

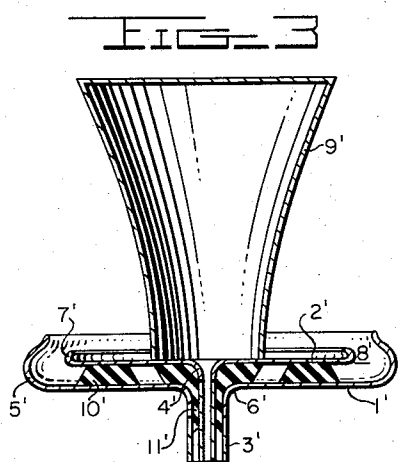
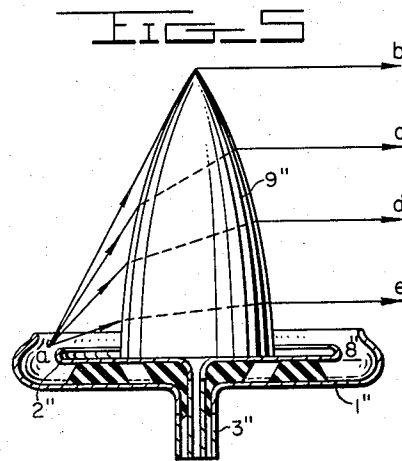
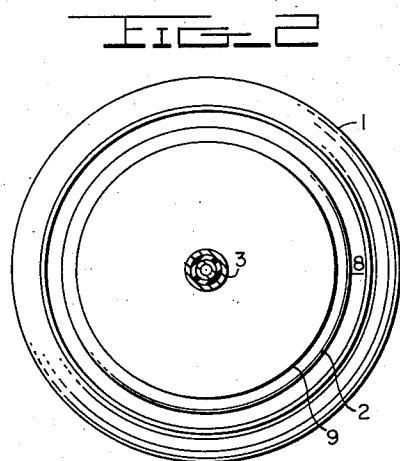
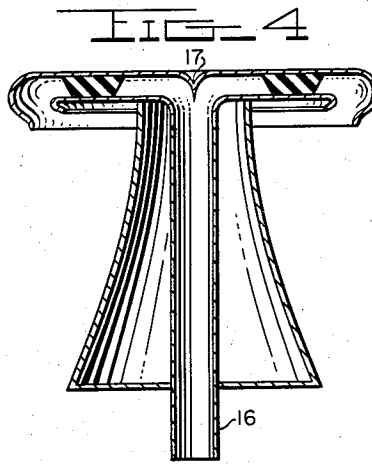
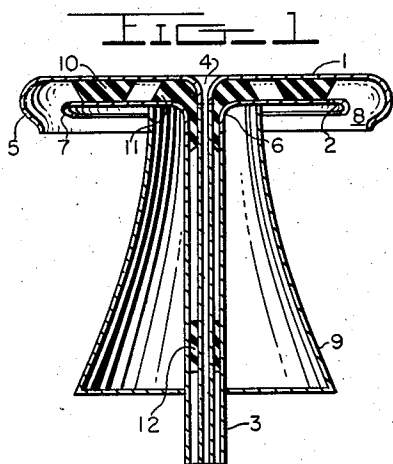
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RING SOURCE OMNIDIRECTIONAL ANTENNA

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RING SOURCE OMNIDIRECTIONAL ANTENNA

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3 Claims. (Cl. 343—753)

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The invention described herein may be manufactured and used by the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates in general to antennas and more particularly to broad band high gain antennas for use in radar and radio beacon systems operating at microwave frequencies.

There has in the past been a concerted attempt to produce a radiation pattern having omnidirectional azimuthal characteristics yet of narrow beam width in the vertical plane. Such a pattern finds utility for example in radio beacon systems where it is desirable to transmit a maximum of energy in a substantially horizontal direction proximate to the ground and in all azimuthal directions. The larger the vertical component of such energy propagation the more reduced is the desirable horizontal component. Stated differently, to achieve high energy propagation in let us say a horizontal direction it is fundamental that the propagation in the vertical direction be limited; and, as propagation in the vertical becomes more and more limited propagation in the horizontal is increased.

While it has been suggested (see for example the Chu Patent No. 2,486,589 and other patents cited therein) that a pattern of narrow beam width in the vertical plane might be achieved by devising an antenna wherein the energy would emanate from a parabolic surface of revolution, such systems have heretofore, for one reason or another, not been entirely satisfactory. One reason for the unsatisfactory operation of the prior art devices, as typified by Chu, lies in the inability to provide a well defined source and only when the source is well defined and approaches a point source will the parabola provide a linear phase front in the vertical plane.

A second problem existing in microwave frequency work involves the provision of an antenna having an omnidirectional radiation pattern and at the same time a relatively small change of impedance with frequency change. The present invention has been found to more adequately meet these two requirements than other known antenna types.

Accordingly, it is one object of this invention to provide an antenna suitable for operation over an extremely wide band of frequencies.

It is another object of this invention to provide a broad band antenna having omnidirectional characteristics.

Another object of this invention is to provide an antenna with high gain in the horizontal plane.

Another object of this invention is to provide an antenna having a radiation pattern of limited vertical height and omnidirectional characteristics.

Another object of the present invention is to provide an antenna having an extremely narrow beam width in the vertical plane.

A further object of this invention is to provide an antenna having a radiation pattern comprising parallel beams of rays in the vertical plane and of omnidirectional characteristics.

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A still further object of this invention is the provision of an antenna structure possessing great rigidity and ruggedness and yet economical to manufacture.

Other objects and features of the present invention will become apparent upon consideration of the following detailed description when taken in connection with the accompanying drawings wherein:

Fig. 1 is a cross-sectional view of an antenna structure according to one embodiment of the invention;

Fig. 2 is a view of the antenna structure as seen when looking toward the feed or ring shaped aperture of the same;

Fig. 3 is a cross-sectional view of the antenna structure showing the elements slightly reoriented;

Fig. 4 shows the antenna structure coupled to a circular waveguide; and

Fig. 5 shows still another modification of the instant invention.

The present invention constitutes a broad band antenna for use in radio beacon systems operating at ultra-high frequencies. As stated previously for such operation it is desirable to produce an energy radiation pattern having omnidirectional azimuthal characteristics yet of extremely narrow beam width in the vertical plane. As the beam width in the vertical plane is decreased energy propagation in the horizontal plane is proportionally increased. To achieve this desired radiation pattern the present invention provides an antenna structure wherein the energy to be propagated converges from a ring aperture toward a surface of revolution. The surface of revolution serves to redirect the energy and is of such a configuration that the energy appears to emanate therefrom as substantially parallel rays in the vertical plane. When the rays leave the antenna at right angles to the axis thereof maximum radiation in the horizontal plane is assured.

One modification of the invention comprises a parabolic surface of revolution for reflecting the energy leaving the ring aperture. Another modification contemplates a surface of revolution in the form of a lens to refract the rays of energy leaving the ring aperture.

Referring now to the drawings and more particularly to Fig. 1, there is shown a pair of spaced, circular, parallel plates 1 and 2. Plate 1 is provided with an intumed portion 4 near its center and a peripheral, laterally extending, flange portion 5. The inwardly turned portion 4 abuts and is secured to the inner conductor of the coaxial cable 3 and serves to introduce the energy from the coaxial cable into the medium between the parallel plates without the energy encountering any abrupt change of impedance. While the inner conductor of the coaxial cable 3 has been shown as hollow in cross-section it is understood that it could also be solid, as is probably more common. Plate 2 is likewise intumed as at 6 and abuts and is secured to the outer conductor of the coaxial cable 3. Plate 2 is also provided with a peripheral, laterally extending, flange portion 7. The flanged portions 5 and 7 define therebetween a ring shaped aperture 8 which serves to direct the energy introduced into the medium between the parallel plates toward the surface of revolution 9.

The surface 9 can be described geometrically as that surface generated by rotating a parabola $y^2=4px$ around the vertical axis. The energy leaving the ring shaped aperture 8 converges upon the parabolic surface of revolution 9 and is reflected thereby. Paraboloid 9 may be of hollow construction or may be a shaped block of wood with a metallic surface sprayed thereon. It is held in position by welding or the like or any type of mechanical fastening well known in the art.

Each of the flanged portions 5 and 7 are provided with a slightly flared lip for insuring proper directivity of the energy converging onto surface 9. For optimum

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performance the energy should illuminate substantially all of the curved surface of the parabola from its vertex to its terminated end. Further, for optimum performance the aperture 8 must not be too small nor too large. Too small an aperture will of course provide insufficient directivity to the energy and the same will spew all over, much even missing the paraboloid. Too large an aperture will result in only a segment of surface 9 being utilized. The exact width of aperture 8, will of course be dependent upon the height of the surface 9 which is to be illuminated.

Thus, the coaxial cable 3 introduces the microwave energy axially into the medium between the parallel plates and it travels to aperture 8 where it is directed toward surface 9. This surface, in the form of a parabolic surface of revolution, reflects the energy and the same is propagated out into space in all directions at substantially right angles to the axis of the antenna. The energy thus appears in the form of parallel rays of beams in the vertical or axial direction and of omnidirectional azimuthal characteristics. Since the energy leaves the antenna as parallel rays in the vertical direction, a radiation pattern of limited vertical height is achieved. The height of the surface of revolution 9 will of course determine the vertical beam width of the radiation pattern. For optimum performance this paraboloid should be of a height of at least eight wavelengths, at the lowest frequency in the operating range of the antenna. The spacing between the parallel plates, while not critical, should be something less than a half wavelength at the highest operating frequency. The radius of the parallel plates is not at all critical.

A circular insulating ring 10 is placed between the plates 1 and 2 and serves primarily as a support for plate 1. Insulator 11 is in the form of a surface of revolution and functions both as a support and as a means of insuring the symmetrical positioning of the inner conductor of coaxial cable 3 with respect to parallel plates 1 and 2. Any asymmetry of the cable with respect to these plates would distort the omnidirectional characteristics of the antenna pattern. As shown in the drawing, the side edges of the insulators 10 and 11 are tapered to reduce mismatch. The element 12 is merely the common type insulator used in coaxial cables.

While it has been found that a parabolic surface of revolution is the most desirable for the intended purpose, it should be understood that other surfaces of revolution could be used especially when radiation patterns of different vertical configuration are desired. For example, should it be desired to provide an omnidirectional pattern having a lop-sided vertical beam, for example one with an increased upward directivity, the surface 9 could readily be modified to provide the same. Again, should it be desired to have maximum radiation in a direction above or below the horizon at some prescribed angle it would be necessary only to use as the generatrix for the reflector a section of a parabola of which the line between its vertex and focus makes the desired angle with the horizontal. The exact surface necessary to provide a prescribed vertical beam pattern can be arrived at through mathematical or empirical means.

Fig. 2 shows the antenna structure when looking toward the open aperture 8. This figure has been used to merely point up the circular configuration of the elements.

Fig. 3 shows an antenna structure similar in most respects to that of Fig. 1 except for the fact that the elements thereof are slightly rearranged. In this embodiment the plates 1' and 2' are arranged to have the ring shaped aperture 8' direct the energy upwardly toward the parabolic surface of revolution 9. The paraboloid is inverted so that the energy striking it is reflected outwardly at right angles to the axis of the antenna. In the sense that the parabolic reflecting surface redirects the rays of energy to render the same parallel in the ver-

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tical plane, and at right angles to the axis of the antenna, it functions as a collimator.

In Fig. 3, the coaxial cable 3' approaches the plates 1' and 2' from a different direction. For this arrangement it is necessary to couple the outer conductor of cable 3' to plate 1' and the inner conductor to plate 2'. Except for these modifications, this antenna structure functions in the same manner as the antenna structure of Fig. 1.

Turning to Fig. 4, an antenna structure, substantially the same as that of Fig. 1, is shown coupled to a circular waveguide 16. The microwave energy is transmitted in the circular waveguide in the TM_{01} mode and is introduced axially into the medium between the parallel plates. The pointed nub 17 assists in the introduction of the energy into the medium without it encountering any abrupt change of impedance. In all other respects this antenna is the same in structure and operation as the antenna of Fig. 1.

The antenna of Fig. 5 is different from those previously described in that the energy is refracted or focused by a lens. The microwave energy being transmitted by coaxial cable 3'' is axially introduced into the medium between parallel plates 1'' and 2'' and thence travels to ring shaped aperture 8'' where it is directed toward the lens 9''. Lens 9'' is in the form of a surface of revolution aligned with and symmetrical with respect to the axis of the parallel plates; and, is preferably made of a plastic material such as polystyrene or the like.

The lens 9'' functions as a collimator in that it redirects the rays of energy leaving aperture 8'' and renders them parallel in the vertical plane. The configuration of the lens surface can be arrived at empirically and is such that all the rays leaving a point source, located at aperture 8'', have the same electrical path length. That is, the electrical path length from a to b will be equal to that from a to c , a to d , and a to e . Thus, the energy leaving the antenna in any one direction possesses a linear phase front in the vertical. It should be clear at this point that the energy converging on the surface of revolution from any one azimuthal direction will, for all practical purposes, appear to be coming from a point source.

As has been stated previously, the structure of the instant invention possesses very broad banded characteristics, considering of course the fact that its radiation pattern is of very high directivity in the vertical plane. Typically, the voltage standing wave ratio, for one of the models tested, was found to be less than 1.5 over a band from 8200-9600 megacycles.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A broad band antenna system comprising: a microwave transmission line, a pair of spaced plates centered on a common axis with the major planar surfaces of said plates in parallel planes, said transmission line being coupled to said plates to introduce microwave energy into the space between said plates, at least one of said plates having a peripheral flange portion for directing said microwave energy from said space in rays toward a portion of said common axis, and a lens means pervious to microwaves centered on said portion of said common axis for refracting said microwave energy so that said rays in any plane containing said common axis are substantially parallel.

2. A broad band antenna system comprising, a microwave transmission line, a pair of spaced plates, the major planar surfaces of said plates being parallel and centered on a common axis, said plates being coupled to said transmission line to introduce microwave energy into the space therebetween, at least one of said plates having a

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peripheral flange portion for directing said energy from said space toward a portion of said common axis, and a lens of circular cross-section and pervious to microwave energy centered on said portion of said common axis with the axis of revolution of said lens aligned with said common axis, whereby said lens refracts said microwave energy in a predetermined pattern around said common axis.

3. A broad band antenna system for microwave energy comprising: a section of coaxial transmission line, a first circular plate, a second circular plate, and a circular lens, centered in sequence along a common axis with the axis of revolution of said first and second plates, said transmission line and said lens aligned with said common axis, said coaxial line having an inner and an outer conductor, said outer conductor being terminated by con-

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nection to said first plate, said first plate having a central aperture through which said inner conductor passes, said inner conductor being terminated by connection to the center portion of said second plate, said lens consisting of a dielectric solid of revolution pervious to microwave energy connected to said second plate, and flange means connected to at least one of the peripheries of said first and second plates for directing microwave energy from the space between said plates to the surface of said lens, whereby said lens refracts said energy in a predetermined pattern around the said common axis.

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