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MICROWAVE BROADCAST ANTENNA

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FIG. 1

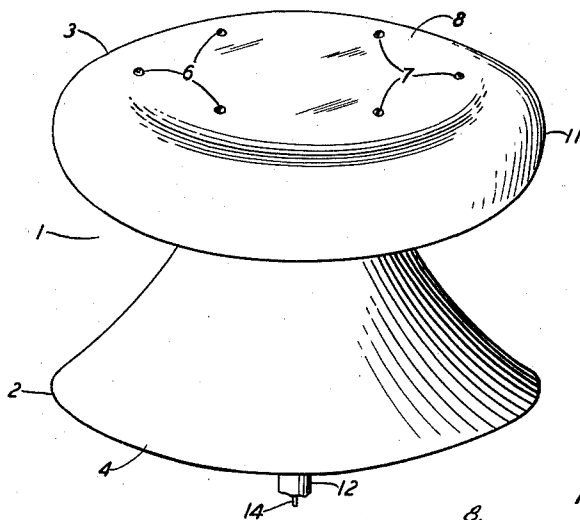


FIG. 2

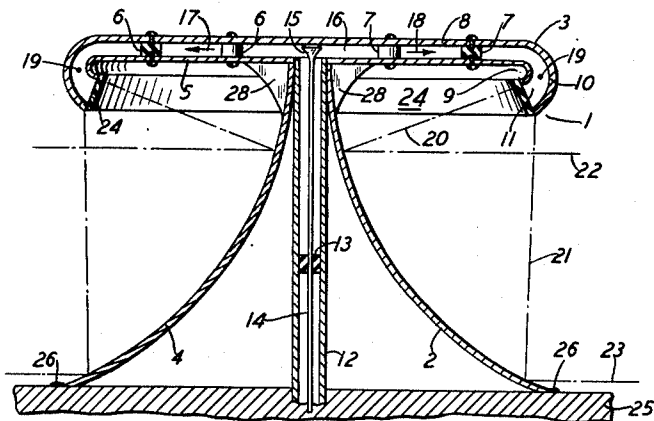


FIG. 6.



FIG. 8.

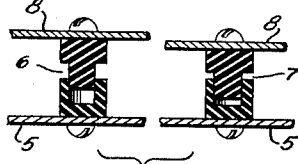


FIG. 7

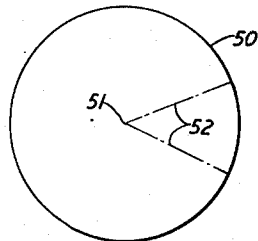


FIG. 3

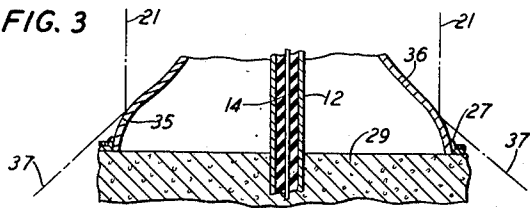


FIG. 5

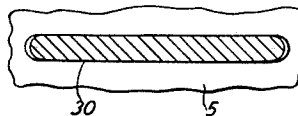
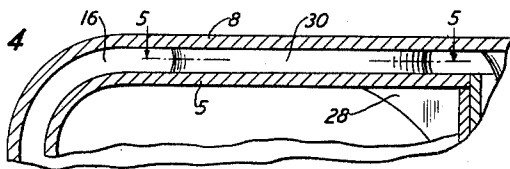


FIG. 4



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MICROWAVE BROADCAST ANTENNA

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This invention relates to microwave antennae, and particularly to a highly directive broadcast antenna system.

The use of properly directive transmitting antenna arrays has been made increasingly desirable by the extension of television, frequency modulation, and other broadcasting services into progressively higher carrier frequencies. The transmitting antenna is required to "illuminate" the desired service area efficiently. This necessitates a uniform distribution of energy throughout that portion of the horizontal plane to be included within the station coverage. Ordinarily this portion will be circular, although in certain cases a smaller sector may be appropriate. The requirement of economy of operation, and the limited amounts of power which may be generated at the frequencies involved, make it essential to obtain the maximum gain possible in the antenna system, which demands a minimum beam spread in the vertical plane.

Antenna directivity may be obtained by using an array of discrete sources such as dipoles, by a continuously distributed source, or by properly shaped reflector surfaces in combination with suitable sources.

The circular horizontal pattern, or "pancake," has frequently been obtained by the use of a dipole array. The directivity of such an array is proportional to the number of dipoles employed. The dipoles have in many cases been arranged in a co-linear self-supporting array for vertical polarization. For horizontal polarization, the "turnstile" and "folded dipole" or circular array have been successfully used. With such arrays, the number of radiating elements necessary to produce the requisite amount of vertical directivity was so large that, to give adequate strength, a central supporting structure was necessary having a cross-section of the same order of size as the dipoles themselves. This in turn led to the use of a plurality of arrays of dipoles about the supporting structure in order to get uniform horizontal illumination, and the vertical stacking of similar elements to get the required vertical directivity. The result has been that large directive antennae for broadcasting have required the arraying of the dipoles in both horizontal and vertical directions, even though the directivity was required primarily in the vertical plane only. Such arrangements require a large number of dipole elements, which are difficult to tune and to weather-proof.

The instant disclosure is concerned with an improved antenna system peculiarly suited to the

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higher frequencies, using a reflector surface properly shaped to obtain the necessary directivity in both the vertical and horizontal planes, and making the element constituting the reflector surface act also as the principal support for the system. The reflector is formed as a surface of revolution about a vertical axis. The generating curve is a parabola. Only the lower half of the toroidal paraboloid thus formed is used, and it may be modified to secure illumination in an area close to the base. The energy to be radiated is fed upwardly through the center of the structure, using a coaxial line or a wave guide, and is spread outwardly at the top. It is then directed against the reflecting surface by a retroverted annular horn, a leaky pipe, a girdle of dipoles, or equivalent device.

The mechanical problems in insulating, tuning, and supporting large dipole arrays are substantially eliminated by this compact, self-supporting system, while a substantial improvement is obtained in the electrical characteristics.

It is to be understood that the embodiments described below are illustrative only of the principles of the invention. The invention is not intended to be limited thereby, but to include all modifications and embodiments embraced within the scope of the appended claims.

This invention may be better understood by reference to the drawings, in which:

Fig. 1 is a perspective view of the antenna assembly;

Fig. 2 is a cross-sectional view of the assembly of Fig. 1;

Fig. 3 is a fragmentary sectional view of a modified form of the reflector;

Fig. 4 is a fragmentary sectional view of a modification of a portion of the embodiment of Fig. 1;

Fig. 5 is a sectional view of the embodiment of Fig. 4, taken as indicated by line 5—5 of that figure;

Fig. 6 is a schematic top view of a modification of the invention;

Fig. 7 is a graph showing the radiation pattern produced by the antenna system of the invention; and

Fig. 8 is a fragmentary cross-sectional showing, enlarged relative to Figs. 1 and 2, of an arrangement for varying the vertical dimension of the distributing chamber in the antenna assembly of the invention.

Referring now to Fig. 1 of the drawings, there is shown an antenna system, indicated generally as 1. The system 1 includes a supporting mem-

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ber 2 which carries the mushroom head 3. The outer surface of the supporting member 2 constitutes the reflector 4, while the member 2 is surmounted by an annular plate 5 which acts as the lower surface of an annular feed chamber, to be described more fully hereafter. Parallel to annular plate 5, and supported concentrically above it by conventional means such as symmetrically spaced insulating bushings 6 and 7, is disposed a circular plate 8, which acts as the upper surface of the annular feed chamber. About the peripheries of plates 5 and 8, and formed integrally therewith, are disposed curved annular members 9 and 10, respectively, retroverted downwardly toward the reflector 4 and cooperating to form an annular horn 11 directed toward the reflector. Circular plate 8, and the curved annular member 10 joined peripherally thereto, together constitute the external portion of the mushroom head 3.

The supporting member 2 has a feed member, here shown as a coaxial line 12, extending upwardly centrally thereof. Within line 12, any conventional means, such as insulating washers 13, may be used to maintain the concentric spacing of a central conductor 14. Another type of coaxial line is shown in Fig. 3, in which a solid dielectric is used throughout to support the central conductor.

Central conductor 14 of the coaxial line 12 terminates in a reflecting knob 15 shaped as shown in Fig. 2 to insure proper impedance matching and to direct energy fed through line 12 outwardly uniformly in a horizontal sheet through the cylindrical chamber 16 defined by annular plate 5 and circular plate 8, as indicated by arrows 17 and 18.

At the periphery of the cylindrical chamber 16, the radiations are delivered to the retroverted annular horn 11, and thence to the reflector 4. Horn 11 is so shaped that, examining any diametral section such as that of Fig. 2, the energy delivered from the horn to the reflector may be considered as originating in a point source 19 substantially coincident with the focus of the parabola defining the reflector surface 4. The locus of the parabolic foci for all rotational positions of the parabolic generating curve is called the "focal ring," or "ring focus" of the reflector surface, and the entire energy delivered to the horn may be considered as originating, relative to the reflector, at the focal ring. The energy is radiated toward reflector 4 as indicated roughly by the dot-and-dash lines 20 and 21, and reflected in a substantially horizontal sheet as indicated by dot-and-dash lines 22 and 23. The ratio between the aperture of horn 11 and the length of reflector 4 included between lines 20 and 21 may conveniently be about one to ten, but it will be obvious that this ratio may be varied as desired. The horn may be open, or may be closed by a window 24 of such material and thickness that it presents no obstacle to the passage of the radiations, while preventing the entry of dirt, rain, or other undesired matter. In cases where the window 24 is of adequate strength, it may be used to support the external portion of the mushroom head 3, and the other supporting means shown may be eliminated.

The radiated energy travels with uniform distribution toward the horizon after leaving reflector 4. This distribution is obtained because microwaves follow the line of sight, and because of the well understood geometrical principle that radiations from the focus toward a parabola are

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reflected parallel to the parabolic axis. Thus the desired result, uniform horizontal distribution plus high gain due to improve selectivity in the vertical plane, is obtained. It will also be apparent that the toroidal wave front produced by the annular horn is converted into a substantially cylindrical wave front by the parabolic reflector.

The assembly may be fixed to a metal base plate 25 by a peripheral weld 26, as seen in Fig. 2, by brackets 27 bolted to a base structure 29 and secured peripherally to the supporting and reflecting member 2, as seen in Fig. 3, or by other equivalent means.

Rigidity between the supporting member 2 and the mushroom top 3 may be insured by adding webs 28 extending radially therebetween. Similarly radial fins, not shown, might be used within the support member 2.

Separation between the walls of the cylindrical chamber 16 may be accomplished by means other than the insulating bushings 6 and 7. For example, suitably secured metal fins 39 radially disposed between annular plate 5 and circular plate 8 may be used, as seen in Figs. 4 and 5.

When it is desired to secure a distribution of the broadcast energy in the vertical plane differing from that indicated in Fig. 2, the form of the support member 2 and reflector surface 4 may be changed as indicated in Fig. 3. This figure shows how part of the radiated energy may be directed into the area immediately surrounding the base of the antenna support, by modifying the parabolic nature of the generating curve near the outer periphery of the base. The outer peripheral portion 35 is reversely curved downwardly, giving the reflector 36 a shape similar to that of the lower portion of an hour-glass. The peripheral radiations from annular horn 11, as indicated by line 21 of Fig. 2, will in Fig. 3 be reflected downwardly below the horizon as indicated by dot-and-dash line 37.

A directional distribution in the horizontal plane may be obtained by the use of a suitable mechanism, for varying the vertical dimension of the distributing chamber selectively. For example, the supporting bushings may be made adjustable in height, and the height of bushings 6 may be increased, and that of bushings 7 correspondingly decreased, about a diameter of chamber 16 normal to the direction in which an increased proportion of the radiated energy is to be transmitted as illustrated in Fig. 8.

Another arrangement for obtaining a directional pattern uses only a sector of the cylindrical chamber, annular feed horn, and reflecting surface. Such an embodiment is shown in schematic top view in Fig. 6, where the sectoral unit 40 includes the mushroom head sector 43 surmounting the reflector sector 44.

The normal "pancake" radiation pattern produced by the array of Fig. 1 is shown at 50 in Fig. 7, assuming the antenna 1 to be located at the center 51. With the sector feed system of Fig. 6, the radiated energy is largely included within the sector indicated by the dot-and-dash lines 52.

From the above description, it will be apparent that the invention provides a simple microwave antenna structure, which is free from the mechanical and electrical difficulties of construction and maintenance found in the prior art, and is adapted to produce a uniform or selectively directional radiation pattern in the horizontal

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plane, while being sharply directional vertically.

What is claimed is:

1. A unitarily formed radiating system for electromagnetic radiations, comprising a supporting member having a directional reflecting surface defined thereon by a portion of a parabola rotated about a vertically disposed directrix, a feed line disposed within said member, an expanding chamber communicating with said feed line, and an annular horn formed peripherally about and merging with said chamber and turned terminally inward toward said reflector surface.

2. A unitarily formed radiating system for electromagnetic vibrations, comprising a supporting member having a reflecting surface thereon defined by the rotation about a substantially vertical directrix of a parabola, an annular horn arranged to deliver radiations toward said reflecting surface and disposed substantially coincident with the focal ring of said member, a feed line disposed about said vertical axis within said system, and an impedance matching chamber disposed between said feed line and said annular horn.

3. A directional radiating system for vibrations of frequencies having substantially rectilinear propagation characteristics, comprising a supporting and reflecting member having a surface defined by the lower portion of a parabola of revolution truncated near its vertex, a feed line disposed within said reflector member, a cylindrical chamber communicating with said feed line, and an annular horn communicating with said chamber and arranged to direct radiations against said reflecting surface.

4. A directional radiating system comprising a concave supporting and reflecting member, a feed line extending upwardly within said member, an annular chamber fixed on said member and communicating with said feed line, and an annular horn formed co-terminally with said annular chamber and curved to direct radiations therefrom against said reflecting member.

5. A directional radiating system, comprising a skirt having a surface defined by the rotation about a vertically disposed directrix of a truncated parabola, a feed line disposed substantially vertically within said skirt and secured thereto, a circular feed chamber connected to said feed line, an annular horn communicating with said feed chamber and arranged to direct radiations against said skirt, and means for limiting in azimuth the distribution of radiations within said feed chamber and against said skirt.

6. A microwave antenna system, comprising a self-supporting reflecting member defined by rotating a truncated parabola about a vertical directrix, a ring-shaped horn supported on and arranged to be fed centrally through said reflecting member and being retroverted to direct radiations from said horn focally against said reflector, whereby a toroidal wave front from said horn is converted to a substantially cylindrical wave front from said reflector.

7. A microwave transmitting antenna system comprising a self-supporting reflecting surface generated by the rotation of a parabola about a vertical directrix, a coaxial line vertically disposed within said reflecting surface, an annular chamber concentrically disposed terminally about said coaxial line, a reversely curved annular throat formed circumferentially about said concentric chamber and so terminated as to direct radiations therefrom against said reflecting surface, and means disposed at the junction of

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said coaxial line and said annular chamber for producing a desired distribution of energy from said coaxial line through said chamber.

8. In a microwave antenna system, a combination of a central feed, an annular chamber arranged to receive energy from said feed, a ring-shaped horn arranged to receive energy from said chamber, and a truncated parabolic member formed by the rotation of a portion of a parabola about a directrix substantially coincident with said central feed, said member being arranged to reflect radiation directed thereagainst by said horn in an omnidirectional horizontal beam having an exceedingly narrow vertical plane width.

9. A self-supporting antenna structure for microwave transmission comprising a reflecting surface defined by the rotation of a portion of a parabola about a directrix normal to its axis and displaced from the focus thereof, a supporting skirt formed by modifying the lower portion of said surface, a coaxial line disposed vertically within said reflecting surface and formed integrally with the upper portion thereof, an annular chamber communicating with said coaxial line and having the lower boundary thereof secured integrally with said coaxial line and said upper portion of the reflecting surface, and a ring-shaped horn merging circumferentially with said annular chamber and retroverted toward said surface.

10. A directional radiating system for vibrations of frequencies having substantially rectilinear propagation characteristics, comprising a supporting and reflecting member having a surface defined by the rotation about a vertical axis of a parabola and shaped to reflect horizontally all radiations incident thereagainst from the focal ring of said member, a feed line disposed axially within said surface, means connected to said feed line arranged to direct radiations outward radially therefrom, and annular means encompassing the focal ring of said reflecting member for directing said radiations back toward said reflecting member from said focal ring.

11. A directional radiating system for vibrations of frequencies having substantially rectilinear propagation characteristics, comprising a supporting and reflecting member having a surface defined by the rotation about a vertical axis of a parabola and arranged to reflect horizontally radiations incident thereagainst from the focal ring of said member, a feed line disposed axially of said member, means communicating with said feed line for directing radiations radially outward therefrom, an annular horn communicating with said means and retroverted toward said reflecting member and including the focal ring of said member, and means for limiting the distribution in azimuth of radiations from said feed line, horn and reflecting member.

12. A directional radiation system for electromagnetic vibrations of frequencies having substantially rectilinear propagation characteristics, comprising a supporting member shaped to constitute a reflecting surface defined by the revolution about a vertical directrix of a portion of a substantially parabolic curve, a feed line disposed axially of said supporting member, energy-directing means communicating with said feed line and extending radially outward therefrom, and an annular horn communicating with said energy-directing means and retroverted toward

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said reflecting surface and including therewith-
in the ring focus of said reflecting surface.

13. In a microwave transmitting antenna system, the combination of a reflecting member defined by the rotation about a vertical axis parallel to the directrix of a parabola and arranged to act as the support for said system, a feed line disposed within said reflecting member, a distributing chamber communicating with said feed line, and an annular horn including the ring focus of said member joined to said distributing chamber and retroverted toward said reflecting member.

14. In a microwave transmitting antenna system, the combination of a supporting member having a reflecting surface defined by the rotation about a vertical axis parallel to, and displaced from the directrix of a parabolic curve, a feed line disposed about said vertical axis, a distributing chamber arranged to receive radiations from said feed line and direct said radiations radially outward, and an annular horn connected to said distributing chamber retroverted to enclose the ring focus of said parabolic

curve and direct therefrom against said reflecting surface radiations received from said feed line through said distributing chamber.

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