United States Patent

[11] 3,573,834

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[21] Appl. No. 772,300
[22] Filed Oct. 31, 1968
[45] Patented Apr. 6, 1971
[73] Assignee The United States of America as represented by the Secretary of the Air Force

[54] CRESCENT SHAPED CAVITY BACKED SLOT ANTENNA
10 Claims, 3 Drawing Figs.

[52] U.S. Cl. 343/769, 343/789
[51] Int. Cl. H01q 13/12
[50] Field of Search 343/767, 768, 769, 789

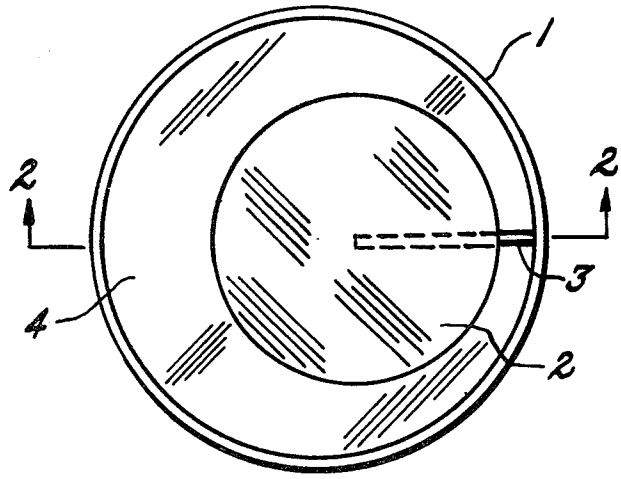
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ABSTRACT: The invention comprehends a cavity backed slot antenna having improved RF bandwidth characteristics. The cavity is cylindrical and has a series coaxial transmission line feed which provides radially symmetrical TEM mode cavity field excitation. The slot is substantially crescent shaped. A radially disposed vane member within the cavity is used to generate an internal E field.



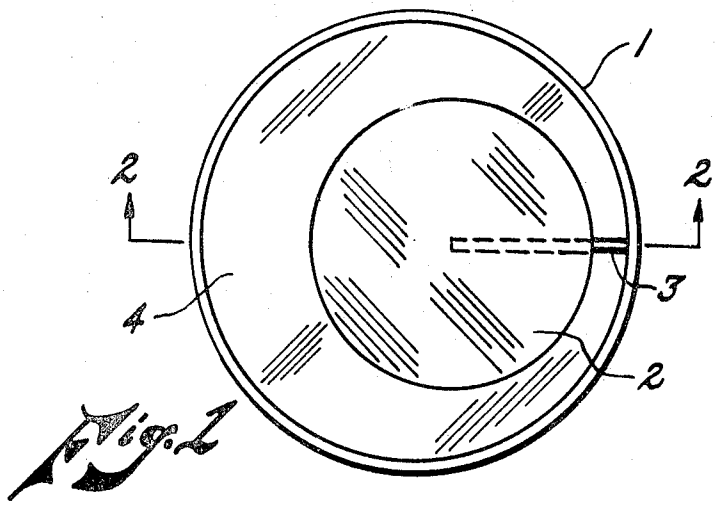


Fig. 1

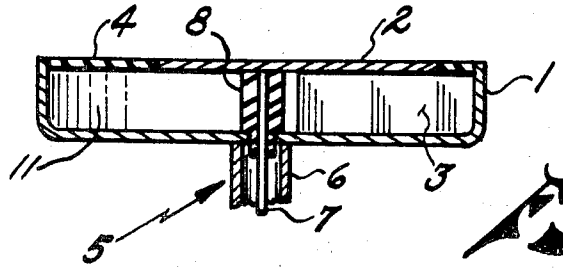


Fig. 2

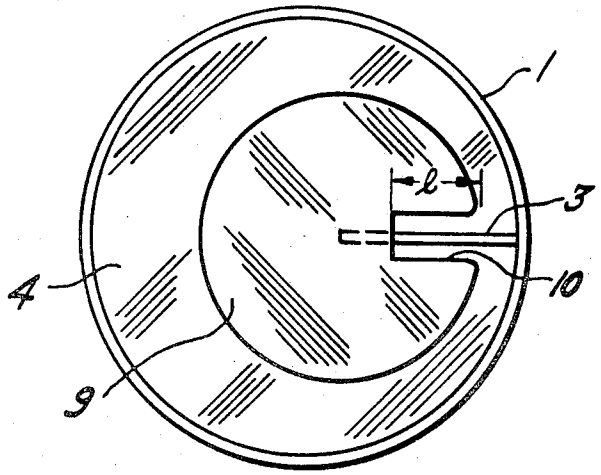


Fig. 3

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CRESCENT SHAPED CAVITY BACKED SLOT ANTENNA

BACKGROUND OF THE INVENTION

The invention relates to antennas for use in airborne applications and, in particular, to cavity backed slot antennas capable of high power broadband radiation of electromagnetic wave energy in the radio frequency spectrum.

Space vehicle, missile and aircraft packaging design requirements call for antennas having small sized cavities and slots. This represents a severe restriction on the design of such antennas because small sizes are not amenable to broadband, high-power reasonable gain systems.

Historically, slot antennas have taken several shapes—rectangular, elliptical, "dumbbell," "bowtie," cruciform, U, H, and annular. In order to prevent radiation from both sides of the slot, the antenna is provided with a backup cavity.

Antenna designers are currently faced with the problem that for matched bandwidths, antenna impedance and input VSWR have a direct dependence on the slot length. If the slot length of a rectangular slot antenna is small in terms of wavelength, the self impedance of the slot has but small real impedance and is highly reactive. Furthermore, when conventional feed systems are used, only certain modes above a given cutoff frequency can be sustained by the backup cavity. Such a cutoff frequency is determined by the cavity dimensions.

Rectangular slots of a given length have a characteristic radiation reactance which is a function of the length. As a slot is made shorter and shorter in terms of wavelengths, its radiation resistance becomes lower and the amount of power contributing to radiation is reduced. To date, in order to obtain broadband operation, larger volume devices have been resorted to. The current state of the art, therefore, indicates a need for smaller volume antennas of this type that are capable of high gain, high power, broadband operation.

SUMMARY OF THE INVENTION

An electrically short rectangular slot and a shallow backup cavity result in a high Q antenna because of high reactances and low resistances. These are the predominant parameters that limit the bandwidth and increase the VSWR of a basic slot antenna. Furthermore, the backup cavity will normally only sustain certain modes above the cutoff frequency determined by its dimensions. The present invention eliminates the cutoff frequency limitation by means of providing a coaxial series feed to the center of the backup cavity. Such a series feed, in which the cavity becomes a transformer from the coaxial TEM mode, provides the antenna backup cavity with a radially symmetric TEM mode which has no cutoff frequency.

The limitations imposed by the short rectangular slot geometry have been overcome in the present invention by stretching the shape of the slot into the form of a crescent. A cavity backed antenna having such a geometry is readily fabricated in accordance with the principles of the invention by eccentrically positioning a conductive disc in the open end of a right circular cylindrical cavity structure; the plane surface of the disc being parallel to the surface of the bottom of the cavity structure.

The crescent shaped aperture of the antenna can be filled with dielectric material and the center operating frequency can, in part, be established by the electrical properties and dimensions of such material.

The invention further comprehends, in combination with the above described structure, the introduction of a conductive vane between the disc and the cavity wall. The conductive vane is effective to generate an internal E field within the cavity and to excite currents around the slot edges. This is a necessary condition for radiation of electromagnetic energy from the antenna.

An alternative embodiment of the invention provides an elongated aperture. This is accomplished by means of removing a portion of the disc member in the vicinity of the conductive vane.

It is a principal object of the invention to provide a new and improved radio frequency cavity backed slot antenna that is adaptable to aerospace and missile applications.

It is another object of the invention to provide a radio frequency cavity backed slot antenna that is smaller in size than currently available antennas having the same electrical specifications.

It is another object of the invention to provide a radio frequency cavity backed antenna having larger bandwidth operating capabilities than currently available antennas of similar size.

It is another object of the invention to provide a radio frequency cavity backed slot antenna that has higher power handling capabilities than currently available antennas of similar size.

It is another object of the invention to provide a radio frequency cavity backed slot antenna that has higher gain than existing state of the art devices of similar size.

It is another object of the invention to provide a radio frequency cavity backed antenna having no low frequency cutoff restrictions inherent in the cavity excitation method.

These, together with other objects, advantages and features of the invention will become more apparent from the following detailed description when taken in conjunction with the illustrative embodiments in the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a plan view of one presently preferred embodiment of the invention;

FIG. 2 is a sectional view of FIG. 1 taken at 2–2; and

FIG. 3 illustrates a plan view of an alternative embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIGS. 1 and 2, there is disclosed thereby an antenna constructed in accordance with the principles of the invention. Right circular cylindrical member 1 in combination with disc member 2 defines a microwave cavity 11. Right circular cylindrical member 1 and disc member 2 are fabricated of conductive material and their physical dimensions are determined by the frequency of the electromagnetic waves to be radiated by the antenna. The antenna is fed with a radially symmetric TEM mode by means of coaxial cable 5. Coaxial cable 5 is connected through the center of the bottom of right circular cylindrical member 1. This is accomplished by electrically connecting the center conductor 7 of the coaxial cable to disc member 2 and the sheath member 6 to right circular cylindrical member 1. Insulating plug 8 electrically isolates center conductor 7 from right circular cylindrical member 1. Disc member 2 is eccentrically positioned within the opening of right circular cylindrical member 1 so as to establish a crescent shaped aperture 4. Although the fabrication method herein described for establishing such a crescent shaped aperture presently appears to be the most feasible approach, it is pointed out that any method of forming a microwave cavity of conductive material having such a crescent shaped aperture would be equally effective to implement the teachings of the invention. Crescent shaped aperture 4 can be filled with dielectric material as illustrated. Such dielectric material can be used to establish a desired central operating frequency of the antenna. A vane element 3 of conductive material is radially disposed within right circular cylindrical member 1. Vane element 3 is positioned at the points of the crescent. This geometrical arrangement provides a maximum gap (the widest portion of the crescent) in the portion of the antenna in which corona breakdown is most likely to occur, thus greatly improving the power handling capability of the device. Cavity 11 can be filled with lightweight dielectric foam (not shown) in order to prevent vibration of parts.

An alternative disc configuration is illustrated in FIG. 3. This disc 9 has a cutaway portion 10 located in the vicinity of vane element 3. Cutaway portion 10 in combination with vane

element 3 cooperates to extend the crescent shaped aperture by a length of 2 *l*. This arrangement has the effect of providing a more gradual transition from the TEM coaxial mode to the TE cavity mode and from the TE cavity mode to the crescent shaped aperture TE mode, thereby providing an even broader bandwidth antenna.

While the invention has been described in one presently preferred embodiment, it is understood that the words which have been used are words of description rather than words of limitation and that changes within the purview of the appended claims may be made without departing from the scope and spirit of the invention in its broader aspects.

We claim:

1. An antenna comprising:
- a structure of electrically conductive material defining a microwave cavity, said structure having a crescent shaped aperture disposed therein;
- means for exciting said microwave cavity with radially symmetrical TEM modes of electromagnetic wave energy; and
- means, disposed within said cavity effective to generate an internal E field and current flow along the edges of said crescent shaped aperture.

2. An antenna as defined in claim 1 having dielectric material disposed within said crescent shaped aperture.

3. An antenna as defined in claim 1 wherein said structure of electrically conductive material is in the form of a right circular cylinder having planar top and bottom surfaces.

4. An antenna as defined in claim 3 wherein said crescent shaped aperture resides along the peripheral portion of said planar top surface.

5. An antenna as defined in claim 4 wherein said means for generating an internal E field comprises a vane member radially disposed within said structure of electrically conductive material, said vane member being positioned between the crescent points of said aperture and being normal to said top and bottom planar surfaces.

6. An antenna as defined in claim 5 wherein said means for exciting said microwave cavity comprises a coaxial cable, said coaxial cable being connected through the center of said bottom surface.

7. An antenna comprising:
- a substantially cylindrical electrically conductive sidewall member;
- an electrically conductive closure member terminating one end of said sidewall member;
- an electrically conductive disc-shaped member having a diameter less than the diameter of said sidewall member disposed within the other end of said sidewall member;
- the normal axis of said disc shaped member being parallel to and offset from the major axis of said sidewall member;
- means for exciting the cavity bounded by said sidewall member, said closure member and said disc shaped member with radially symmetric TEM modes of electromagnetic wave energy; and
- means disposed within said cavity effective to generate an internal E field and current flow along the edges of said disc-shaped member.

8. An antenna as defined in claim 7 wherein said means for exciting said cavity with radially symmetrical TEM modes of electromagnetic wave energy comprises a coaxial cable, having a center conductor and a sheath member, said center conductor being electrically connected to said disc-shaped member and said sheath member being electrically connected to the center of said closure member.

9. An antenna as defined in claim 8 wherein said means for generating an internal E field comprises a planar vane member of conductive material radially disposed within and electrically connected to said sidewall member in a plane normal to the plane of said disc-shaped member.

10. An antenna as defined in claim 9 wherein said disc-shaped member is recessed in the vicinity of said vane member.