

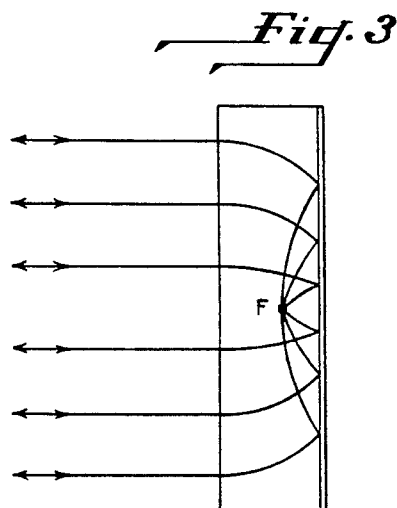
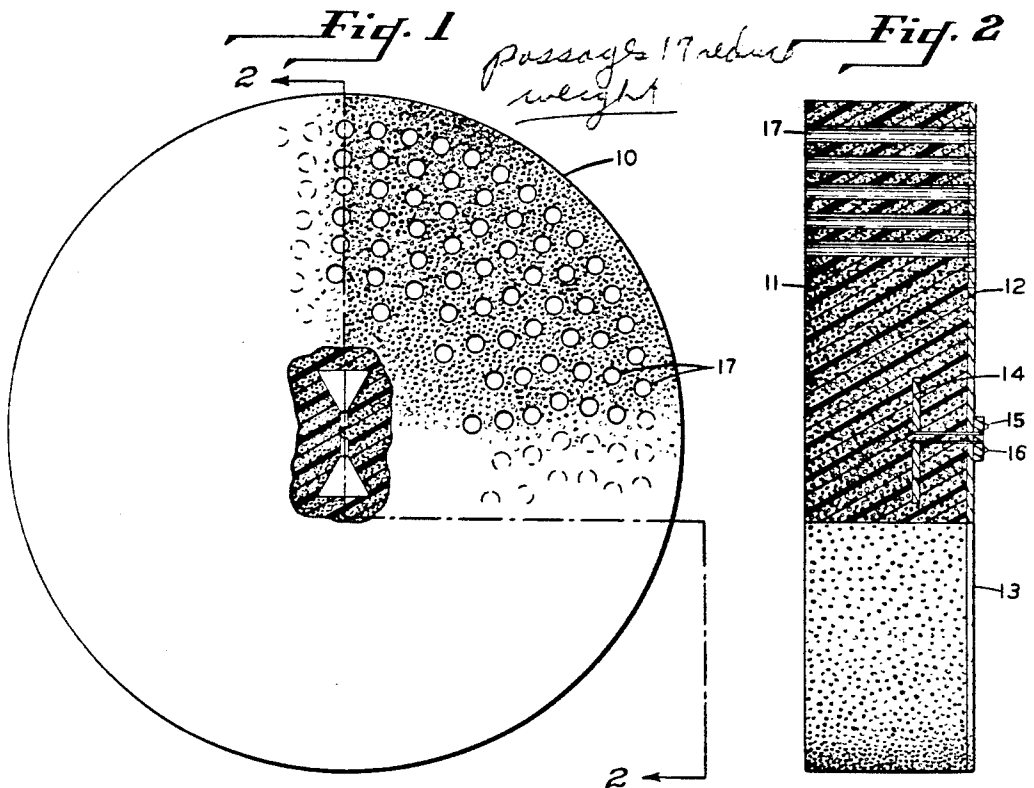
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This invention relates to an antenna and is a continuation-in-part of co-pending application Ser. No. 217,751, filed Aug. 17, 1962, now Patent No. 3,256,373, issued June 14, 1966.

In this earlier application, there is disclosed a cylindrical, dielectric lens having a continuously varying dielectric constant and a method for making said lens. This continuously varying dielectric constant is achieved by the use of an artificial dielectric consisting of an array of randomly oriented metallic particles supported by a low density dielectric material, for example. The metallic particles may comprise insulated aluminum slivers, and the supporting matrix may be in the form of a low loss, polystyrene foam fabricated from low density polystyrene beads or spheroids. This earlier application also contemplated a lens with an internal focus and a constant thickness Kelleher lens wherein the focus exists on a line passing through the geometric axis of the cylinder. In the latter case, it was contemplated that a feed or active pickup (transmitting) could be located at the focal point to provide plane wave propagation in a direction normal to the plane surfaces of the cylindrical lens or that a passive pickup could be so placed to allow the device to be used as a receiver.

In the present invention, it has been found that a compact, efficient, and relatively uncomplex antenna may be provided by forming a dielectric body having at least one relatively flat face, at least one layer of reflector material covering a portion of said face, a second face spaced from said reflector material covered face, and a focus located on or between said faces. A suitable pickup or feed may be provided in the area of the focal point.

It is an object of the present invention to provide an antenna having at least one pair of spaced faces, at least one layer of reflective material covering a portion of one of said faces, and a focus and pickup located on or between said faces.

Other objects of the present invention will be readily apparent from the detailed description thereof with reference to the drawings wherein—

FIGURE 1 is a front view in elevation of an antenna according to the present invention;

FIGURE 2 is a sectional view of the antenna shown in FIGURE 1 taken along line 2—2 therein; and

FIGURE 3 is a wave diagram for the antenna shown in FIGURES 1 and 2.

Referring now to FIGURES 1 and 2 there is shown an antenna in the form of a cylindrical body 10 having a relatively flat front face 11 and rear face 12. A layer of reflector material 13 extends over the rear surface 12 of the antenna body. The gradation of the dielectric material forming the body is such that electromagnetic waves entering the front face 11 will pass through the body and be reflected by the reflector material 13 back into the body so as to be focused in the area of point F as shown in FIGURE 3, for example. It has been found that the optimum condition and greatest gain is obtained when point F is located approximately in the area of the $\frac{1}{4}$ wavelength position. However, this pickup may be located in the area of multiples of $\frac{1}{2}$ wavelength beyond the $\frac{1}{4}$ wavelength position in accordance with the formula

$$2n-1$$

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wherein n is any positive integer. It is to be noted that the focus at point F may be located on the geometric axis of the cylindrical body.

A suitable pickup (active or passive) such as a fan-type dipole 14 may be located in the area of focal point F at the $\frac{1}{4}$ wavelength position. Dipole 14 is imbedded in the antenna body and is thereby protected from the weather and other external forces. Suitable leads 15 and 16 are connected to the appropriate points of the dipole and extend through the antenna body to the exterior thereof. Leads 15 and 16 may be connected either to suitable receiving apparatus or to suitable transmitting apparatus. When used as a transmitting antenna, the embodiment shown in FIGURES 1 and 2 transforms the wave front generated by dipole 14 into a plane wave front upon emergence of the wave front from the body 10 after being reflected from the reflector material 13.

Is desired, a plurality of passages 17 extending through the antenna body and reflector material 13 may be provided. Passages 17 reduce the wind resistance of the antenna. These passages 17 usually will not adversely affect the performance of the antenna if each passage has dimensions which are somewhat less than the wavelength of interest or operation. A general rule of thumb in the art has been to keep such dimensions in the area of less than about $\frac{1}{2}$ wavelength. However, the passage dimensions may exceed this limitation in some cases. Further, the passages 17 may be configured individually and/or cumulatively to minimize the reflection characteristics of the antenna front as is known in the art.

One form of the present invention may comprise a cylindrical antenna approximately 25" in diameter and 6" thick having a thin sheet of aluminum foil approximately .001" thick adhesively secured to one of the faces of said cylinder. The cylindrical body may be formed of dielectric material such as that disclosed in the co-pending application Ser. No. 217,751 noted above.

Such an antenna appears to give the best results when its diameter is in the area of or greater than $\frac{1}{4}$ of the wavelength of interest or operation. The dielectric gradation of such an antenna may be determined by the relationship:

$$n(r) = n_{(o)} \operatorname{sech} \left[\frac{\pi r}{2T} \right]$$

wherein

$n_{(r)}$ is the refractive index of the dielectric material as a function of radius;

$n_{(o)}$ is the refractive index of the dielectric material along the geometric axis thereof;

r is the radial variable which ranges from 0 to the radius of the dielectric body; and

T is the thickness of the dielectric material from the wave receiving or transmitting face to the plane containing the focus.

In the described embodiment, it was found that the thickness of the dielectric material as used in this formula could be halved if a reflector element was provided adjacent one face of the cylinder. Thicknesses greater than $T/2$ may be used in other embodiments.

A fan or other type dipole may be imbedded at the $\frac{1}{4}$ wavelength position within the cylindrical body. This dipole will have suitable leads extending to the exterior of the antenna for connection to suitable receiving or transmitting apparatus. This antenna may have about 200 passages approximately $\frac{3}{4}$ " in diameter passing there-through to reduce the wind resistance of said antenna.

The body of this antenna may be constructed using composite dielectrics or may be loaded with aluminum slivers such that the dielectric constant varies continuously from the center of the cylinder outwardly to the

rim and such that incident energy will be properly focused. The frequency range may be approximately 470 megacycles to 890 megacycles. The weight of such an antenna may be on the order of about 4.7 pounds. This antenna may have a weather resistive coating of resin (e.g., epoxy or polyester) and/or acrylic paint. The advantage of a lens-type antenna such as that described above is that it provides improved results when compared with equal area conventional antenna configurations. These results are deemed to be due to the greater aperture efficiency, improved directivity, and improved impedance characteristics.

The embodiment of the antenna described above may be formed by following the procedure and formulas outlined heretofore and in the copending application Ser. No. 217,751 wherein the desired gradation is predetermined and the materials forming the dielectric body are metered into a mold. However, in the case of the present antenna the mold might be provided with a plurality of core rods to provide the plurality of passages through the antenna body. These core rods could be secured to the bottom of the mold cavity in such a manner that they would extend upwardly through said mold cavity in a direction parallel to the axis of the cylindrical body to be formed. Prior to filling the mold with the appropriate artificial dielectric materials, a suitable dipole and layer of reflector material could be located within the mold cavity. The upwardly directed surface of the reflective material could be coated with a suitable adhesive for adherence of the reflective material to the dielectric material to be molded. Subsequently, the appropriate mix could be poured into the mold cavity and fused by a steam molding process. Upon removal of the mold, the antenna is ready for a finishing operation such as painting, for example, if such an operation is desired or required.

It is apparent that the antenna of the present invention is compact in form, light in weight, and readily fabricated. The pickup is imbedded in the body thereby reducing the possibility of damage thereto. The antenna is weather resistant and may be easily installed on suitable, lightweight support apparatus which may be fabricated by a skilled mechanic.

It is to be understood that the present invention is not limited to the particular embodiment shown and described herein. The particular dimensions, materials of construction, configuration, type of dipole, etc., may be varied. Conventional pickups other than dipoles may be substituted therefor. Although the best results have been obtained when the pickup and focus are located at the $\frac{1}{4}$ wavelength position, the position of these elements may be varied. The focus may be located on or between the spaced faces of the body. Additional pickups may be provided at the $\frac{3}{4}$ wavelength, $\frac{5}{4}$ wavelength, etc., positions. In such a case, it may be desirable to extend the length of the cylindrical body in accordance with the dielectric requirements such that the additional pickups will also be internal. However, it is not necessary that the additional pickups be internal. They may be wholly internal, partially internal, or wholly external. Further the pickup at the $\frac{1}{4}$ wavelength position may be partially internal or imbedded and partially external. If a single pickup is used, it may be partially imbedded and partially external. If multiple pickups are used, any one may be similarly located. Each pickup associated with a given antenna need not be located or imbedded in the same manner as the remainder of pickups, if any, associated with said antenna.

The pickup need not be imbedded or covered but may be partially or wholly recessed into the body between the faces thereof. However, imbedded or covered pickups are preferable since they are inherently protected by the body from the weather and other external forces.

Any suitable reflective material or coating may be utilized for the layer on one face of the dielectric body.

The reflective layer need not be adhesively secured to the body but may be positioned with respect thereto by conventional fastening means. Further, the reflective material may cover only a portion of the flat face of the antenna. The reflective material may be in multi-layer form.

As mentioned above, the shape or configuration and/or gradation of the antenna according to the present invention may be varied. For example, the antenna may be rectangular in nature and have the dielectric graded in one dimension only.

It is also understood that the face of the antenna away from the reflective covered face may be grooved, corrugated, waffled, drilled, pimpled, etc., or otherwise modified to minimize reflections therefrom.

In addition to the primary reflective layer heretofore described, an additional reflective layer or layers may be provided on the wave receiving or emitting face of the antenna to obtain multiple reflections of the waves in the antenna. The gradation of dielectric, location of pickup, and antenna dimensions may be suitably adjusted to provide a workable antenna of this type. Directors of conventional type may be used with the antenna according to the present invention.

The term "pickup" as used herein includes the active or transmitting and passive or receiving types.

Various modifications in the present invention may occur to those skilled in the art without departing from the spirit and scope of the invention as defined in the claims.

I claim:

1. An antenna comprising a body of dielectric material having a central axis and relatively flat face and reflector material covering at least a portion of said face, said body having at least one other face spaced from said first-mentioned face, a focus located in the area of said central axis in the space defined by said faces at a distance approximately $\frac{1}{4}$ wavelength from said face associated with said reflector material, a pickup, at least a portion of which is located in the area of said focus in the space defined by said faces, said body having a substantially constant thickness, a disc-shape and a plurality of passages therethrough, and said dielectric material having a continuously varying gradation.

2. An antenna comprising a body of dielectric material having a continuously varying gradation, a relatively flat face, and reflector material covering at least a portion of said face, said body having at least one other planar face spaced from said first-mentioned face, a focus located in the space defined by said faces, and a pickup.

3. An antenna according to claim 2 wherein said body has at least one passage therethrough.

4. An antenna according to claim 3 wherein said body has a plurality of passages therethrough.

5. An antenna comprising a body of dielectric material having a continuously varying gradation, substantially constant thickness, a relatively flat face, and reflector material covering at least a portion of said face, said body having at least one other planar face spaced from said first mentioned face, a focus located in the space defined by said faces, and a pickup.

6. An antenna comprising a body of dielectric material having a continuously varying gradation, a relatively flat face, and reflector material covering at least a portion of said face, said body having at least one other face spaced from said first mentioned face, a focus located in the space defined by said faces, and a pickup, at least a portion of said pickup being located in the area of said focus in the space defined by said faces.

7. An antenna comprising a disc-shaped body of dielectric material having substantially constant thickness, a continuously varying gradation, a relatively flat face, and reflector material covering at least a portion of said face, said body having at least one other face spaced from said first mentioned face, a focus located in the space de-

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defined by said faces, and a pickup, at least a portion of said pickup being located in the area of said focus in the space defined by said faces.

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