SOME INVESTIGATIONS ON DIELECTRIC ROD AERIAL EXCITED IN MIXED HE_{11} AND E_{01} MODES

By (Mrs.) R. CHATTERJEE, Sqn. Ldr. V. BALASUBRAMANIAN AND S. K. CHATTERJEE

[Department of Electrical Communication Engineering, Indian Institute of Science, Bangalore 12, India

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ABSTRACT

Theoretical and experimental investigations of the radiation pattern of a circular cylindrical dielectric rod excited in mixed HE_{11} and E_{01} modes and also of the open-ended $H_{01}^{\square} - H_{11}^{0} + E_{01}^{0}$ mode transducer used to excite the dielectric rod aerial have been made. A comparative theoretical and experimental study of the field distributions in the mode transducer with and without a resonant ring filter has also been made. Theoretical and experimental results on the radiation patterns of the aerial as well as of the mode transducer for different percentages of mixture of the respective modes show fair agreement.

INTRODUCTION

The present investigations which form a part of the work[1-11] on dielectric rod aerials that is being conducted for the last few years has been motivated to develop a launcher that will excite a dielectric rod aerial in the pure E_{01} mode. The dominant mode in a circular cylindrical guide which feeds the dielectric rod being H_{11}, it is difficult to eliminate entirely the H_{11} mode. It has therefore been thought worthwhile to investigate the radiation pattern of a dielectric rod aerial excited in different percentages of the mixed dominant H_{11} and the desired E_{01} mode. The study will enable the determination of the purity of the E_{01} mode launched by the transducer. As far as information can be collected from the available literatures no such study has been reported by any other author.

THEORETICAL

(i) *Field Components: Mode Transducer*

The field components of E_{01}^{0} and H_{11}^{0} pure modes in a circular cylindrical H S P guide are given respectively by the following expressions

E_{01} :

$$E_z = A\, J_0 (h\rho)$$
$$E_\rho = -j (\beta A/h)\, J_1 (h\rho)$$
$$H_\phi = -j (A\omega\, \epsilon_0/h)\, J_1 (h\rho) \qquad [1]$$

Where J_0 and J_1 represent Bessel functions of the first kind and of order zero and one respectively.
and for H_{11}^0 mode

$$H_z = C_1\, J_1 (h\rho) \cos\phi$$
$$H_\rho = -j (\beta\, C_1/h)\, J_1' (h\rho) \cos\phi$$
$$H_\phi = j (\beta\, C_1/h^2 \rho)\, J_1 (h\rho) \sin\phi$$
$$E_\rho = j (\omega\, \mu\, C_1/h^2 \rho)\, J_1 (h\rho) \sin\phi$$
$$H_\phi = j (\omega\, \mu\, C_1/h)\, J_1' (h\rho) \cos\phi \qquad [2]$$

where the time dependence is exp $(j\omega t)$ and the radial and axial wave numbers h and γ are related to each other by the wave number k_0 for plane waves in free space are as follows. The prime sign on J indicates derivatives with respect to the argument

$$h^2 = \gamma^2 + k_0^2$$
$$k_0^2 = \omega^2\, \mu_0\, \epsilon_0$$
$$\gamma = \alpha + j\beta \simeq j\beta \qquad [3]$$

The field components of the mixed mode $E_{01}^0 + H_{11}^0$ are obtained from equations [1] and [2]

$$E_z = A\, J_0 (h\rho)$$
$$E_\rho = j\, C_1 (\omega\, \mu/h^2 \rho)\, J_1 (h\rho) \sin\phi - j\, A (\beta/h)\, J_1 (h\rho)$$
$$E_\phi = j\, C_1 (\omega\, \mu/h)\, J_1' (h\rho) \cos\phi$$
$$H_z = C_1\, J_1 (h\rho) \cos\phi$$
$$H_\rho = -j\, C_1 (\beta/h)\, J_1' (h\rho) \cos\phi$$
$$H_\phi = j\, C_1 (\beta/h^2 \rho)\, J_1 (h\rho) \sin\phi + j\, A (\omega\, \epsilon_0/h)\, J_1 (h\,\rho)$$

Dielectric Rod :

The field components of the HE_{11} mode on the dielectric rod due to H_{11}^0 dominant mode in the transducer are

$$E_\phi = -B\, [(1/\rho)\, J_1 (k_1 \rho) + (b/B) (\gamma\, k_1/j\,\omega\, \epsilon_1)\, J_1' (k_1 \rho)] \sin\phi \exp(-\gamma z)$$
$$E_\rho = -B\, [k_1\, J_1' (k_1 \rho) + (b/B) (1/\rho) (\gamma/j\,\omega\, \epsilon_1)\, J_1 (k_1 \rho)] \cos\phi \exp(-\gamma z)$$

$$E_z = B\,(b/B)\,(k_1^2/j\,\omega\,\epsilon_1)\,J_1\,(k_1\,\rho)\sin\phi\,\exp\,(-\gamma\,z)$$

$$H_\rho = B\,[(\gamma\,k_1/j\,\omega\,\mu_1)\,J_1'\,(k_1\,\rho) + (b/B)\,(1/\rho)\,J_1\,(k_1\,\rho)]\cos\phi\,\exp\,(-\gamma\,z)$$

$$H_\phi = -B\,[(1/\rho)\,(\gamma/j\,\omega\,\mu_1)\,J_1\,(k_1\,\rho) + (b/B)\,(1/\rho)\,J_1\,(k_1\,\rho)]\sin\phi\,\exp\,(-\gamma\,z)$$

$$H_z = -B\,(k_1^2/j\,\omega\,\mu_1)\,J_1\,(k_1\,\rho)\cos\phi\,\exp\,(-\gamma\,z) \qquad [4]$$

where ρ represents the radial coordinate and A & B are excitation constants. The field components for the E_{01} mode are

$$E_{\rho 1} = (\gamma_1\,B\,k_1/j\,\omega\,\epsilon_1)\,J_1\,(k_1\,\rho)\,\exp\,(-\gamma_1\,z)$$

$$E_{z1} = (B\,k_1^2/j\,\omega\,\epsilon_1)\,J_0\,(k_1\,\rho)\,\exp\,(-\gamma_1\,z) \qquad \text{for } \rho < a \text{ (radius of the rod)}$$

$$H_{\phi 1} = B\,k_1\,J_1\,(k_1\,\rho)\,\exp\,(-\gamma_1\,z) \qquad [4a]$$

$$E_{\rho 2} = (-\gamma_2\,D\,k_2/j\,\omega\,\epsilon_1)\,H_0^{(1)'}\,(k_2\,\rho)\,\exp\,(-\gamma_2\,z)$$

$$E_{z2} = (D\,k_2^2/j\,\omega\,\epsilon_2)\,H_0^{(1)}\,(k_2\,\rho)\,\exp\,(-\gamma_2\,2) \qquad \rho > a$$

$$H_{\phi 2} = -D k_2\,H_0^{(1)'}\,(k_2\,\rho)\,\exp\,(-\gamma_2\,z)$$

where,

$$k_1^2 = \omega^2\,\mu_0\,\epsilon_1 + \gamma^2$$

$$k_2^2 = \omega^2\,\mu_0\,\epsilon_0 + \gamma^2$$

$$\bar{\epsilon}_1 = \epsilon_1/\epsilon_0$$

$$\frac{B}{b} = \frac{j\,\omega\,u_1}{\gamma\,\epsilon_1}\,\frac{x_1\,x_2}{x_1^2 - x_2^2}\left[\frac{\epsilon_1}{x_1}\,\frac{J_1'\,(x_1)}{J_1\,(x_1)} - \frac{\epsilon_2\,H_1^{(1)'}\,(x_2)}{x_2\,H_1^{(1)}\,(x_2)}\right] \qquad [5]$$

$$x_1 = k_1\,d/2,\quad x_2 = k_2\,d/2$$

d = diameter of the dielectric rod

x_1 and x_2 are the solutions of the the following equation derived by applying proper boundary conditions and using appropriate field components

$$\left[\frac{1}{x_1}\,\frac{J_1'\,(x_1)}{J_1\,(x_1)} - \frac{1}{x_2}\,\frac{H_1^{(1)'}(x_2)}{H_1^{(1)}(x_2)}\right]\left[\frac{\bar{\epsilon}_1\,J_1'(x_1)}{x_1\,J_1\,(x_1)} \quad \frac{1}{x_2}\,\frac{H_1^{(1)'}(x_2)}{H_1^{(1)}(x_2)}\right]$$

$$= \frac{(x_1^2 - x_2^2)\,(x_1^2 \quad x_2^2\,\bar{\epsilon}_1)}{x_1^4\,x_2^4} \qquad [6]$$

where, x_1 aad x_2 are related to each other by the relation

$$x_1^2 + (x_2/j)^2 = (\pi\,d/\lambda_0)^2\,(\bar{\epsilon}_1 - 1) \qquad [7]$$

(ii) Radiation Pattern: Mode Transducer

The radiation pattern of the open ended mode transducer is derived by applying vector Huyghen's principle. By assuming the existence of only a pure H_{mn}^0 mode in the transducer and neglecting the higher order modes due to the current distributions over the exterior wall of the transducer, the radiation field at a distant point (r, θ, ϕ) from the open end of the transducer are given by the following relation

$$E_r = 0$$

$$E_\theta = j^{m+1} \frac{m \omega \mu}{2r} \left[1 + \frac{\beta_{mn}}{k} \cos\theta + \Gamma \left\{ 1 - \frac{\beta_{mn}}{k} \cos\theta \right\} \right] \times$$

$$J_m(K_{mn} a) \frac{J_m(ka \sin\theta)}{\sin\theta} \sin m\phi \exp(-jkr)$$

$$E_\phi = j^{m+1} \frac{ka \omega \mu}{2r} \left[\frac{\beta_{mn}}{k} + \cos\theta - \Gamma \left\{ \frac{\beta_{mn}}{k} - \cos\theta \right\} \right] \times$$

$$\frac{J_m(K_{mn} a) J_m'(ka \sin\theta)}{\{1 - (k \sin\theta / K_{mn})^2\}} \cos m\phi \exp(-jkr) \quad [8]$$

where, Γ represents the reflection coefficient of the wave at the open end of the transducer. Neglecting the effect of reflection at the aperture field at the mouth of the transducer, the E_θ component of the radiated field for the H_{11}^0 mode is

$$E_\theta = j^2 \frac{\omega \mu}{2r} \left[1 + \frac{\beta_{11} \cos\theta}{k} \right] J_1(K_{11} a) \frac{J_1(ka \sin\theta)}{\sin\theta} \sin\phi \exp(-jkr) \quad [9]$$

where, a is the inner radius of the transducer. The radiated field at any distant point (r, θ, ϕ) for the transducer supporting only pure E_{01} mode is

$$E_\phi = j \frac{ka K_{01}}{2r \sin\theta} \cos\phi \left[\frac{\rho_{01}}{k} + \cos\theta \right] \frac{J_0(ka \sin\theta) J_0'(K_{01} a)}{\{1 - (K_{01}/k \sin\theta)^2\}} \exp(-jkr) \quad [10]$$

The radiation pattern of the mode transducer excited in the mixed mode $H_{11}^0 + E_{01}^0$ is computed by superposition of the radiation field of the two modes for different percentages of combination.

In the $\phi = 0^\circ$ and $\phi = 180^\circ$ planes, E_θ of the mode H_{11}^0 is zero and that of E_{01}^0 is maximum, hence the radiated field of the mixed mode is the same as that of the pure E_{01}^0 mode. But in the $\phi = 90^\circ$ and $\phi = 270^\circ$ planes, the E_ϕ of the E_{01}^0 mode is zero and that of the H_{11}^0 mode is maximum. Hence the radiated field of the mixed mode is the same as that of H_{11}^0 mode.

But for any other ϕ = constant plane both the modes E_{01}^{0} and H_{11}^{0} exist and the radiation pattern of the mixed mode will depend not only on the percentages of the two modes, but will also show different structure in different ϕ planes.

Dielectric Rod :

The radiation pattern of a dielectric rod excited in the HE_{11} mode has been derived by using the following relation and appropriate field components [eqn. 4].

$$\mathbf{E}_p = j\omega\mu_0 \mathbf{A}^H - (1/j\omega\epsilon_0) \text{ grad div } \mathbf{A}^H - \text{curl } \mathbf{A}^E$$
$$\mathbf{H}_p = j\omega\epsilon_0 \mathbf{A}^E - (1/j\omega\mu_0) \text{ grad div } \mathbf{A}^E + \text{curl } \mathbf{A}^H \quad [11]$$

where, the magnetic $\mathbf{A}^H$ and electric $\mathbf{A}^E$ vector potentials within the surface Σ of the rod are respectively

$$\mathbf{A}^H = \frac{1}{4\pi} \int_\Sigma \mathbf{J} \frac{\exp\{j(\omega t - kr_1)\}}{r_1} d\Sigma$$

$$\mathbf{A}^E = \frac{1}{4\pi} \int_\Sigma \mathbf{M} \frac{\exp\{j(\omega t - kr_1)\}}{r_1} d\Sigma \quad [12]$$

where r_1 is the distance of a distant point (r, θ, ϕ) from an element $d\Sigma$ on the surface of the rod and the electric and magnetic current sheets $\mathbf{J}$ and $\mathbf{M}$ respectively over Σ are given in terms of the magnetic $\mathbf{H}^\circ$ and electric $\mathbf{E}^\circ$ fields respectively on the surface of the rod

$$\mathbf{J} = -\mathbf{n} \times \mathbf{H}^\circ$$
$$\mathbf{M} = \mathbf{n} \times \mathbf{E}^\circ \quad [13]$$

where $\mathbf{n}$ is the outward unit normal vector.

The radiation pattern in the $\phi = 0^\circ$ and the $\phi = 180^\circ$ planes are

$$\mathbf{E}_p = \mathbf{u}_\phi \, \mu_0 \, \omega \, K_1^H \left[\frac{\sin\{(\beta - k\cos\theta) L\}}{\beta - k\cos\theta)} \right] 2\pi J_1 \left(\frac{kd}{2} \sin\theta \right)$$
$$+ \mathbf{u}_\theta \, k \, K_1^E \left[\frac{\cos\{(\beta - k\cos\theta) L\}}{(\beta - k\cos\theta)} \right] \frac{2\sqrt{(2\pi)}}{\sqrt{(kd/2)}\sin\theta} J_{1/2} \left(\frac{kd}{2} \sin\theta \right) \quad [14]$$

where
$$K_1^H = \frac{\beta\, d\, k_1^2}{8\pi\omega\mu_1} J_1 \left(\frac{k_1 d}{2} \right)$$

and
$$K_1^E = \frac{\beta\, d\, k_1^2}{8\pi\omega\epsilon_1} J_1 \left(\frac{k_1 d}{2} \right)$$

so
$$|\mathbf{E}_p| = \sqrt{(E_\phi^2 + E_\theta^2)} \quad [15]$$

By using the same principle as above the radiation pattern of a dielectric rod excited in the pure symmetrical mode E_{01} is given by the following relation

$$E_\theta = \psi \left[J_0 (k\, a \sin\theta) \sin\theta - \frac{(n^2 - n_a^2)^{1/2}}{n^2} \frac{J_0(\lambda_1 a')}{J_1(\lambda_1 a')} J_1 (k\, a \sin\theta) \right] \times$$

$$\frac{ld}{2} \left[\frac{(\pi/2)\, D \cos\{(kl/2)(n_a - \cos\theta)\}}{(\pi/2)^2 - \{(kl/2)(n_a - \cos\theta)\}^2} + \frac{\sin\{(kl/2)(n_a - \cos\theta)\}}{\{(kl/2)(n_a - \cos\theta)\}} \right] \times$$

$$\exp\{ j (kl/2)(n_a - \cos\theta)\} \qquad [16]$$

where, n = index of refraction of the rod

n_a = apparent index of refraction $= \lambda_0/\lambda_g$

$\lambda_1 = k\,(n^2 - n_a^2)^{1/2}$

$\psi = 1/a' \exp(j k a' - j\omega t)$

The term $\psi\, ld/2$ is a constant term and the amplitude of

$$\exp\{ j (kl/2)(n_a - \cos\theta \}$$

is unity. Hence these terms are neglected in numerical computation. For a dielectric rod of length $l = 6\,\lambda_0$, the radiation pattern is

$$E_\theta = \left[J_0 (k\, a \sin\theta) \sin\theta - \frac{(n^2 - n_a^2)^{1/2}}{n^2} \frac{J_0(\lambda_1 a')}{J_1(\lambda_1 a')} J_1 (k\, a \sin\theta) \right] \times$$

$$\left[\frac{\sin\{(kl/2)(n_a - \cos\theta)\}}{(kl/2)(n_a - \cos\theta)} \right] \qquad [17]$$

The radiation patterns of a dielectric rod excited in the mixed mode $HE_{11} + E_{10}^{0}$ mode are computed for different percentages of the combination of the two modes.

NUMERICAL CALCULATIONS

(i) *Field distributions : Mode transducer*

Taking $\lambda_0 = 3.2$ cms, $\epsilon_r = 2.6$, inside diameter of the mode transducer $= 2.87$ cm, and $(h a)_{01} = 2.405$, $(h a)_{11} = 1.84$ which are obtained from $J_0(ha) = 0$ and $J_1'(ha) = 0$, the field distributions (E_ρ vs. ρ) in the mode transducer have been computed from eqn. [3], when H_{11} and E_{01} modes are mixed in different percentages (Fig. 1)

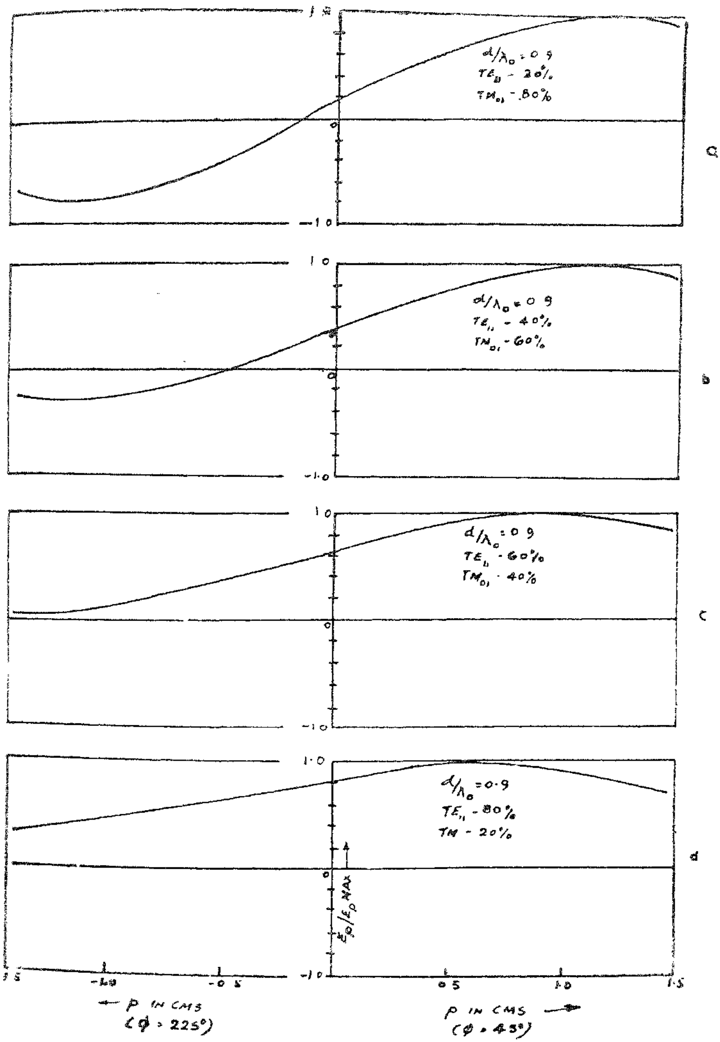

Fig. 1

Theoretical Field Distribution (E_ρ vs ρ) in the Mode Transformer

(ii) *Radiation patterns : Mode transducer*

The radiation pattern of the open-ended mode transducer excited in mixed modes $E_{01}+H_{11}$ of different relative strengths have been computed from equations [9] and [10] by using the following values of different parameters.

H_{11} :

$d = 2.87$ cms., $\lambda_0 = 3.2$ cms., $\lambda_c = 4.9$ cms, $\lambda_g = 4.1$ cms, $k = 1.98\ \text{cm}^{-1}$,

$K_{11} = (2\pi/\lambda_c = 1.28\ \text{cm}^{-1}$, $\beta_{11} = 1.53\ \text{cm}^{-1}$

$$E_\theta(H_{11}) = [1 + 0.765 \cos\theta]\frac{J_1(2.87 \sin\theta)}{\sin\theta} \qquad [18]$$

E_{01} :

$\lambda_c = 3.75$ cm., $\lambda_g = 5.74$ cm, $K_{01} = 1.675\ \text{cm}^{-1}$, $\beta_{01} = 1.1\ \text{cm}^{-1}$

$$E_\theta(E_{01}) = \frac{(0.545 + \cos\theta)\, J_0(2.87 \sin\theta)}{\sin\theta\,[1 - (0.7/\sin^2\theta)]} \qquad [19]$$

The results of computation for the mixed modes are shown in Fig. 2. For the sake of comparison $E_\theta(E_{01})$ vs. θ and $E_\theta(H_{11})$ vs. θ are also shown in Fig. 3.

(*iii*) *Radiation pattern of dielectric rod* :

A graphical solution of eq [6] for $d/\lambda_0 = 0.8$, $\epsilon_1 = 2.6$ (Fig. 4) yields $x_1 = 2$, $k_1 = 1.57$, $x_2 = 2.46$, $k_2 = 1.94$, $\beta = 2.77\ \text{cm}^{-1}$ and $k = 1.98\ \text{cm}^{-1}$ which are used for HE_{11} mode pattern computations.

For the E_{01} mode, the following values are used

$$n = 1.6,\ n_0 = 1.16,\ a = 1.27\ \text{cm},\ a' = 0.65\ a = 0.825\ \text{cm},\ k = 1.98\ \text{cm}^{-1}$$

$$\lambda_1 = k\,(n^2 - n_0^2)^{1/2} = 2.2$$

$$\frac{J_0(\lambda_1 a')}{J_1(\lambda_1 a')} = 0.564, \quad C = \frac{(n^2 - n_0^2)^{1/2} J_0(\lambda_1 a')}{n^2 J_1(\lambda_1 a')} = 0.242$$

$$(kl/2) = 18.8$$

The radiation patterns $|E_\theta|$ vs. θ of the dielectric rod aerial excited in mixed mode $E_{01} + HE_{11}$ in different percentages of combination are shown in Fig. 5 Radiation patterns of the rod excited in pure HE_{11} and pure E_{01} are shown in Figures 6 and 7 respectively for the sake of comparison.

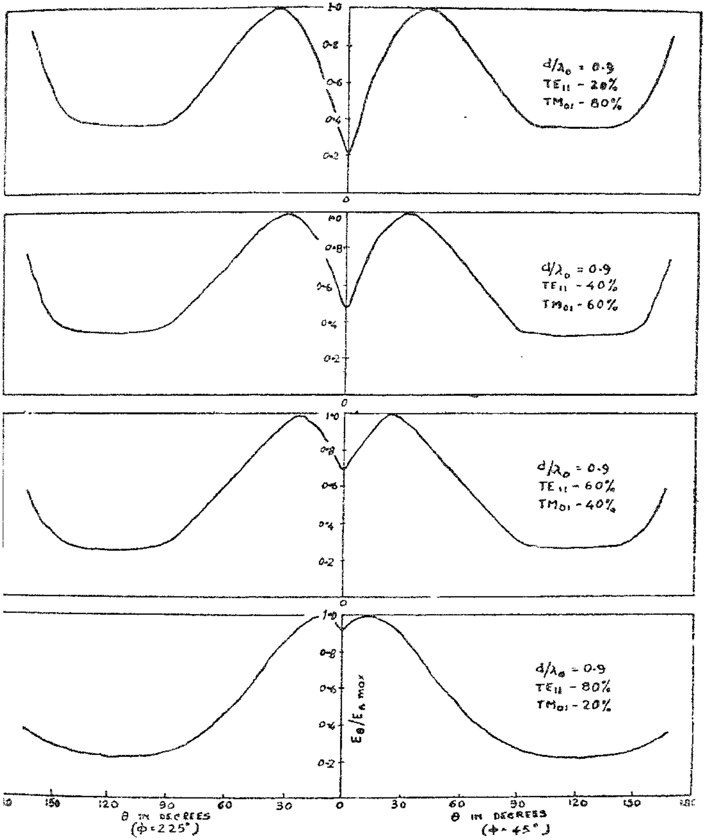

FIG. 2

Theoretical Radiation Pattern (Field, E_θ *vs* θ) of the open-ended Mode Transformer Excited in mixed TE^0_{11}—and TM^0_{01} =Modes,

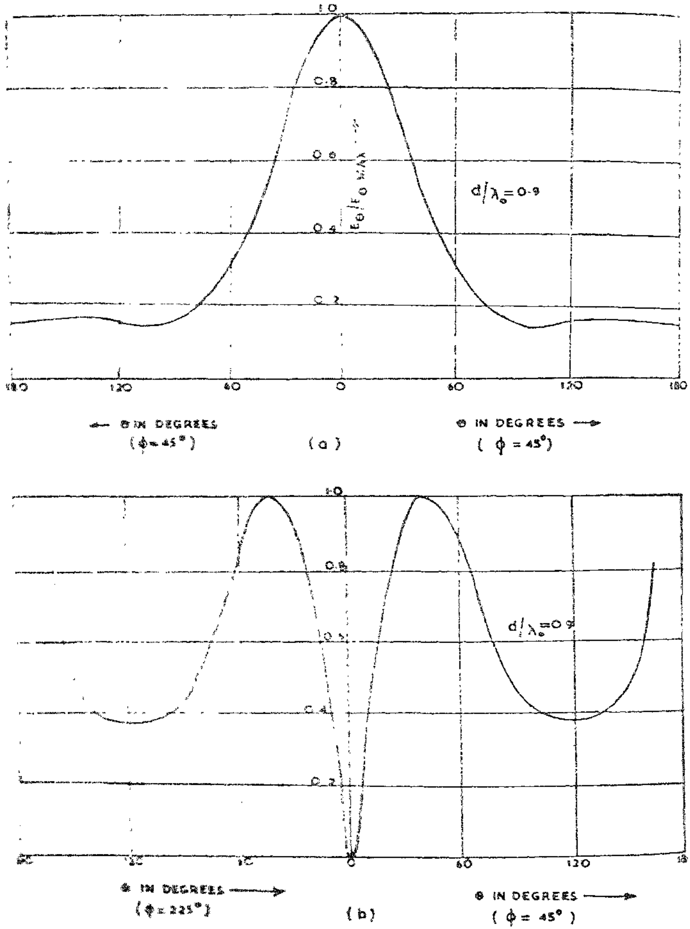

Fig. 3

a, b Theoretical Radiation Pattern (Field E_θ vs θ) TM^0_{01}—Mode Excited Waveguide

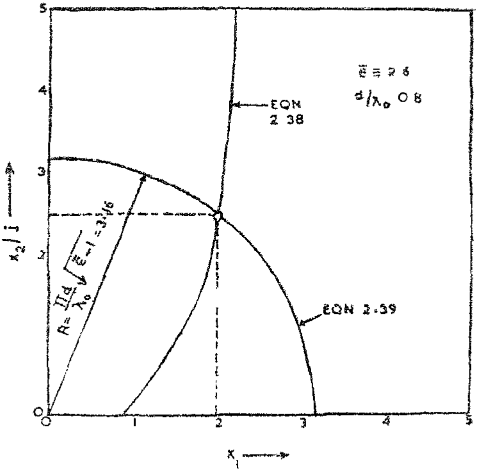

FIG. 4
Graphical Solution of the Equations 2.38 & 2.39 for the
HE^{0}_{11}—Mode in Dielectric Rod.

EXPERIMENTAL

(i) The mode transducer which is a transition from a tapered rectangular o a circular guide has been constructed, keeping in view, that $\lambda_c(H^0_{11}) = 3.41\ a$ nd $\lambda_c(E^0_{01}) = 2\ 61\ a$ A sectional dimensional sketch of the transducer which ias been designed and constructed is shown in Fig. 8. The mode transducer ias also been used with resonant filters in an attempt to suppress the domi- iant H_{11} mode. Fig. 9 shows sectional views of the resonant ring filters used nvestigations to determine an optimum resonant ring show that ring No III s the most effective in filtering the H_{11} mode. Symmetric inductive matching liaphragms have also been used in the rectangular guide and the location of he diaphragm is determined from the following relation

$$x = \frac{90^\circ - \text{arc}\ \tan |B/2|}{720^\circ} \lambda_g \qquad [20]$$

where, the susceptance B is given by the relation

$$B = -(\lambda_g/a)\ \cot^2(\pi d/a) \qquad [21]$$

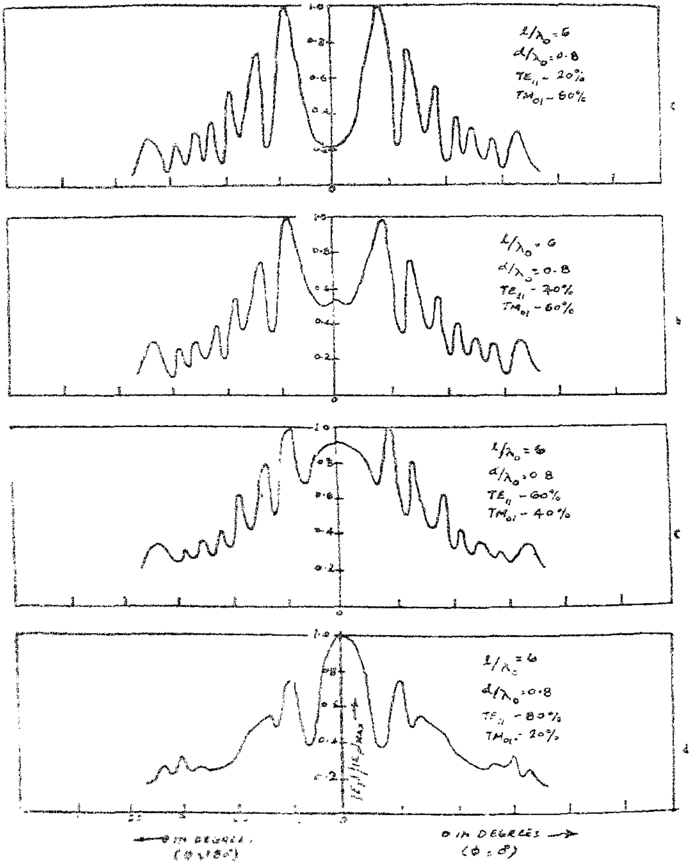

FIG. 5

Theoretical Radiation Pattern (Field, $|E_\theta|/|E_\theta|_{max}$) of the Dielectric Rod Aerial Excited in Mixed HE^0_{11}—and TM^0_{11}—Modes

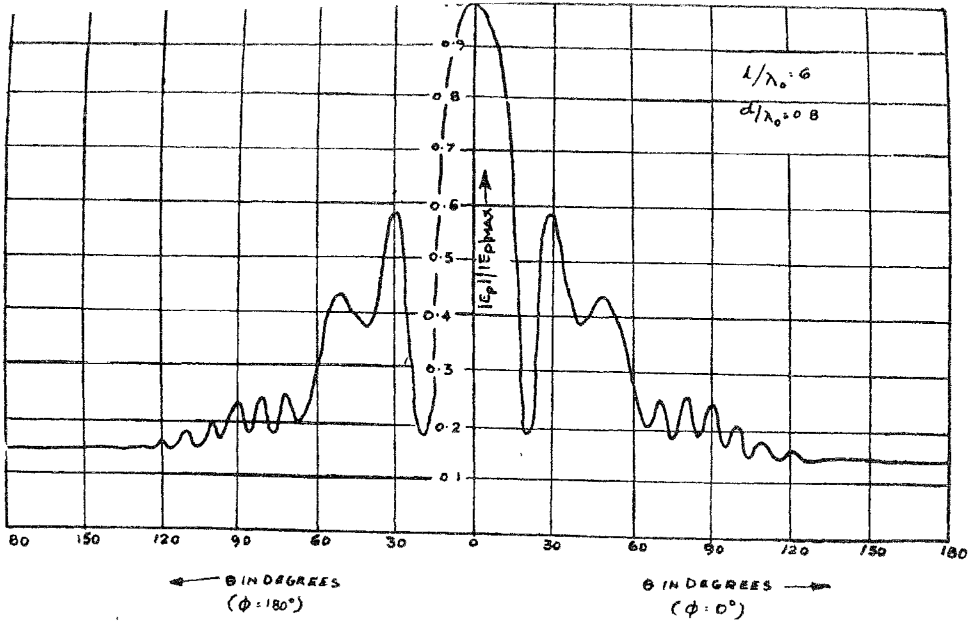

FIG. 6

Theoretical Radiation Pattern (Field $|E_\varphi|$ vs θ) of HE^0_{11}—Mode Excited Dielectric Rod Aerial.

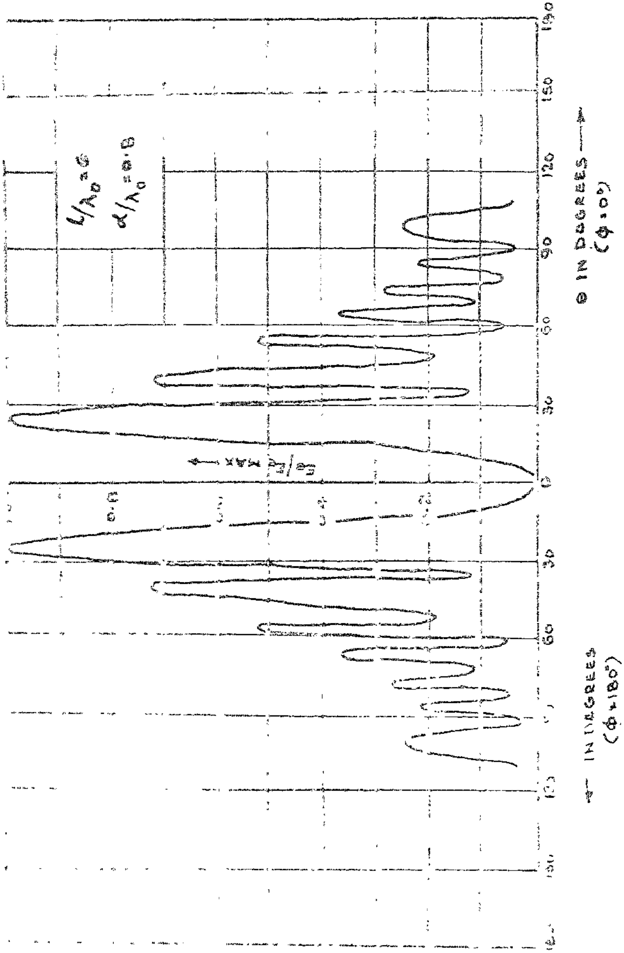

FIG. 7

Theoretical Radiation Pattern (Field, E_θ vs θ) of TM^0_{01}—Mode Excited Dielectric Rod Aerial.

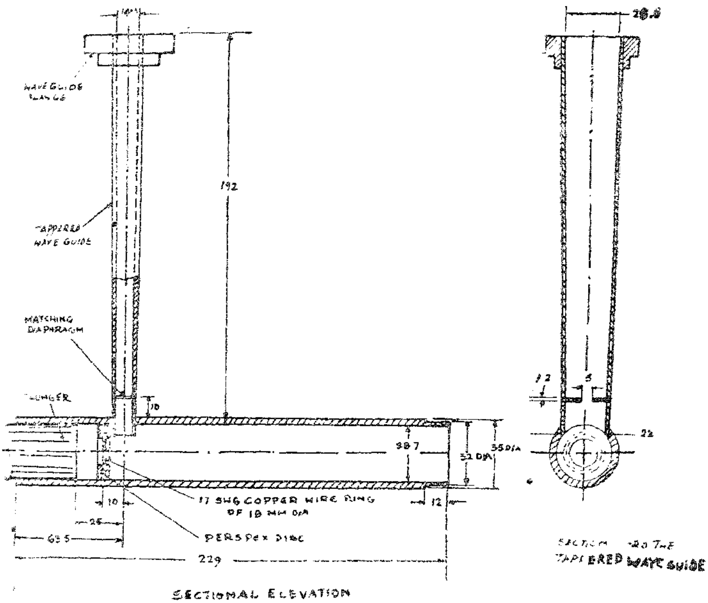

FIG. 8

Sectional Views of the $TE^{\square}_{10} - TM^{0}_{11} + TM^{0}_{01}$ Mode Transformer.

d = aperture width centered between the guide walls

a = the longer of the cross-section inside dimension of the guide

x = distance between the reflecting element and a voltage minimum

λ_g = guide wavelength of the lowest mode.

(ii) *Field distribution : Mode transducer*

The field distributions E_z vs. ρ and E_ρ vs. ρ near the mouth of the mode transducer have been determined in different planes and the results are shown in Figs. 10 & 11.

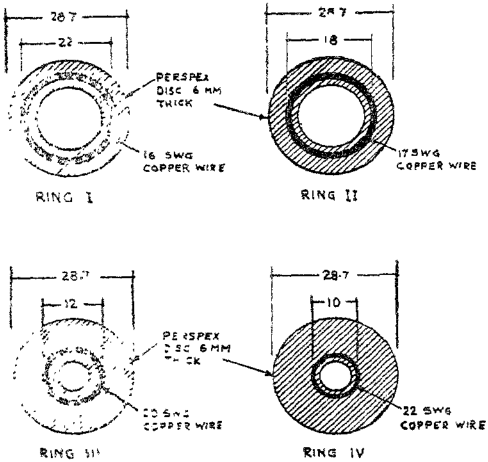

FIG. 9
Sectional views of the Resonant Ring Filters.

(iii) *Relative* [illegible] *of* E_{01} *and* H_{11} *modes in the mode transducer :*

The radial components of E_{01} and H_{11} modes at the periphery of the guide vary respectively as

$$E_\rho\,(E_{01}) = E_e \exp\{j\,[\omega t - (2\pi x/\lambda_{01})]\} \qquad [22]$$

$$E_\rho\,(H_{11}) = E_h \sin\phi \exp\{j\,[\omega t - (2\pi x/\lambda_{11})]\} \qquad [23]$$

where,

E_e, E_h = amplitudes of E_{01} and H_{11} modes respectively

x = distance along the axis

λ_{01} = guide wavelength for E_{01} mode

λ_{11} = guide wavelength for H_{11} mode

When the two modes are propagated simultaneously the radial component of the electric field is

$$E_\rho = E_e \exp\{j\,[\omega t - (2\pi x/\lambda_{01})]\} + E_h \sin\phi \exp\{j\,[\omega t - (2\pi x/\lambda_{11} + \alpha)]\} \qquad [24]$$

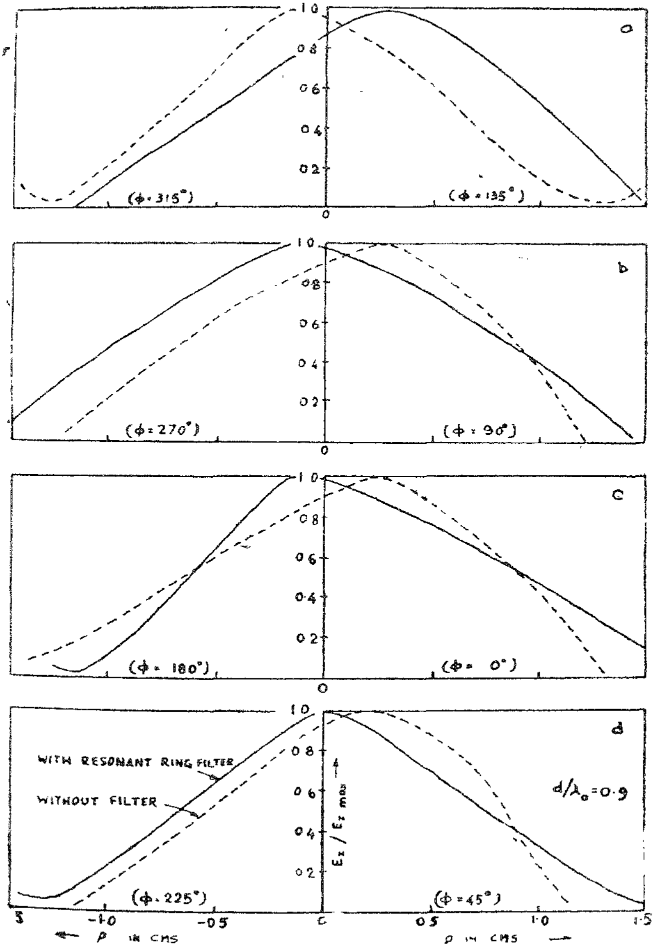

FIG 10

Observed Field Distribution (E_z vs ρ) near the mouth of the mode Transformer Excited in mixed TE^{0}_{11} and TM^{0}_{01} Modes.

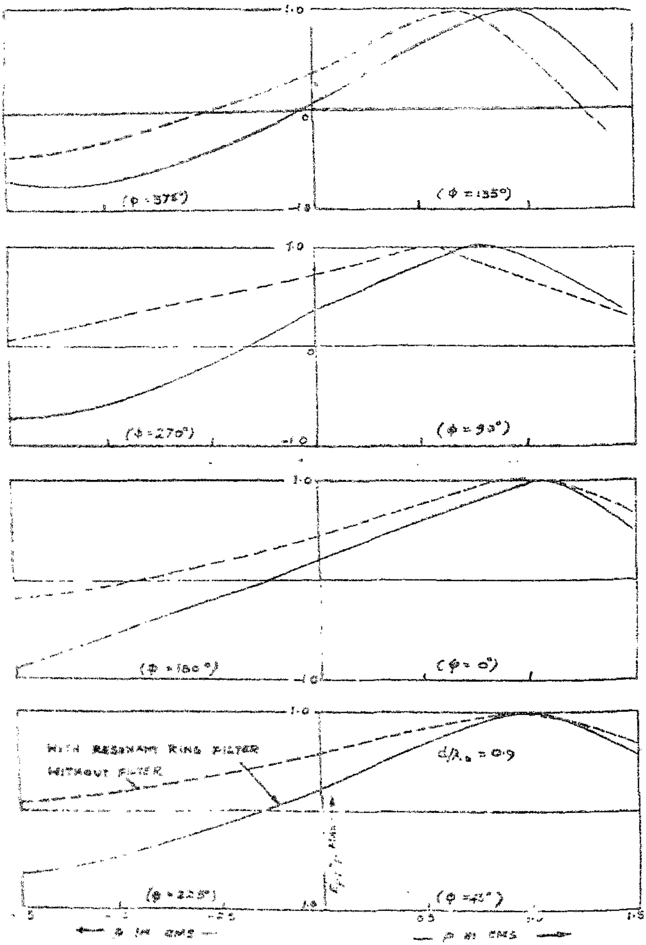

FIG. 11

Observed Field Distribution (E_ρ vs ρ) near the mouth of the Mode Transformer Excited in mixed TE^0_{11} and TM^0_{01} Modes where, α is the phase difference between the two modes at $x=0$ and $t=0$. The amplitude is

$$E_p = E_e + E_h \sin\phi \exp\{j[(2\pi x/\lambda') + \alpha]\} \quad [25]$$

where,

$$1/\lambda' = 1/\lambda_{11} - 1/\lambda_{01} \quad [26]$$

It is observed that maximum and minimum values of the field are obtained by rotating the pipe when $\exp\{j[(2\pi x/\lambda') + \alpha]\} = \pm 1$ and

$$E_{max} = E_e + E_h$$
$$E_{min} = E_e - E_h \quad [27]$$

Hence

$$(E_e/E_h) = (r+1)/(r-1)$$

where $r = E_{max}/E_{min}$. The results of measurement with resonant ring filter placed in proper location shown in Fig. 12 yields $r = 1.6$ which gives $E_e = 4.4\ E_h$, *i.e.*

$$E_{01}\ (\text{Field}) = 81.5\%$$
$$\text{and}\ H_{11}\ (\text{Field}) = 18.5\%$$

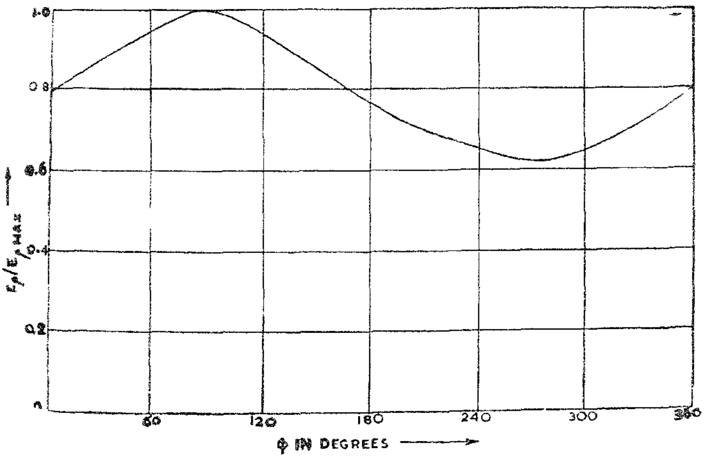

FIG. 12
Measurement of the Percentage of TM^0_{01} and TE^0_{11} Modes (Field) in the Mode Transformer.

(iv) Radiation from the open end of the mode transducer :

The radiation pattern E_θ vs. θ of the transducer in various-planes are shown in Fig. 13.

(v) Radiation pattern of the dielectric rod :

The radiation pattern of $6\lambda_0$ dielectric rod aerial excited in mixed $E_{01} + HE_{11}$ modes in various ϕ – planes are shown in Fig 14. For measuring the near field distribution and the radiation patterns standard known methods[1, 8] have been used.

DISCUSSION AND CONCLUSION

The theoretical and observed field distributions at the mouth of the transducer is shown in Fig. 15. The theoretical and experimental radiation patterns for the transducer are shown in Fig. 16. The theoretical and experimental radiation patterns for a dielectric rod ($l = 6\lambda_0$ and $d = 0.8\lambda_0$ are compared in Fig. 17.

By comparing the theoretical and observed field distributions and radiation patterns of the mode transducer, it may be concluded that there is fair agreement.

(i) in the $\phi = 45°$ and $\phi = 225°$ planes for the combination H_{11} (20%) + E_{01} (80%) when the resonant ring filter is used.

(ii) in the $\phi = 45°$ and $\phi = 225°$ planes for the combination H_{11} (60%) + E_{01} (40%) when the transducer is used without the resonant filter.

But in the case of the radiation pattern of the dielectric rod agreement between the theoretical and experimental results is not so satisfactory especially with regard to the minor lobes. The divergence is probably due to the fact that the radiation from the feed end of the rod which is due to the the discontinuity which is invariably present, has not been considered in the derivation of the radiation pattern of the rod.

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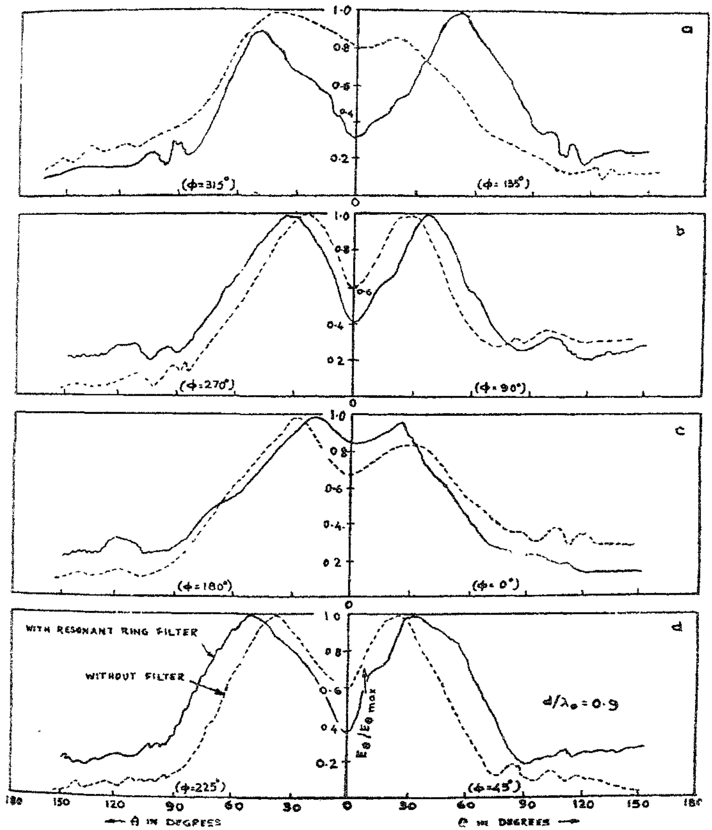

FIG. 13
Observed Radiation Pattern (Field E_θ *vs* θ) of the open-ended Mode Transformer Excited in mixed TE^0_{11} and TM^0_{01} Modes.

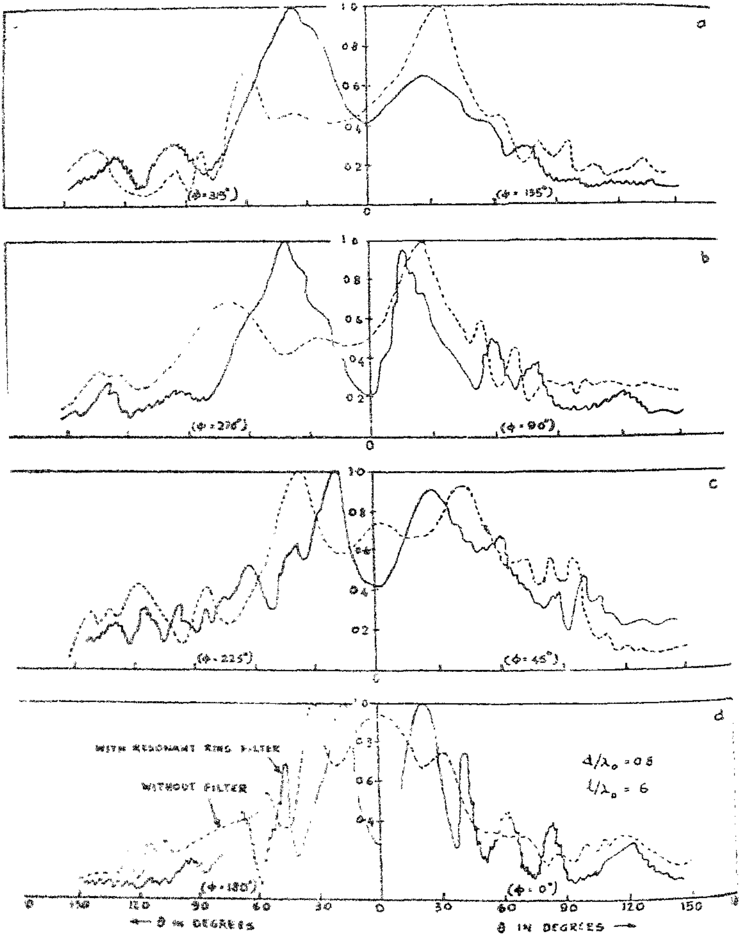

FIG. 14

Observed Radiation Pattern (Field, $|E_\theta|$ vs θ) of the Dielectric Rod Aerial Excited in mixed HE_{11}^{0}—and TM_{01}^{0}—Modes.

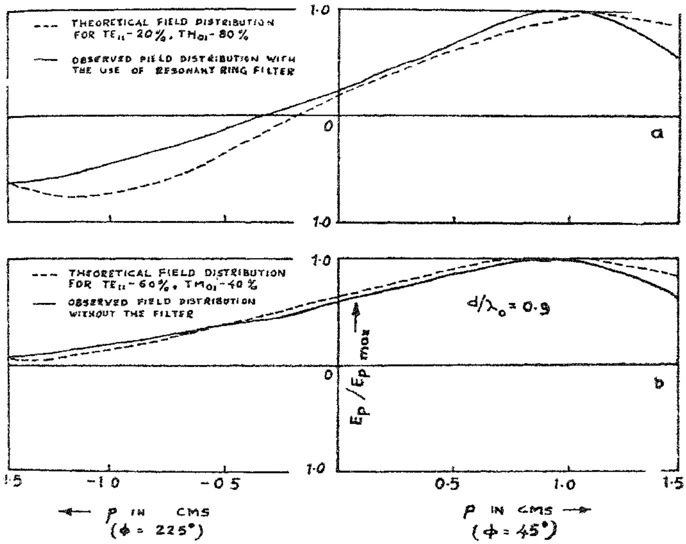

FIG. 15

Comparative study of the Theoretical and Experimental Field Distributions (E_ρ vs ρ) in the Mode Transformer.

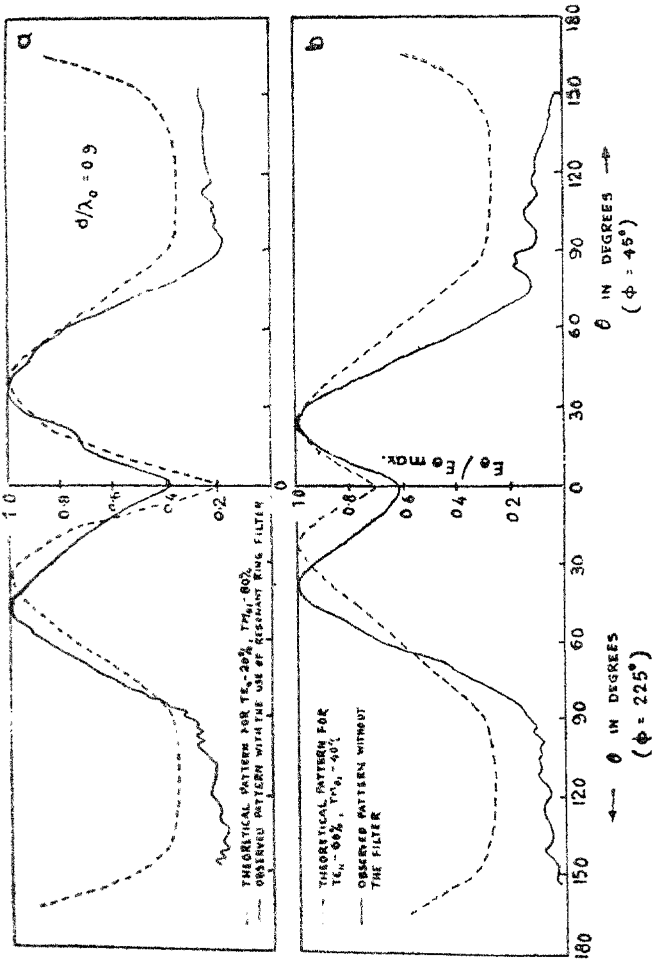

FIG. 16

Comparative study of the Theoretical and Experimental Radiation Pattern (Field E_θ vs θ) of the Mode Transformer

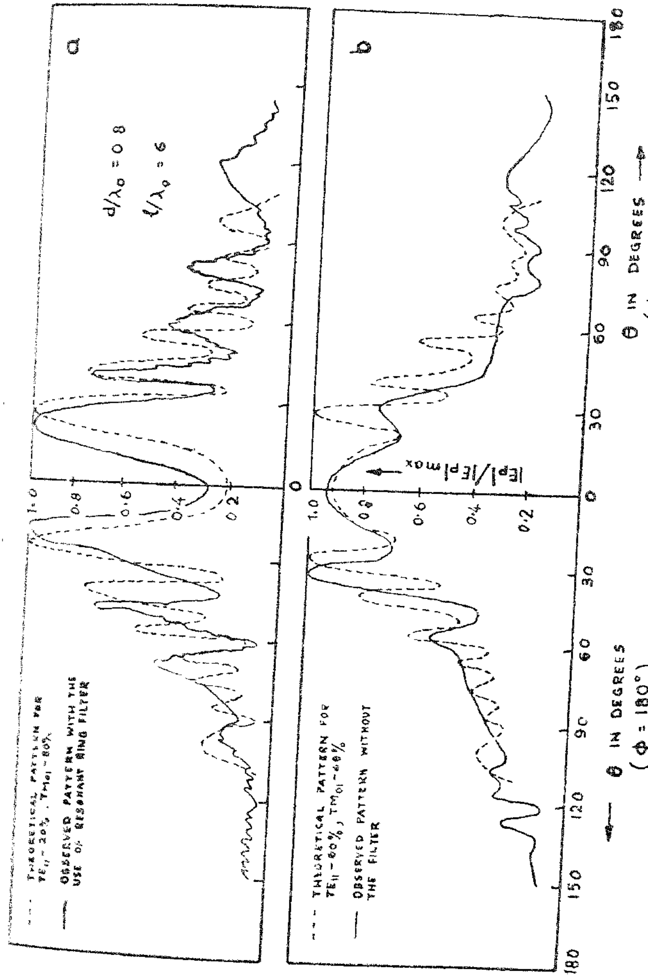

FIG. 17

Comparative study of the Theoretical and Experimental Radiation Pattern (Field E_θ vs θ) of the mode Transforme

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