Oct. 30, 1956 W. E. KOCK 2,769,171

WAVE ENERGY COMPOUND REFRACTORS

Filed Oct. 19, 1951

FIG. 1

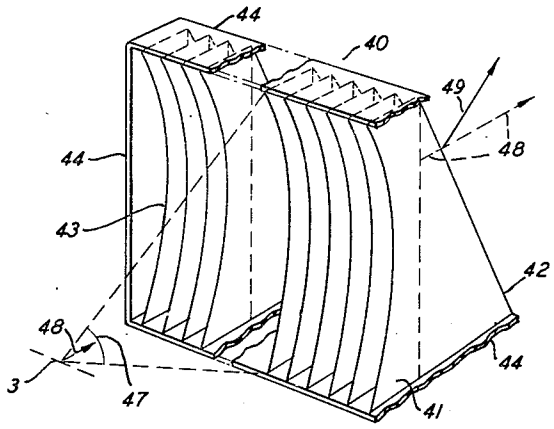


FIG. 2

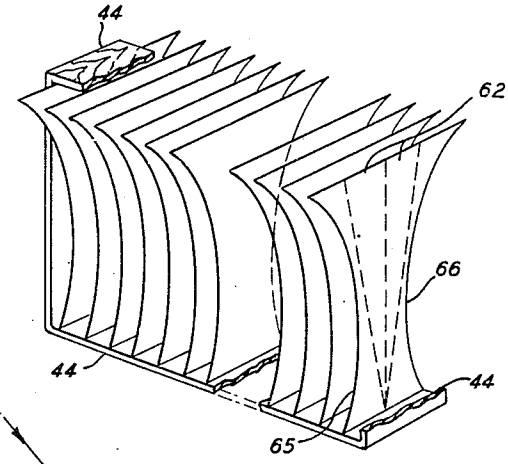
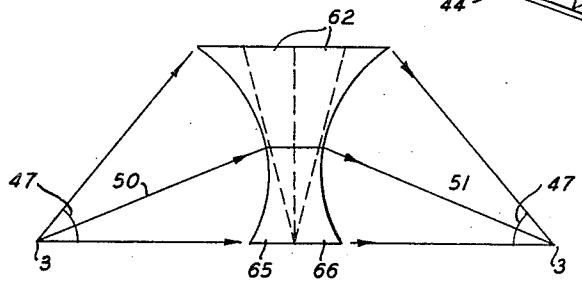


FIG. 3



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WAVE ENERGY COMPOUND REFRACTORS

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5 Claims. (Cl. 343—909)

This invention relates to compound phase-advance type refractors for use in wave energy transmission systems. More particularly, it relates to spaced parallel reflecting plate type wave energy refractors combining prismatic and focusing effects.

This application is a division of my copending application Serial No. 68,542, filed December 31, 1948, which matured into United States Patent 2,599,763, granted June 10, 1952, for "Directive Antenna Systems," which, in turn, is a continuation-in-part of my application for "Radio Relay Systems," Serial No. 5,952, filed February 3, 1948, which last-mentioned application matured into United States Patent 2,530,826, granted November 21, 1950.

Phase-advance type refractors and lenses for high frequency electromagnetic wave energy are disclosed and claimed in my copending applications No. 642,722, which matured into United States Patent 2,588,249, granted March 4, 1952, and 642,723, which matured into United States Patent 2,736,894, granted February 28, 1956, respectively, both of which applications were filed on January 22, 1946. It is further disclosed and claimed in my copending application Serial No. 660,337, filed April 8, 1946, which matured into United States Patent 2,603,749, granted July 15, 1952, that wire curtains or grids of conductive members can replace the plane conductive sheets employed in the devices of the first-mentioned two applications.

The general principle is that the spaced members or partitions comprising the refractor and/or lens (sheets, wire curtains, or grids) must be capable of reflecting substantially all wave energy of the wavelengths with which they are to be employed. On the other hand, only sufficient mechanical rigidity to maintain the partitions in their respective proper positions is required. Indeed, for very high frequency electromagnetic waves, the partitions can be, for example, of extremely thin copper foil and the required mechanical rigidity can be provided by affixing the foil to suitable surfaces of dielectric material such as "polyfoam," or the like. Alternatively, the dielectric material can have its appropriate surfaces coated with a thin layer of highly conductive paint or the like. The blocks are preferably of the appropriate thickness and dielectric constant to serve as the dielectric channels between the conductive surfaces. Polyfoam, since it has very nearly the same dielectric constant as air, is frequently employed in blocks of appropriate dimensions to serve as spacers and supports for the conductive members or partitions in phase-advance type refractors and lenses, and is, obviously, readily adaptable for use in devices of the invention designed to be used with high frequency electromagnetic wave energy.

It is a principal object of the present invention to obtain a compact, easily constructed, wave energy refractor comprising the combination in a unitary structure of a phase-advance type prism with one or several phase-advance type lenses.

Another object is to provide a novel structure for use

in radio systems which will alter the direction of a plane wave front wave, and convert it into a curved front wave having a predetermined focal position.

A further object is to provide a novel structure for use in radio systems which will convert a curved front wave into a plane front wave and alter the direction of the plane front wave.

Other and further objects will become apparent during the course of the following detailed description of illustrative embodiments of the invention and from the appended claims.

The principles of the invention will be more readily understood from the following description of two simple embodiments of the invention and from the accompanying drawings, in which:

Fig. 1 is a perspective view of a compound phase-advance type wave energy refractor constructed in accordance with the principles of the invention and comprising a prism section and a lens section; and

Figs. 2 and 3 are perspective and side views, respectively, of another compound phase-advance type wave energy refractor constructed in accordance with the principles of the invention and comprising a prism section assembled between two lens sections.

In more detail, Figs. 1 and 2 illustrate compound phase-advance type, wave energy refractors which are, by way of example, especially suitable for use in radio relay systems such as that disclosed in my above-mentioned patent, 2,530,826. The refractor 40 of Fig. 1 comprises a focusing section or plano-concave lens **41**, such as that disclosed and claimed in my copending application Serial No. 642,723, filed January 22, 1946 (United States Patent 2,736,894), and a non-focusing or prism section **42**, such as that disclosed in my copending application Serial No. 642,722, also filed January 22, 1946 (United States Patent 2,588,249). Each section comprises a plurality of parallel spaced plates **43**, which for radio wave energy can be metallic sheets or grids of metallic members (i. e., wire curtains as disclosed in my copending application Serial No. 660,337, filed April 8, 1946, which matured into United States Patent 2,603,749, granted July 15, 1952). Inasmuch as the shape of lens **41** is plano-concave, the lens portion of each plate **43** inherently has oppositely disposed plane edge boundaries that form a straight line on the plane side of the lens and a curved concave arc on the concave side of the lens. Similarly, the prism portion of each plate **43** inherently has oppositely disposed plane edge boundaries forming straight lines that intersect each other at an angle. Each plate is common to both sections so that, while, from an electrical or refractive standpoint, the two sections can be considered as being distinct, the two sections are mechanically or physically integrated into a unitary structure. Thus the plane shape of a unitary plate **43** has one straight line boundary and one curved concave arcuate boundary oppositely disposed from the straight line boundary. In view of the shape of the prism, an extension of the straight line boundary forms an angle with the extension of the chord joining the ends of the arcuate boundary. The plates are, for the embodiments illustrated in the drawing, held in position by the wooden members **44**. In the embodiment of Fig. 2, the prism section **62** is, as indicated by the dash lines, included between two thin plano-concave lenses **65** and **66**, as more clearly shown in Fig. 3. Thus both oppositely disposed edge boundaries form curved concave arcs the chords of which intersect at an angle.

In operation, in Fig. 1, the lens section **41** functions, for example, to convert the circular front wave **47** originating at the line focus **3** to a plane front wave having a propagation direction as indicated by the arrow **48** and the prism section **42** functions to change the direc-

tion of propagation from the direction indicated by the arrow **48** to the direction indicated by the arrow **49**. Similarly, in the system of Figs. 2 and 3, the lens section **65** operates to convert the circular wave front **47** originating at the left focal line **3** to a plane wave front and the right lens section **66** changes the plane front to a circular front converging on the right focal line **3**. The intermediate prism section **62** changes the propagation direction from the mean direction **50** incoming to lens **65** to the mean direction **51** outgoing from lens **66**.

Although the invention has been explained in connection with certain specific embodiments, it is to be understood that it is not to be limited to the described embodiments since numerous and varied other arrangements clearly within the spirit and scope of the invention, can, obviously, be readily devised by those skilled in the art.

What is claimed is:

1. A compound phase-advance type of wave energy refractor for high frequency wave energy, comprising a plurality of like plane members spaced parallel to each other, adjacent members being separated by an interval exceeding one-half wavelength of the lowest frequency of the wave energy with which the refractor is to be used, each member being a substantially complete reflector of the wave energy with which it is to be employed, the plane of each member having two principal boundaries oppositely disposed to each other, one of said boundaries being a straight line, the other of said boundaries being a concave arc, an extension of said straight line boundary forming an angle with an extension of a chord joining the ends of said arcuate boundary.

2. A compound phase-advance type wave energy refractor for high frequency electromagnetic waves which comprises a plurality of like, parallel, plane conductive members, consecutive ones of said members being spaced apart a distance which is greater than one-half wavelength of the lowest frequency with which the refractor is to be used, the plane of each of said members having two principal curved edges oppositely disposed to each other, the extension of a chord joining the ends of one of said curved edges forming an angle with the extension of a chord joining the ends of the other of said curved edges.

3. The structure of claim 2 wherein the said curved edges are concave.

4. A compound refractor for high frequency wave energy comprising a plurality of like, equally spaced, parallel plane members, each of said members being an efficient reflector of said wave energy, the plane of each of said members having two principal boundaries oppositely disposed to each other, both of said boundaries being a concave arc, the extension of a chord joining the ends of one of said arcs forming an angle with the extension of a chord joining the ends of other of said arcs whereby said overall structure can impress both focusing and prismatic directional effects upon the wave energy directed through said refractor.

5. A compound refractor for high frequency wave energy comprising a plurality of like, equally-spaced, parallel, plane members, each of said members being an efficient reflector of said wave energy, the plane of each of said members having two principal boundaries oppositely disposed to each other, at least one of said boundaries being a concave arc, the extension of a chord joining the ends of said concave arc forming an angle with an extension of a straight line joining the ends of the other of said boundaries whereby said over-all structure can impress both focusing and prismatic directional effects upon said wave energy directed through said refractor.

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