June 6, 1950 R. W. MASTERS 2,510,290

DIRECTIONAL ANTENNA

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Fig. 1

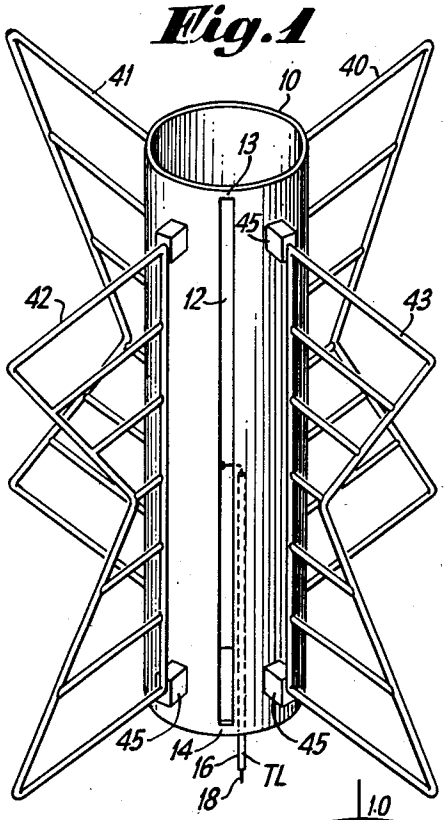


Fig. 2

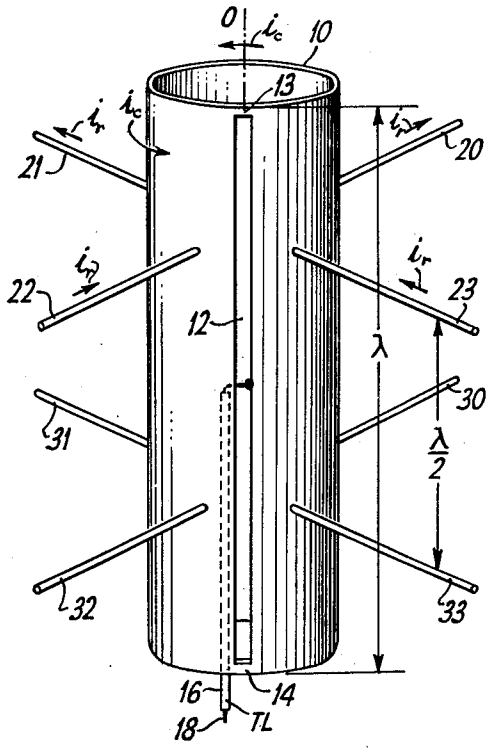
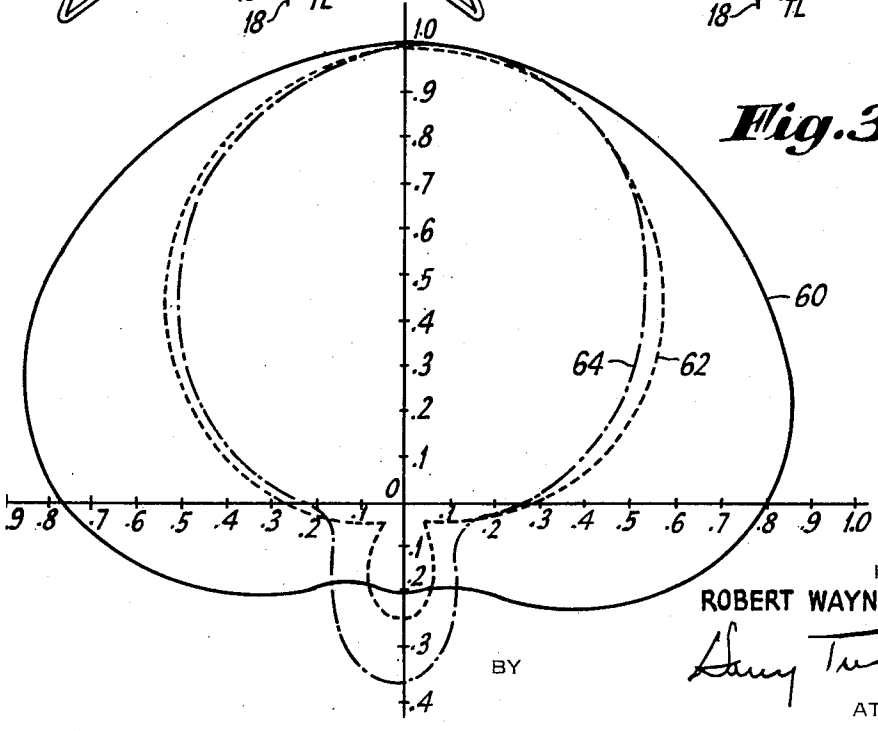


Fig. 3



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Fig. 4

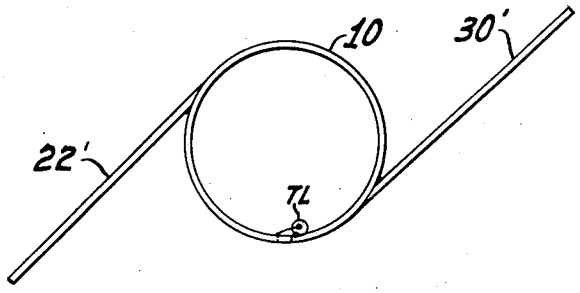
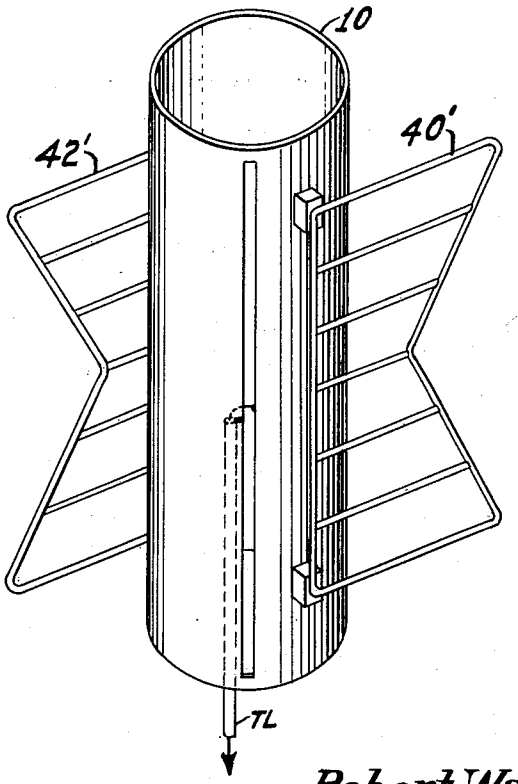


Fig. 5



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DIRECTIONAL ANTENNA

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Application June 10, 1947, Serial No. 753,781

13 Claims. (Cl. 250—33.51)

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The present invention relates to directional antennas and more particularly to directional ultra short wave antennas.

An object of the present invention is to provide an antenna which permits wide control of the horizontal radiation pattern from one which is essentially circular to an essentially uni-directional pattern over a comparatively wide frequency range.

Another object of the present invention is the provision of an antenna as aforesaid which may be installed without using phasing networks.

Another object of the present invention is the provision of a radiating unit which is in itself a complete directional antenna and which may also constitute an element of an array.

A further object of the present invention is the provision of a unit for a multi-element directional antenna system which requires only one transmission line and end-seal per bay of the antenna.

Still another object of the present invention is the provision of a slot-type antenna with supplementary radiators connected thereto for altering the radiation pattern as required.

The foregoing objects and others which may appear from the following detailed description are attained by providing an antenna in the form of a vertically disposed hollow conductive cylinder having a circumference equal to a half wavelength at the operating frequency and an overall length of the order of one wavelength. A longitudinal slot, closed at each end, is provided along the length of the cylinder. A multiplicity of radiating elements are mounted upon the cylinder arranged to extend outwardly therefrom, and electrically connected to the cylinder. The radiating elements may be adjusted in length and their peripheral position may be so chosen as to provide for tuning and pattern shaping. The radiating elements may be either in the form of simple conducting rods arranged in layers spaced a half wavelength apart or they may be current sheet radiators such as described in my prior filed application, U. S. Serial No. 580,120, filed February 28, 1945, now U. S. Patent 2,480,155 issued August 30, 1949.

The present invention will be more fully understood by reference to the following detailed description which is accompanied by a drawing in which:

Figure 1 illustrates in perspective an embodiment of the present invention, while

Figure 2 illustrates in perspective a modified form of the present invention,

Figure 3 is a family of curves illustrating various directivity patterns obtainable with the structure shown in Figure 1,

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Figure 4 illustrates in plan view a modification of the arrangement of Figure 2, and

Figure 5 illustrates in perspective a modification of the arrangement shown in Figure 1.

Referring now to Figures 1 and 2 there is shown a vertically disposed hollow conductive cylinder 10 having a longitudinal slot 12 extending from one end to the other. The extreme ends of slot 12 are closed by conductive strips 13 and 14 which may be either separate conductive strips bolted or otherwise secured into place or they may be integral portions of the conductive cylinder 10. The conductive cylinder is arranged to be coupled to suitable radiant energy transducer means, such as a transmitter, by means of a transmission line TL. The transmission line TL is preferably, but not necessarily, in the form of a coaxial transmission line having an outer sheath 16 and an inner conductor 18. The outer conductor 16 is electrically connected to the cylinder 10 along one edge of slot 12 at a point approximately midway along the length of slot 12. There, the inner conductor 18 extends across slot 12 and is connected to the opposite edge. In effect, each conductor of a two conductor transmission line is connected to one edge of slot 12. The cylinder 10 as above described, is shown in Figure 2, as having a number of conducting rods 20, 21, 22 and 23 arranged in a single horizontal plane connected to the cylinder 10 and arranged to extend outwardly from the surface of the cylinder. While I have shown the radiator rods 20 to 23 as extending radially away from the surface of the cylinder in Figs. 1 and 2, a tangential arrangement as shown in Figs. 4 and 5 may under some circumstances be used, especially if only a single pair of radiating rods is used in each horizontal plane. When thus arranged magnetic coupling between currents in the cylinder and in the radiator provides additional latitude of adjustment for pattern control. The rods may have a length of the order of a quarter of the mean operating wavelength. My invention is, however, not limted to the use of quarter wave rods, other lengths being useful in the pattern control. However, the quarter wavelength rods have been found to work well, and, in most cases, to provide sufficient radiating length to control the resultant pattern. A second layer of radiating rods 30, 31, 32 and 33 is similarly arranged about the conductive cylinder 10 with vertical spacing from the first set of radiators equal to one half of the operating wavelength. Preferably, the arrangement is symmetrical with respect

to the midpoint of the slot 12. That is, the rods 20, 21, 22 and 23 are a quarter wavelength above the midpoint of slot 12 while rods 30 to 33 inclusive are a quarter wavelength below the midway of slot 12. Such spacing results in a concentration of the radiation in the vertical plane.

Now, slotted cylinder 10 behaves as though there are very large standing waves of current and voltage about the peripheral surface. Thus, all voltages on the left side of the slot are opposite in polarity to those on the right half. The currents flow in the directions indicated by arrows i_c curving about the surface of reflector 12. In general, it will be found that, due to the short circuiting of slot 12 at the ends, the voltages across the slot are zero at the ends of cylinder 10, increasing in magnitude as the center is approached. Since the voltage across slot 12 is balanced with respect to ground, there is a vertical line on the cylinder 10 opposite the slot at which the voltage is zero. The null line at the side of the cylinder opposite slot 12 is indicated by line 0. The radiators located near the null line opposite the slot or near the ends of slot 12 will not be driven very strongly due to the low voltage. On the other hand, the radiators located near a voltage maximum, for instance near the less extreme portions of the slot in the case of a cylinder a half wave in circumference, will be driven strongly. Thus, a set of symmetrically located radiators such as those described with reference to Figure 2 may be driven with currents in the relationship indicated by the arrows i_r in the figure. The radiators 20 to 23 and 30 to 33 will radiate according to the magnitude and phase of the currents flowing in them. The separate layers, being symmetrically placed on the cylinder, will be energized in an in-phase relationship. The radiation pattern of the radially arranged rod radiators will combine with that of the vertical cylinder to obtain a radiation pattern shape which may readily be varied over very wide ranges.

If a wider band width is desired than that obtainable with the use of simple rod radiators, current sheet radiators such as described in my prior application, Serial No. 580,120, filed February 28, 1945, may be used. Such an arrangement is shown in Figure 1. The conductive cylinder and slot arrangement is the same as heretofore described, the only difference being the substitution of sheet radiator elements 40, 41, 42 and 43 for the rod radiators of Figure 2. Each sheet radiator element comprises a plurality of rod or tube members spaced from each other by a small fraction of a wavelength so that electrically each radiator acts as a continuous sheet and hereinafter the terms "sheet", "sheet radiator", "current sheet radiator" are to be construed to include the last described type of radiator element as well as those of solid form. Preferably the edges of sheet radiators 40 to 43 adjacent cylinder 10 are straight or rectilinear, while the opposite edges are given a butterfly wing formation. That is, the upper and lower edges are wider than the control portions of the sheet. Thus, as described in the above mentioned prior application, an improved directivity pattern is obtained in a vertical plane. Reference may be made to said application for a further analysis of the characteristics of the sheet radiators. The sheet radiators 40 to 43 inclusive are supported on cylinder 10 by conductive brackets 45 at the upper and lower ends of the radiators. In addition to their supporting function, the brackets 45 also serve to electrically connect the sheet radiators to the conductive cylinder 10. Thus, when the conductive cylinder 10 is electrically grounded the entire radiating structure is protected against lightning strokes.

The current sheet radiators 40 to 43 inclusive are energized primarily from the induction field surrounding the conductive cylinder 10 rather than directly by voltages existing on the surface of cylinder 10 since the supporting brackets 45 are connected to the cylinder 10 at comparatively low voltage points. Experimental field patterns obtained with the arrangement of current sheets shown in Figure 1 indicate that the elements 40 to 43 were driven in such a manner as to cause reinforcement of the field of the cylinder in a direction radially from the slot and cancellation in the opposite direction. Measurements made on an antenna arrangement such as that shown in Figure 1 indicate that the antenna is sufficiently broad band for use in television broadcasting. It is also highly effective for use as a frequency modulation broadcasting antenna. As intimated hereinbefore, the current sheet radiators need not be radially arranged with respect to the cylinder 10 but may be inclined at an angle thereto as shown in Fig. 5. Especially where but two such radiators are employed, an additional adjustment is obtained in the variation of the angle which the plane of the current sheet radiator makes with the plane passing radially through the center of cylinder 10, which adjustment may be found useful in obtaining the desired field pattern.

Figure 3 shows measured field patterns obtainable with the antenna of Figure 1 as the frequency applied thereto is varied. The current sheet radiators 40 and 30 were of a size suitable for resonance at about 60 mc. while the cylinder 10 and slot 12 were adjusted for resonance at about 82 mc. The cylinder in the embodiment tested was 23 inches in diameter. Curve 60 shows the radiation pattern shape obtained when the antenna of Figure 1 was energized at 67 mc. while curve 62 shows the radiation pattern at 80 mc. and curve 64 shows the radiation pattern at 90 mc. These curves are of course referred to the horizontal plane with the slot 12 of the radiator of Figure 1 placed at the zero point of the ordinates with the slot facing in the plus y direction.

While I have illustrated a particular embodiment of the present invention, it should be clearly understood that it is not limited thereto since many modifications may be made in the several elements employed and in their arrangement and without departing from the spirit and scope of the invention.

What is claimed is:

1. An antenna including a hollow conductive cylinder having a narrow longitudinal slot along the length thereof, means for coupling a transmission line directly across said slot, and a number of radiators arranged on and extending outwardly from the outer surface of said cylinder in a plane transverse to the axis thereof, said radiators being positioned about the periphery of said cylinder to obtain a predetermined directivity pattern.

2. An antenna including a hollow conductive cylinder having a circumference substantially equal to a half of the operating wavelength and a length of substantially one wavelength and having a longitudinal slot along the length thereof, means for coupling a transmission line directly across said slot, and a number of radiators radially arranged on and extending outwardly from the outer surface of said cylinder, said radiators being

positioned about the periphery of said cylinder to obtain a predetermined directivity pattern.

3. An antenna including a hollow conductive cylinder having a circumference substantially equal to a half of the operating wavelength and a length of substantially one wavelength, and having a longitudinal slot along the length of said cylinder, means for coupling a high frequency transducer directly across said slot, and a number of radiators arranged on and outwardly extending from the outer surface of said cylinder, said radiators being positioned about the periphery of said cylinder to obtain a predetermined directivity pattern.

4. An antenna including a hollow conductive cylinder having a circumference substantially equal to a half of the operating wavelength and a length of substantially one wavelength and having a longitudinal slot along the length of said cylinder, means for coupling a transmission line across said slot, and a number of radiators radially arranged at current maxima at the outer surface of said cylinder, said radiators being positioned about the periphery of said cylinder to obtain a predetermined directivity pattern, said radiators being in the form of spaced outwardly extending radiator elements having at least one end thereof connected to a substantially rectilinear conductor arranged parallel to the surface of said cylinder, and conductive supporting brackets at the upper and lower ends of said rectilinear conductors electrically connecting said radiators to said cylinder.

5. An antenna including a hollow conductive cylinder having a circumference substantially equal to a half of the operating wavelength and a length of substantially one wavelength and having a longitudinal slot along the length of said cylinder, means for coupling a transmission line across said slot, and a number of radiators radially arranged at predetermined points on the outer surface of said cylinder, said radiators being positioned about the periphery of said cylinder to obtain a predetermined directivity pattern, said radiators being in the form of vertically spaced outwardly extending horizontal radiator elements having at least one end thereof connected to a substantially rectilinear conductor arranged parallel to the surface of said cylinder, and conductive supporting brackets at the upper and lower ends of said rectilinear conductors electrically connecting said radiators to said cylinder.

6. An antenna including a hollow conductive cylinder having a narrow longitudinal slot along the length thereof, means for coupling high frequency transducer means directly across said slot, and a number of radiators radially arranged on and extending from the outer surface of said cylinder in a plane transverse to the axis thereof, said radiators being positioned about the periphery of said cylinder to obtain a predetermined directivity pattern.

7. An antenna including a hollow conductive cylinder having a circumference substantially equal to a half of the operating wavelength and a length of substantially one wavelength and having a longitudinal slot along the length of said cylinder, means for coupling a two conductor transmission line directly across said slot near its midpoint, and a number of radiators radially arranged on and extending from the outer surface of said cylinder, said radiators being positioned about the periphery of said cylinder to obtain a predetermined directivity pattern.

8. An antenna including a hollow conductive cylinder having a circumference substantially equal to a half of the operating wavelength and a length of substantially one wavelength and having a longitudinal slot along the length of said cylinder, means for coupling a two conductor transmission line directly across said slot near its midpoint, and a number of radiators arranged in outwardly extending relationship on the outer surface of said cylinder, said radiators being positioned about the periphery of said cylinder to obtain a predetermined directivity pattern.

9. An antenna including a hollow conductive cylinder having a circumference substantially equal to a half of the operating wavelength and a length of substantially one wavelength and having a longitudinal slot along the length of said cylinder, a two conductor transmission line across said slot having one conductor connected to each edge of said slot at substantially its midpoint, and a number of radially arranged radiators at the outer surface of said cylinder, said radiators being positioned about the periphery of said cylinder to obtain a predetermined directivity pattern, said radiators being in the form of outwardly extending rodlike radiator elements spaced apart in the direction of the axis of said cylinder and having one end thereof connected to substantially rectilinear conductor arranged parallel to the surface of said cylinder, and conductive supporting brackets at the upper and lower ends of said rectilinear conductors electrically connecting said radiators to said cylinder.

10. An antenna including a hollow conductive cylinder having a circumference substantially equal to a half of the operating wavelength and a length of substantially one wavelength and having a longitudinal slot along the length of said cylinder, a two conductor transmission line across said slot having one conductor connected to each edge of said slot at substantially its midpoint, and a number of radially arranged radiators at the outer surface of said cylinder, said radiators being positioned about the periphery of said cylinder to obtain a predetermined directivity pattern, said radiators being in the form of quarter wave rods connected at one end to the surface of said cylinder.

11. An antenna including a hollow conductive cylinder having a circumference substantially equal to a half of the operating wavelength and a length of substantially one wavelength and having a longitudinal slot along the length of said cylinder, a two conductor transmission line across said slot having one conductor connected at each edge of said slot at substantially its midpoint, and a number of radially arranged radiators at the outer surface of said cylinder, said radiators being positioned about the periphery of said cylinder to obtain a predetermined directivity pattern, said radiators being in the form of quarter wave rods connected at one end to the surface of said cylinder, said rods being arranged symmetrically in horizontal planes spaced a distance substantially equal to a quarter wavelength above and below the horizontal plane passing through said midpoint.

12. An antenna comprising a hollow conductive cylinder having a narrow longitudinal slot along the length thereof and means for coupling a transmission line across said slot to produce an induction field surrounding said cylinder, a plurality of outwardly extending radiator elements spaced in the direction of said slot and having one end thereof connected to a substantially rec-

tilinear conductor arranged parallel to the surface of said cylinder and electrically coupled to said cylinder at the upper and lower ends of said rectilinear conductors, said elements being energized by said induction field to obtain a predetermined directive radiation pattern.

13. An antenna comprising a hollow conductive cylinder having a narrow longitudinal slot along the length thereof and means for coupling a transmission line across said slot to produce an induction field surrounding said cylinder, a plurality of outwardly extending radiator elements each connected at one end to a substantially rectilinear conductor arranged parallel to the surface of said cylinder, said elements being spaced apart in the direction of the axis of said cylinder, and conductive supporting brackets electrically connecting the upper and lower ends of said rectilinear conductors to said cylinder at current maxima positions about the periphery of said cylinder, said elements being energized by said induction field to produce a predetermined directive radiation pattern.

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The following references are of record in the file of this patent:

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