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R. L. TANNER ET AL

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MULTI-HOP RAMP FEED FOR WIRE-GRID LENS ANTENNA

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2 Sheets-Sheet 1

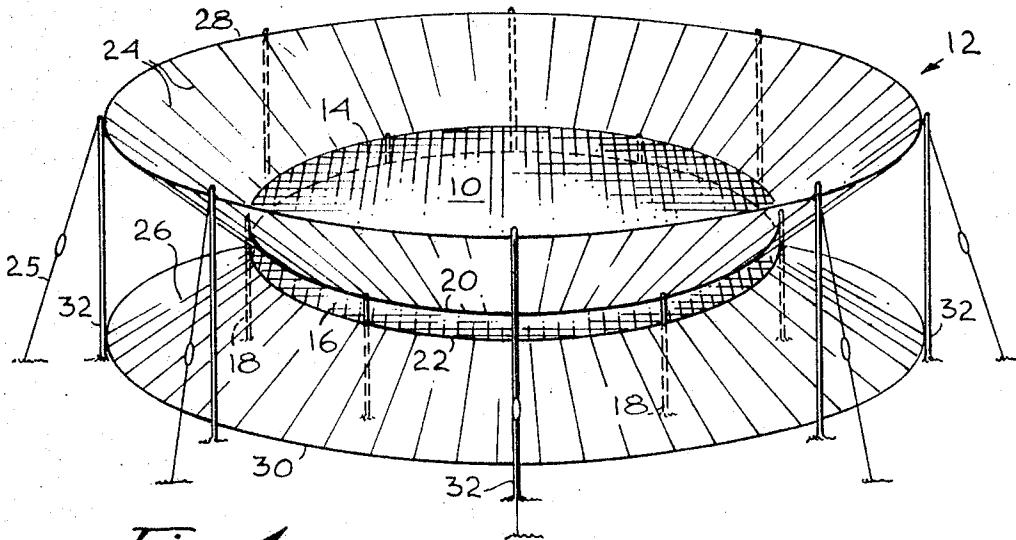


Fig. 1 PRIOR ART

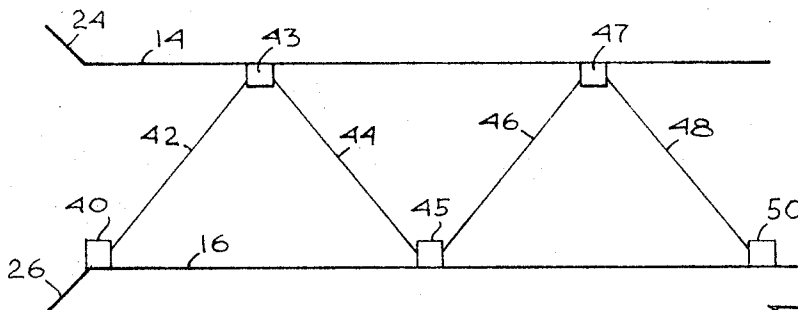


Fig. 2

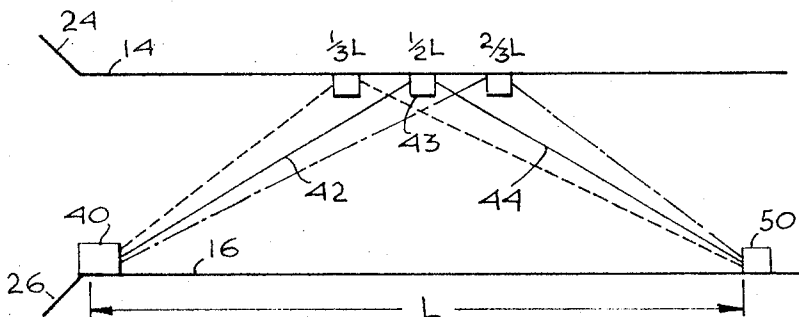


Fig. 3

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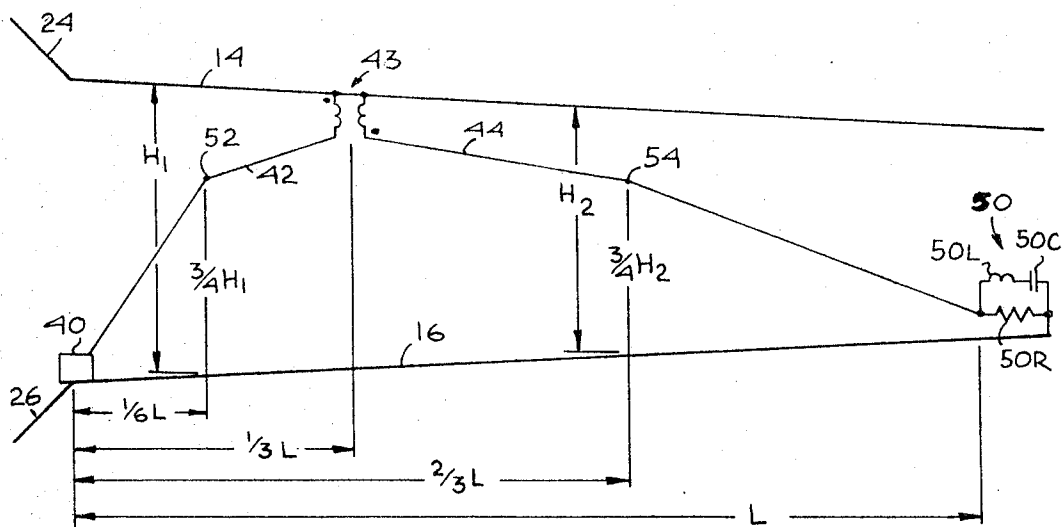
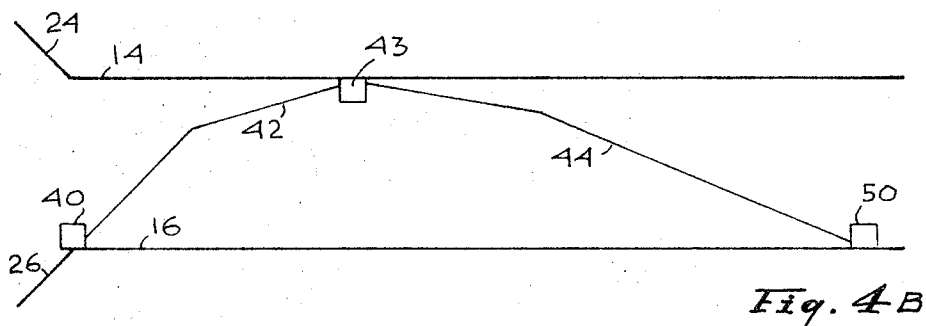
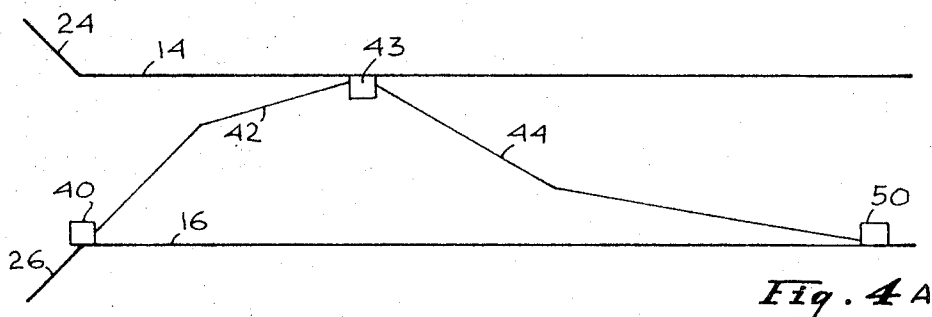
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MULTI-HOP RAMP FEED FOR WIRE-GRID LENS ANTENNA

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3 Claims 10

ABSTRACT OF THE DISCLOSURE

A feed arrangement is provided for a wire grid lens antenna. The antenna comprises a pair of spaced overlying conductive wire grids substantially in the form of two circular concave discs spaced from one another. The feed arrangement for said antenna, in accordance with this invention, comprises at least one conductor which makes multiple transitions or multiple hops between the upper and lower grids. A phase inverting network is connected at each reversal between upper and lower discs of the ramp feed conductors so that all the current of the several sections radiates in phase in one direction. A transmitter is provided at one end of these feed conductors and a terminating network is employed at the other end.

This invention relates to antennas of the type known as wire-grid lens antennas and, more particularly, to an improved arrangement for feeding said antennas.

In an application for patent, Ser. No. 175,369, and also in application Ser. No. 175,374, both of which were filed on Feb. 23, 1962, and are respectively entitled "Uniform Wire-Grid Lens Antenna" and "Non-Uniform Wire-Grid Lens Antenna," and both by Robert L. Tanner, one of the inventors of the present application, there is described and shown a wire-grid lens antenna of a type with which the present invention finds its optimal use. A wire-grid lens antenna may be broadly described as comprising a central lens region surrounded by a horn region. Both the lens and the horn are made of wire grid mesh. The central lens region comprises a pair of spaced overlying conductive wire grids substantially in the form of two circular concave discs, with the lower surface of one opposing the upper surface of the other. The horn region flares outwardly from the disc periphery. Such an antenna has excellent broadband characteristics for operation over the bands lying within the frequency range extending from below one to above 1,000 megacycles per second.

In another application for patent by this inventor, Ser. No. 370,471, filed May 27, 1964, and entitled "Lens Feed System," there is described a novel arrangement for feeding a wire-grid lens antenna of the general type described, which comprises a transmission line connected to the transmitter or receiver by an input network at the lower grid element of the lens and which extends diagonally upward to couple to the upper lens grid element through an output network at a predetermined distance from the edge of the lens. In order to suppress undesirable side radiation, dipole elements are provided and are excited in phase quadrature with the ramp element to assist in minimizing or eliminating the undesirable side radiation.

An object of this invention is the provision of a ramp type feed which minimizes side radiation without using radiating dipoles.

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Another object of this invention is the provision of a feed arrangement for an antenna of the general type described which has an improved efficiency over the single ramp feed and can give low side lobes over the bands lying within the frequency range extending from below one to above 1,000 mHz.

Yet another object of the present invention is the provision of a novel and improved feed for a wire-grid lens antenna.

These and other objects of the invention are achieved in an arrangement wherein instead of the feed conductors making a single transition from the lower to the upper lens, they make multiple transitions or multiple hops between the lower and upper lenses. A phase inverting network is connected at each reversal of the ramp feed conductors so that all the current of the several sections radiate in phase in one direction. A terminating network is employed at the end of the feed.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which:

FIGURE 1 is a perspective view of a wire-grid lens of the general type with which this invention is concerned;

FIGURE 2 is a schematic view of a multihop ramp feed in accordance with this invention for a wire-grid lens;

FIGURE 3 illustrates how the "turn around," or phase inverting point of a two-hop ramp feed may be moved to optimize the location thereof;

FIGURES 4A and B show various configurations of the ramp conductors, which may be employed for improving the radiation pattern; and

FIGURE 5 is a circuit diagram of an optimized two-hop ramp feed for a wire-grid lens antenna.

FIGURE 1 is a perspective view of a wire-grid lens antenna of the general type which has been described and claimed in the previously-indicated patent applications by this inventor. The antenna has a center portion 10 which forms a wire-grid lens for azimuthal beam shaping, and a peripheral portion 12 which is the horn or radiating structure for elevational beam shaping and for matching the impedance between the wire-grid lens 10 and the surrounding space. The radiation structure 12 is shaped in the form of a biconical or radially flared horn.

The wire-grid lens 10 includes an upper wire grid 14 and a lower wire grid 16 spaced in opposite and overlying relationship by means of a plurality of nonconductive suspension or support members 18. As a practical matter, the peripheral portion of the upper wire grid 14 and the lower wire grid 16 may be secured through rim members, such as a pair of metal rings 20, 22, respectively which are light in weight and which form convenient conductive terminating support edges. Furthermore, these rings also provide a convenient means for attaching the radiating structure 12 thereto. The lens wire grids 14 and 16, are formed of composite metallic wires in the form of a mesh structure.

The radiating horn structure 12 has an upper and a lower portion respectively 24, 26, also extending outwardly to support rings respectively 28, 30, which are attached to suitable guy pole supports 32. These pole supports are spaced around the periphery of the biconical horn structure and assist in maintaining it spread out with the proper desired horn shape.

By way of illustration, and not by way of limitation, in the frequency region with which this antenna is employed, the lens portion of the antenna may have a diam-

eter of 600 feet and a distance of separation between the upper and lower elements of the lens at the center is on the order of 6" and at the outer periphery is on the order of 12 feet. The biconical horn portion extends outwardly still farther from the periphery of the lens portion. The feeds in accordance with this invention are installed at the end of the lens portion and may extend from the junction between the lens and the horn portion for a distance on the order of one-fourth of the lens radius towards the center of the lens. In this region the spacing between the grids of the lens is large enough so that the lens elements present approximately parallel conducting planes. In an embodiment of the invention which are built and operated satisfactorily, thirty-six feeds were employed spaced around the lens.

FIGURE 2 is a schematic diagram of a multi-hop ramp feed element for a wire-grid lens, in accordance with this invention. It can be used in the lens antenna for either transmission or reception of electrical signals. When used as a transmitting feed, the current, excited by a source 40 at the input of the feed, travels to the right along the ramp segments respectively 42, 44, 46, and 48, coupling energy into the lens antenna. A phase inverting network respectively 43, 45, and 47 is connected at each reversal of the slope of the ramp segments so that all currents of the several sections or hops radiate in phase toward the right. The ramp feed terminates in a network 50, which as shown in FIGURE 5 is an impedance matching network.

As will be discussed in connection with FIGURE 5, the ramp segments of the multi-hop ramp may consist of one or more electrical conductors in parallel, arranged so as to achieve a desired impedance level.

The ramp feed arrangement, which is schematically represented in FIGURE 2, has an improved efficiency over the single ramp feed shown and described in the application by Robert L. Tanner et al., Ser. No. 370,471, which has been previously mentioned. The purpose of the phase inverting networks which are provided is to cause the waves from both the downward directed ramp segments and the upward directed ramp segments to be added in phase toward the right. Improved coupling efficiency results from the fact that the vertical displacement of the ramp centroid for a given radial distance along the ramp is increased in proportion to the number of hops employed. FIGURE 2 illustrates a four-hop ramp. The same concept can be applied to feeds having two, three, or even five hops. Also, the phase inverting networks can be simple phase inverting transformers or can be transformers plus more general networks.

While a substantial improvement is derived in going from a simple single ramp feed to a two-hop ramp feed, the additional improvement gained by using more than two hops is marginal and is not believed to justify the increased cost and complication entailed. Thus, the description that follows will be made in connection with the two-hop feed ramps. However, this should not be considered as a limitation upon the invention since the concepts to be developed are also applicable to more than two hops.

Another parameter at the disposal of a designer in connection with the multi-hop ramp is the location of the "turn around" or phase inverting point. This is illustrated in FIGURE 3 which shows three possible locations for the phase inverting transformer in a two-hop ramp. Investigation of many configurations, each optimized with respect to the terminating impedance and other factors, indicated that the best overall performance is obtainable when a phase inverting transformer is placed at a point approximately one-third of the radial distance between the feed end 40 and the terminating network end 50 of the ramp.

Still another potentially variable parameter of the ramp is the slope of the ramp conductors 42, 44. The straight line arrangement of the ramp conductors is shown in FIGURE 3. FIGURES 4A and 4B show two other possible arrangements of the conductors 42, 44. In FIGURE

4A, the conductor 42 is bent so that the second half thereof is closer to the upper lens 14. The conductor 44 is bent so that the second half thereof is closer to the lower lens 16. In FIGURE 4B, the conductor 42 remains bent as in FIGURE 4A. However, the conductor 44 is now bent so that the first half is closer to the upper lens 14. Since the source strength per unit length of the ramp is proportional to the vertical displacement of the ramp per unit of radial distance, the illumination function is controlled by placing the ramp conductor along a path where its slope varies. The arrangement shown in FIGURE 4B, which tends to concentrate the radiation from the two-hop ramp near its beginning and near its end proves to give the best patterns of any of the configurations investigated.

FIGURE 5 is a circuit diagram of the ramp feed in accordance with this invention, which shows the preferred slope of the ramp feed segments. These ramp feed segments 42, 44 represent one or more electrical conductors in parallel arranged so as to achieve a desired impedance level. In general, the impedance is lowered by adding conductors or by increasing the spacing between the conductors. The preferred phase inverting structure 43 comprises a phase inverting transformer. The terminating network 50 comprises a resistor connected in series with the ramp segment 44 and to the lower lens element, and across which there is connected an inductance 50L and a capacitance 50C. If the terminating network includes a resistance equal to the characteristic impedance of the ramp segments, the feed energy that is not coupled into the lens antenna will be entirely absorbed by the terminating resistance. However, if the resistance is not so chosen, and other circuit elements are added to the terminating network, such as the inductance 50L and capacitance 50C as shown in FIGURE 4, then some of the feed energy is reflected and can be controlled so as to reduce the side lobe radiation from the lens antenna.

The embodiment of the invention which is preferred is shown in FIGURE 5. The phase inverting transformer is placed at a point approximately one-third of the radial distance (L) between the feed end and the terminating end of the ramp. The ramp segment 42 has the conductors thereof rise from the source 40 to a point 52 three-quarters of the distance between the upper and lower lens element which is also located at a point one-sixth of the distance L, which is the distance between beginning and end of the ramp feed. From this point, the ramp segment conductors extend at a smaller slope to the phase inverting transformer 43. A point 54 marks the location along the conductors of the ramp segment 44 at which the slope thereof to the terminating resistance increases. This point is determined as being at a distance two-thirds L or two-thirds of the distance between the beginning and termination of the ramp feed, and three-quarters of the distance H2 which is the spacing between the upper and lower lens elements at this location.

There has accordingly been described and shown hereinabove a novel, useful and improved arrangement for feeding a wire-grid lens antenna.

What is claimed is:

1. In a wire-grid lens antenna of the type wherein said wire-grid lens comprises an upper and a lower lens element each being made of wire grid and each having substantially the shape of a disc, both resembling two spaced opposite saucers, said upper and lower elements being spaced a predetermined distance from one another,

an improved feeding structure comprising:

first conductor means extending from an edge of one of said two spaced lens elements radially inward to a first location at the surface of the other of said two elements,

a second conductor means extending from said first location radially inward to a second location at the surface of said one of said two lens

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elements, said first location being placed at one-third the distance between said edge and said second location,

phase inverting means located at said first location for transferring electrical energy between said first and second conductors, and

terminating network means at said second location connected between said second conductor and said lower wire-grid lens element.

2. Apparatus as recited in claim 1 wherein said first conductor means extend from said one edge to a point which is substantially one-sixth of the distance between said one edge and said second location and three-quarters of the distance between said upper and lower lens element at that point, and said first conductor means extends from said point to said phase inverting network, and said second conductor means extends from said phase inverting network to a second point which is positioned at a location two-thirds of the distance between said edge and said second location, and which is three-quarters of the distance between said upper and lower lens element at said second point.

3. In a wire-grid lens antenna of the type wherein said wire-grid lens comprises an upper and lower lens element, each being made of wire grid and each having substantially the shape of a disc, both resembling two spaced, opposite saucers, said upper and lower elements being spaced a predetermined distance from one another, an improved feeding structure comprising:

conductor means extending from an edge of one of said two spaced lens elements radially inwardly and making more than one transition between the upper and lower lens elements, the slope made by each

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said conductor means within each transition between upper and lower lens elements relative to said lens elements is changed at least once,

phase inverting means located at each position of said conductor means wherein it makes a transition between said upper and lower lens elements for electrically coupling conductor means at said transition, and

impedance means for terminating said conductor means at the ends thereof.

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U.S. Cl. X.R.

343—739, 753, 773, 905