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ELECTROMAGNETIC WAVE HORN RADIATOR

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Fig. 1

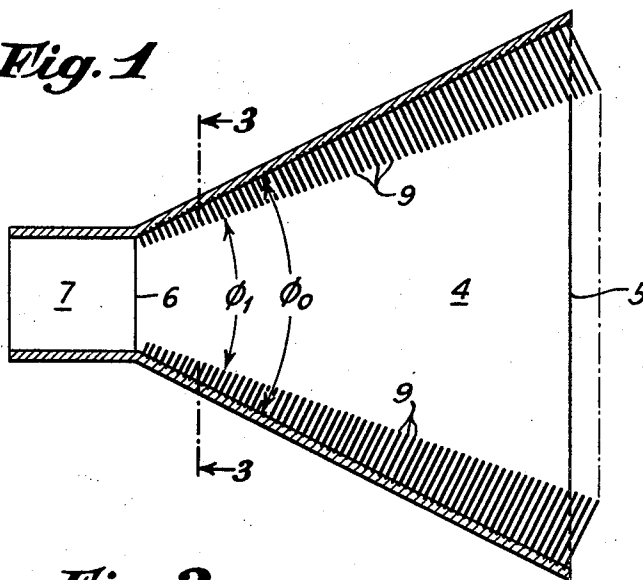


Fig. 2

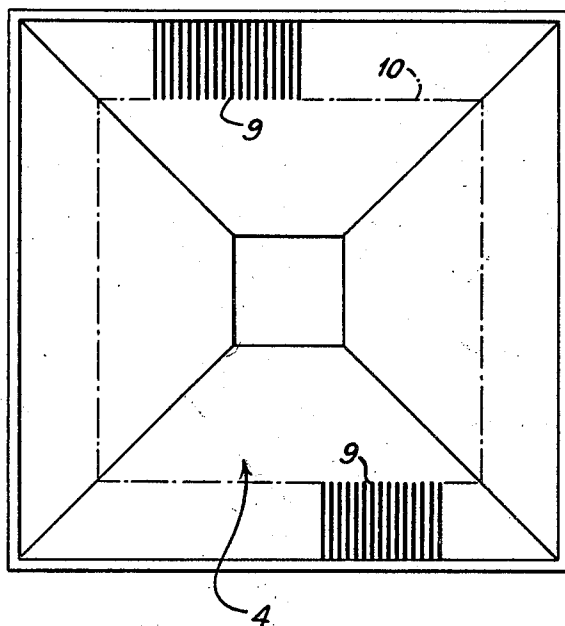
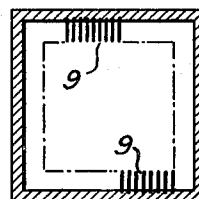


Fig. 3



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ELECTROMAGNETIC WAVE HORN
RADIATORMartin Katzin, Riverhead, N. Y., assignor to
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Application October 29, 1940, Serial No. 363,248

15 Claims. (Cl. 250-11)

The present invention relates to horn radiators for ultra short radio waves and, more particularly, to such horns adapted for duplex operation with two waves of mutually perpendicular polarizations.

An object of the present invention is to improve the efficiency of horn radiators for duplex operation.

A further object of the present invention is the provision of a horn radiator simultaneously operable with a pair of radio waves of mutually perpendicular polarizations.

Still a further object of the present invention is the provision of a horn radiator, as aforesaid, in which the electrical effective angle or flare of the sides of the horn for each wave may be independently adjusted for maximum efficiency.

In designing electromagnetic horn radiators it is desirable to utilize designs which yield optimum power gain for a given size of structure. It has been shown that pyramidal horns excited by vertically polarized, or by horizontally polarized, waves give the optimum gain for a given length of horn when the two flare angles are unequal, the flare angle being smaller in the plane of polarization, that is, in the direction of electric field than in the plane normal to it. This means that such horns will, in general, have rectangular mouths or apertures rather than square mouths. For polarization duplex operation, however, it is desirable to have power gains for the two differently polarized waves equal, thus requiring a square mouth for the radiating horn. This, of course, differs from the requirement for optimum power gains. The present invention shows how the appropriate flare angles for optimum power gain with each direction of polarization may be obtained with horns of square aperture so that it is possible to make the shape of the horn equally effective for optimum power gain with a given length of horn for each direction of polarization.

The horn proper is built with a square mouth and preferably, though not necessarily, with a square throat, the flare angles between each pair of opposite walls being made equal to the larger of the two flare angles for optimum power gain for the length of the horn used. Then fields of wires are installed inside the horn along the interior wall surfaces and perpendicular thereto so that the flare angle is effectively reduced in the plane of the wires to the smaller value of optimum flare angle.

Further features, advantages and objects of the present invention will become apparent from

the following detailed description which is accompanied by a drawing in which Figure 1 illustrates in cross-section an embodiment of the present invention, while Figure 2 shows an end view of the horn structure of Figure 1, and Figure 3 a cross-section taken along line 3-3 of Figure 1.

In Figure 1 there is shown a radiating horn structure 4 having a square mouth 5 and a throat 6 which is preferably, though not necessarily, square. To the throat 6 is connected a wave guide section 7 for the purpose of energizing the horn in the case of a transmitting structure or, in the case of a receiving structure, for conveying the received wave to suitable translating apparatus. The wave guide 7 is so energized by antennae (not shown) that vertically polarized or $H_{0,1}$ waves and horizontally polarized or $H_{1,0}$ waves are simultaneously set up therewithin. The waves set up are conveyed to horn 4 for subsequent radiation to a distant receiving location. Of course, where horn 4 is used for simultaneously receiving vertically polarized and horizontally polarized waves the wave guide 7 conveys the received energy to appropriate means for separating the differently polarized components which are then applied to receiving apparatus. Likewise, horn 4 may be used for receiving waves of one polarization and simultaneously transmitting waves of the other polarization.

The separating or combining means for the waves of different polarization and the antennae associated therewith are not shown in the drawing since the present invention does not involve these portions of the system. They are, however, shown and described in detail in my copending application, Serial No. 354,954, filed August 31, 1940, to which reference may be made for a complete disclosure thereof.

The flare angle ϕ_0 between each pair of opposite walls of the horn 4 is so related to the overall length of horn 4 that optimum gain is obtained of the radiated wave having its direction of polarization substantially parallel to parallel generatrices of planes in which said pair of opposite walls lie. The flare angle between the walls lying in planes having parallel generatrices normal to the polarization of each wave should for optimum gain be smaller than the flare angle ϕ_0 . This condition is accomplished in accordance with my invention by installing on the interior of each wall of the horn fields of perpendicular wires 9. The wires are comparatively short near the throat 6 of the horn and increase in length toward the mouth 5 so that their free ends all lie

in planes defining angle ϕ_1 . Angle ϕ_1 is so proportioned with respect to the length of horn 4 that optimum gain is obtained for waves having their direction of polarization parallel to the plane of angle ϕ_1 . In the figure I have shown as the preferred form of arrangement wires 9 arranged perpendicular to the wall to which they are attached since this represents the best compromise between the theoretical form and considerations of ease of manufacture. The best position of the wires, from the standpoint of theory only, would be along circular arcs centering on the axis of the horn within wave guide 7 at the point where the extensions of the side intersect. Since a pyramidal horn is here under consideration the lines of electric field do not lie in planes, but along circular arcs normal to the walls of the horn and for maximum efficiency the wires should be truly coincident with the lines of electric field. However, in practice, the difference between the perpendicular arrangement of straight and of arcuate wires may be neglected. It is also possible, of course, to arrange the wires in planes parallel to the plane of the mouth of the horn, if desired.

The reduction of the flare angle effected by wires 9 is effective only for the wave whose electric field is parallel to the wires since the presence of the wires does not effect an electric field at right angles to the horn. Therefore, if, for the moment, Figure 1 is considered as a vertical section of a square horn with wire fields on the top and bottom inside walls of the horn and the horn is excited with $H_{0,1}$ waves, such as generated by a vertical exciting rod giving a vertical electric field, the horizontal flare angle will be ϕ_0 while the vertical flare angle will be effectively ϕ_1 determined by the planes of the ends of wire 9. Since the wire fields on the side walls have no effect they may be considered as absent. However, since the sides of the horn are actually treated with wire fields in the same way as the top and bottom walls, the figure may be considered also as representing a horizontal section of a square horn with wire fields on only the inside walls thereof. With the horn excited with $H_{1,0}$ waves, such as generated by a horizontal exciting rod, a horizontal electric field is produced. In this case the effective vertical flare angle will be ϕ_0 while the effective horizontal flare angle will be ϕ_1 determined by the angle between the planes in which lie the ends of wires 1. It will thus be seen that a single horn constructed according to the present invention may simultaneously have an angle of opening ϕ_0 normal to the direction of the electrical field component and a smaller angle of opening ϕ_1 in the direction of the electric field component for each of a pair of mutually perpendicularly polarized waves.

Figure 2 shows an end view of the horn of Figure 1 with only a small portion of the wires 9 actually indicated in order to avoid confusing detail. The dot-dash line 10 indicates the outer ends of the planes defining the angles ϕ_1 .

In the same way Figure 3 shows a section of the horn of Figure 1 taken along line 3, 3 and indicates how the wires 9 decrease in length toward throat 6 of the horn. A pyramidal horn with all four inside walls provided with wire fields in the manner described makes it possible to fix the flare angles both vertically and horizontally for each polarization of excitation independently, as long as the angle ϕ_1 for each wave is not greater than the angle of opening ϕ_0 for the other wave. In this manner duplex polarization operation of

electromagnetic horns may be efficiently carried out.

While I have particularly shown and described several modifications of my invention, it is to be distinctly understood that my invention is not limited thereto but that improvements within the scope of the invention may be made.

I claim:

1. A tapered horn electromagnetic wave radiator having rectangular mouth and throat apertures, said horn having a predetermined rate of taper in its vertical and horizontal dimensions and means for effectively decreasing the rate of said taper in at least one dimension for a wave of a polarization substantially parallel to said dimension, said means having no effect on the rate of taper of said dimension for waves polarized at right angles to said dimension.

2. A tapered horn electromagnetic wave radiator having rectangular mouth and throat apertures, said horn having a predetermined rate of taper in its vertical and horizontal dimensions in relation to the length of said horn and means within said horn for effectively decreasing the rate of said taper in at least one dimension for a wave having a polarizing component parallel to said dimension.

3. A tapered horn electromagnetic wave radiator having rectangular mouth and throat apertures, said horn having a predetermined rate of taper in its vertical and horizontal dimensions and means for effectively decreasing the rate of said taper in at least one dimension for a wave of a polarization parallel to said dimension, said means comprising a field of wires on each of the pair of opposite walls normal to the polarization of said wave and perpendicular to said walls, the free ends of said wires lying in planes defining the angle of the decreased rate of taper.

4. A tapered horn electromagnetic wave radiator having rectangular mouth and throat apertures, said horn having a predetermined rate of taper in its vertical and horizontal dimensions and means for decreasing the rate of said taper in each dimension effective only for a wave having a polarization component parallel to said dimension, said means comprising a field of wires on each of the interior walls, said wires being substantially parallel to the direction of polarization of the wave to be affected, the inner ends of said wires lying in planes defining the angle of the decreased rate of taper.

5. A tapered horn electromagnetic wave radiator having rectangular mouth and throat apertures, said horn having a predetermined rate of taper in its vertical and horizontal dimensions and means for decreasing the rate of said taper in at least one dimension effective only for a wave having a polarization component parallel to said dimension, said means comprising a field of wires extending inwardly from each of the pair of opposite walls normal to the polarization of said wave, the free ends of said wires lying in planes defining the angle of the decreased rate of taper.

6. A tapered horn electromagnetic wave radiator having rectangular mouth and throat apertures, said horn having a predetermined rate of taper in its vertical and horizontal dimensions and means for effectively decreasing the rate of said taper in at least one dimension for a wave of a polarization parallel to said dimension, said means comprising a field of perpendicular wires on at least one pair of opposite walls having elements of the planes on which they lie normal to the polarization of said wave, the free ends of said

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wires lying in planes defining the angle of the decreased rate of taper.

7. A tapered horn electromagnetic wave radiator having rectangular mouth and throat apertures, said horn having a predetermined rate of taper in its vertical and horizontal dimensions and means for decreasing the rate of said taper in at least one dimension effective only for a wave having a polarization component parallel to said dimension, said means comprising a field of wires on the interior surface of at least one pair of opposite walls having elements of the planes on which they lie normal to the polarization of said wave, said wires being perpendicular to said planes and the inner ends of said wires lying in planes defining the angle of the decreased rate of taper.

8. A tapered horn electromagnetic wave radiator having rectangular mouth and throat apertures, said horn having a predetermined rate of taper in its vertical and horizontal dimensions and means for decreasing the rate of said taper in each dimension for waves of predetermined polarization characteristics, said means comprising a field of wires on the interior surface of each of the walls of said horn, said wires being perpendicular to the wall surface and connected thereto at one end, the other end of each of said wires lying in planes defining the angle of the decreased rate of taper.

9. A rectangular horn electromagnetic wave radiator having tapered walls, each pair of opposite walls defining an angle predetermined in relation to the length of said horn for a wave of a polarization parallel to parallel generatrices of planes in which said walls lie and means within said horn for defining a smaller effective angle between at least one pair of opposite walls for a wave of a polarization normal to parallel generatrices of planes in which said last mentioned pair of walls lie.

10. A rectangular horn electromagnetic wave radiator having tapered conductive walls, each pair of opposite walls defining a predetermined angle between planes in which said walls lie and means within said horn for defining a smaller effective angle between at least one pair of opposite walls for a wave of a polarization normal to parallel generatrices of planes in which said last mentioned pair of walls lie.

11. A rectangular horn electromagnetic wave radiator having tapered conductive walls, each pair of opposite walls defining an angle predetermined in relation to the length of said horn for a wave of a polarization parallel to parallel generatrices of planes in which said walls lie and means for defining a smaller effective angle between at least one pair of opposite walls for a wave of polarization normal to parallel generatrices of planes in which said last mentioned pair

of walls lie, said means comprising a field of wires on each of the pair of opposite walls normal to the polarization of said wave and perpendicular to the planes of said walls, the free ends of said wires lying in planes defining said smaller effective angle.

12. A rectangular horn electromagnetic wave radiator having tapered conductive walls, each pair of opposite walls defining an angle predetermined in relation to the length of said horn for a wave of a polarization parallel to parallel generatrices of planes in which said walls lie and means for defining a smaller effective angle between each pair of opposite walls for a wave of polarization normal to parallel generatrices of planes in which said last mentioned pair of walls lie, said means comprising a field of wires perpendicular to the interior surface of said walls and connected thereto at one end, the free ends of said wires lying in planes defining said smaller effective angle.

13. A rectangular horn electromagnetic wave radiator having tapered walls, each pair of opposite walls defining an angle predetermined in relation to the length of said horn for a wave of a polarization parallel to parallel generatrices of planes in which said walls lie and means for defining a smaller effective angle between at least one pair of opposite walls for a wave of a polarization normal to parallel generatrices of planes in which said last mentioned pair of walls lie, said means comprising a field of wires extending inwardly from at least one pair of opposite walls having elements of the planes in which they lie normal to the plane of polarization of said wave, the inner ends of said wires lying in planes defining said smaller effective angle.

14. A rectangular electromagnetic wave guide structure having each dimension transverse to the direction of propagation of energy along said guide so chosen as to provide an optimum transmission characteristic for waves having a polarization normal to said dimension and means within said guide for decreasing at least one of said transverse dimensions effective only for waves having a polarization component parallel to said one dimension.

15. A rectangular electromagnetic wave guide structure having each dimension transverse to the direction of propagation of energy along said guide so chosen as to provide an optimum transmission characteristic for waves having a polarization normal to said dimension and means within said guide for decreasing each of said transverse dimensions effective only for waves having a polarization component parallel to each of said dimensions, said means comprising a field of wires extending inwardly from the walls of said guide.

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