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DIELECTRIC-LOADED ANTENNA WITH MATCHING WINDOW

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FIG. 1

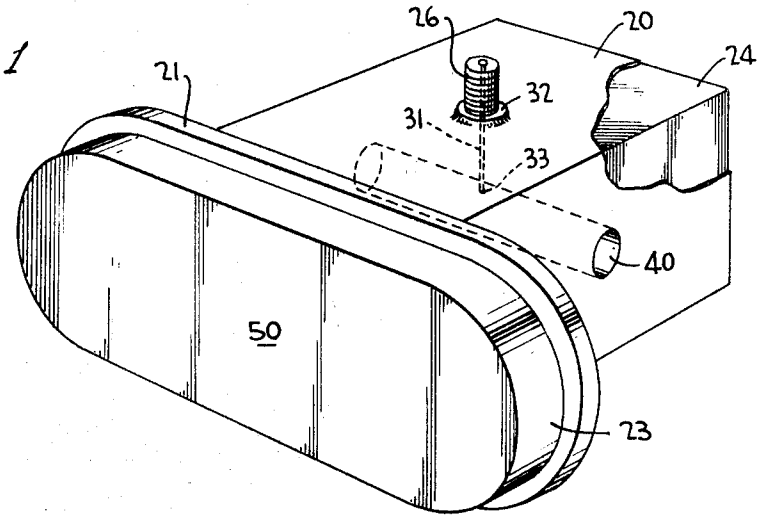
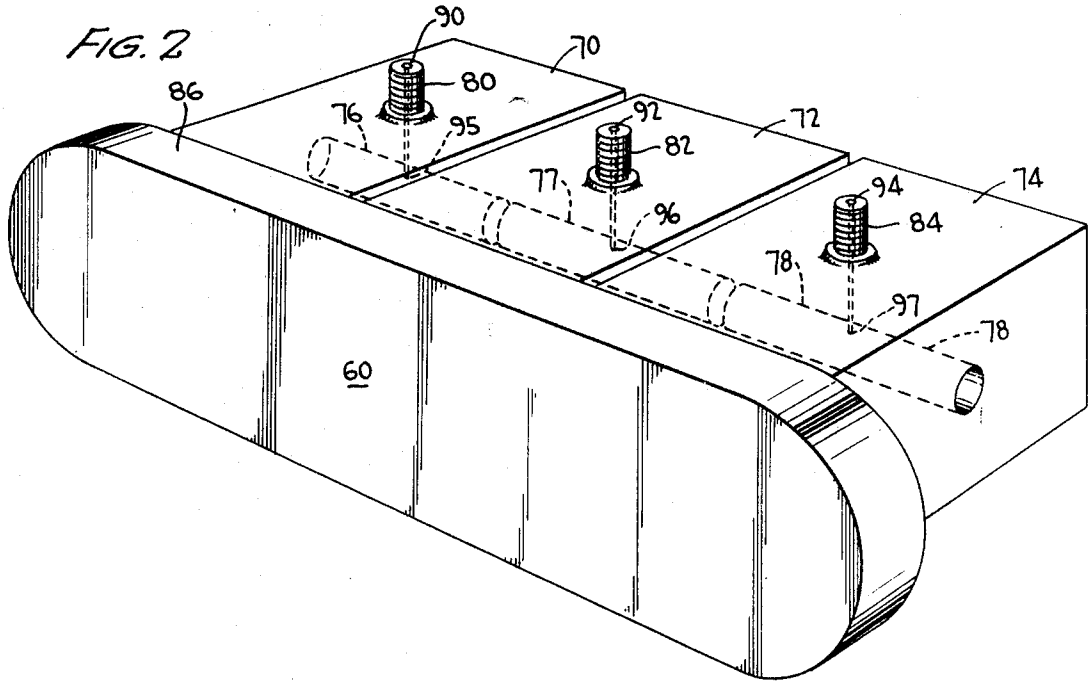


FIG. 2



INVENTOR,
HOWARD S. JONES, Jr.
BY Harry M. Saragovitz
Edward J. Kelly, Herbert Berl
& J. D. Edgerton
ATTORNEYS

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DIELECTRIC-LOADED ANTENNA WITH MATCHING WINDOW

Howard S. Jones, Jr., Washington, D.C., assignor to the United States of America as represented by the Secretary of the Army

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ABSTRACT OF THE DISCLOSURE

A microwave waveguide antenna with a matching dielectric window that is a monolithic structure and is greatly reduced in size from previous antennas. A single block of dielectric material is shaped to conform to the inner dimensions of a standard waveguide antenna whose dimensions are reduced by a factor that is determined by the constant of the dielectric being used. The same block is also shaped to form a window at the end of the waveguide. The dielectric is then plated with a metallic coating of the required thickness leaving the front of the window unplated so that the signal can radiate through it. The input to the waveguide is connected by any of the well-known methods. By using a dielectric material that has high temperature resistance the antenna can be inserted directly in the heat shield or surface of an atmosphere re-entry type vehicle. Control of the direction of radiation of the antenna and increased gain can be achieved by an antenna using multiple waveguide cavities with a single window which is constructed in the same manner.

The invention described herein may be manufactured, used, and licensed by or for the Government for governmental purposes without the payment to me of any royalty thereon.

BACKGROUND OF THE INVENTION

Microwave circuits have broad applications in diverse fields such as radar and communications systems, missile fuzes, and computer circuitry. Such circuits are also used extensively in space vehicles. The primary disadvantages of microwave circuits using waveguide components are their great weight and high cost of manufacture. The chief factor contributing to excess weight and bulkiness in standard waveguide systems is the use of metal waveguides and flanges having thick walls. Standard microwave systems fabricated from hollow waveguides are generally made from brass or copper alloy tubing with wall thicknesses varying from 0.125 to 0.025 inch depending on the application. While lighter metals such as aluminum and magnesium can be utilized this would greatly increase the cost of such systems. Even if light metals are used, standard waveguide systems are undesirably heavy and bulky for many important airborne and space vehicle applications.

Another problem encountered when dealing with antenna systems on re-entry type vehicles is that of providing a window for the antenna in the outside of the vehicle so that it can radiate towards a receiving station. Previous solutions to this problem involved the insertion of a separate window into the vehicle which was placed adjacent to the radiating end of the waveguide antenna. This window had to be made of a material which would transmit the electromagnetic waves from the antenna and still withstand the heat to which the outside of the vehicle would be subjected when it re-entered the atmosphere. While these antennas have performed satisfactorily, they are cumbersome, heavy and expensive to install.

It is therefore an object of the invention to provide a microwave antenna that is mechanically rigid and thermally stable but which is a fraction of the weight of conventional microwave antennas.

An additional object of this invention is to provide a microwave antenna that can be inserted directly into the surface of a re-entry type vehicle and is a monolithic structure.

It is a further object of the invention to provide a microwave antenna that can be manufactured easily and inexpensively.

SUMMARY OF THE INVENTION

Briefly, in accordance with this invention, a microwave waveguide antenna comprising a solid mass of dielectric material preferably heat-resistant, with a dielectric constant substantially greater than that of air is shaped to correspond to the inner contour of a standard dielectric-loaded waveguide antenna with a window attached to the end of it. A thin metallic layer is plated onto the material so that the metallic surface will be thick enough to carry the RF current fed to the antenna. The front of the window-shaped dielectric, through which the electromagnetic wave will be transmitted from the waveguide, is unplated. When installed in a re-entry type vehicle the waveguide window comprising the uncovered heat-resistant dielectric is inserted directly into the surface of the vehicle. Since the dielectric is compatible with the heat-resistant material of the vehicle, a separate window for the waveguide is no longer necessary.

While a single cavity waveguide antenna is sufficient in applications where a broad beam is needed, it will not be satisfactory where a forward angle of radiation or higher gain is necessary. In such cases the antenna can be made with multiple cavities all of which have a common window. Such an antenna can be made in a monolithic structure by having the dielectric conform to the inner dimensions of the multi-cavity antenna with a common window. The dielectric is plated and inserted into the vehicle as with the single cavity antenna.

BRIEF DESCRIPTION OF THE DRAWING

The specific nature of the invention, as well as other objects, aspects, uses and advantages thereof, will clearly appear from the following description and from the accompanying drawing, in which:

FIG. 1 is a perspective view of a typical microwave waveguide antenna with a matching window, in accordance with the present invention.

FIG. 2 is a perspective view of a microwave waveguide antenna with a matching window which utilizes a plurality of waveguide cavities, in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A basic concept utilized in the embodiments shown in FIGS. 1 and 2 is that loading waveguide with a dielectric material will allow reduction in the dimensions of the waveguide dimensions by a factor of $\sqrt{\epsilon}$, where ϵ is the dielectric constant. There is a limiting factor however as to the value of the dielectric constant that can be utilized, that factor being the bandwidth. The higher the value of the dielectric constant, the smaller the cross section of the waveguide and the narrower the bandwidth of the antenna. For the antennas used in re-entry type vehicles a dielectric constant between three and six has been found to provide sufficient reduction in size without undue limitation of the bandwidth of the antenna.

In order to allow the design of a waveguide antenna which has a matching window adapted to fit into the heat shield or outer surface of a re-entry vehicle it is

necessary that the dielectric used to load the waveguide also have sufficient heat-resistant properties. It has been found that several standard dielectric materials such as fused silica, aluminum oxide, and boron nitride have the required dielectric constants while also having good high temperature characteristics. These materials can withstand temperatures in the range of 500° to 4000° F., and they have low loss tangents.

A further reduction in bulk and weight of the standard waveguide antenna can be achieved by replacing the heavy metal waveguide walls with a lighter conductive layer. This is done by taking the dielectric, which has been shaped to conform to the inner dimensions of the waveguide, and plating it with a highly conductive metallic coating that has sufficient thickness to carry the RF current. Such a process has been described in my copending application Ser. No. 482,955, filed Aug. 26, 1965, entitled "Copper Plated Foam Dielectric Antenna and Waveguide Components and Method of Making Same."

Using the concept of dielectric loading and the plating process described above, the basic design will result in an antenna as shown in FIG. 1. A block of dielectric **24**, having the requisite characteristics, is shaped so as to conform to the inner dimensions of a standard dielectric-loaded waveguide antenna (shown at the cutaway of the metal coating), and an antenna window **23**. The waveguide and window are made as a monolithic structure. The waveguide and window are then plated using the method described in the aforementioned copending application.

During the plating of the waveguide **24** and the window **23**, it is important that the side sections are plated while the front section **50** is left unplated. It is through this unplated section **50** that the antenna radiates. The antenna can be inserted into the heat shield or other surface of a re-entry type vehicle and the heat resistant window **50** will be compatible with this outer surface. A flange **21** aids in the mounting of the waveguide and window in the vehicle. By using an antenna having a matching window, it is no longer necessary to have a separate window mounted in the vehicle to permit transmission of the energy radiated from the antenna.

The input signal to the antenna enters the waveguide through a coaxial cable connector **26** which has its outer conductor connected to the top of the metal coated waveguide at **32** and its inner conductor **31** soldered to the inside surface of a transverse hole **40** through the waveguide shaped dielectric and which has its inner surface plated. This is a standard T-bar connector for waveguides and is well known in the art.

While the single cavity antenna described in FIG. 1 will radiate a broad beam, it is sometimes desirable to have the electromagnetic energy of the radiating beam to be at an angle with respect to the axis of transmission from the waveguide. With the single cavity antenna it is hard to control the direction of radiation of the energy and there is a limit to the gain that can be achieved with such an antenna. The problems of insufficient gain and control of the direction of the radiation can both be solved by using an antenna that has multiple cavities. Such an antenna is shown in FIG. 2.

The multiple cavity antenna of FIG. 2 is constructed similar to the single cavity antenna. The cavities **70, 72, 74** are made from a single block of dielectric with the requisite characteristics and each conforms to the inner dimensions of a standard dielectric-loaded waveguide antenna. A matching window **86** is also made from the dielectric block reduced in size by the same factor so that the result will be a monolithic unit having multiple waveguides and a single window. Each of the waveguide cavities is similarly constructed and holes **76, 77, 78** are drilled through each waveguide in a transverse direction. The dielectric block is plated as previously described with a thin metallic coating leaving the form **60** of the window **86** unplated. The inputs to the multiple cavity antenna are through coaxial cable connectors **80, 82,** and **84** having center conductors **90, 92** and **94** respectively connected at points **95, 96** and **97** to the plated surface of the T-bar connector. The outer conductors of the cables are soldered to the metallic coating on the waveguides. This results in a multiple cavity antenna with a single window **60** which may be inserted into the heat shield or outer surface of a re-entry type vehicle. Since the dielectric material of the window **60** will withstand high temperatures, it is no longer necessary to have a large bulky metal waveguide with separate windows for each of the multiple cavities. Additionally by using multiple cavities it is possible to control the angle of radiation by changing the phase between the different cavities. Because of the array of the waveguides it also becomes possible to achieve an increase in the gain of the antenna.

It will be apparent that the embodiments shown are only exemplary and that various modifications can be made in construction and arrangement within the scope of the invention as defined in the appended claims.

I claim as my invention:

1. A microwave waveguide antenna comprising:

(a) a solid mass of dielectric material shaped to conform to the inner dimensions of a standard waveguide and having a dielectric constant greater than that of air and a high temperature resistivity;

(b) a thin metallic coating covering a substantial portion of said dielectric material, said coating having a thickness sufficient to conduct the RF current of an electromagnetic wave propagating through said dielectric material;

(c) an uncoated portion of said dielectric material defining a window for radiating electromagnetic waves, said window being an enlarged integral extension of said dielectric mass; and

(d) means to introduce an electrical signal into said dielectric material.

2. The waveguide antenna as defined in claim **1** wherein said dielectric material is selected from the group consisting of fused silica, aluminum oxide and boron nitride.

3. The waveguide antenna as defined in claim **1** further comprising a flanged section located around the perimeter of said window to aid in mounting said window flush with the outer surface of a space vehicle.

4. The invention of claim **1** wherein the means to introduce an electrical signal is a T-bar connector.

5. A waveguide antenna as defined in claim **1** wherein said solid mass of dielectric material is partially divided into a plurality of sections, each section shaped to conform to the inner dimensions of a standard waveguide, and wherein said window is common to and contiguous with each of said sections.

6. The waveguide antenna as defined in claim **5** wherein said dielectric material is selected from the group consisting of fused silica, aluminum oxide and boron nitride.

7. The invention of claim **5** wherein the means to introduce an electrical signal into each of said waveguides is a T-bar connector.

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ELI LIEBERMAN, Primary Examiner

U.S. Cl. X.R.

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