United States Patent

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[54] MICROSTRIP AERIALS

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[30] Foreign Application Priority Data

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[52] U.S. Cl.................................343/846, 343/708, 343/908
[51] Int. Cl. H01q 1/48
[58] Field of Search...................343/772, 776, 705, 708, 828

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Assistant Examiner—Richard E. Berger
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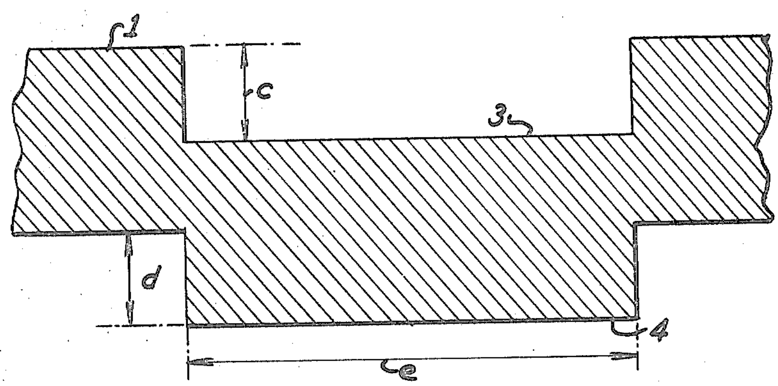
[57] ABSTRACT

A microstrip aerial having a plurality of equally spaced radiating discontinuities obtained by laterally shifting the edges of the strip.

4 Claims, 12 Drawing Figures



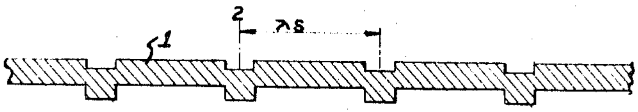


Fig.1

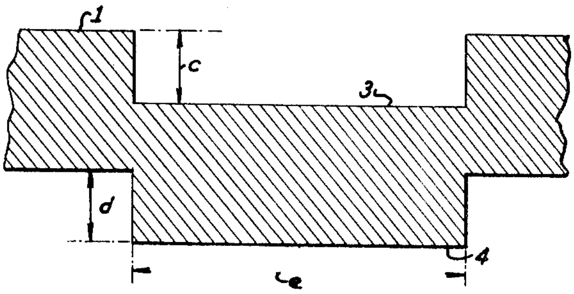


Fig.2

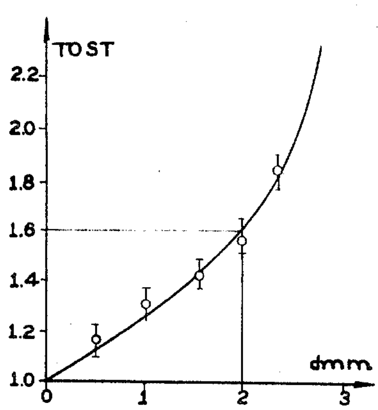


Fig.3

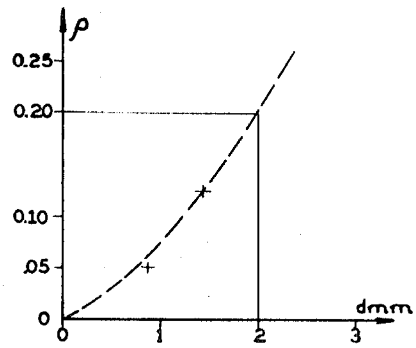


Fig.4

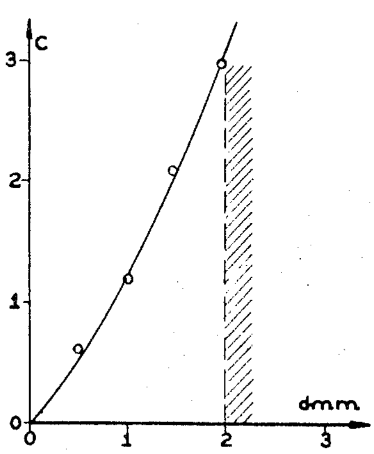


Fig.5

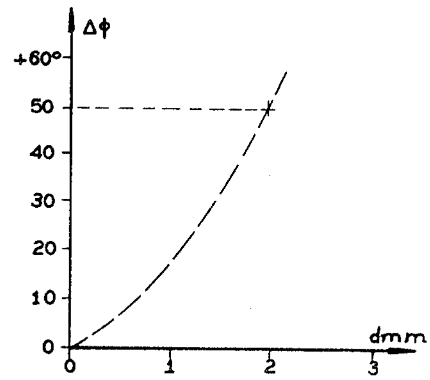


Fig.6

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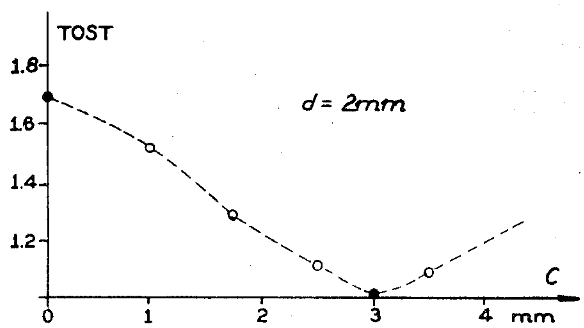

Fig-7

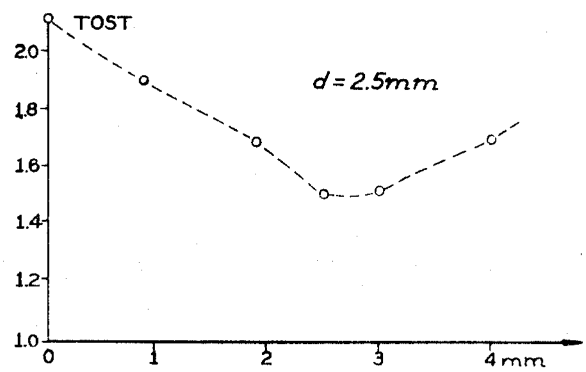

Fig-8

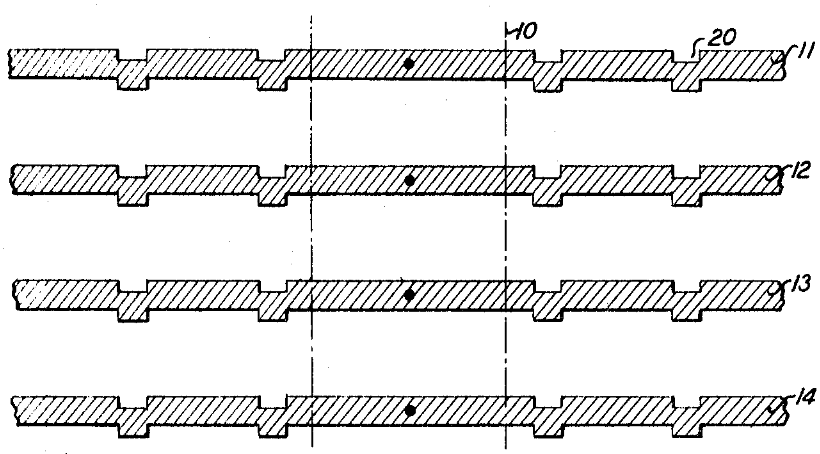

Fig-9

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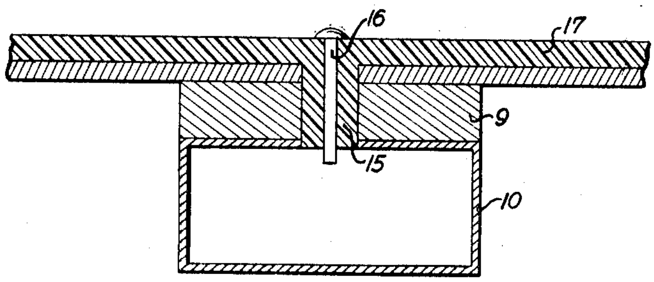

Fig. 10

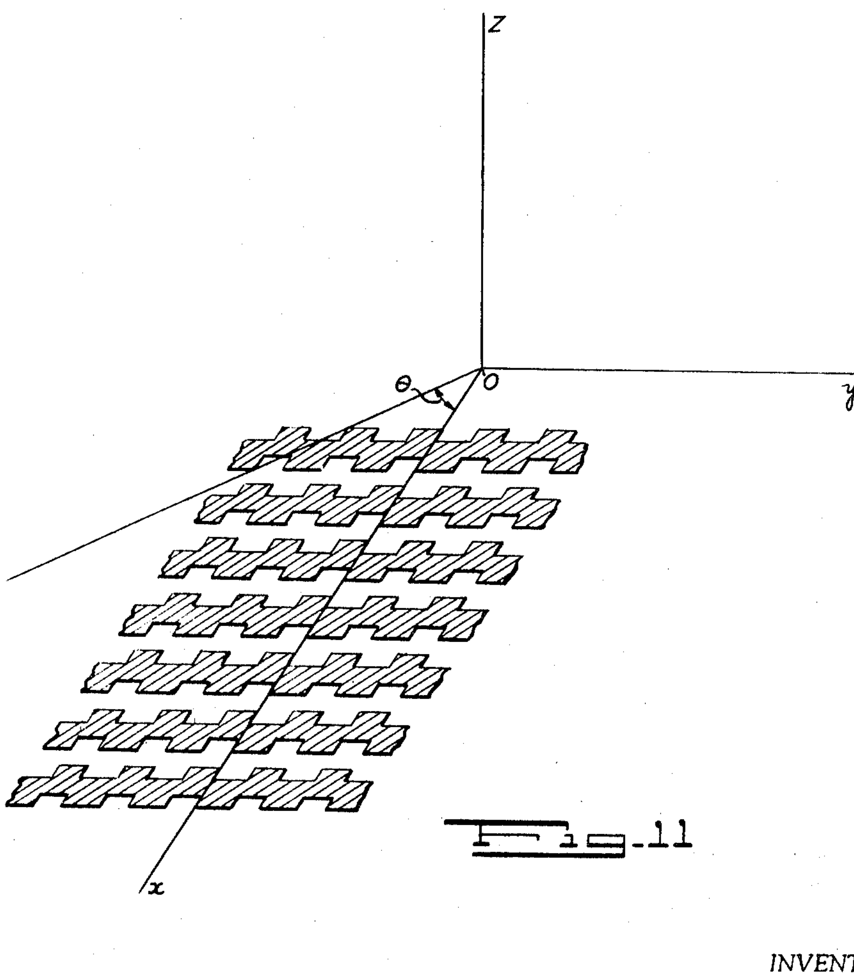

Fig. 11

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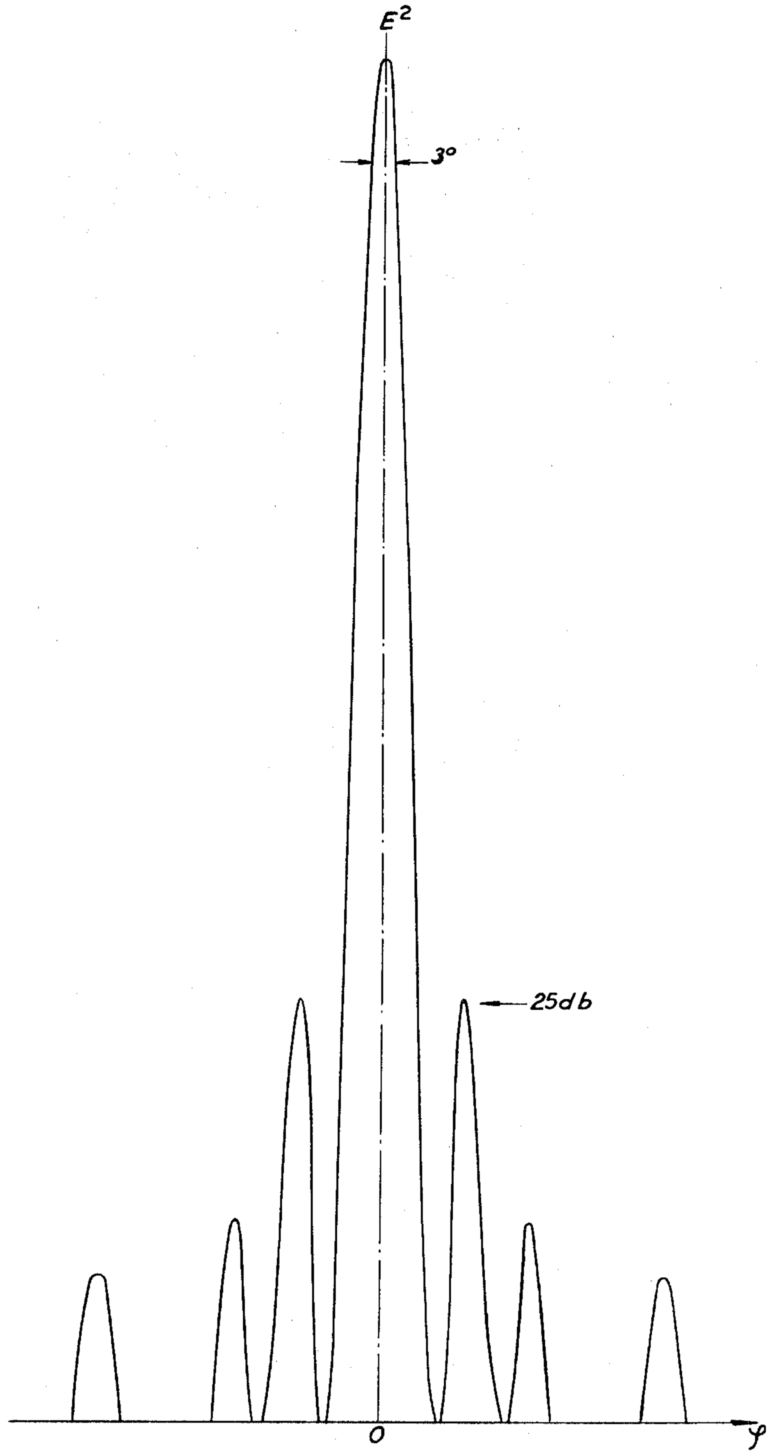

Fig. 12

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MICROSTRIP AERIALS

The present invention relates to directional aerials and more particularly to directional aerials for use in moving bodies whose aerodynamical characteristics should be affected as little as possible by the presence of the aerial.

An aerial according to the invention comprises, at least, one microstrip having a plurality of equally spaced radiating discontinuities obtained by laterally sifting the edges of the strip, thus forming laterally set off rectangular strip portions.

The invention will be best understood from the following description and appended drawing wherein:

FIG. 1 is a diagrammatic top view of the microstrip aerial according to the invention;

FIG. 2 is a detail of the aerial of FIG. 1;

FIGS. 3 to 8 are explanatory curves;

FIG. 9 is an embodiment of a directive aerial according to the invention;

FIG. 10 illustrates a cross section of the aerial of FIG. 9;

FIG. 11 is an explanatory perspective view; and

FIG. 12 is a radiating pattern of an aerial according to the invention.

In FIG. 1, a microstrip line 1 is illustrated as viewed from above, the ground plate being disposed in the plane of the figure. According to the invention this line comprises a plurality of discontinuities 2, spaced from each other by λ_s, λ_s designating the wavelength in the line of the energy propagating along the same.

As shown in FIG. 2, each discontinuity 2 is formed by laterally shifting the edges of a portion of the strip in a direction perpendicular to the longitudinal axis thereof. In FIG. 2, edge 3 is shifted by a distance c and edge 4 by a distance d.

The length l of each discontinuity is, in the embodiment shown, substantially equal to $\lambda_s/4$. The radiation factor ρ, i.e., the ratio of the radiated energy to the incident energy, varies as a function of d.

To each length d corresponds a length c for which the discontinuity is matched to the line. All discontinuities being matched to the line, the energy fed to the line propagates as a progressive wave.

The projecting strip portions radiate energy and the reentrant portions insure the matching.

FIGS. 3, 4 and 5 show curves indicating how different parameters vary as a function of d, namely: the standing wave ratio with $c=0$ (FIG. 3); the radiation factor ρ (FIG. 4), distance c with the standing wave ratio equal to 1.

FIG. 6 shows the phase shift Φ due to energy radiation as a function of d.

All these diagrams have been established for a line operating in the 10,000 Mc.-band. The line is constituted by a "rexolite" plate 1.6-mm.-thick and metallized on both faces. The strips are established according to the printed circuit techniques. The strip is 34μ thick and 4.5 mm. wide. The wavelength in such a microstrip is 19.8 mm. at 10,000 mc., and $l=\lambda s/4=5$ mm.

It appears from the diagrams of FIGS. 3 and 5 that, for $c=0$ and $d=2$, the standing wave ratio is 1.6, the radiation ratio ρ being equal to 0.2.

It will be apparent from FIG. 5 that, for each value of d less than $d=2$ mm., there is a value of c such that the standing wave ratio is made equal to 1. For d greater than 2, this correction is no longer possible. This may be clearly seen from FIGS. 7 and 8. FIG. 7 illustrates the standing wave ratio as a function of c for $d=2$ mm. It is seen that this ratio is about 1.7 for $c=0$ and equal to 1 for $c=3$.

In FIG. 8, for $d=2.5$ mm., the standing wave ratio has a minimum equal to 1.5, for $c=2.5$.

FIG. 9 illustrates a guide, which feeds a plurality of lines 11, 12, 13 and 14, each line being fed at its center. The distance between two adjacent lines is $\lambda/2$, λ being the operating wavelength. FIG. 10 shows in section how each line is coupled to guide 10. A metal plate 5 which is common to microstrips 10 and 14, is supported on a metal block 9 which rests on guide 10. A passage 15 is formed in block 9, symmetrically with respect to guide 10, for coupling strips 11 to 14 to the guide. A dielectric layer 17 rests on plate 5, the same dielectric lining passages 15. A probe 16 couples the conductive strips 1 to guide 10, probe 16 and lining 15 thus forming a coaxial cable.

The discontinuities 20 are all fed in phase; they are separated by an electrical distance l substantially equal to λ_s and given more precisely by the formula:

$$l=\lambda_s(1-\Delta\Phi/2\pi).$$

An aerial according to the invention is directional. The radiation direction is along a straight line defined by the intersection of:

a. The symmetry plane of the large side of guide 10 in which all the discontinuities are radiating in phase. This plane corresponds to plane x0z in FIG. 11, 0x being the axis of guide 10 and 0y parallel to the longitudinal axis of the strips.

b. A plane including axis 0y and making an angle θ with the axis 0x, with $\cos \theta = c./Vg.$, c being the velocity of light and Vg. the phase velocity of the wave in guide 10.

FIG. 12 shows the directive pattern obtained with an aerial according to the invention, operating at 10,000 mc., in the above defined planes. The width M of the beam at a level 3 db. below the maximum is given by the formula;

$$M=\lambda/a$$

where a is the transversal dimension of the aerial. The highest secondary lobes are 25 db. lower than the main lobe. The gain is 27 db., i.e., 2 db. above the gain given by formula:

$$G=4\pi_s\lambda^2$$

where s is the surface of the aerial.

The invention, is of course, not limited to the embodiment shown, which is given by way of example. In particular, the distance between the discontinuities could be different from λ_s. In this case the two planes respectively comprising the radiation directions would be inclined over the horizontal. The distance between the points where the strips are coupled to the guide could be separated by distance different from $\lambda/2$.

What is claimed is:

1. A microwave directional aerial comprising at least one microstrip line having a ground plate, an insulating plate and a conductive strip superimposed upon each other, said strip having edges; means for feeding to said line ultrahigh frequency energy; both edges being laterally set off in the same direction at uniformly spaced points, thus forming radiating discontinuities.

2. A microwave directional aerial comprising a plurality of parallel, equally spaced lines having a common ground plate and a common insulating plate, each line having a conductive strip, said strips having edges; means for feeding to said lines ultrahigh frequency energy; both edges of each line being laterally set off in the same direction at uniformly spaced points, thus forming radiating discontinuities.

3. A microwave directional aerial comprising a plurality of parallel equally spaced lines, having a common ground plate and a common insulating plate, each line having a conductive strip, said strips having edges; means for feeding to said lines ultrahigh frequency energy; both said edges being laterally set off in the same direction, thus forming along a predetermined length of said strips radiating discontinuities, said discontinuities being spaced apart by the length in said microstrip of the operating wave and said predetermined length being the same for all the strips.

4. A microwave directional aerial comprising a plurality of parallel equally spaced strip lines, having a common ground plate and a common insulating plate, each line having a conductive strip, said strips having edges; both said edges being laterally set off in the same direction thus forming along a predetermined length of said strips radiating discontinuities, said discontinuities being spaced apart by the length in said microstrip of the operating wave and said predetermined length being the same for all the strips; a wave guide extending normally to said strip lines, said guide having a pair of large walls, one of said walls supporting said ground plate; and probes respectively coupling said strips to said guide.