

Oct. 13, 1970

JAMES E. WEBB
ADMINISTRATOR OF THE NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION
HIGH IMPACT ANTENNA

3,534,376

Filed Jan. 30, 1968

2 Sheets-Sheet 1

FIG. 1

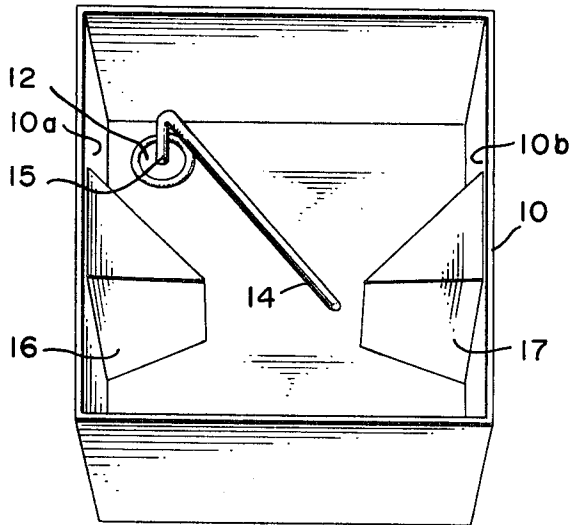


FIG. 2

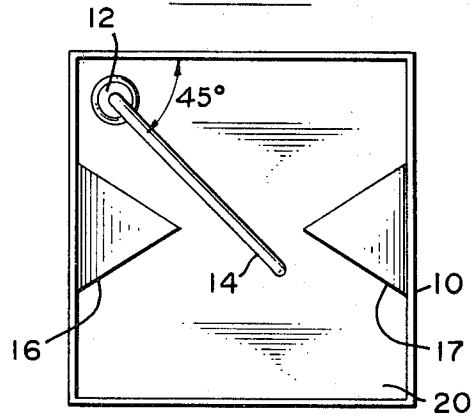


FIG. 3

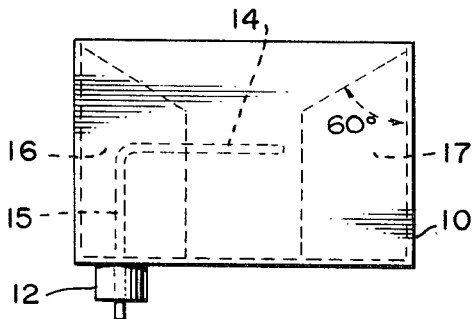


FIG. 4

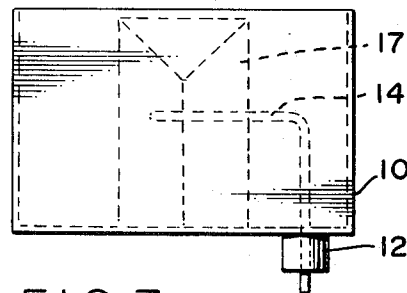


FIG. 7

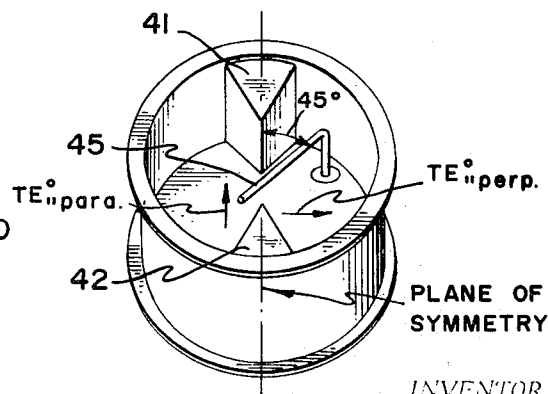
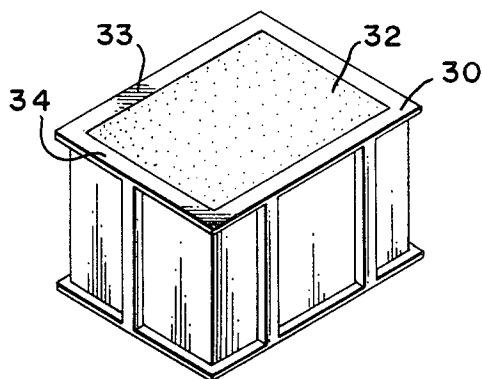


FIG. 6



INVENTOR,
KENNETH E. WOO

BY

J. H. Warden
Wm. C. Long
ATTORNEYS

Oct. 13, 1970

JAMES E. WEBB
ADMINISTRATOR OF THE NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION
HIGH IMPACT ANTENNA

3,534,376

Filed Jan. 30, 1968

2 Sheets-Sheet 2

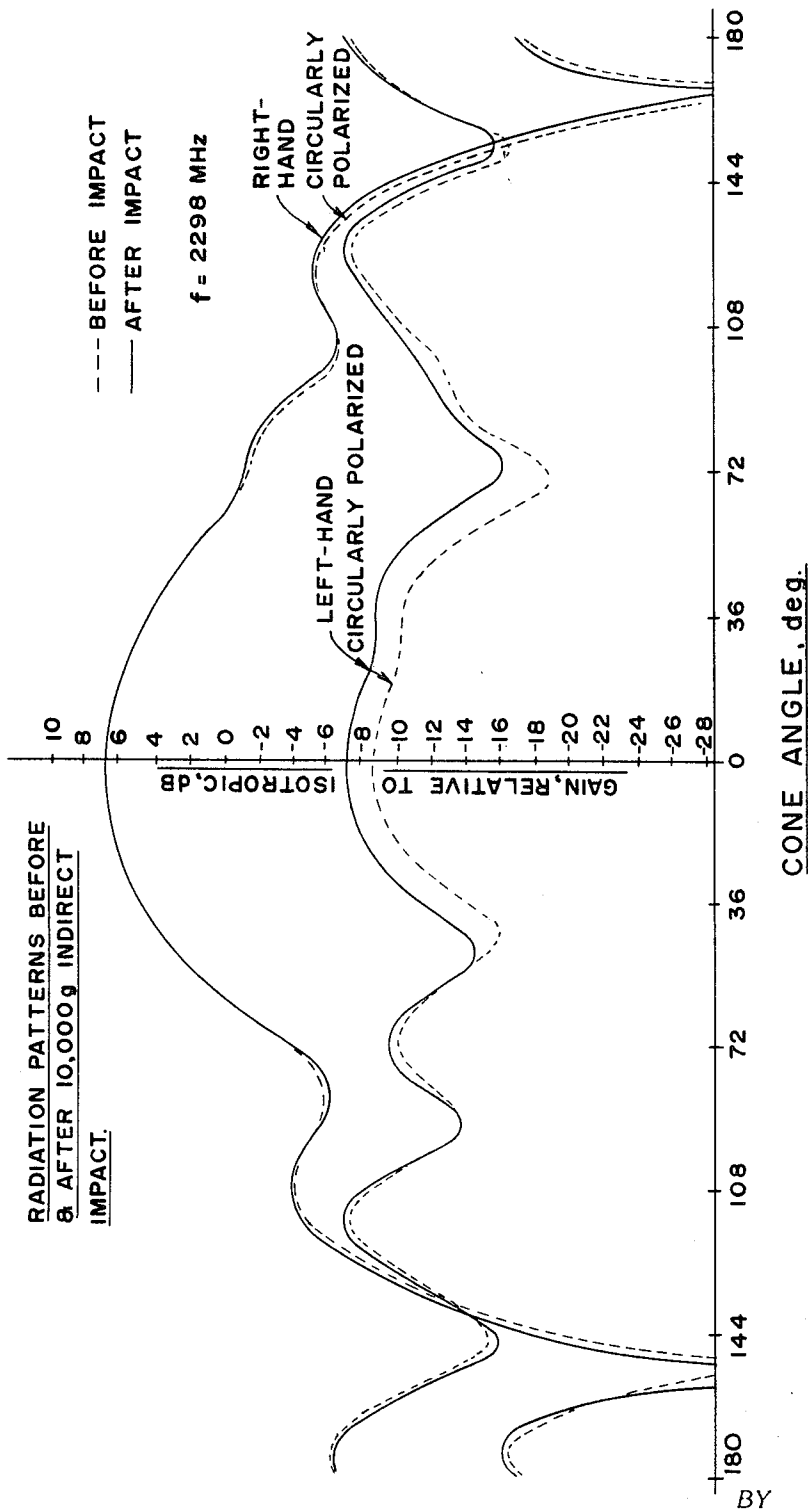


FIG. 5

INVENTOR.
KENNETH E. WOO
J. H. Warden
G. H. Warden
ATTORNEYS

1

3,534,376

HIGH IMPACT ANTENNA

James E. Webb, Administrator of the National Aeronautics and Space Administration, with respect to an invention of Kenneth E. Woo, South Pasadena, Calif.
Filed Jan. 30, 1968, Ser. No. 701,767
Int. Cl. H01q 13/02

U.S. Cl. 343—786

10 Claims

ABSTRACT OF THE DISCLOSURE

A high impact antenna is disclosed which consists of a cup, whose open end defines the antenna's radiating aperture. A probe, which is energized with microwave energy, is positioned within the cup, parallel to the cup's shorted end at a selected distance therefrom and at an angle with respect to the cup's side walls to excite modes therein, which radiate outwardly through the open end at a selected polarization. Dielectric material fills the cup to support the probe, as well as strengthen the side walls from collapsing, when the antenna is subjected to high impact. The dielectric material serves to keep foreign matter out of the antenna and enables the construction of an antenna of reduced size.

ORIGIN OF INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 U.S.C. 2457).

BACKGROUND OF THE INVENTION

Field of the invention

This invention generally relates to energy-radiating devices and, more particularly, to an antenna capable of withstanding high impact.

Description of the prior art

The exploration of space has led to the design and development of a large number of instruments and systems, which are capable of operating satisfactorily under space conditions. Many instruments and systems have been developed which can withstand high impact of a magnitude, which may be encountered when instruments hard land on the moon, or other bodies in space. Since the success of any space exploration mission is dependent on the ability to communicate with the systems aboard a vehicle in space, considerable effort has been directed to the development of antennas, through which signals may be received from and transmitted to earth.

Among the desired characteristics of an antenna which has to withstand a high impact are simplicity of design, high radiating efficiency, small size, high power, broad bandwidth, adaptability to provide a desired energy polarization, and beam shape. Additional desirable characteristics are light weight and satisfactory operation at high temperatures. Although some, presently known antennas, may possess some of these features, they have been found wanting, particularly in applications intended to survive high impact. High impact is intended to mean indirect impact in the range of 10,000g and direct impact in the range of 250 ft./sec. of impact velocity.

OBJECTS AND SUMMARY OF THE INVENTION

It is a primary object of this invention to provide a new improved antenna.

Another object of this invention is to provide an antenna which has substantially all the aforementioned characteristics.

2

Yet another object of the invention is to provide a new high impact antenna.

A further object of the invention is the provision of an antenna of a relatively simple, though basic design. The specific dimensions of the antenna are chosen to provide desired energy polarization and beam shape characteristics.

Still a further object of this invention is to provide a small, simple, highly adaptable antenna which is capable of withstanding a high impact.

These and other objects of the invention are achieved by providing an antenna which in one embodiment consists of a rectangular metallic cup, excited by a conductive probe. The cup is closed or shortened at one end and open at the opposite end, which defines an antenna radiating aperture. The probe is slanted between two opposite walls of the cup so that when signals are supplied thereto, the probe excites the orthogonal rectangular modes TE_{10} and TE_{01} . By properly selecting the cup's dimensions, including its cross-section and depth, the probe size and its location and angle of inclination within the cup, hereafter referred to as the probe's position, orthogonal waves of selected amplitudes and phase velocities may be excited. Consequently, at the cup's open end, which defines the antenna's radiating aperture, the amplitude of the waves and their phase relationship are such that radiation of a selected polarization and in the form of a beam of selected shape are obtained.

For example, by choosing a cup with a selected rectangular cross-section and by controlling its depth and the proper positioning of the probe, the two orthogonal waves which are excited may become equal in amplitude and in phase quadrature at the aperture, so that circularly polarized radiation is achieved. If the cup's cross-section is chosen to be square, the proper amplitude and phase relationship of the two waves, at the aperture, may be obtained by the use of suitable perturbations.

In addition to the probe which is supported in the cup, the latter is preferably filled with a dielectric material. Its function is to secure the probe's position in the cup when subjected to high impact, as well as to strengthen the cup's side walls so as to minimize their distortion due to the impact. It is appreciated that when dielectric material fills the cup it keeps foreign matter out of it. Also, due to dielectric loading, a cup of reduced size may be utilized, thus resulting in a smaller size antenna.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention will best be understood from the following description when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric view of one embodiment of the present invention;

FIGS. 2, 3 and 4 are three mutually perpendicular views of the embodiment of FIG. 1, with FIG. 2 representing the front view;

FIG. 5 is a diagram of radiation patterns of an antenna constructed in accordance with the teachings of the invention, recorded before and after high impact;

FIG. 6 is an isometric view of another embodiment of the invention; and

FIG. 7 is an isometric view of still another embodiment of the invention consisting of a cup antenna with a circular cross-section.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference is now made to FIG. 1 which is an isometric view of one embodiment of a cup antenna, constructed in accordance with the teachings of the present invention.

Dielectric material, which in practice fills the cup, is purposely deleted in order to diagram various internal parts of the antenna. FIGS. 2, 3 and 4 are respective front and two side views of the same embodiment. The antenna consists of a ruggedized metallic cup 10, having a substantially square cross-section with a closed or shorted bottom end and an opposite open end. The open end defines the radiating aperture of the antenna.

A coaxial connector 12 is supported at the bottom end of the cup. The center conductor of the connector is electrically coupled to a probe 14 which is supported in the proper position within the cup by a probe section 15. Hereafter however, whenever the probe is mentioned it refers to the section, designated by numeral 14.

The probe 14, which may take the form of a dipole, a loop, or any other configuration, hereafter all referred to as probe, is supported so as to slant between two opposite side walls of the cup, such as walls 10a and 10b, at a predetermined selected distance from the bottom end of the cup and preferably parallel thereto. By supplying energy to the probe, due to its slanted position and the shape of the cup 10, it excites the rectangular modes TE_{10} and TE_{01} , perpendicular to one another. Due to the equal dimensions of the sides of cup 10, i.e., since the cup is of square cross-section, the two modes will propagate with the same phase velocity. To introduce differential phase between the modes, in order to produce radiation in a selected polarization, the presently described embodiment of the invention includes a pair of perturbations, designated 16 and 17, respectively positioned on the opposite sides or walls 10a and 10b of the cup. These two perturbations are in the form of angular ridges.

As is appreciated by those familiar with the art, by properly selecting the cup's dimensions, including its depth and cross-section, the dimensions and shapes of the perturbations, the probe size and its position, the two modes excited thereby may be made to be at a desired amplitude and phase relationship at the aperture of the cup. Consequently, energy which radiates at a selected polarization may be obtained. For example, the various dimensions and positions may be selected so that the two orthogonally excited modes are equal in amplitude and in phase quadrature at the aperture, so that the energy radiating out of the open end of the cup, i.e., the antenna's radiating aperture, is circularly polarized.

As previously remarked, in order to enable the antenna to sustain high impacts, the cup is filled with a dielectric material 20 (FIG. 2). Its function is to secure the position of the probe 14 within the cup despite the high impact, as well as to help prevent the cup walls from distorting or collapsing during the impact. In addition, it serves to keep any foreign matter from entering the cup and thereby distort its characteristics. The dielectric material is chosen to have high compressive strength, low electric losses, and good performance characteristics at high temperature. For antenna applications in a vacuum, it is preferred that the dielectric material also have low outgassing characteristics. In addition, the chosen dielectric material should have a reasonably high dielectric constant so that the overall size of the antenna can be reduced, due to the dielectric loading produced by the material.

Dielectric materials which have been found to be quite satisfactory include Eccofoam PT, and Stycast 1090, all of which are manufactured and sold by Emerson and Cuming, Inc., of Canton, Mass. Other materials which have been found useful include fused silica and Imidite SA, the latter sold by Whittaker Corporation. It should be pointed out that these materials exhibit different characteristics and therefore the particular material which is selected would depend on the particular conditions which the antenna may be subjected to. Also, it should be apparent that other dielectric materials may be used, and therefore the enumerated materials should be regarded as exemplary only.

In one specific embodiment which was actually reduced

to practice, the antenna was designed to radiate energy at 2298.3 mHz. The antenna cup of metallic material was square, with internal dimensions of 2.1 by 2.1 inches and 2.2 inches. A probe of 0.093 inch in diameter was supported within the cup at an inclination of 45° . The probe length was 1.368 inches measured from the center of section 15 and its center was spaced 1.740 inches from the bottom of the cup.

Two triangular ridges were centrally positioned within the cup on opposite side walls, such as 10a and 10b. The base of each ridge was 0.583 inch, while its height was 0.535 with the front sides of the ridges sloped at a 60° angle, as diagrammed in FIG. 3. The ridges 16 and 17 were purposely used to provide circularly polarized radiation. The dielectric material was Eccofoam PT. The radiation patterns measured before and after an indirect impact of 10,000 g over a duration of 0.6 millisecond are diagrammed in FIG. 5 to which reference is made herein. As seen from the figure, impact did not produce any appreciable change in the electrical performance of the antenna.

In addition to the high impact characteristics of the antenna of the present invention, other of its desirable characteristics include its small size, partly accountable by the dielectric loading, provided by dielectric material 20, its simple construction, and light weight, relatively broad bandwidth, and its adaptability to radiation of energy at selected polarization. The latter feature is accomplished by controlling the cup's dimensions, its perturbations, the probe size, and its position. Also, since the antenna's radiating aperture is defined by the open end of the cup, the antenna has a relatively large aperture favoring high power operation, which is enhanced by placing the connector at the cup's corner where the field is relatively small. The large aperture minimizes the danger that the antenna's aperture may be closed by a high impact.

It should further be pointed out that when utilizing the embodiment in which the antenna cup has a square cross-section, the shape of the radiating beam is substantially equal in all directions about the longitudinal axis of the antenna. This feature may be particularly desirable when the final orientation of the antenna with respect to a receiver or transmitter is not known. In some applications, however, it may be desirable to produce radiation of unequal beam width. In such a case, a cup of rectangular cross-section, may be employed. An isometric view of an antenna, employing such a cup, is shown in FIG. 6, to which reference is made herein. Therein, the cup is designated by numeral 30, the dielectrical material by numeral 32, and adjacent side walls of different lengths by 33 and 34. In such an arrangement, if circular polarized radiation is required, the cross-sectional dimensions of the cup, as well as its depth, are controlled to produce phase quadrature between the two modes at the aperture, without resort to perturbations or ridges, such as those shown in FIG. 1. That is, the dimensions of the rectangular cross-section, the depth of the cup, probe's position within the cup and the dielectric material are selected to provide two orthogonal modes which are equal in amplitude and in phase quadrature at the aperture, which defines the antenna's radiating aperture, to produce circularly polarized radiation.

Due to the high impact characteristics of the novel antenna of the present invention, the antenna can be used advantageously in space exploration where hard landing of instruments is planned or contemplated. In addition, the antenna may be utilized, in conjunction with a transmitter designed to survive very high impact, as a search beacon antenna for aircraft. The combination of such a transmitter with the novel antenna of the present invention would be most advantageous in locating the site of a downed aircraft. The antenna may similarly be used aboard ship, since the dielectric material 20, which fills the cup, would serve as a filling material to minimize the

adverse effect of moisture or ship vibration on the antenna's operation.

In another embodiment of the invention, the cup antenna may be of circular cross-section, as shown in FIG. 7, to which reference is made herein. In FIG. 7, the dielectric material is purposely deleted in order to show two internal ridges 41 and 42, and a probe 45. Since a circular cup antenna is symmetrical about its longitudinal axis, its structure may be found to be more advantageous in certain applications, such as in a high pressure environment or when dictated by space restrictions. In FIG. 7, the two ridges are shown extending along the cup's inside wall. The probe 45 is inclined at 45° with the plane of symmetry. The probe excites the dominant TE₁₁ mode in the cup. This mode may be considered as a superposition of two, approximately equal amplitude, orthogonal TE₁₁ modes, one perpendicular and the other parallel with the plane of symmetry. The function of the ridges is to introduce appropriate phase shift between this mode pair for circular polarization.

There has accordingly been shown and described herein a novel high impact antenna, consisting primarily of a cup of a preselected cross-sectional configuration and dimension. One end of the cup is closed or shorted and the other end is open, acting as the antenna's radiating aperture. By controlling the depth of the cup, and the position of a probe within the cup, radiation of a selected polarization may be obtained with or without the use of perturbations as may be required. By filling the cup with dielectric material of selected properties, the cup size is reduced and the probe is secured within it to withstand high impact, as well as to support the cup's side walls from distortion during the impact. The probe may be replaced by a dipole antenna or loop or any other means, designed to excite two orthogonal electromagnetic waves within the cup, which, as a function of their amplitudes and phase relationship at the cup's aperture, produce the desired polarization and pattern of the radiated energy.

It is appreciated that those familiar with the art may make modifications and/or substitute equivalents in the arrangements as shown. Therefore, all such modifications and/or equivalents are deemed to fall within the scope of the invention as claimed in the appended claims.

What is claimed is:

1. An antenna comprising:

a cup-like member having one shorted end perpendicular to a longitudinal axis of said member, and an opposite parallel open end, said open end serving as an antenna radiating aperture, said member having a cross-section of a preselected geometric configuration in a plane perpendicular to said longitudinal axis;

a probe, positioned in said cup-like member at a preselected distance from said shorted end and in a preselected orientation;

means coupled to said probe to supply it with signals so as to excite electromagnetic waves of predetermined modes in said cup-like member; and

a dielectric material filling said cup, the geometric configuration of said member being a square, and said probe being positioned parallel said shorted end and slanted between opposite walls of said cup-like member, said walls extending from said shorted end to the open end.

2. The antenna as recited in claim 1 further including at least a first perturbation positioned in said member to control the amplitudes and phase relationship of electromagnetic waves at the open end thereof.

3. The antenna as recited in claim 2 wherein the waves excited in said cup-like member are in modes TE₁₀ and TE₀₁ and said at least first perturbation controls the phase and amplitudes thereof to radiate circularly polarized electromagnetic energy.

4. The antenna as recited in claim 3 wherein said dielectric material has a relatively high compressive strength to increase the member's ability to withstand a relatively high impact with minimal deformation.

5. The antenna as recited in claim 3 wherein said antenna includes a second perturbation, positioned opposite said first perturbation.

6. The antenna as recited in claim 1 wherein said geometric configuration is a rectangle and said probe is positioned parallel said shorted end and slanted between opposite walls of said cup-like member, said walls extending from said shorted end to the open end.

7. The antenna as recited in claim 6 wherein the waves excited in said cup-like member are the rectangular modes TE₁₀ and TE₀₁ and the cross-sectional dimensions of said cup, its depth, the position of the probe and the dielectric material are selected to produce radiation of energy of a preselected polarization.

8. The antenna as recited in claim 7 wherein said dielectric material has a relatively high compressive strength to increase the member's ability to withstand a relatively high impact with minimal deformation.

9. An antenna comprising:

a cup-like member having one shorted end perpendicular to a longitudinal axis of said member, and an opposite parallel open end, said open end serving as an antenna radiating aperture, said member having a circular cross-section in a plane perpendicular to said longitudinal axis;

a probe, positioned in said cup-like member at a preselected distance from said shorted end and in a preselected orientation;

means coupled to said probe to supply it with signals so as to excite electromagnetic waves of preselected modes in said cup-like member;

first and second ridges in said member to control the relative amplitudes and the phase relationships of the modes excited therein; and

a dielectric material filling said member.

10. The antenna as recited in claim 9 wherein said first and second ridges control the relative amplitudes and the phase relationship at the open end of said member of two orthogonal modes TE₁₁ excited therein, to produce radiation at a selected polarization.

References Cited

UNITED STATES PATENTS

2,814,039 11/1957 Watson ----- 343-789 X
3,239,838 3/1966 Kelleher ----- 343-789

HERMAN KARL SAALBACH, Primary Examiner
M. NUSSBAUM, Assistant Examiner

U.S. Cl. X.R.

343-789