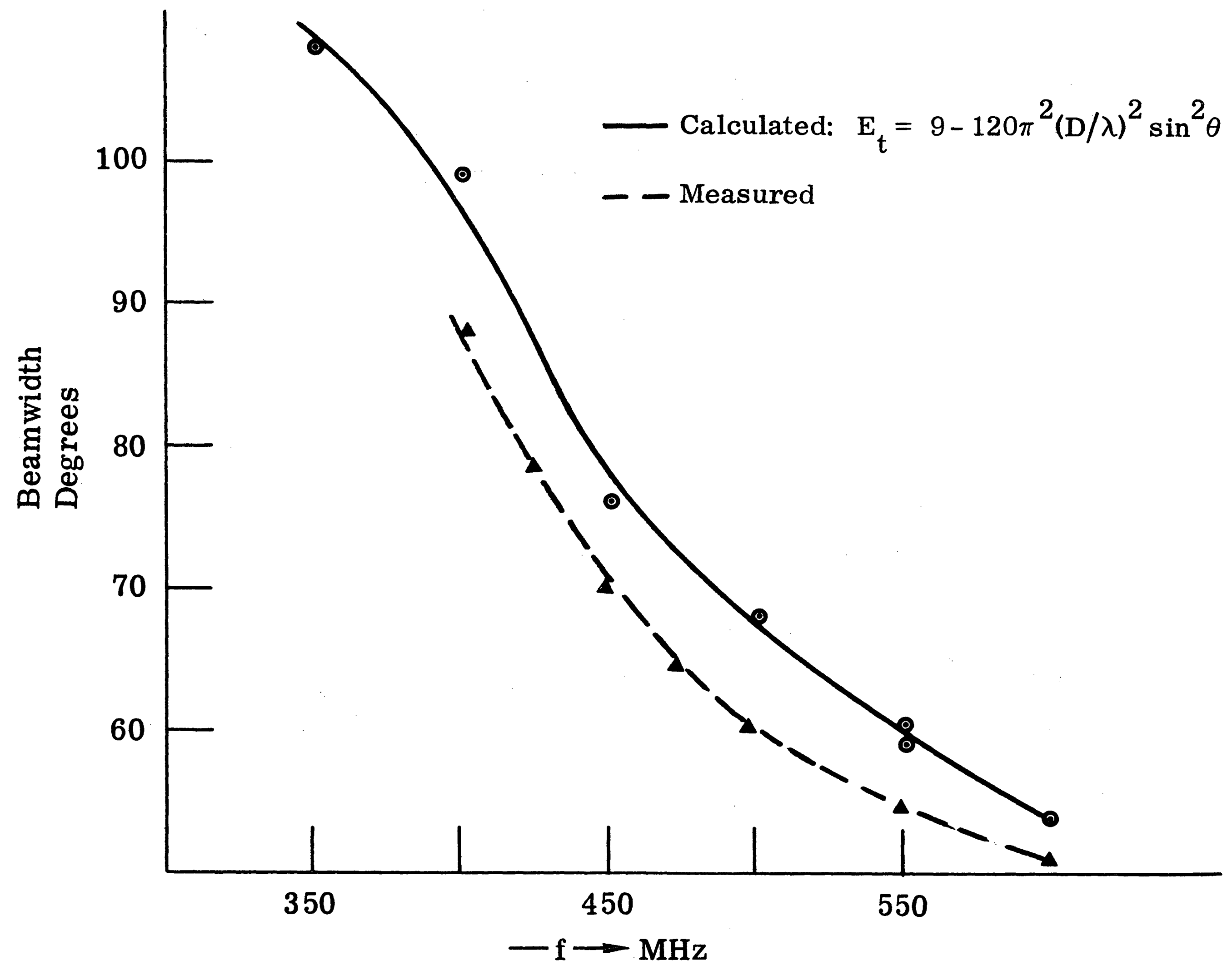

FIG. 7: CALCULATED AND MEASURED BEAMWIDTH FOR RADANT STRUCTURE FOR A 2-INCH SPACING BETWEEN RADANT AND FERRITE SLOT AND 7/8 INCH PLATE-TO-PLATE SPACING.

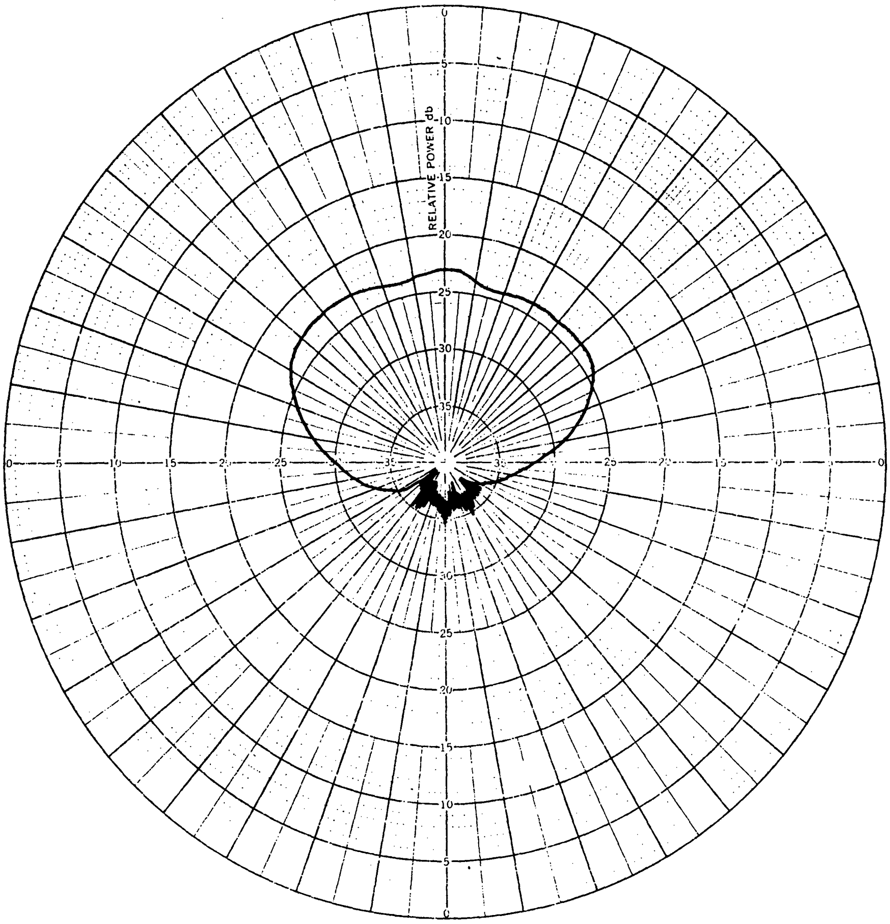

FIG. 8: E-PLANE PATTERN OF FERRITE ANTENNA IN 48"x48" GROUND PLANE AT 550 MHz (NO RADANT)

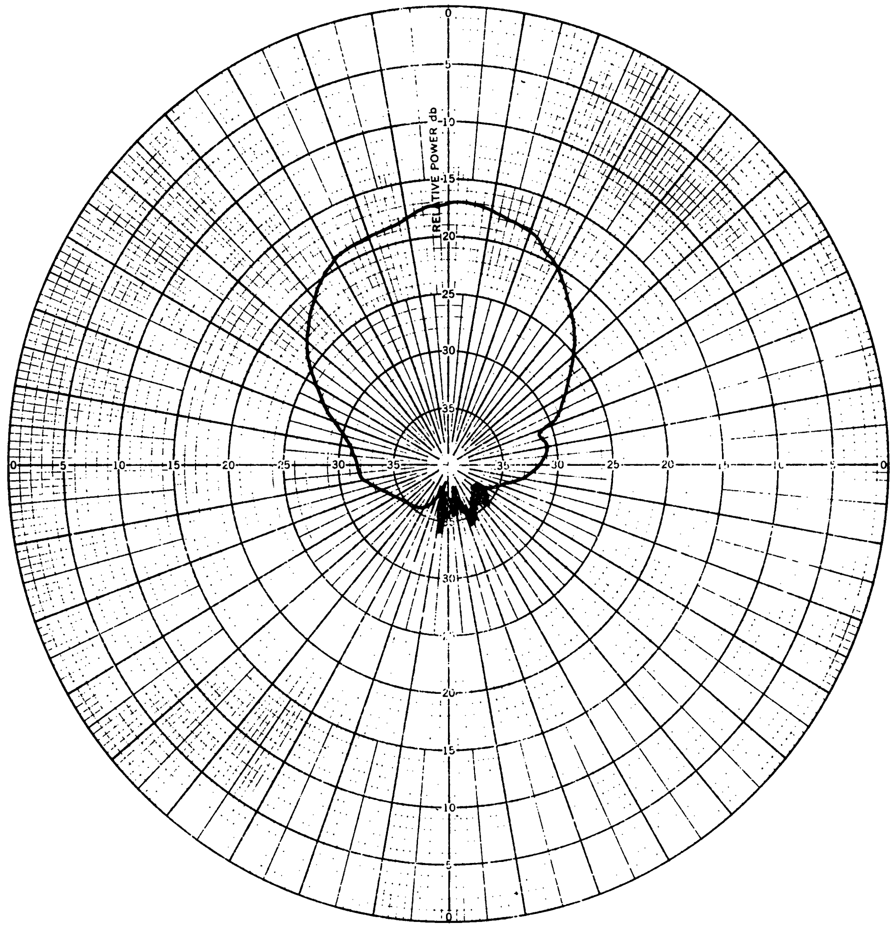

FIG. 9: E-PLANE PATTERN OF RADANT STRUCTURE WITH FERRITE ANTENNA IN 48"x48" GROUND PLANE AT 550 MHz AND A 2" SPACING

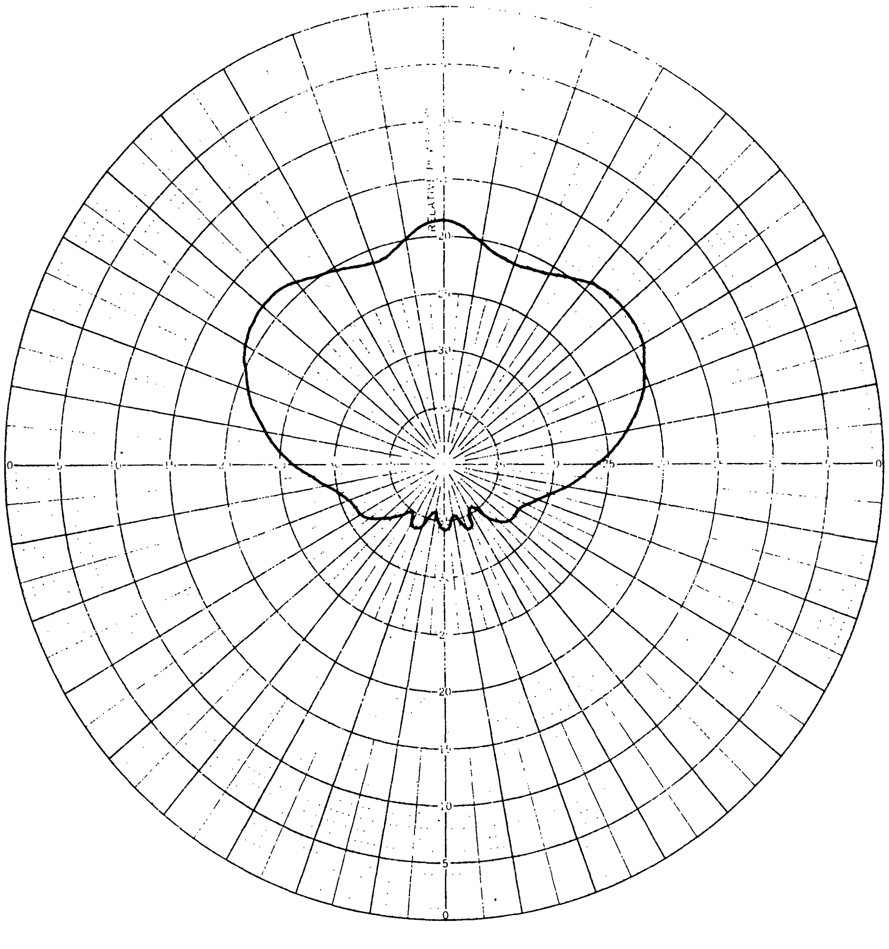

FIG. 10: E-PLANE PATTERN OF FERRITE ANTENNA IN 48" x 48" GROUND PLANE AT 595 MHz (NO RADANT)

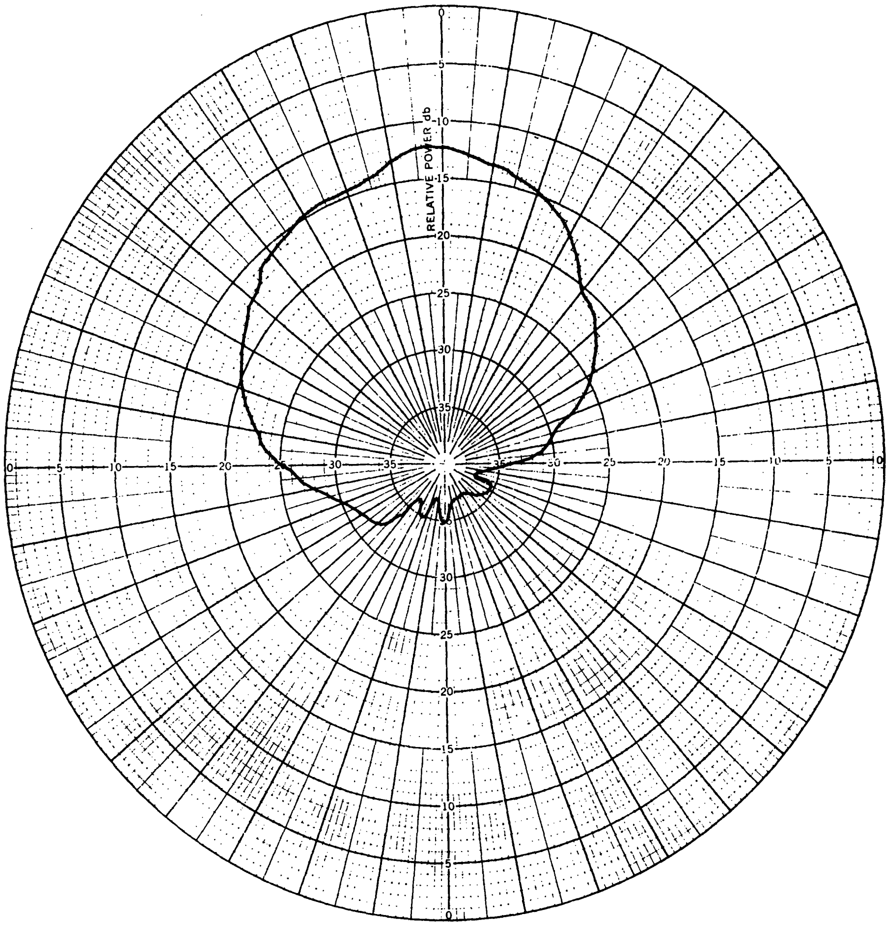

FIG. 11: E-PLANE PATTERN OF RADANT STRUCTURE WITH FERRITE ANTENNA IN 48" x 48" GROUND PLANE AT 595 MHz AND A 1-1/2 INCH SPACING

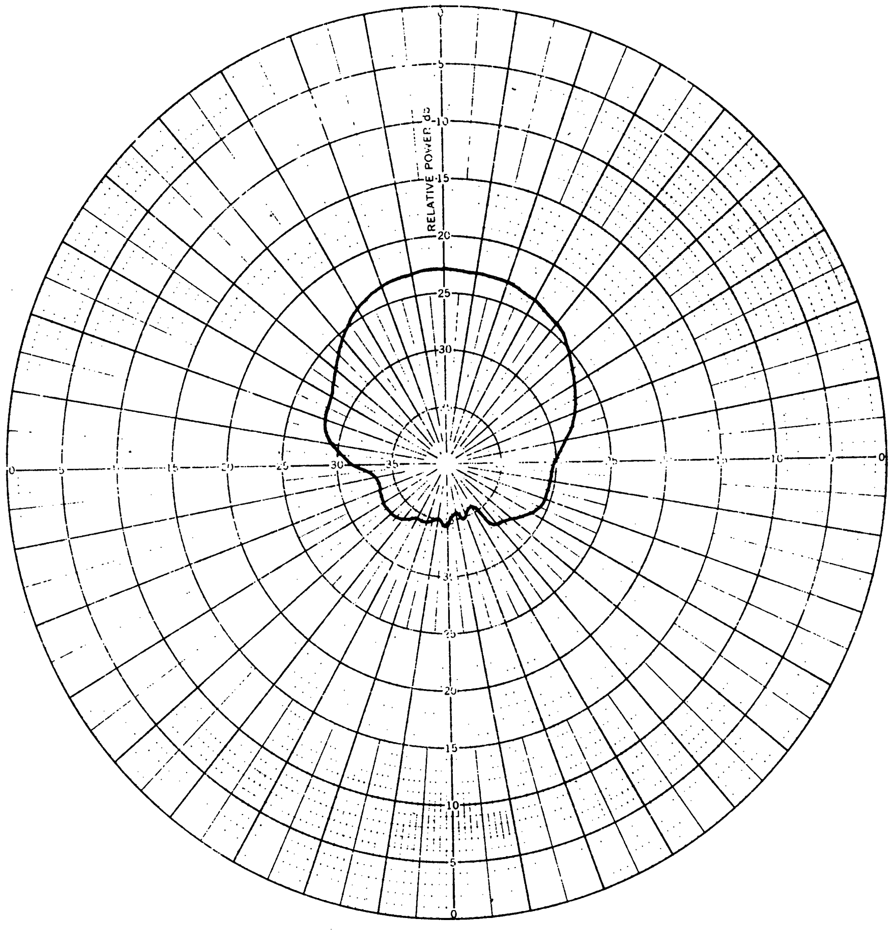

FIG. 12: E-PLANE PATTERN OF FERRITE ANTENNA IN 18" x 18" GROUND PLANE AT 550 MHz (NO RADANT)

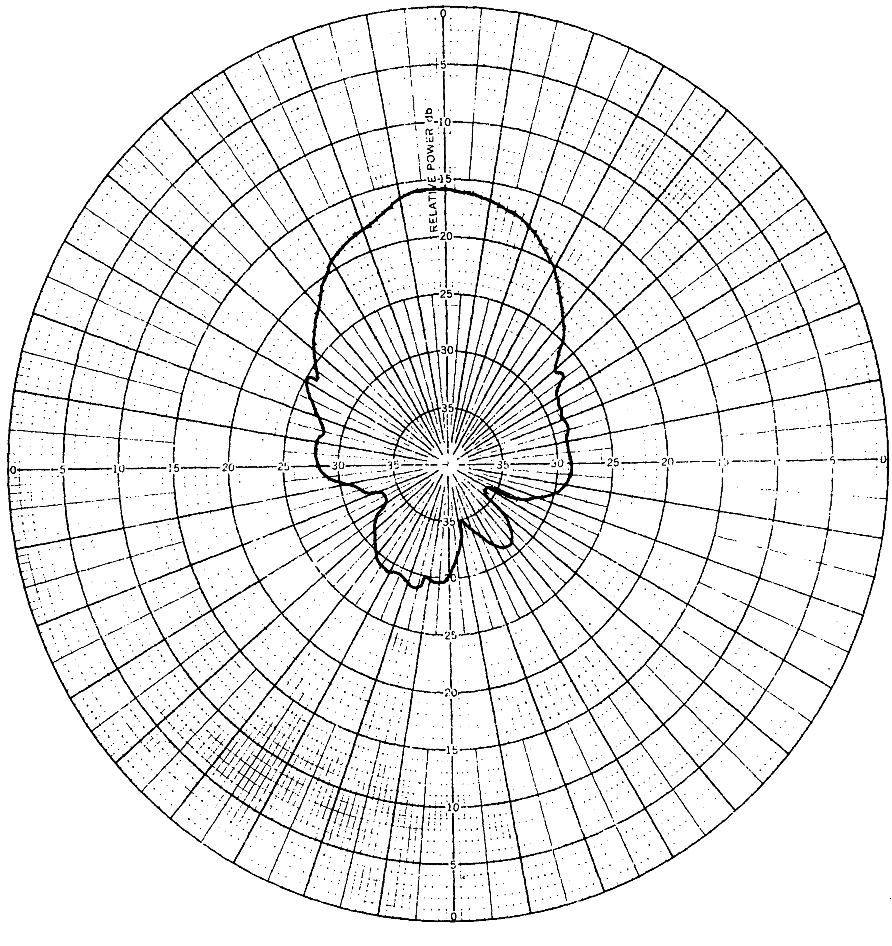

FIG. 13: E-PLANE PATTERN OF RADANT STRUCTURE WITH FERRITE ANTENNA IN 18"x18" GROUND PLANE AT 550 MHz AND A 2 INCH SPACING

TABLE I
PATTERN DATA FOR FERRITE LOADED SLOT ANTENNA AND RADANT STRUCTURE, f = 595 MHz

	48" x 48" Ground Plane	
	Δdb$^+$	Beamwidth
Without Radant	---	*
3/8" Spacing	4.5	*
3/4" Spacing	5.5	74^o
1" Spacing	5.5	70^o
1-1/2" Spacing	6.0	62^o
2" Spacing	5.5	50^o

TABLE II
PATTERN DATA FOR FERRITE LOADED SLOT ANTENNA AND RADANT STRUCTURE, f = 550 MHz

	48" x 48" Ground Plane		18" x 18" Ground Plane	
	Δdb	Beamwidth	Δdb	Beamwidth
Without Radant	---	*	---	100^o
3/8" Spacing	5.5	*	7.0	98^o
3/4" Spacing	6.0	92^o	---	---
1" Spacing	6.0	90^o	8.0	70^o
1-1/2" Spacing	7.0	70^o	8.0	50^o
2" Spacing	7.0	54^o	7.0	50^o

$^+$ Δdb = power received with radant - power received without radant.

* half-power beamwidth cannot be ascertained because of multiple lobes.

to Dorne (1947) the directions of the maximum and minimum radiation may be calculated from the assumption that the far field is produced by three sources. The first source is located at the slot and the other two at the edges of the ground plane. The pattern characteristics may be calculated from the following expression:

$$\phi_{m_M} = \arc\cos n\frac{\lambda}{L}$$

where

n = integer

λ = free space wavelength

L = ground plane length

ϕ_{m_M} = angle of maxima or minima (maxima corresponds to even values of n and minima to odd values of n).

Using the above expression, the locations of the first and second maxima and the first minimum were calculated at 660 MHz. Calculated and experimental results are shown in Fig. 14.

2.4 Conclusions

The following conclusions may be drawn in regards to using the ferrite antenna as the primary feed for the radant structure.

(1) With the ferrite slot antenna mounted in a square 18x18 inch ground plane, the radant improves its directivity by approximately 8 db.

(2) The directivity improves as a function of frequency (with fixed spacings) as is shown in Fig. 7.

(3) The maximum measured directivity for a spacing of approximately 1-1/2 inches occurs at a frequency of 595 MHz.

(4) Ground plane size is a factor in system directivity.

(5) The poor efficiency of the ferrite slot antenna and ground plane effects suggest that other antenna types should be considered as primary sources to study the properties of a radant structure.

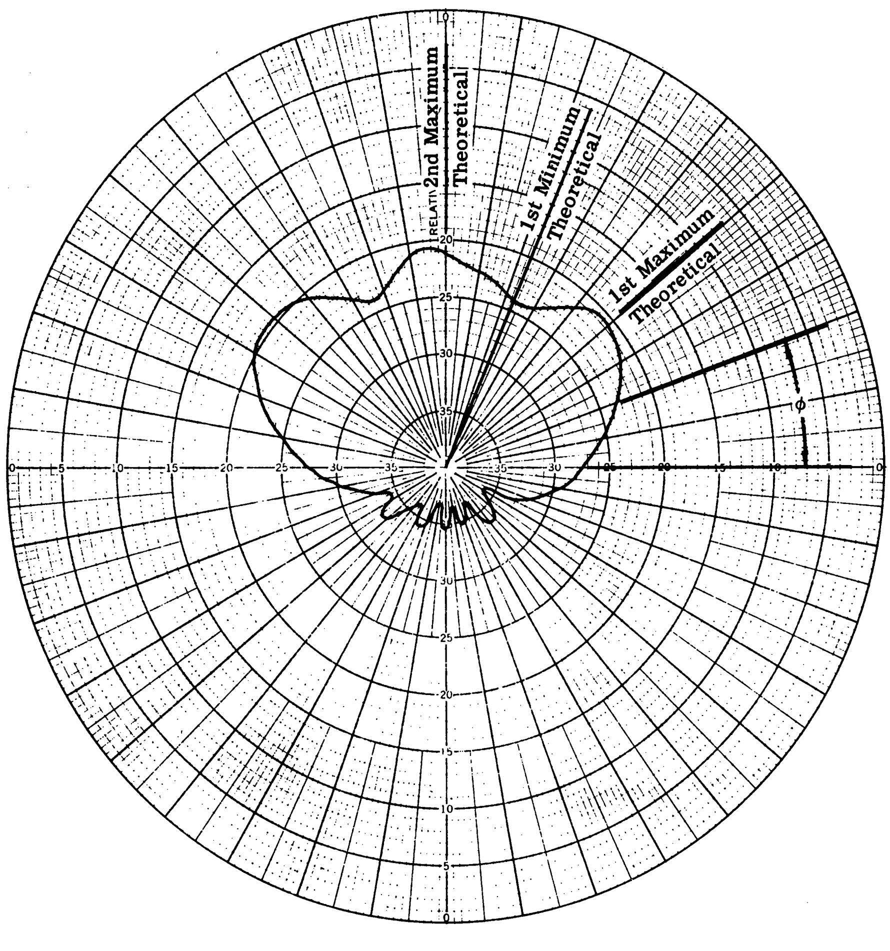

FIG. 14: EXPERIMENTAL E-PLANE PATTERN OF FERRITE ANTENNA AT 660 MHz SHOWING CALCULATED MAXIMA AND MINIMUM

III
THREE ALTERNATE RADANT CONFIGURATIONS

The radant structure discussed in the previous two sections consisted of an array of loops oriented such that the plane of the loop was parallel to the E-field with the ferrite antenna as a feed (Fig. 15). An analysis of the system has been presented by Pitts (1965), which treats the problem in accordance with array theory. Pitts analyzes the radant as a single layer of dipoles and the half power beamwidths calculated from this analysis are found to be comparable to the experimental data shown in Fig. 7.

To further verify Pitts' analysis, an experimental study was performed using the ferrite antenna to excite three different radant structures: (1) the standard radant structure, an array of loops oriented parallel to the E-field, (2) double layer of dipoles oriented parallel to the E-field obtained when all connections between two dielectric sheets are removed (Fig. 16) and (3) a combination consisting of loops along the sides of the radant and a double layer of dipoles in the middle region of the radant as shown in Fig. 17. The half-power beamwidths were measured at two frequencies and for a spacing of two inches between the radant and ferrite antenna. The results are given in Table III and it can be seen that the standard radant using an array of loops is slightly more directive than either of the other two configurations. At the above frequencies, the loop array was observed to be approximately 10 percent more directive. For the purposes of this study, the ground plane used with the ferrite antenna was 48 x 48 inches.

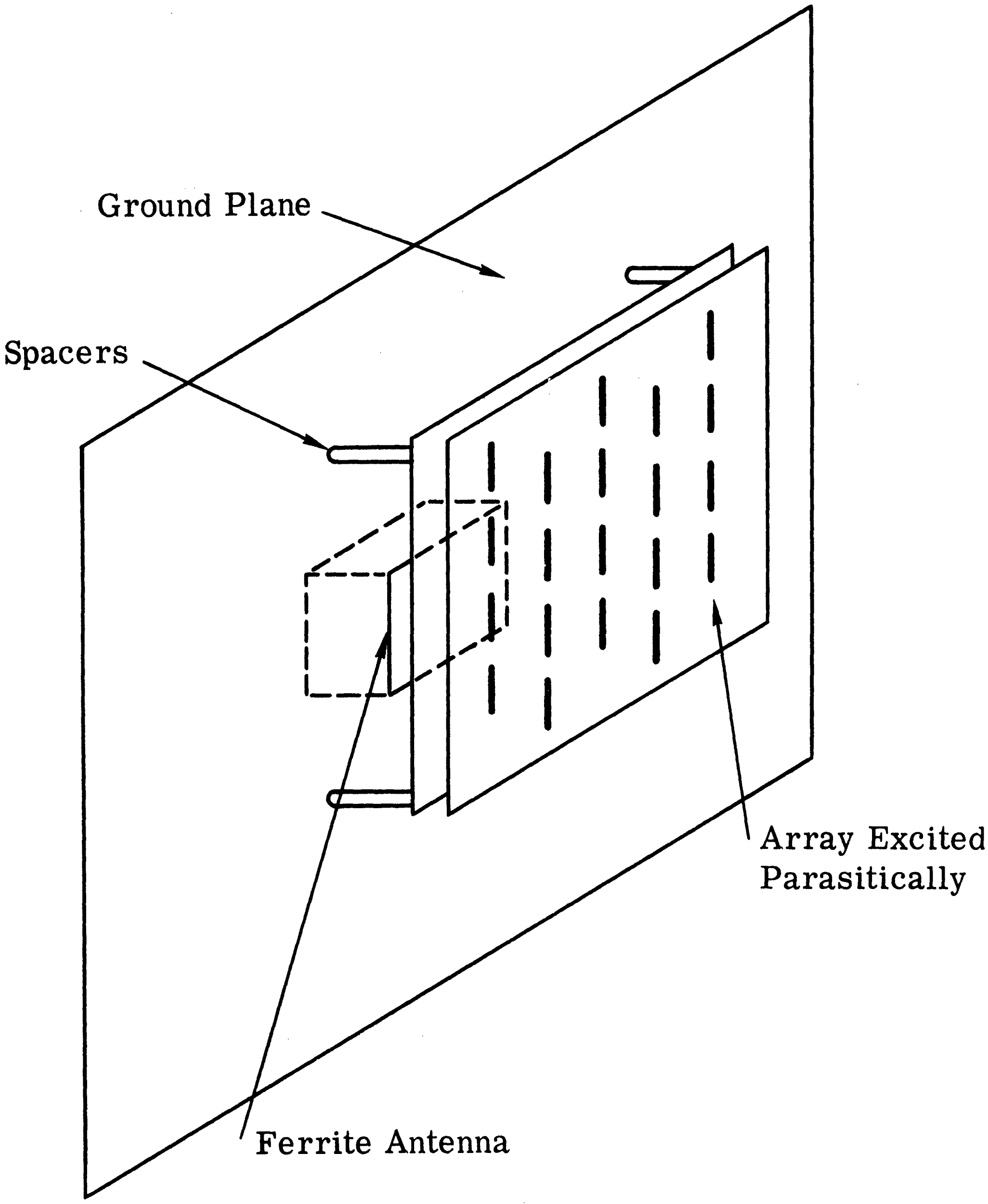

FIG. 15: FERRITE ANTENNA - RADANT CONFIGURATION

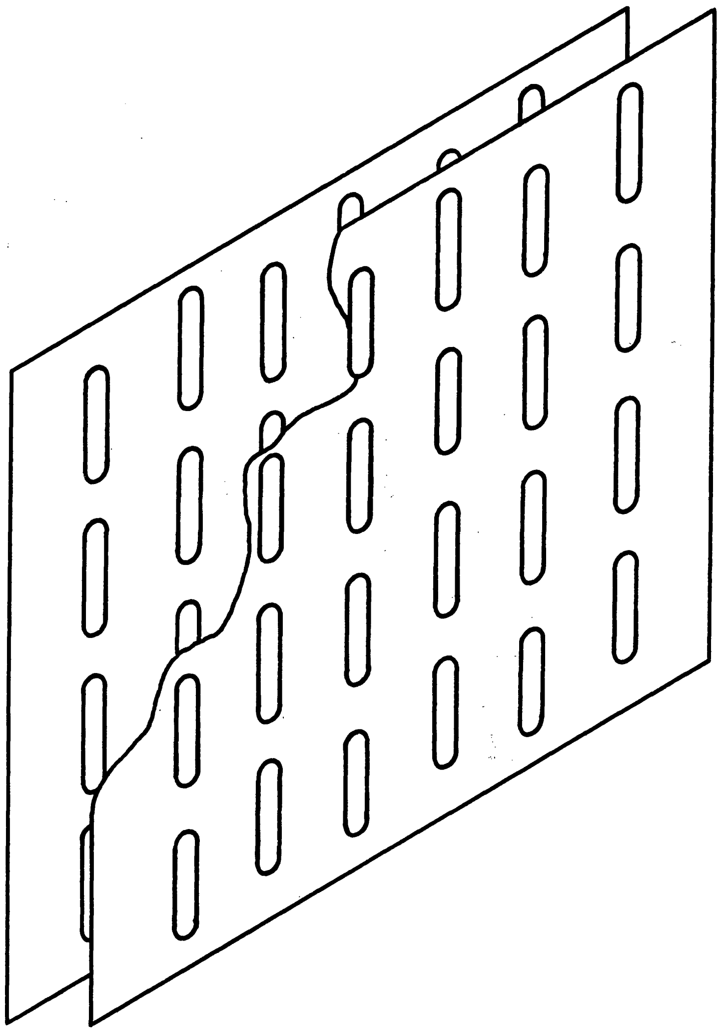

FIG. 16: DIAGRAM OF ALTERNATELY PLACED DOUBLE LAYER OF DIPOLES

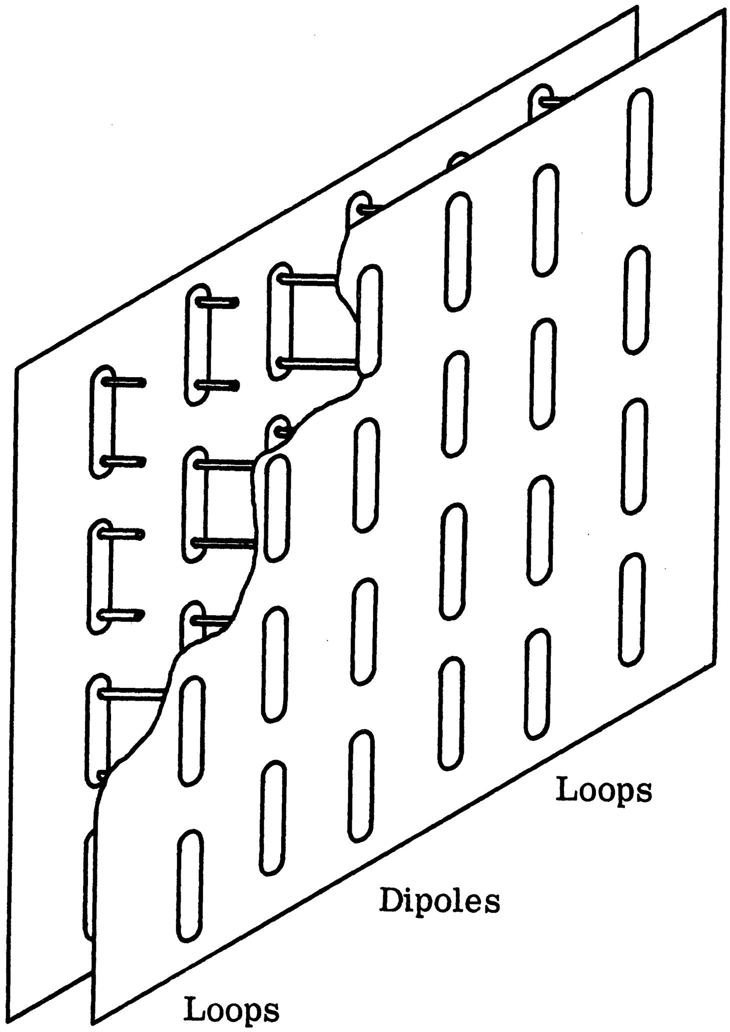

FIG. 17: DIAGRAM OF SEVERAL COLUMNS OF DOUBLE LAYERS OF DIPOLES AND SEVERAL COLUMNS OF LOOPS AT EACH SIDE

TABLE III
HALF-POWER BEAMWIDTH IN THE E-FIELD
FOR DIFFERENT RADANT STRUCTURES

Frequency	Array of Loops (36 columns)	Loops and Dipoles	Two Layers of Dipoles
341 MHz	104^{o}	108^{o}	112^{o}
375 MHz	102^{o}	106^{o}	110^{o}

IV
RADANT STRUCTURE FED BY A RIDGED HORN AND $\lambda/2$ DIPOLE

VSWR and pattern measurements of the radant structure employing the ferrite-loaded slot antenna as the primary source have been reported in the previous section. However, this data was misleading because of the high losses of the ferrite load material at the higher frequencies. A further limitation of this antenna was the finite ground plane which caused undulation effects in the pattern. To further understand the electrical characteristics of the radant structure VSWR, impedance and pattern data was collected using two additional feed configurations. The feeds employed during this part of the study were a broadband (10:1) ridged horn with a cutoff of 850 MHz and a resonant $\lambda/2$ dipole (480 MHz).

4.1 VSWR Data

The ridged horn was originally flush mounted in an 18x18 inch ground plane behind the radant structure, and data collected at several frequencies within its bandwidth. At each frequency, the spacing between the antenna aperture and radant structure was changed. The spacing was varied from 1/8 inch to 2 inches in 1/2 inch increments and 2 to 20 inches in 1 inch increments. Data for several frequencies is shown as a function of spacing in Figs. 18-20. These curves are characterized by high VSWR values for those spacings that are multiples of $\lambda/2$. Initially these high VSWR values were attributed to the interaction between the ground plane and the radant structure. To help verify this assumption, the radant was fed by the ridged horn without the ground plane. The data obtained was similar to that of Figs. 18-20. Because the VSWR characteristics both with and without the ground plane were similar, the following conclusion was drawn. Since the radant structure is located in the near field region of the ridged horn a precise analysis cannot be made in terms of plane waves. Therefore, one must consider the interaction between the apertures of the primary and secondary sources. A further fact that supports the aperture interaction hypothesis is the change of the VSWR curves as a function of

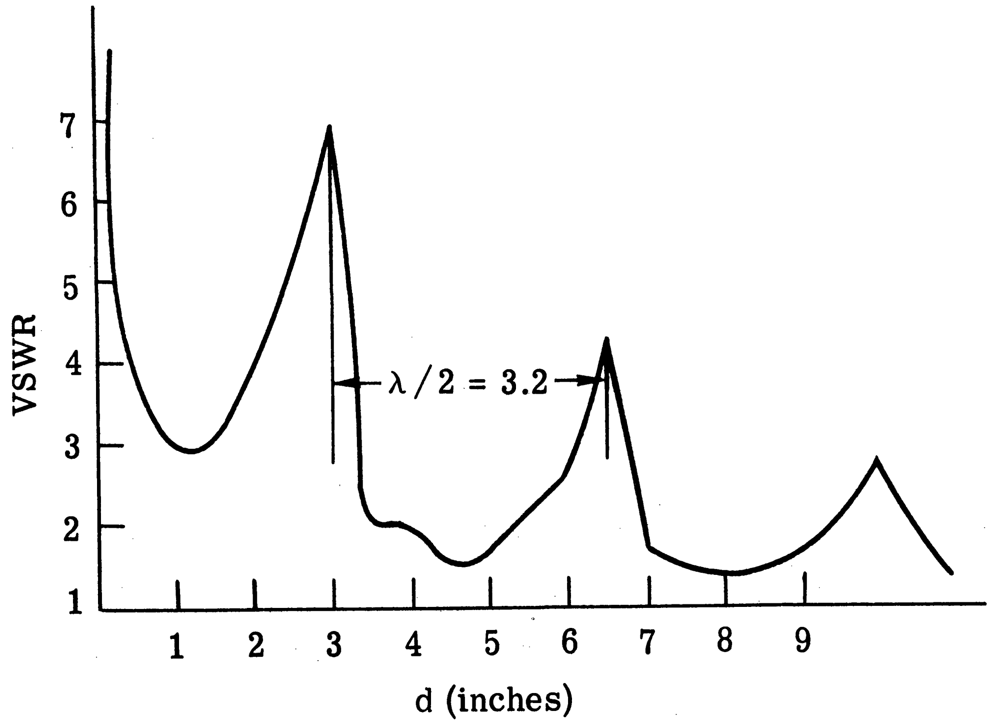

FIG. 18: VSWR VS. SPACING FOR RIDGED HORN MOUNTED IN 18"x18" GROUND PLANE WITH RADANT STRUCTURE (f = 1800 MHz)

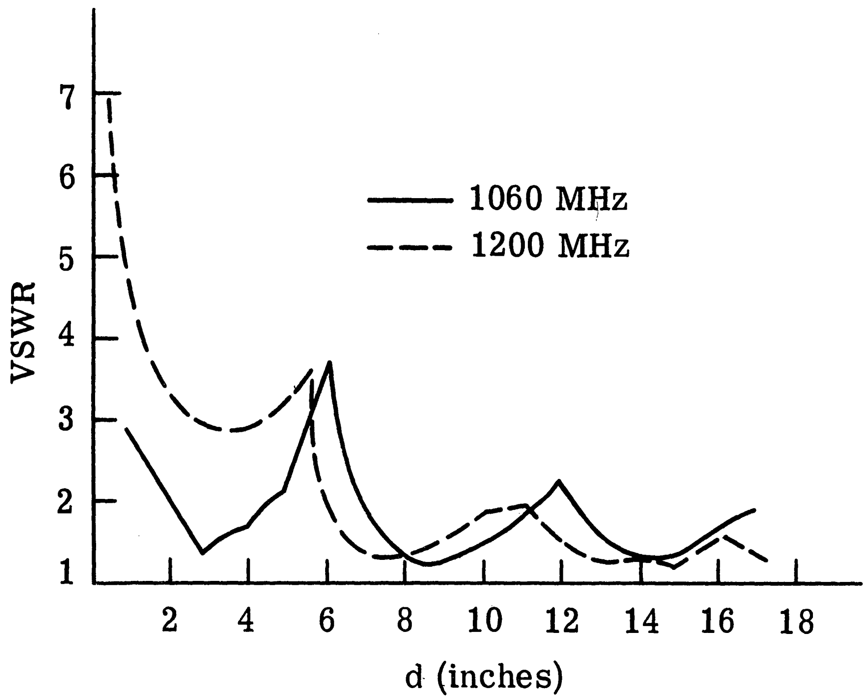

FIG. 19: VSWR VS. SPACING FOR RIDGED HORN FLUSH MOUNTED IN 18"x18" GROUND PLANE WITH RADANT STRUCTURE

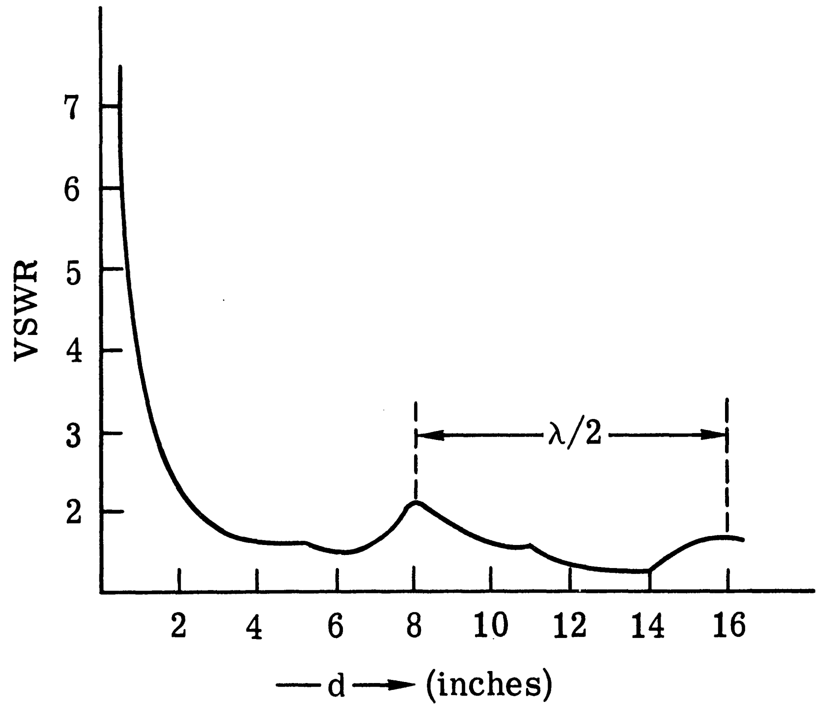

FIG. 20: VSWR VS. SPACING FOR RIDGED HORN FLUSH MOUNTED IN 18"x18" GROUND PLANE WITH RADANT STRUCTURE (f = 880 MHz)

spacing. Figure 21 presents VSWR data for the radant structure with the ridged horn both mounted and unmounted in the ground plane. It is interesting to note that these two curves have essentially the same characteristics. This curve was obtained by maintaining the frequency fixed at 1060 MHz and varying the spacing between the radant structure and aperture of the primary feed. A second set of data was obtained with the spacing fixed and varying the frequency from 800 to 4000 MHz, thus effecting an electrical variation in spacing. A similar variation in VSWR characteristics is noted in these curves. The VSWR characteristics of the ridged horn itself is included for comparison with the ridged horn-radant combination (Fig. 22).

To further evaluate the radant, additional VSWR data was collected using $\lambda/2$ dipole to excite the radant. The $\lambda/2$ dipole was fed through $\lambda/4$ balun and was tuned to a frequency of 480 MHz. From Fig. 23, it can be seen that the resonant frequency of the dipole tended to shift in the same manner that it shifted with the ferrite antenna (Section 2). Further, the data obtained with the ridged horn is considerably different from that obtained with either the $\lambda/2$ dipole or the ferrite antenna. One cause for this variation in data is perhaps the weak ground plane currents excited by the ridged horn as compared to the strong ground plane currents that are excited by the $\lambda/2$ dipole and ferrite antennas.

4.2 Impedance Data of Radant Excited by Ridged Horn

Impedance data of the ridged horn-radant combination was obtained by maintaining a fixed frequency and varying the spacing between the horn aperture and radant structure. A Smith chart plot of the data is shown in Fig. 24. Since the frequency was maintained constant during these tests, the impedance of the ridged horn was measured and is indicated as point **A** in Fig. 24. It was previously reasoned that as the spacing is increased, the coupling between the horn aperture and radant structure would decrease, with the result that the impedance curve of the horn alone and that of the radant system would approach one another. This is readily observed from Fig. 24, supporting the aperture coupling hypothesis.

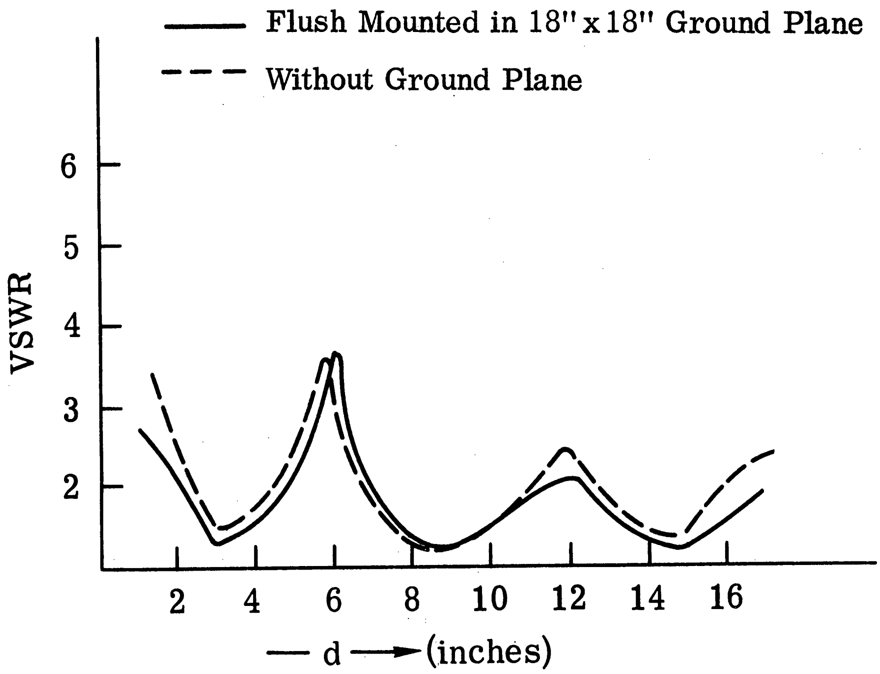

FIG. 21: VSWR FOR A RIDGED HORN AS A PRIMARY SOURCE FOR THE RADANT AT 1060 MHz

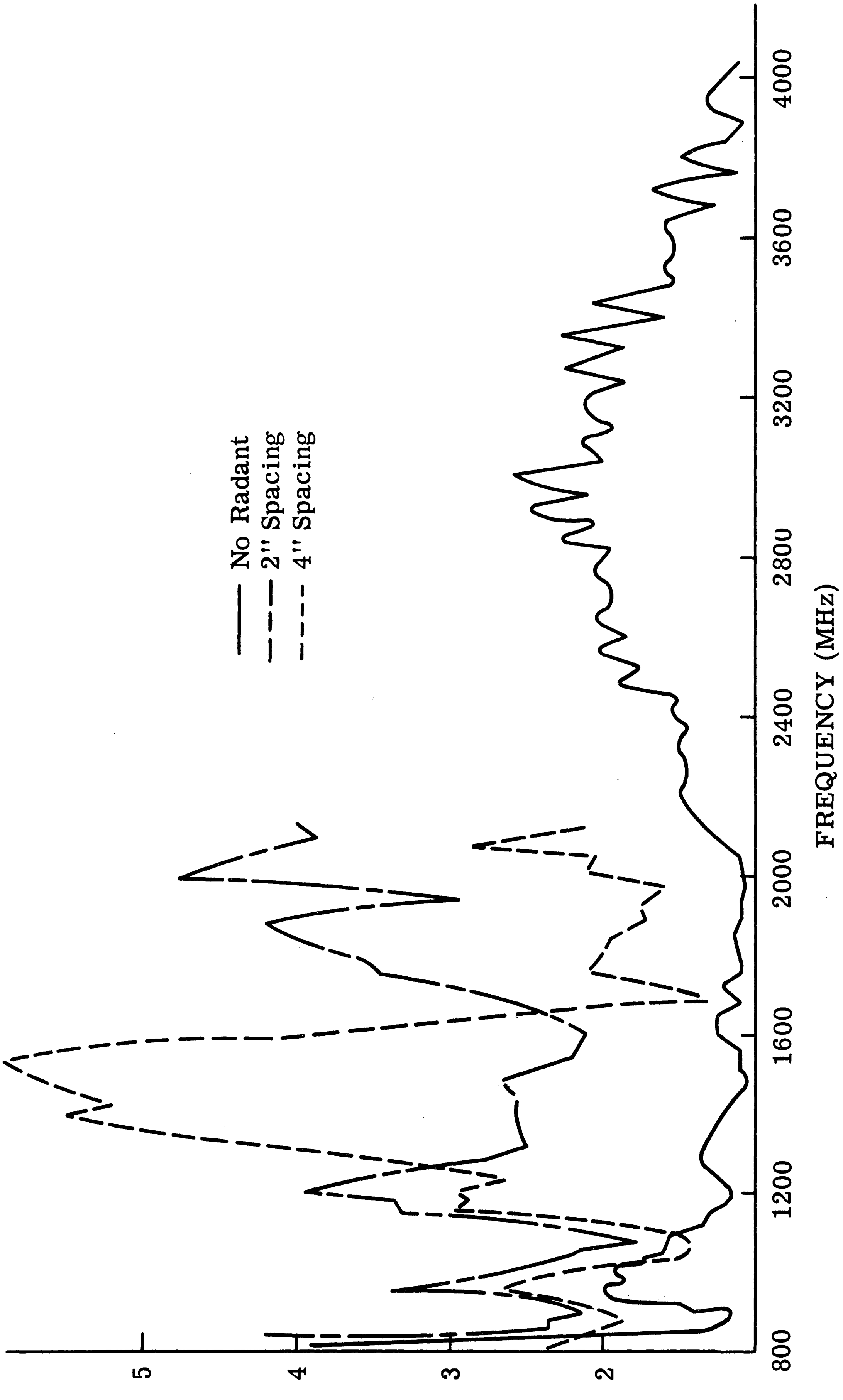

FIG. 22: VSWR VS. FREQUENCY FOR FIXED SPACINGS (RADANT USING RIDGED HORN AS PRIMARY SOURCE

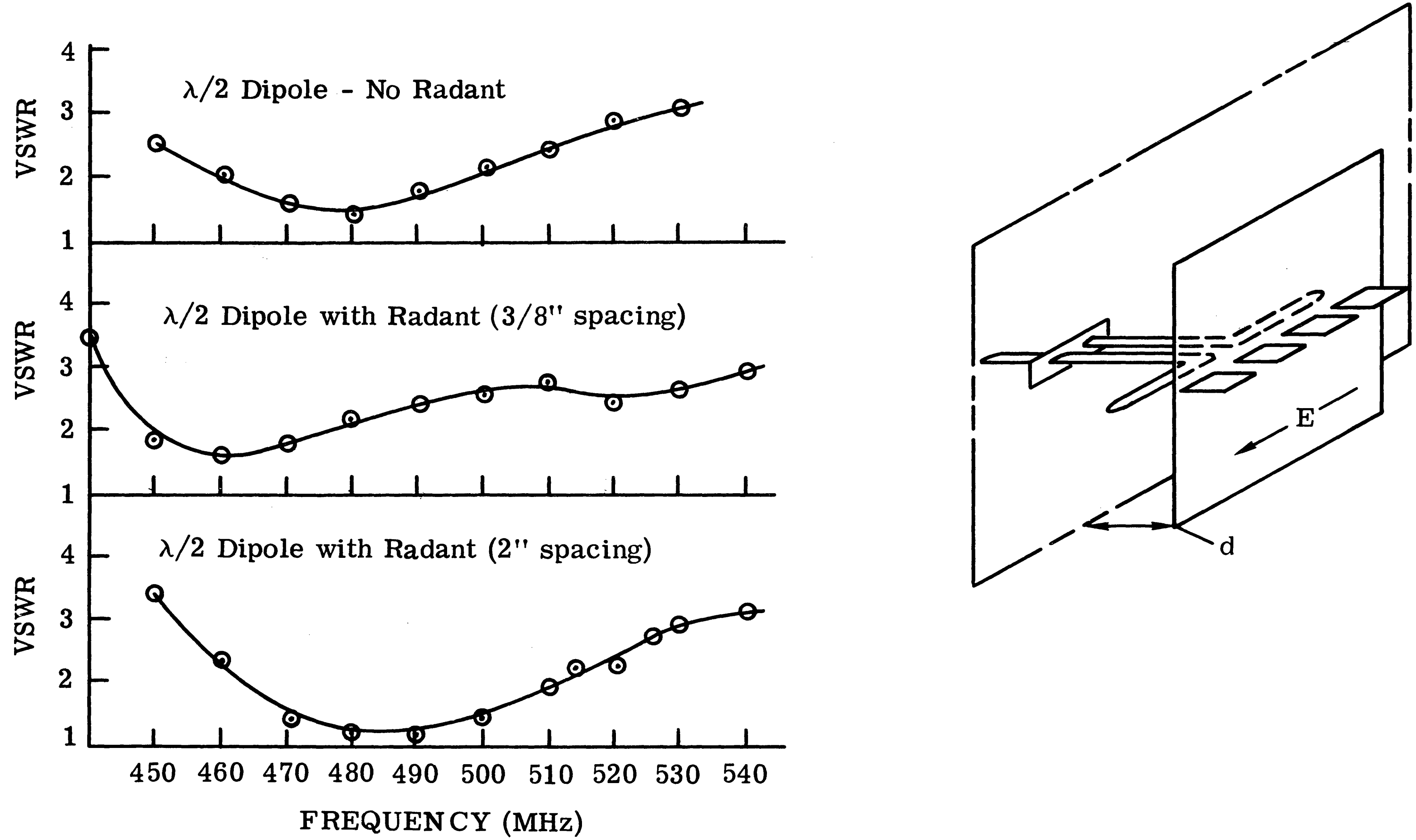

FIG. 23: VSWR VS. FREQUENCY FOR THE $\lambda/2$ DIPOLE AND THE RADANT CONFIGURATION

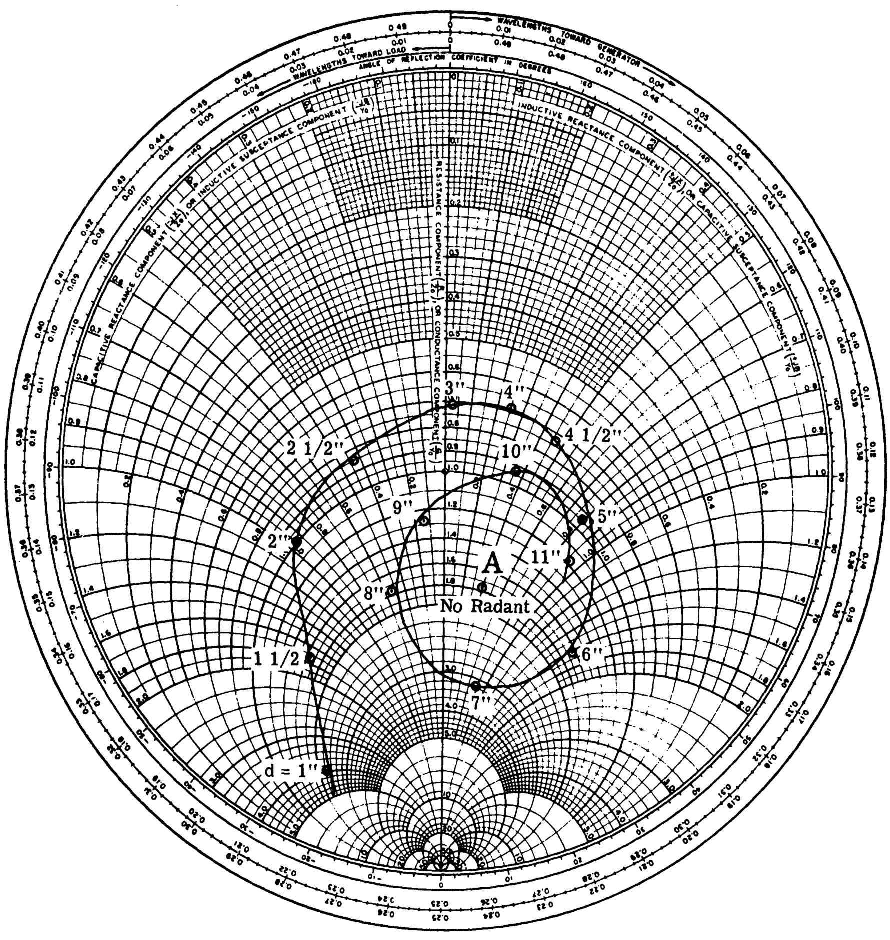

FIG. 24: IMPEDANCE OF RIDGED HORN EXCITING RADANT AS A FUNCTION OF SPACING (f = 1040 MHz)

4.3 Pattern Measurements of the Radant Excited by a Ridged Horn

The radiation patterns of the radant excited by the ridged horn were recorded at frequencies of 1000 and 8500 MHz. Because of the short wavelengths associated with the higher frequencies the dielectric sheet imperfections became an appreciable part of a wavelength and presented an additional source of error, causing unpredictable variations in the pattern structure. Although these mechanical discontinuities were present in the radant structure, the half-power beamwidth of the ridged horn was found to decrease from 19^{o} in the E-plane without the radant to 11^{o} in the E-plane with the radant at 8.5 GHz. For the purposes of these tests, the spacing between the dielectric panels of the radant structure was adjusted to be approximately 5.3 mm. Pattern data for the above configurations are shown in Figs. 25-27. Although the beamwidth of the major lobe tended to decrease, the side lobe level increased from -25 db to -15 db along with a general reduction in antenna gain. This degradation of the pattern is assumed to be caused by the coupling effects associated with the radant structure and aperture of the antenna. To optimize the angenna gain, a tuning stub was employed effecting an improvement of 2 db. As the plate to plate spacing was increased, considerable degradation in the pattern was observed, in particular for spacings of 10 and 15 mm (Fig. 28). At 1000 MHz, pattern data was recorded for the ridged horn both with and without the radant structure. Figures 29 and 30 illustrate the degree to which the pattern was sharpened when using the radant structure. Although an improvement in the directivity of the antenna is seen, these figures also demonstrate the extent the antenna gain may be reduced due to the interaction of the radant and antenna. To otpimize the antenna gain, it was necessary to use a tuning stub to minimize the radant system VSWR mismatch. Since a tuning stub was required to correct the system VSWR a decrease in the operational frequency band was observed.

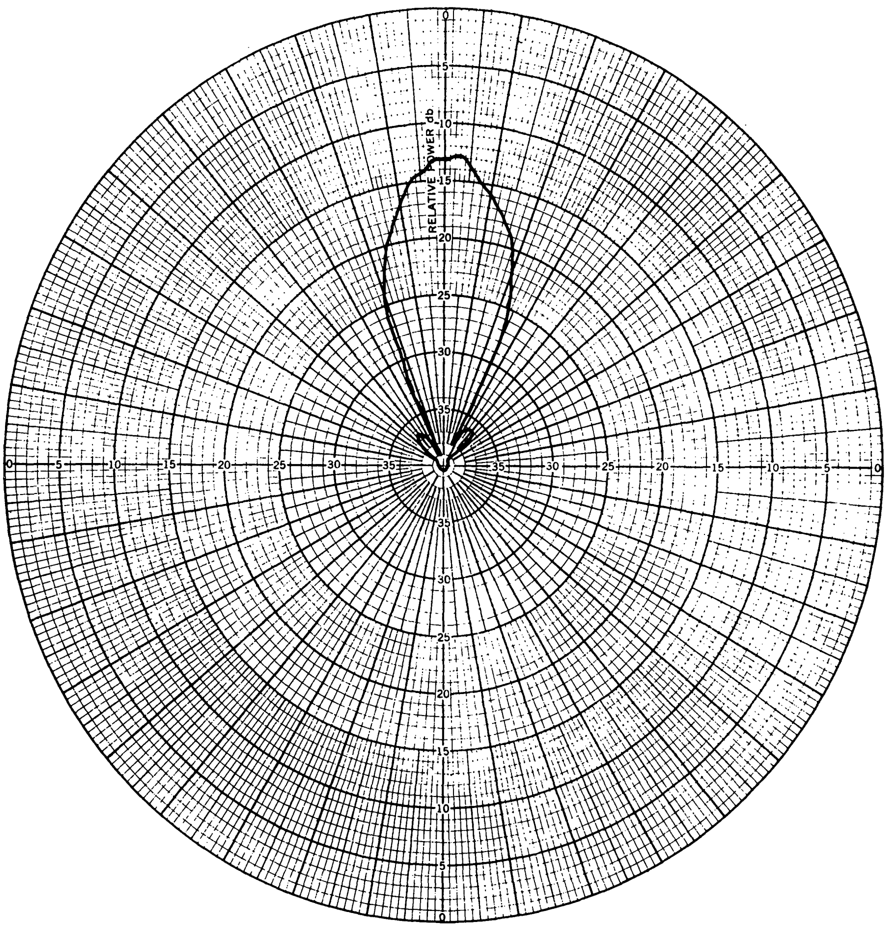

FIG. 25: E-PLANE PATTERN OF RIDGED HORN IN 18" x 18" GROUND PLANE AT 8500 MHz (NO RADANT)

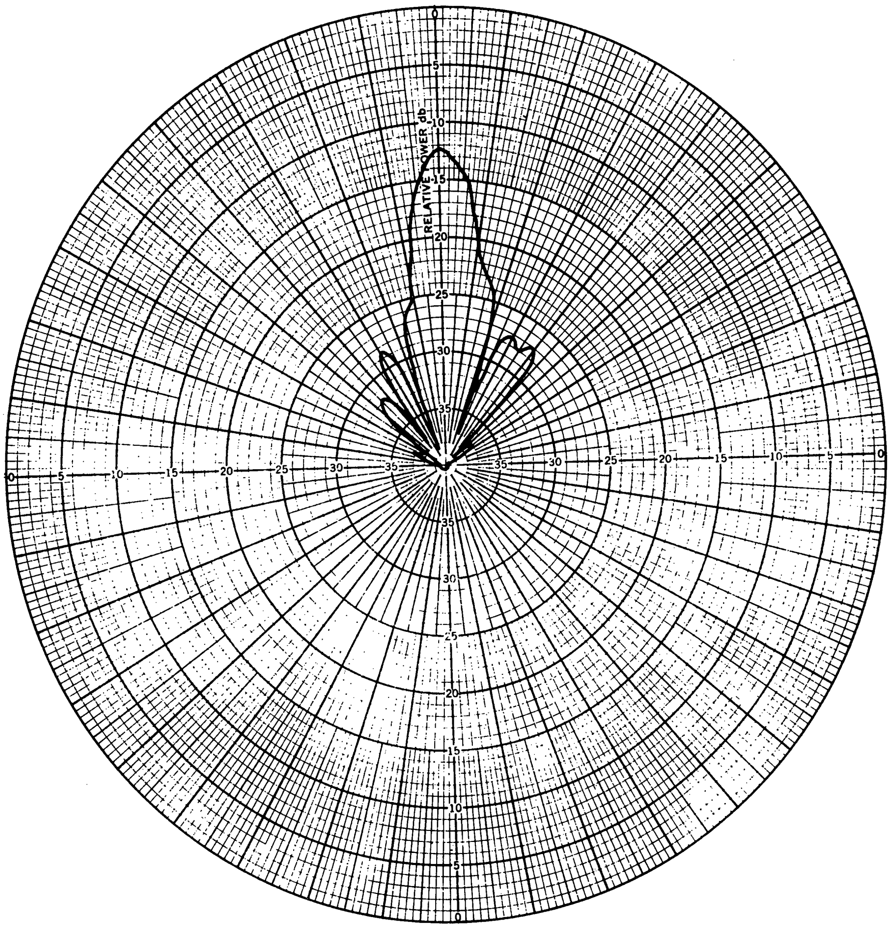

FIG. 26: E-PLANE PATTERN OF RADANT STRUCTURE WITH RIDGED HORN IN 18" x 18" GROUND PLANE AT 8500 MHz AND A 3 mm SPACING

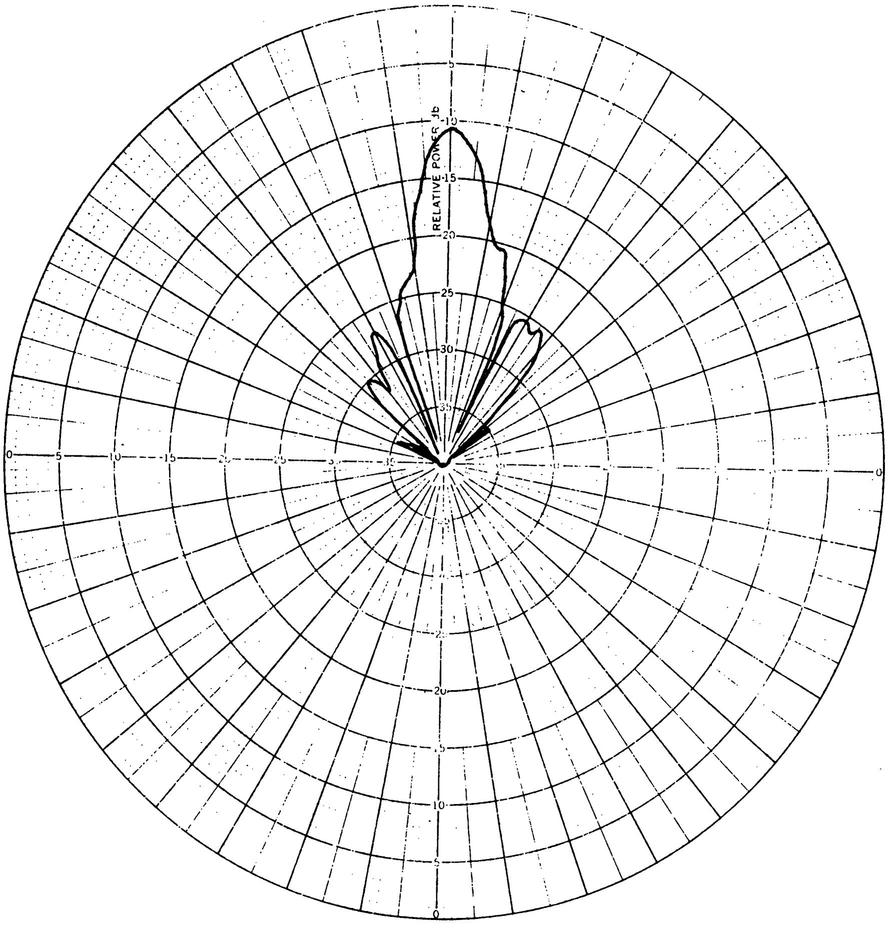

FIG. 27: E-PLANE PATTERN OF RIDGED HORN IN 18"x18" GROUND PLANE AT 8500 MHz AND A 5 mm SPACING

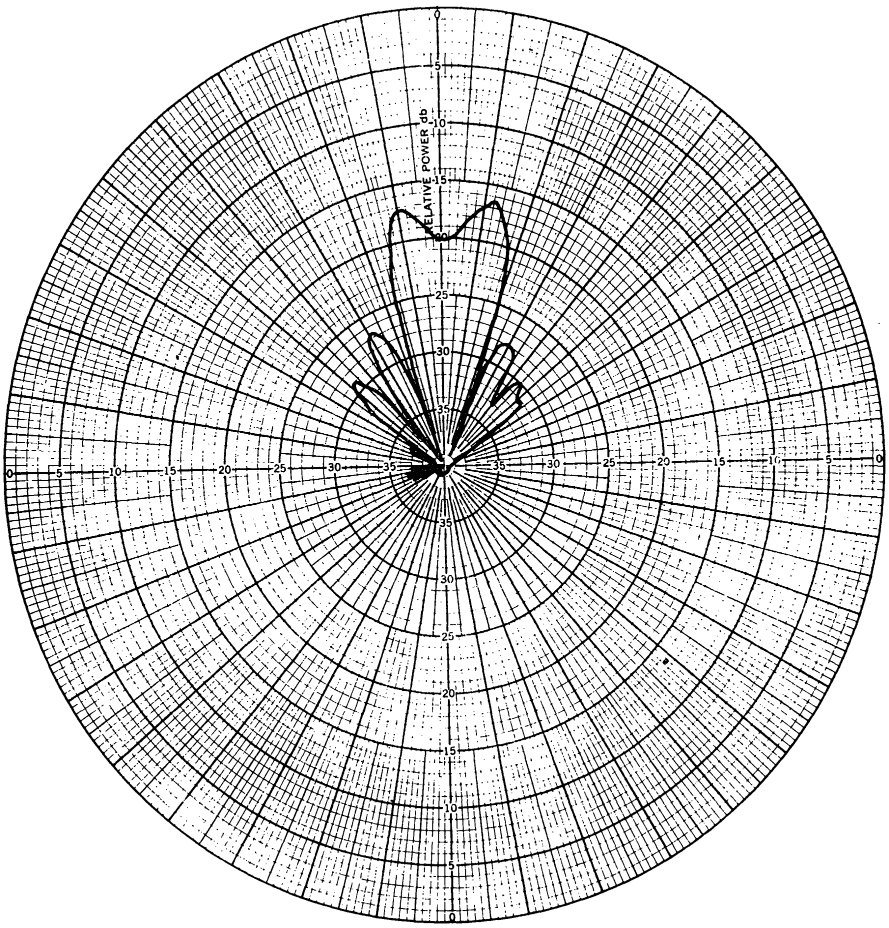

FIG. 28: E-PLANE PATTERN OF RADANT STRUCTURE WITH RIDGED HORN IN 18"x18" GROUND PLANE AT 8500 MHz AND A 10 mm SPACING

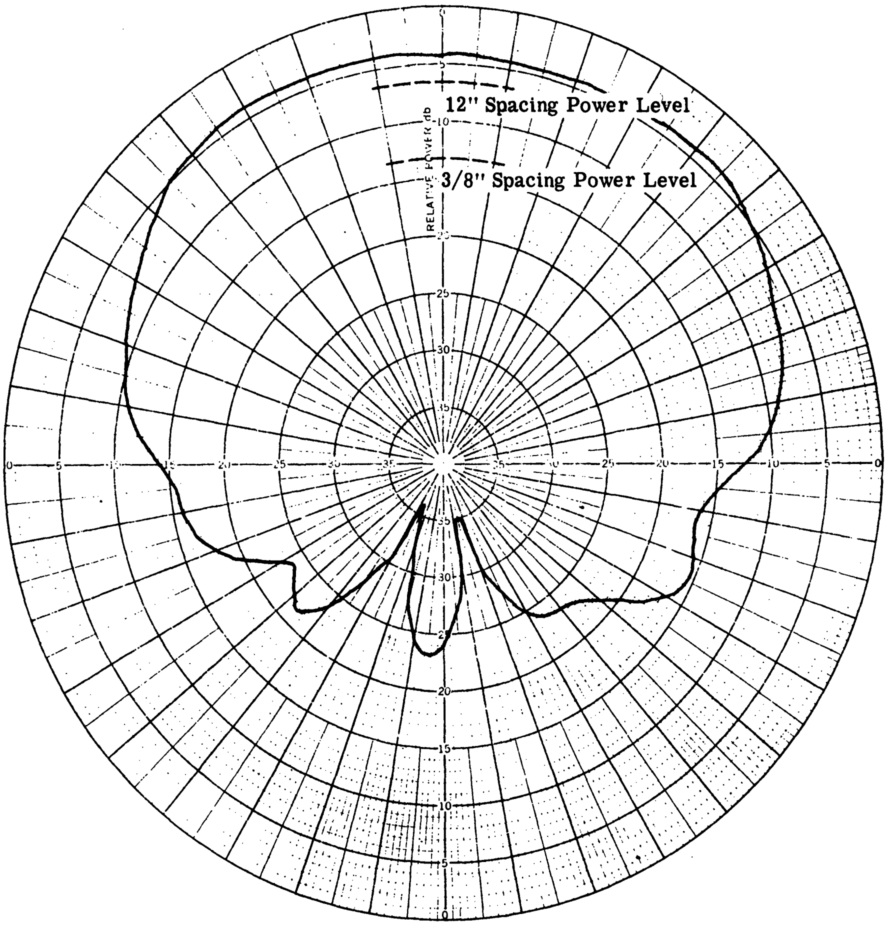

FIG. 29: E-PLANE PATTERN OF RIDGED HORN IN 18"x18" GROUND PLANE AT 1000 MHz (Relative Power Levels are Shown with the Radant Present for Two Spacings)

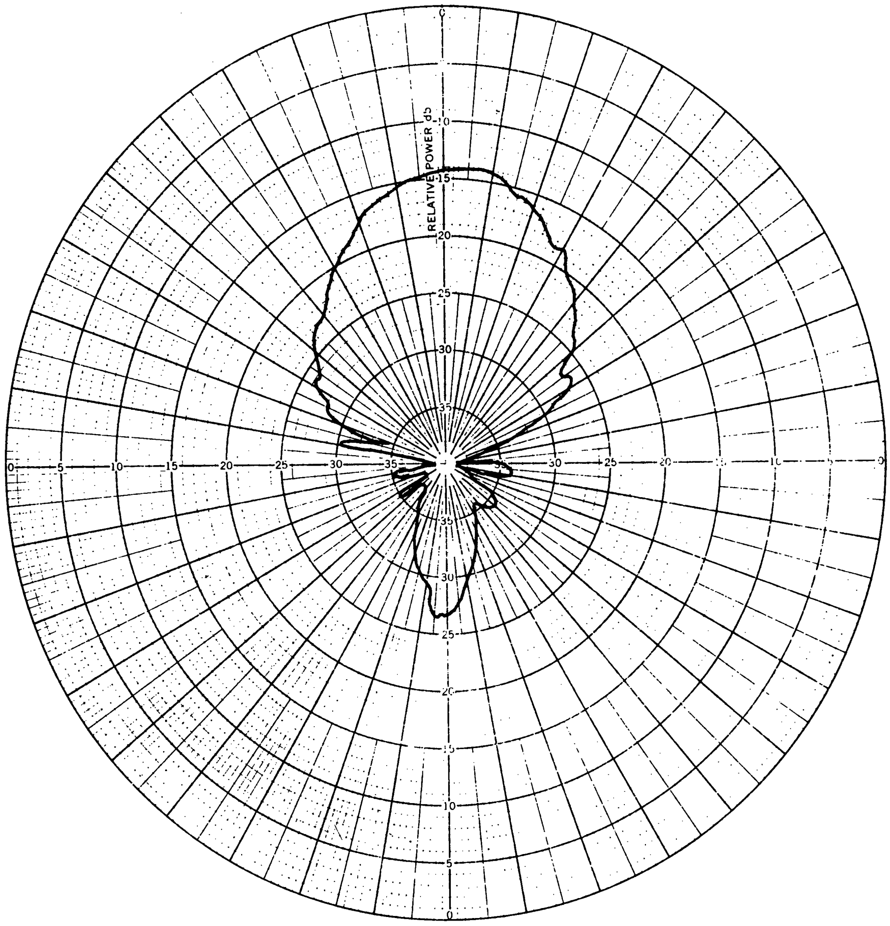

FIG. 30: E-PLANE PATTERN OF RADANT STRUCTURE WITH RIDGED HORN IN 18"x18" GROUND PLANE AT 1000 MHz AND A 1/2 INCH SPACING

V
SCATTERING OF A PAIR OF DIPOLES LINKED BY A TRANSMISSION LINE

The problem to be analyzed is sketched in Fig. 31

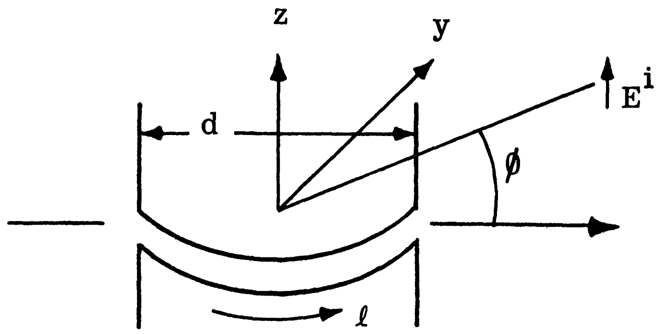

FIG. 31: SCATTERING BY A PAIR OF DIPOLES LINKED BY A TRANSMISSION LINE

It is assumed that the incident E field is polarized in the z direction and is incident on the array at an angle ϕ. By applying the superposition theorem and the reciprocal theorem, it can be shown that for two half-wave dipoles the induced terminal currents at the antennas can be solved from the following equations:

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{12} & Y_{11} \end{bmatrix} \begin{bmatrix} V_1^{(i)} + V_1 \\ V_2^{(i)} + V_2 \end{bmatrix} \tag{1}$$

where

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_a & Z_b \\ Z_b & Z_a \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} \tag{2}$$

where

$$Z_a = jZ_c \cot \frac{2\pi\ell}{\lambda}$$

η $$Z_b = jZ_c \csc \frac{2\pi \ell}{\lambda}$$

Z_c = characteristic impedance of the line

ℓ = length of the line

Y_{11}, Y_{12} = self and mutual admittances of the two antennas

$$V_1^{(i)} = \frac{\lambda}{\pi} E_1$$

$$V_2^{(i)} = \frac{\lambda}{\pi} E_2 = \frac{\lambda}{\pi} E_1 e^{jkd\cos\phi}$$

The formulae which were obtained are the same as the ones previously described by Larsen (1964) in a study of the Van Atta array based upon an equivalent circuit which was not derived in the original report.

VI
CONCLUSIONS AND RECOMMENDATIONS

The results described in previous sections are summarized in Table IV. Data has been obtained for two narrow band feeds ($\lambda/2$ dipole and ferrite antenna) used as primary sources for the radant structure. A shift in the resonant frequency of these two antennas was noted when they were used in conjunction with the radant structure. This shift is assumed to be caused by ground plane surface currents associated with these antenna types. In addition to these antennas, a broadband ridged horn (10:1 frequency band) was used as the primary feed. When using the horn, no shift in frequency was noted. For two of the feeds used a decrease of the far field radiation pattern beamwidth was observed when the radant was introduced. As yet the effects of the radant structure on the characteristics of the primary feed, e.g. directivity, transmission efficiency, polarization transformation, are not well established. Therefore, further study will be required.

To obtain an understanding of the transmission characteristics of the radant structure, a finite isotropic panel (51 x 51 x 1 inch plexiglass) is under study. The results with the pure dielectric panel will be compared with those from the loop panel radant structure when each are excited by a dipole or a small loop at frequencies in the 300-600 MHz range. In addition to the isotropic panel study, a loop element of the present loop radant structure will be fed directly to determine the effectiveness of this method of feeding. Additional gain measurements with the radant excited by the ridged horn and dipole will be made to complete this phase of the study.

TABLE IV
RADANT EFFECTS ON DIFFERENT PRIMARY SOURCES

Antenna Type	Antenna Features: Without Radant	Antenna Features: With Radant	Frequency Shift	Beamwidth Improvement
Ferrite Loaded	f_c = 348 MHz Bandwidth: Narrow	f_c = 330 MHz Bandwidth: Narrow Capacitive-reactive	Observed	100^o to 50^o in E-Plane
Ridged Horn	Cutoff frequency: 850 MHz 10:1 Bandwidth	Bandwidth: Narrow Strongly reactive Capacitive-reactive	Not Observed	110^o to 40^o in E-Plane
$\lambda/2$ Dipole	Central frequency: 480 MHz Bandwidth: Narrow	Central frequency: 450 MHz Bandwidth: Narrow	Observed	Not measured

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Tai, C.T., M.A. Plonus and E.S. Andrade (1965) "Radant Analysis Studies - Interim Report No. 1", The University of Michigan Radiation Laboratory Report No. 7300-1-T

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13. ABSTRACT

The transmission characteristics of an anisotropic panel have been investigated experimentally and the initial results are presented. The anisotropic panel is formed from conducting strips being palced on a dielectric sheet. Three variations of the above panel have been considered during this reporting period. In addition, three antenna configurations have been considered as primary feeds for the anisotropic panel. Two of these feeds were inherently narrow banded (ferrite loaded slot and a $\lambda/2$ dipole) and the third was a broadbanded (10:1 frequency band ridged horn) antenna.

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