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A. E. BOWEN
WAVE GUIDE PHASE SHIFTER
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2,701,344

FIG. 1

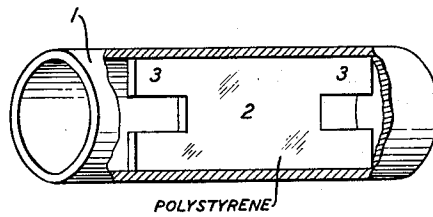


FIG. 2A

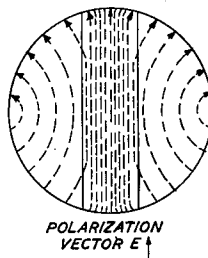
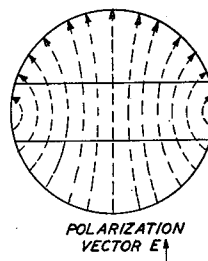


FIG. 2B



INVENTOR
A. E. BOWEN
BY
N. D. Ewing
ATTORNEY

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WAVE GUIDE PHASE SHIFTER

Arnold E. Bowen, Bloomfield, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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3 Claims. (Cl. 333—98)

This invention relates to the transmission of high frequency electromagnetic waves and more especially to wave guide phase shifters.

Wave guide phase shifters having a dielectric plate therein dimensioned and proportioned to provide a predetermined phase shift have been disclosed in the United States patent application of A. G. Fox, Serial No. 640,498, now Patent No. 2,599,753, June 10, 1952, filed concurrently herewith. In devices of this character, undesirable reflections may be set up by the dielectric plate as a result of impedance discontinuities.

A principal object of the invention is to provide an improved reflectionless wave guide phase shifter of the kind described.

In accordance with the invention applicant has provided a reflectionless wave guide phase shifter having a low loss dielectric plate therein that is shaped to provide integral impedance matching terminations.

Referring to the figures of the drawing:

Fig. 1 shows a wave guide phase shifter in accordance with the invention.

Figs. 2A and 2B show explanatory electric force diagrams in connection with the operation thereof.

Fig. 1 of the drawing shows a section of cylindrical wave guide 1 provided with an integral dielectric plate 2 of low loss, high dielectric constant material, for example polystyrene or other suitable materials such as described in the aforementioned patent application of A. G. Fox, Serial No. 640,498, now Patent No. 2,599,753, June 10, 1952, filed concurrently herewith. The longitudinal plate may extend completely across the guide in a diametral plane as shown, or it may extend only partially thereacross, to constitute an internal fin, loading the wave guide section electrically.

The electric field patterns shown in Figs. 2A and 2B show clearly that the transmission characteristics are more profoundly altered when the plate 2 is set parallel to the electric field than when it is set perpendicular thereto.

The amount of phase shift will depend primarily on the dielectric constant, the longitudinal dimension of the plate and its thickness, and secondarily, on the orientation of the plate with respect to the direction of polarization of the input dominant wave, as more fully disclosed in said United States patent application of A. G. Fox, Serial No. 640,498, now Patent No. 2,599,753, June 10, 1952.

A longitudinal loading plate or fin causes not only a change in phase velocity but also in characteristic impedance, relative to a uniform cylindrical wave guide section. An abrupt change in impedance properties between the principal guide and the phase shift section would result in undesirable and disturbing reflections.

To eliminate or to minimize reflection effects arising from impedance discontinuities, terminal portions 3 are provided on the dielectric plate integral therewith, for the purpose of establishing an impedance match and a consequent reflectionless transmission of wave energy.

The terminal portions 3 are reduced in cross section over an electrical length capable of providing a quarter wave matching transformer. The characteristic impedance K'' of the quarter wave transformer must be chosen so that $K'' = \sqrt{KK'}$, where K and K' are the characteristic impedances of the principal guide and the loaded section respectively. Correspondingly, it might be noted that the phase velocity v'' and guide wave length λ_g'' of the transformer section will be intermediate in value between v , λ_g and v' , λ_g' associated with the principal wave guide

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and the loaded section respectively. The length of the matching transformer terminal will be

$$\frac{\lambda_g''}{4}$$

The quarter wave transformer provides a perfect match at a given frequency. At adjacent frequencies, the transformer will not be a perfect match and reflections will arise. However, the reflections from the two terminations may be made to mutually cancel each other by a resonance effect, based on a suitable choice of the overall length of the loading plate 2. A fuller disclosure of how the impedance match may be made substantially perfect over a range of frequencies may be found in the United States application of W. A. Tyrrell, Serial No. 590,365, filed April 26, 1945, now Patent No. 2,546,840, March 27, 1951.

The impedance matching terminals 3 are formed by cutting a rectangular section out of the ends of the dielectric plate 2, thereby providing a U-shaped, notched portion with parallel dielectric terminals of reduced cross section. The longitudinal length of the terminals is

$$\frac{\lambda_g''}{4}$$

and the impedance of the matching section is substantially the geometric mean of the characteristic impedances of the free wave guide and the dielectrically loaded phase shifting section.

In another form of wave guide phase shifter comprising a longitudinally disposed plate of dielectric material, wave reflection is prevented or minimized by tapering the end portions of the plate over a considerable length as for example, a wave length or more. Such a phase shifter is disclosed in the United States patent applications of D. H. Ring Serial No. 640,495, now abandoned, and of N. I. Hall and C. A. Warren, Serial No. 640,496, now Patent No. 2,629,773, February 2 4,9153, both filed concurrently herewith, and in British Patent 641,227 published August 9, 1950, which corresponds to the D. H. Ring application aforementioned.

What is claimed is:

1. A reflectionless non-radiating phase shifter for providing a differential phase shift to microwaves polarized in quadrature relationship comprising a low-loss, short section of closed cylindrical wave guide, a rectangular slab of dielectric material shorter than said section and of predetermined length and thickness to provide said differential phase shift, said slab extending completely across the guide section in a diametral plane to divide the latter longitudinally into equal sections, both ends of said section being unoccupied by said slab, coplanar impedance-matching terminals integral with said slab, each terminal being of dielectric material and having a U-shaped notch therein providing parallel fingers

$$\frac{\lambda_g''}{4}$$

in length, where λ_g'' is intermediate in value between λ_g , the wavelength associated with the empty guide, and λ_g' , the wavelength associated with the loaded section, the impedance of the matching terminals being the geometric mean of the characteristic impedances of the free wave guide and the dielectrically loaded phase shifting section, said slab and section being revolvable to orient said slab angularly with respect to said quadrature polarizations.

2. Apparatus for the control of the polarization of waves in a wave guide system comprising a length of substantially cylindrical wave guide, and a plate of dielectric material disposed axially of said length of wave guide in a diametral plane thereof, said plate being of a width equal to the internal diameter of said wave guide and of a thickness substantially less than the width, said plate of dielectric providing a large wavelength modification to the component of the incident waves which is parallel to the plane of said plate and a relatively small wavelength modification to a component of the incident waves oriented perpendicularly to the plane of said plate.

3. Apparatus for the control of the polarization of waves in a wave guide system comprising a length of

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substantially cylindrical wave guide, and a plate of dielectric material disposed axially of said length of wave guide in a diametral plane thereof, said plate being of a width equal to the internal diameter of said wave guide and of a thickness substantially less than the width, said plate having notches in the axial extremities thereof of a depth of approximately one quarter of the mean wavelength of oscillations desired to be transmitted in said guide, said notches providing an approximate impedance match between the portions of said guide respectively occupied and unoccupied by said plate.

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