United States Patent

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[54] **ELECTRICALLY SMALL CAVITY ANTENNA**
4 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **343/708,** 343/769, 343/789
[51] **Int. Cl.** **H01q 1/28**
[50] **Field of Search** 343/705, 708, 773, 774, 775, 789, 830, 908, 769

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ABSTRACT: An electrically small cavity antenna especially adapted for flush mounting in an aircraft vertical stabilizer. A cavity is formed in the vertical stabilizer so as to have a pair of radiation windows or apertures on opposite sides of the stabilizer. An energy coupling device is placed substantially in the center of the cavity to couple energy from a feeding network to the cavity. The energy coupling device includes a pair of spaced-apart plates with a tapered portion disposed between the plates. Energy is coupled from the feed network to one of the plates and the narrow end or apex of the tapered portion.

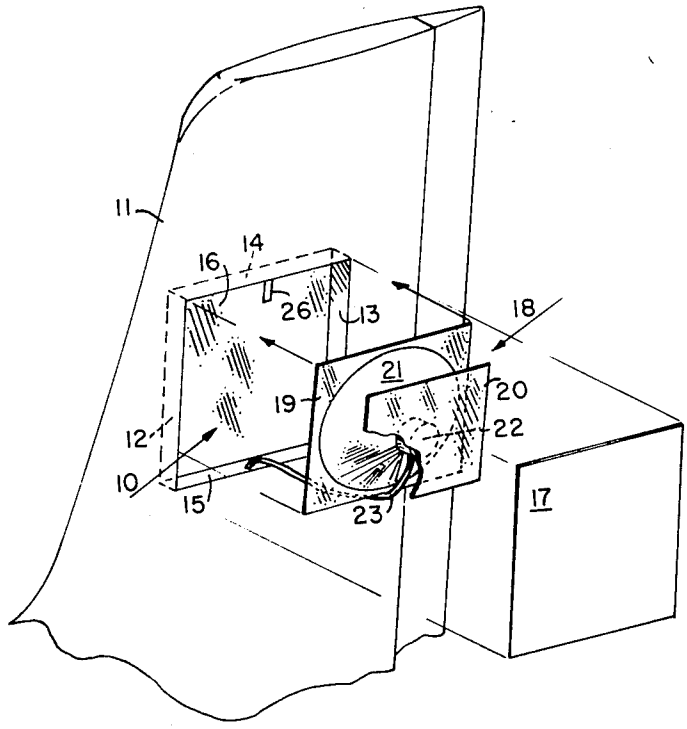


FIG. 1

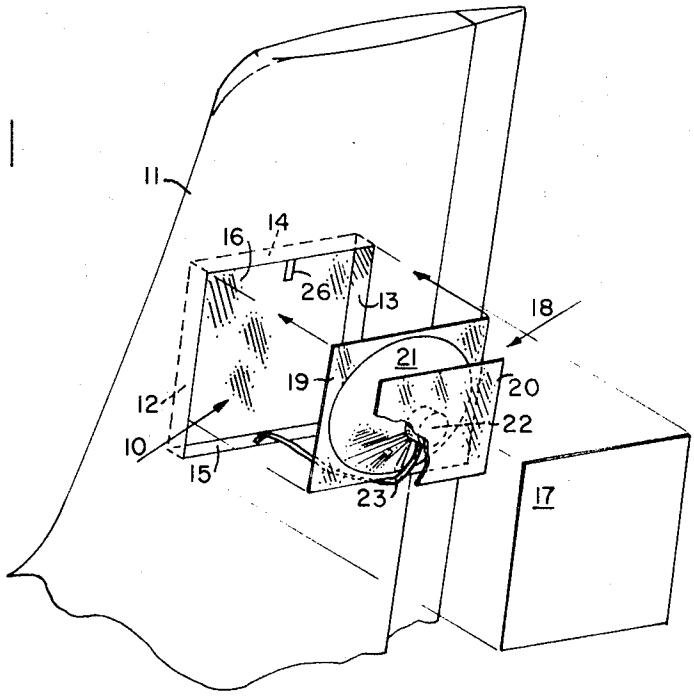
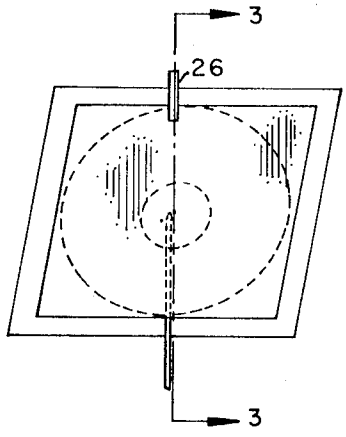


FIG. 2



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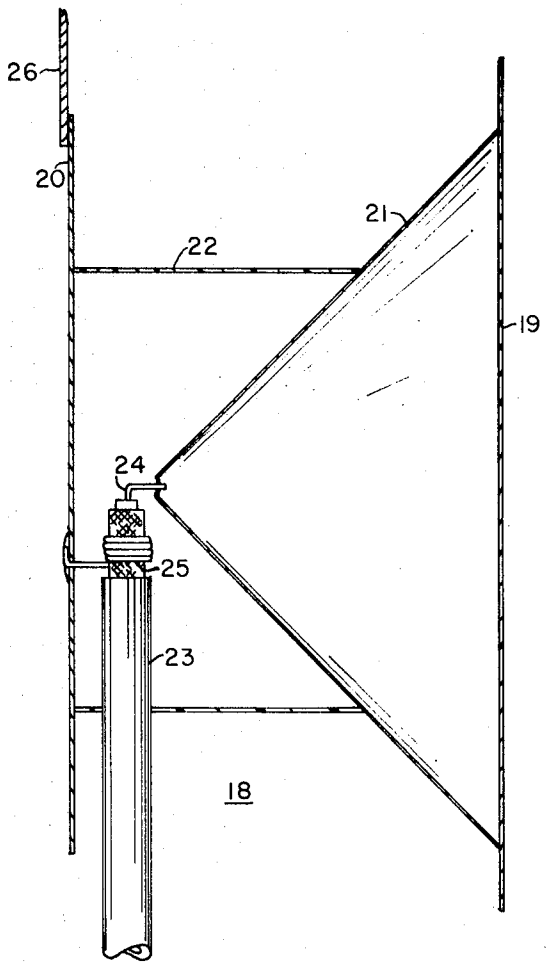
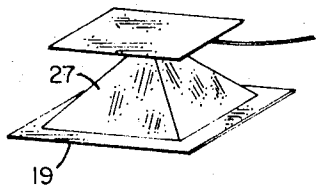


FIG. 3

FIG. 4



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ELECTRICALLY SMALL CAVITY ANTENNA

BACKGROUND OF THE INVENTION

This invention relates to a new and improved antenna and, in particular, to a cavity type antenna which is of relatively small physical size.

The fundamental limitations imposed on the performance of a small cavity antenna by its physical size are well known. In general, as a cavity antenna is made smaller, its radiation efficiency and bandwidth become smaller. Such limitations, as the foregoing, become most severe when the maximum physical dimension of the cavity antenna aperture is considerably less than one-half of a free space wavelength at the lowest frequency of interest.

For such small cavity antennas, the bandwidth can be increased by resistive loading. However, such resistive loading decreases the radiation efficiency such that the gain is reduced by the same factor as the bandwidth is increased. That is, the overall gain is the product of the directive gain and the radiation efficiency.

For example, at the very high frequency (VHF) range of communications used by aviation (118 to 136 megahertz, Mhz), a free space half wavelength corresponds to an aperture dimension on the order of 4 feet. It is apparent that, for most aircraft, a cavity having aperture dimensions on the order of 4 feet would seriously disrupt the design of the aircraft for either external or internal (flush) mounting. By employing the aforementioned resistive loading technique, low efficiency cavity antenna dimensions on the order of 20 inches have been flush mounted in relatively large aircraft in the navigation band (108 Mhz.). However, such resistively loaded cavity antennas not only have low efficiency, but are impractical for use in smaller aircraft.

BRIEF SUMMARY OF THE INVENTION

An object of this invention is to provide a new and improved cavity antenna.

Another object is to provide a novel cavity antenna having aperture dimensions considerably less than one-half wavelength without resistive loading but yet having the electrical characteristics of a much larger cavity antenna.

Yet another object is to provide a new and improved energy coupling device.

In brief, a cavity antenna embodying the present invention includes a cavity having at least one aperture and an energy coupling device supportably mounted within the cavity. The coupling device includes an electrically conductive tapered portion having a narrow and a wide end. An electrically conductive plate is supported adjacent the narrow end of the tapered portion. Energy feeding means has separate connections to the plate and to the narrow end of the tapered portion.

In one embodiment of the invention, the tapered portion has the shape of the cone while in another embodiment it has a multisided shape. In either case, another electrically conductive plate is preferably attached to and covers the wider end of the cone or multisided tapered portion.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, like reference characters denote like structural elements; and

FIG. **1** is a dimensional view of a flush mounted cavity antenna embodying the invention; and

FIG. **2** is a planned view of an energy coupling device embodying the present invention; and

FIG. **3** is a sectional view taken along the lines of **3**—**3** of FIG. **2**; and

FIG. **4** is a dimensional view of another energy coupling device embodying the invention.

DESCRIPTION OF PREFERRED EMBODIMENT

Although the cavity antenna of the present invention can be used in any desired frequency range, it is especially useful for

VHF communications. By way of example and completeness of description, the cavity antenna of the invention, herein illustrated, is embodied as a flush mounted aircraft communications antenna. Generally, VHF communications aviation band antennas are required to operate over the frequency range of 118 to 136 Megahertz (Mhz.), to have a voltage standing wave ratio (VSWR) of less than 2:1, to have a nominal gain of zero decibel (db.), to have vertical polarization and to have an essentially omnidirectional radiation pattern in the azimuth plane.

In the flush mounted embodiment shown in FIG. **1**, a cavity **10** is formed in a suitable portion of the aircraft frame, such as vertical stabilizer **11**, of which only a portion is illustrated. The cavity **10** is formed in a suitable portion of the aircraft frame, such as vertical stabilizer **11**, of which only a portion is illustrated. The cavity **10** has a pair of sidewalls **12** and **13**, a top wall **14**, and a bottom wall **15**; each wall being of a suitable electrically conductive material, such as metal, for example, aluminum. Each of the walls may have a geometrical contour, as illustrated, so as to conform to the contour and structural design of the aircraft. The cavity **10** also has a pair of apertures (or windows) disposed on opposite sides of vertical stabilizer **11** and having suitable radomes **16** and **17** attached thereto. The radomes **16** and **17** may be of any suitable electromagnetically transparent material, such as fiberglass, and are attached to stabilizer **11** by any suitable fastening means, such as screws or bolts (not shown).

Radome **17** is shown in FIG. **1** as removed from stabilizer **11** in order to conveniently illustrate the cavity **10** and an energy coupling device **18**, which is disposed within cavity **10** when assembled. The arrows in FIG. **1** illustrate the respective locations of coupling device **18** and radome **17** relative to cavity **10** when in assembled form.

The coupling device **18** includes front and backplate portions **19** and **20**, respectively, and a tapered or flared portion **21** disposed therebetween. The plates **19** and **20**, and the tapered portion **21** may be any suitable electrically conductive material; such as metal, for example, brass, aluminum, copper, and the like. The tapered portion **21**, which may suitably have the shape of a cone, has its wide end attached to front plate **19** by any suitable means, for example, a solder or weld joint. The cone **21** is secured by way of a dielectric support **22** to backplate **20** such that the narrow end (apex) of the cone is electrically isolated, as by spacing, from backplate **20** (best seen in FIG. **3**). The dielectric support **22** is attached to the backplate **20** and to the cone **21** by any suitable means, such as bonding or hardware. The backplate **20** has been partially broken in FIG. **1** in order to illustrate the support **22**.

The coupling device **18** is fed by any suitable feeding device **23**, such as the illustrated coaxial cable. The cable **23** extends downwardly through the bottom wall **15** of cavity **10** into the vertical stabilizer **11** and hence to the aircraft fuselage (not shown) where it is connected to a transmitting and/or receiving device (also not shown). The attachment of cable **23** to the coupling device **18** is best seen in FIGS. **2** and **3**. The central conductor **24** is attached, as by soldering, to the narrow end of the cone **21** and the outer conductor **25** is attached to the backplate **20**. Although the connecting order of the central and outer conductors may be reversed, the illustrated order is preferred for lightening protection. In assembled form, the coupling device **18** is located substantially in the center of cavity **10** and is supported therein by any suitable supporting means, preferably of a low dielectric material. For example, in one cavity antenna embodiment actually constructed, the coupling device **18** has been supported in cavity **10** by means of a low dielectric constant foamlike material. Also in the assembled form, the radome covering **17** is fastened to the vertical stabilizer **11** so as to fit over the cavity aperture and secure the supporting foam and coupling device **18** within the cavity.

For impedance matching purposes, a stub **26** (for example, a strip of metal) is coupled between he backplate **20** of coupling device **18** and the top wall **14** of cavity **10**. The stub **26** may be fastened to backplate **20** and the cavity wall **14** by

any suitable electrical connecting technique as, for example, a solder joint or a bolted joint. The width and the length of stub **26** are preferably selected for optimum impedance matching of cavity **10** with coupling device **18** and feed cable **23**. Although stub **26** may have other locations (e.g., between cone **21** and plate **20**), it preferably has the illustrated location for mechanical support as well as lightening protection.

The coupling device **18** serves the function of transferring energy between cavity **10** and the feed cable **23**. It has been found that the coupling device **18** permits the apertures of cavity **10** to have physical dimensions substantially smaller than one-half of a free space wavelength at the lowest frequency of interest, but yet provide the electrical characteristics of a much larger cavity. For example, in one cavity antenna design for the VHF aviation communication band, the aperture dimensions were approximately 12 inches. That is, the cavity walls **12, 13, 14** and **15** were each approximately 12 inches in length which corresponds to an aperture dimension on the order of one-tenth of a free space wavelength at the lowest frequency (118 Mhz.) of interest. The azimuth patterns of the constructed cavity antenna (which was vertically polarized) were omnidirectional within 1 db. and were measured every 2 Mhz. from 118 to 136 Mhz. The gains, which were measured by comparing the antenna to a vertically polarized dipole, varied from −2.0 to 1.0 db. with respect to the dipole. The antenna range used to measure the radiation patterns and relative gain was a 100-foot ground plane range calibrated for measurements in the VHF band. The VSWR was less than 2:1 throughout the frequency band of 118 to 136 Mhz.

The conical shape of the tapered portion **21** is preferred since it can be easily fabricated at low cost. However, other tapered shapes can be employed. For example, a multisided shape, such as the four sided (pyramidal) shape **27** illustrated in FIG. **4** can be used. The plate **19** of the conical and pyramidal coupling device embodiments is desirable to provide symmetry as well as to provide an area which is compatible with the area of the aperture. However, it is to be noted that the cavity antenna will also operate with plate **19** removed.

It should also be noted that cavity **10** could be located in portions of the airframe other than the vertical stabilizer **11** and that the antenna can be designed for frequency bands other than the aviation band. Indeed, the cavity antenna can be embodied in applications other than flush mounted aircraft applications.

What is claimed is:

1. A cavity antenna comprising

a cavity enclosure having first and second apertures on opposite sides thereof;

an energy coupling device including

first and second electrically conductive plates

an electrically conductive tapered portion having a narrow end supported adjacent the first plate and a wide end which is attached to and covered by the second plate;

means for supportably mounting said coupling device substantially in the center of the cavity with the first and second plates facing the first and second cavity apertures, respectively; and

energy feeding means having separate connections to the first plate and to the narrow end of the tapered portion.

2. The invention according to claim **1**

wherein said tapered portion has a conical outer surface, said narrow end corresponding to the apex of said conical surface.

3. The invention according to claim **1**

wherein said tapered portion has a multisided outer surface, said narrow end corresponding to an apex of said multisided surface.

4. The invention according to claim **2**

wherein said cavity is formed in the vertical stabilizer of an aircraft, the cavity apertures being located on opposite sides of said stabilizer such that the cavity extends between the apertures and through said stabilizer.