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[54] **FREQUENCY EXTENSION OF CIRCULARLY POLARIZED ANTENNA**

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[52] **U.S. Cl.** **343/802,** 343/806, 343/895
[51] **Int. Cl.** **H01q 9/26,** H01q 1/38
[58] **Field of Search** 343/802, 806, 789, 895

[56] **References Cited**

UNITED STATES PATENTS

2,495,399 1/1950 Wheeler 343/895

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411,888 7/1945 Italy 343/895

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Assistant Examiner—Wm. H. Punter
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[57] **ABSTRACT**

The frequency response of a cavity-backed planar microwave antenna having an element including a pair of spiral antenna tracks fixed to a substrate of insulating material is substantially extended by connecting a pair of cavity-backed outwardly extending dipole elements to the outer ends of each of said spiral tracks. The lower range of useful frequency response is thereby changed from a minimum operating frequency wherein the diameter of the spiral tracks constitutes approximately one-half wave length to a value wherein one-half wave length is approximately equal to the width of the antenna elements including the dipoles. This composite structure may be curved to some degree to enable it to conform to the inside surface of a curved radome.

6 Claims, 3 Drawing Figures

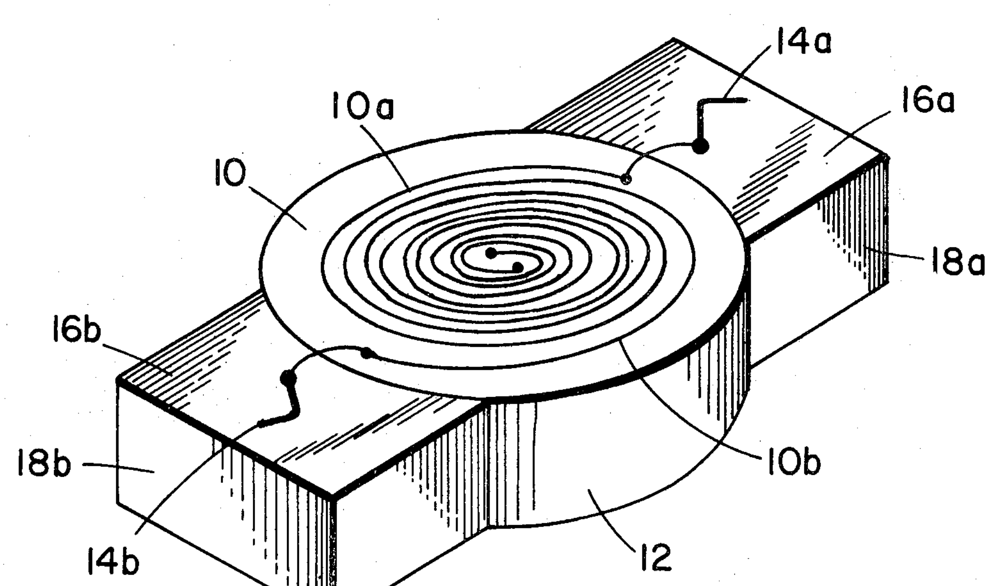

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FIG. 1

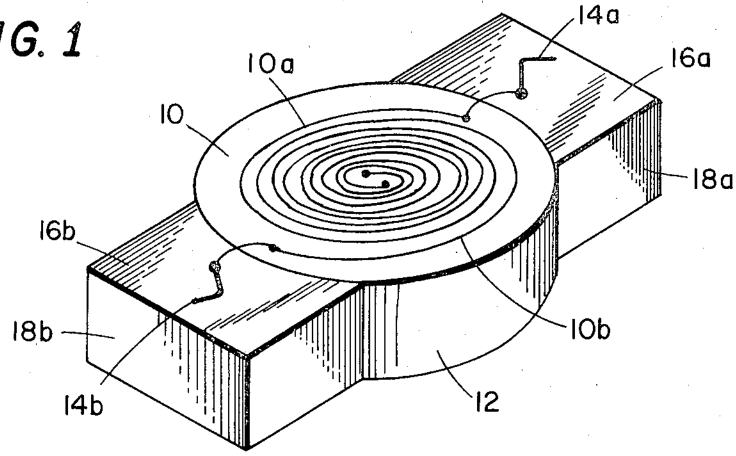


FIG. 2

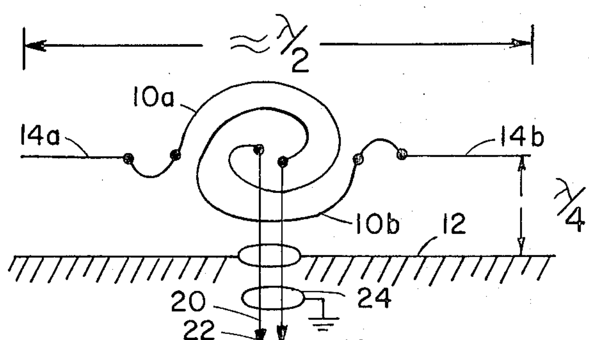
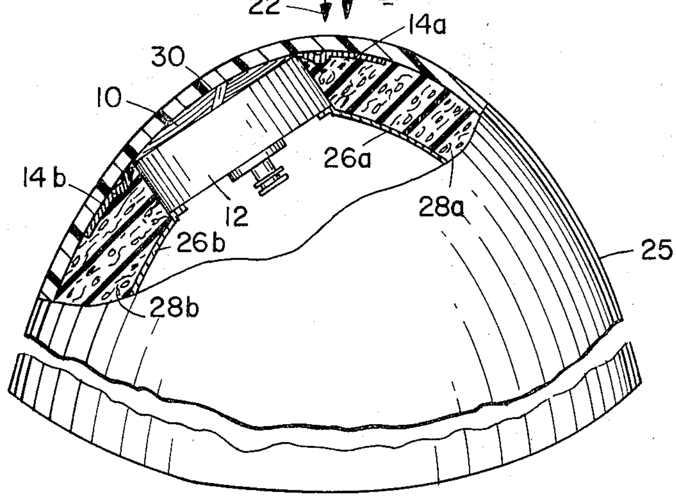


FIG. 3



FREQUENCY EXTENSION OF CIRCULARLY POLARIZED ANTENNA

This invention relates to circularly polarized, cavity-backed microwave spiral antennas and more particularly to a method and structure for providing a linearly polarized low-frequency extension of the antenna's operation.

For radar warning direction-finding systems installed on aircraft and using remotely located antennas, particularly those installed adjacent to radome structures, it occasionally becomes necessary to extend operating frequencies into lower frequencies without major modifications of the existing antenna locations and radome configurations. In addition to extending the low frequency response of the existing circularly polarized spiral antennas, there may also be a requirement for response to left and right circular polarization, linear polarization and dominantly horizontally polarized lower frequencies.

In most applications, radar warning direction finding systems use circularly polarized, cavity-backed spiral antenna elements operating in the axial mode and producing a cosine pattern. In this mode of operation, maximum radiation will occur along a line normal to the plane of the spiral element. If a reflecting cavity is placed behind the spiral element, a single lobed radiation pattern perpendicular to the plane of the spiral exists. The present invention is concerned with an extension of this mode of operation into lower frequency bands and with response to left and right-hand circular polarization, as well as linear polarizations and dominantly horizontal polarizations at lower frequency bands.

For the axial mode, the generally accepted theoretical basis for operation of the spiral antenna is the "current" band theory. If a spiral antenna is fed so that energy entering the two spiral tracks at the origin is 180° out of phase, the first current band will occur where current in one arm returns to an in-phase condition with the other arm. This condition will occur because of the geometry of the spiral element; that is, each successive turn of the spiral progressively is longer. Analysis indicates that current in adjacent conductors will reach an in-phase condition where the circumference of the ring is equal to one wave length.

To extend the lower frequency capability of the cavity-backed spiral antenna, the generally accepted approach is to increase the diameter of the antenna until the circumference equals one wave length at the lowest frequency required. This approach is incompatible with the need to extend operating frequencies without major modifications of the existing antenna sites.

The applicants' approach herein depends upon using a spiral antenna whose feed systems provide the 180° phase difference for a suitable band width to satisfy both the initial frequency and the extended (lower) frequencies.

The outside ends of the cavity-backed spiral elements are extended by the integration of a cavity-backed dipole element whose effective aperture approximates one half wave length at the lowest required operating frequency. The selected sense of a dominant linear polarization is optional and is determined by the orientation of the dipole elements with respect to the radius vector from the origin of the spiral elements.

In the drawings:

FIG. 1 is a perspective view of an extended frequency range antenna according to our invention.

FIG. 2 is a schematic diagram of the antenna of FIG. 1.

FIG. 3 is a view of a typical radome, shown partly in section, with our antenna installed.

Referring now to FIG. 1, a planar spiral microwave antenna element **10** having two separate interlaced spiral tracks **10***a* and **10***b* is normally formed as a printed circuit on a substrate of insulating material. Antenna element **10** is positioned overlying a microwave cavity consisting of a cylindrical container **12** which is normally lined internally with microwave absorber material which may be held in place by plastic foam material. Details of the construction of a similar cavity-backed microwave antenna appear in U.S. Pat. No. 3,441,937 (common assignee). Wired to the outside ends of each of conductor tracks **10***a* and **10***b* are dipole elements **14***a* and **14***b*. Each of dipole elements **14***a* and **14***b* is physically positioned on an insulating substrate **16***a* and **16***b*, respectively, supported on housings **18***a* and **18***b* which constitute extensions of the microwave cavity housing **12**. These housings are also lined with microwave absorber material.

FIG. 2 is a schematic drawing showing some of the electrical properties of the device of FIG. 1. A pair of conductors **20** and **22** are connected to the antenna element with conductor **20** connected to spiral track **10***a* and conductor **22** connected to spiral track **10***b*. These conductors are normally supplied through a coaxial connector having a shield **24**. The dipole elements **14***a* and **14***b* are connected to the spiral elements **10***a* and **10***b*, respectively, as described above, and these are held physically displaced from the back side of the cavity element **12**. In the space between cavity **12** and elements **10***a*, **10***b*, **14***a* and **14***b* is placed a layer of microwave absorber material.

In FIG. 3 is shown a radome **25** which is partially broken away to show the antenna installation against its inside wall. In this installation the insulating substrate for the antenna element **10** is formed in a dome-shaped configuration to minimize the air space between the antenna surface and the interior surface of the radome **25**. The dipole extensions **14***a* and **14***b* are positioned against the inside surface of the radome and therefore curved to follow its configuration. Attached to the lower part of housing **12** are metal plates **26***a* and **26***b* which constitute ground plane elements for the dipole antenna elements **14***a* and **14***b*, respectively. Located between ground plane element **28***a* and antenna element **14***a* is a layer of material which may be all microwave absorber material or partially microwave absorber material and partially a plastic foam material which is used as a spacer. Similar material is shown at **28***b* between ground plane **26***b* and antenna element **14***b*. To take up any possible remaining air space between the surface of antenna element **10** and the interior surface of the radome **25**, a spacer **30** of flexible compressible material may be used between these members. Such a spacer may be made of silicon rubber or other suitable material having dielectric characteristics very similar to that of the radome material.

While only a single embodiment is shown and described herein, modifications may be made to suit certain particular installations. The curved arrangement shown in FIG. 3 causes a flattening or broadening of the antenna characteristic but otherwise has little effect. From the foregoing, it will be appreciated that applicants have provided an antenna structure which conforms to the internal dimensions of the radome **25** to much better advantage than would the cavity-backed spiral antenna of substantially larger diameter, yet its performance is quite similar.

We claim:

1. A wide band microwave antenna assembly comprising:

a planar spiral antenna mounted on a substrate of insulating material, said antenna including a pair of interlaced spiral elements having terminals near the axis of said assembly,

a cavity structure of generally cylindrical configuration supporting said antenna element and positioned at the back of said planar spiral antenna,

and a lower frequency linearly polarized antenna extension comprising a cavity-backed dipole element electrically connected to the outside ends of each of said spiral elements.

2. A wide band microwave antenna assembly comprising:

a cylindrical cavity,

an antenna element overlying said cavity including a substrate of insulating material and a pair of interlaced spiral antenna tracks fixed to said substrate,

and a lower frequency extension comprising a cavity-backed dipole element connected to the outside end of each of said tracks such that the overall width of the assembly is approximately one-half wave length at the lowest frequency for which the antenna is expected to provide significant gain.

3. A wide band antenna assembly as set forth in claim **2** wherein said cavity and the cavities backing said dipole elements are lined with microwave absorber material.

4. A wide band antenna assembly as set forth in claim **2** wherein said spiral track and said dipole elements are conformed to fit against a rounded radome structure.

5. A wide band antenna assembly as set forth in claim **2** wherein said substrate is dome-shaped and said dipole elements are curved.

6. A wide band antenna assembly as set forth in claim **2** wherein the height of said antenna tracks and dipole members from the back walls of their respective cavities is less than one-quarter wave length over the frequencies received.

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