United States Patent

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[73] Assignee **The United States of America as represented by the Secretary of the Army and/or the Administration of Federal Aviation Administration**

[54] **PARASITIC LOOP COUNTERPOISE ANTENNA**
3 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **343/837,** 343/741, 343/848
[51] **Int. Cl.** **H01q 19/10**
[50] **Field of Search** 343/834, 845, 846, 847, 848, 899, 908, 741, 837

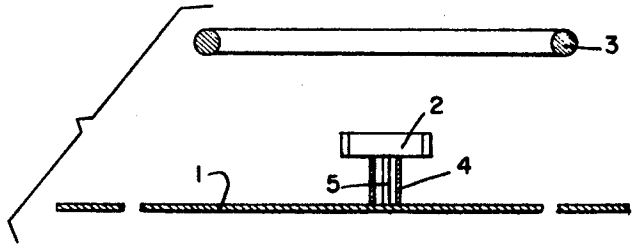
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ABSTRACT: An antenna system comprising an active radiating element, such as an Alford loop, for radiating electromagnetic energy, a surface positioned below the radiator element to form a ground plane or counterpoise, and one or more passive parasitic loop elements positioned above the radiator so that the radiation from the parasitic elements is of a magnitude and polarity to cancel the radiation field below the plane of the counterpoise.



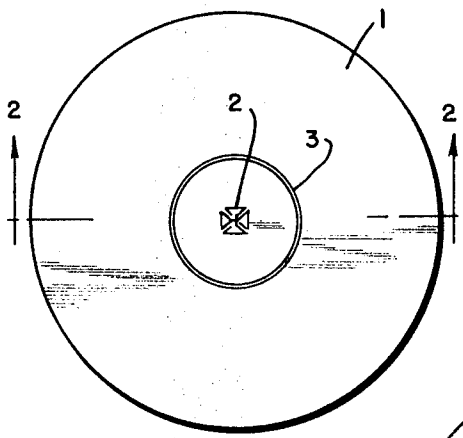


FIG. 1

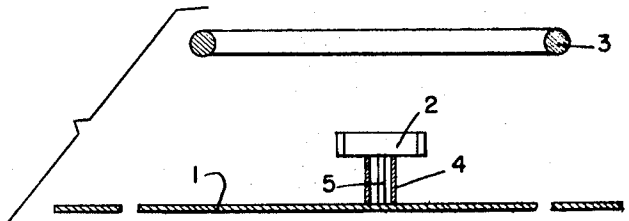
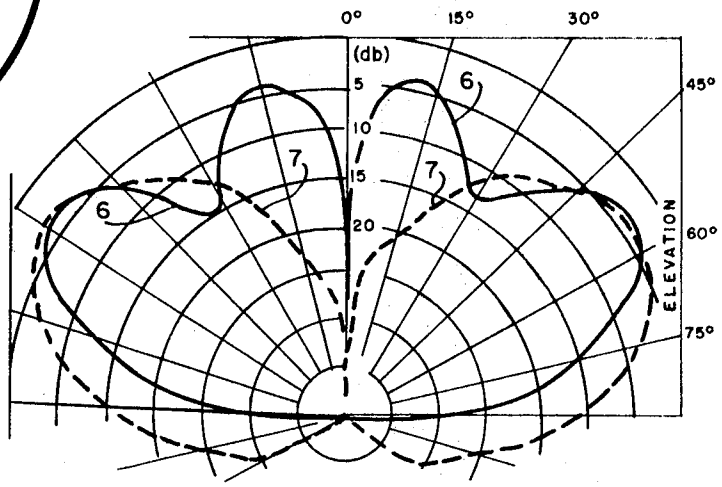


FIG. 2



MEASURED FAR FIELD ELEVATION PATTERNS OF VOR ANTENNAS

FIG. 3

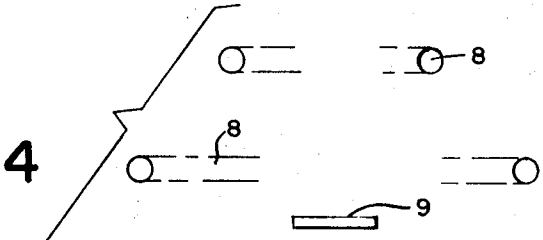


FIG. 4

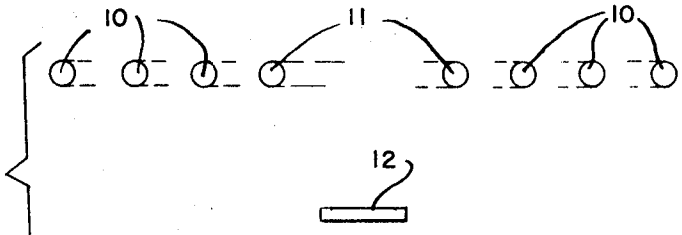


FIG. 5

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PARASITIC LOOP COUNTERPOISE ANTENNA

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an improved counterpoise antenna in which the radiation field below the plane of the counterpoise has been substantially reduced by the addition of parasitic loop elements above the radiator element.

2. Description of the Prior Art

Often a particular application requires an antenna system which produces radiation above a given plane but does not establish a radiation field below the plane. Counterpoise antennas are normally used for this purpose, but due to the finite size of the counterpoise surface, edge diffraction effects cause a certain amount of radiation to be directed below the plane of the counterpoise, thus producing undesirable effects. For example, a counterpoise antenna ideally suited for use in an existing VHF Omni Range (VOR) system would produce no radiation field below the plane of its counterpoise. Existing antennas, however, due to the counterpoise edge diffraction effects, have considerable response in directions below the plane of the counterpoise. Because of the existence of a radiation field below the plane of the counterpoise, ground reflection effects and scattering from objects such as trees and buildings in the vicinity of VOR installations produce errors in the VOR bearing indicators. Elimination of these effects using present antenna systems would require an infinitely large counterpoise, and extension of counterpoise diameters beyond those presently used is impractical. One proposed solution involved the use of a stacked array of a plurality of Alford loop antennas above a counterpoise. By properly choosing the amplitude and phase of the excitation of the loops, the rate of decrease of the electromagnetic field below the horizon can be increased. Successful operation of this system requires proper phasing and feed networks for the Alford loops, and although the theoretical value for the rate of decrease of field is high, the actual response of the antenna below the plane of the counterpoise was found to be quite high. Horn and lens antenna systems theoretically provide partial solutions; however, the extreme size of these systems at the frequencies presently employed makes their use impractical.

SUMMARY OF THE INVENTION

This invention substantially reduces the radiation field existing below the plane of the counterpoise of a counterpoise antenna system by using one or more parasitic loop elements positioned above the active radiator element. The parasitic loop or loops are positioned so that the radiation resulting from the electric current induced in the parasitic element by the electromagnetic field produced by the active radiator element is of proper magnitude and phase to cancel the radiation field existing below the plane of the counterpoise.

It is therefore an object of the invention to provide a counterpoise antenna system which has a minimal radiation field below the plane of the counterpoise.

It is a further object of the invention to provide an improved counterpoise antenna system which can be used with existing VOR systems.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a particular embodiment of the invention.

FIG. 2 is a cross-sectional view taken along the line 2—2 of FIG. 1.

FIG. 3 is a graph showing the radiation field pattern of both a conventional counterpoise antenna and a counterpoise antenna with the invention.

FIG. 4 is a cross-sectional view of an alternative embodiment of the invention showing a collinear arrangement of the parasitic elements.

FIG. 5 is a cross-sectional view of an alternative embodiment of the invention showing a coplanar arrangement of the parasitic elements.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIGS. 1 and 2 there is shown an antenna system comprising an active radiator element 2, such as an Alford loop, for radiating electromagnetic energy, a surface 1 positioned below the radiator element to form a counterpoise or ground plane, and one or more parasitic loop elements 3 positioned above the radiator element. The active radiator element 2 is chosen to fit the needs of the particular situation, and application of the invention is not restricted to a particular type of class of radiator elements. The radiator element 2 is structurally supported above the counterpoise in a conventional manner so that the radiator element is electrically insulated from the counterpoise 1. FIG. 2 illustrates one possible manner of supporting the radiator element 2 through use of an insulating material 4 surrounding a transmission line 5 to supply the radiator element 2 with energy.

The counterpoise 1 is composed of a metallic substance so that a conductive plane surface is formed, and its dimensions are preferably large compared to the wave length of the radiator element.

The system also comprises one or more passive loop elements 3 positioned above the radiator element 2. The parasitic element or elements may be structurally supported above the counterpoise 1 by means of dielectric support members which for the sake of simplicity have not been shown. These passive elements are made of a conducting metallic substance and are formed into a closed loop which may be of any desired cross-sectional configuration. One or more of the parasitic loop elements 3 may be used, and they may be successively stacked above the radiator element 9 as shown in FIG. 4 and referred to as a collinear system so that all the parasitic elements 8 share a common longitudinal axis with the radiator element 9. Alternatively as shown in FIG. 5, the parasitic loop elements 10 may be concentric about a central parasitic element 11 positioned above the radiator element 12 and referred to as a coplanar system so that all the parasitic loop elements share a common longitudinal axis with the radiator element. The dimensions of the parasitic loop elements, their relative positions, and the number of parasitic elements employed are determined by mathematical calculations well known to those skilled in the art based on the desired radiation field distribution.

The radiation produced by the parasitic elements is calculated through the use of conventional techniques of electromagnetic field analysis by determining the current induced in the parasitic elements by the radiation field from the active radiator element. This parasitic radiation is then summed with the radiation from the active element to determine to total radiation field propagated by the system. As this calculation may be made in terms of the dimensions and placement of the parasitic elements, the parameters of the parasitic elements may be completely specified for a desired radiation field.

An embodiment of an antenna system constructed in accordance with the invention described herein is illustrated in FIGS. 1 and 2. The requirements of this system were that the radiation field be omnidirectional above the plane of the counterpoise, and that it be zero below the plane of the counterpoise. An Alford loop antenna, described in U.S. Pat. No. 2,283,897, was selected as the active radiator element because of its omnidirectional radiation field characteristics, and it was positioned 0.44λ above the counterpoise. One parasitic loop element with a diameter of 2.5λ was used, and it was positioned 0.59λ above the counterpoise. The loop was formed from a brass strip of rectangular cross section with a thickness of $9.15\times10^{13}\lambda$ and a width of $1.83\times10^{11}\lambda$. The circular counterpoise was cut from an aluminum sheet of 0.125-inch thickness, and it had a diameter of 5.7λ. A frequency of 1080 MHz, was used to excite the active radiator element.

The radiation field produced by the improved antenna system is shown by the solid line 6 in FIG. 3. The broken line 7 represents the radiation field obtained from the Alford loop and the counterpoise without the parasitic loop element. It can be seen from FIG. 3 that the improved antenna system has practically eliminated the radiation field below the plane of the counterpoise.

We claim:

1. An antenna system comprising a counterpoise in the form of a conducting metal surface, a radiator element for radiating electromagnetic radiation positioned above said counterpoise, and parasitic means comprising a plurality of circular loop elements positioned above said radiator element so that said radiator element is intermediate said parasitic means and said counterpoise and positioned in cooperative relation thereto as a function of the frequency of radiated energy.

2. The device of claim 1 in which said circular loop elements are successively stacked above said radiator element so that said circular elements share a common longitudinal axis with said radiator element.

3. The device of claim 1 in which said circular loop elements are concentric about a central circular element positioned above the radiator element to that said circular elements are located in the same plane and share a common longitudinal axis with said radiator element, the mutual spacing of said circular elements and the spacing of said elements relative to said counterpoise and said radiating element relative to said counterpoise being a function of the frequency of radiated energy.