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Campbell et al.

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[54] OMNIDIRECTIONAL SLOT ANTENNA FOR MOUNTING ON CYLINDRICAL SPACE VEHICLE

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[73] Assignee: **The United States of America as represented by the Administrator of the National Aeronautics and Space Administration**

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[52] **U.S. Cl.** **343/708,** 343/771, 343/873

[51] **Int. Cl.** **H01q 13/10**

[58] **Field of Search** .....343/705, 708, DIG. 2, 769, 343/770, 771, 873

[56] **References Cited**

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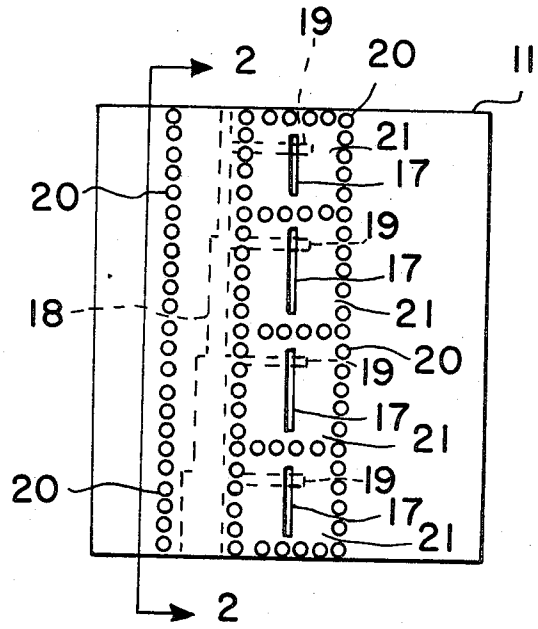
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[57] **ABSTRACT**

An extremely thin microwave array antenna which is bonded, circumferentially to the outside surface of a spacecraft and coated with a dielectric for thermal protection. This antenna was designed for a specific payload application in the S-band (2,200 to 2,300 MHz.) frequency range and provides an omnidirectional radiation pattern in the plane of the array and a near-omnidirectional pattern in the planes perpendicular to the array.

9 Claims, 4 Drawing Figures



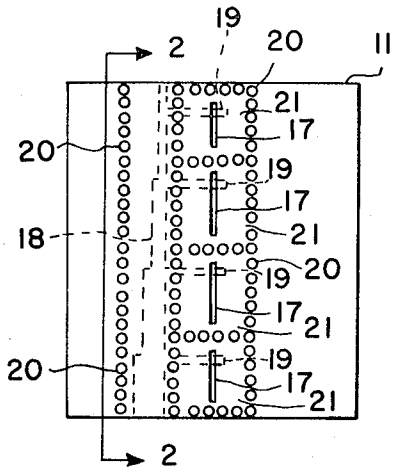


FIG. 1

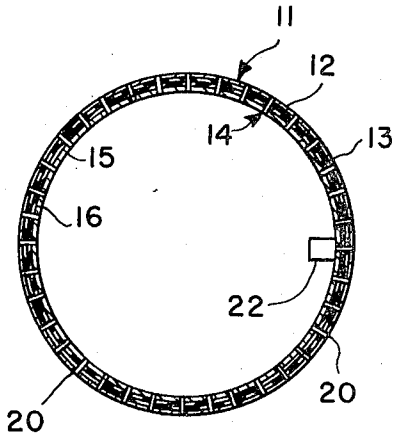


FIG. 2

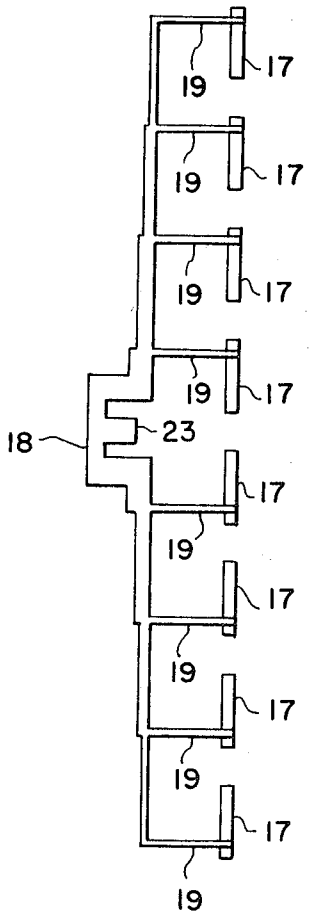


FIG. 3

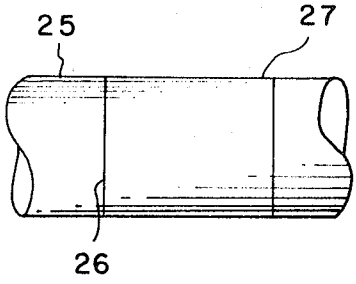


FIG. 4

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OMNIDIRECTIONAL SLOT ANTENNA FOR MOUNTING ON CYLINDRICAL SPACE VEHICLE

ORIGIN OF THE INVENTION

The invention described herein was made by an employee of the United States Government and may be manufactured and used by or for the government without payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention relates generally to antennas and more specifically concerns an extremely thin omnidirectional microwave array antenna.

In the past, the standard telemetry frequencies for rocket launched payloads have been in the 220–260 MHz. range. Presently, however, the military and scientific requirements have caused these frequencies to become less available, thereby causing most scientific telemetry applications to shift to the higher frequencies of 2,200–2,300 MHz. Due to the nature of the tracking problem at S-band frequencies and higher, omnidirectional radiation patterns are a stringent requirement for most spacecraft antenna systems. Therefore, a major problem expected in the shift to the S-band frequencies in the designing of antenna arrays mounted on surfaces large in terms of a wavelength that will (1) provide nearly omnidirectional patterns with a minimum fluctuation, (2) satisfy the structural requirements while arraying a large number of antennas, and (3) perform properly through expected spacecraft environments. It is therefore the primary purpose of this invention to provide an S-band frequency antenna array suitable for space-craft applications.

SUMMARY OF THE INVENTION

The antenna array that constitutes this invention consists of circumferential slots fed by a stripline circuit that is an integral part of the array. The array is formed by laminants of copper-clad dielectric material producing a total antenna thickness of 0.094 inch. Due to the slight thickness of the array, it is bonded to the outside surface of the spacecraft and then coated with a suitable ablation material. All antennas are interconnected by way of the stripline circuit between the laminants and the array is fed by providing a single hole through the spacecraft structure for a radio-frequency connector. This design is unlike a discrete array in which mounting holes, brackets, and structural doublers would be required for each antenna as well as provisions for power-distribution circuits. For a payload application tested, this array reduced the antenna weight considerably over that of a discrete source array, provided additional space inside the spacecraft for instrumentation, and provided excellent antenna characteristics.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of the antenna array that constitutes this invention;

FIG. 2 is the sectional view 2—2 in FIG. 1;

FIG. 3 is a schematic drawing of the stripline circuit used in the antenna array; and

FIG. 4 is a schematic drawing of the antenna array attached to the outside surface of a spacecraft.

DETAILED DESCRIPTION OF THE INVENTION

Turning now to the embodiment of the invention selected for illustration in the drawings, the number **11** in FIGS. **1** and **2** designates the outside layer of the antenna which consists of a cylindrical sheet of copper-clad dielectric cloth having an outside layer of copper **12** and an inside layer of dielectric material **13**. Located inside cloth **11** is another cylindrical sheet of copper-clad dielectric cloth **14** having a layer of copper **15** and a layer of dielectric material **16** which is against the layer of dielectric material **13**. Layer **12** has eight circumferential slots **17** cut through it. A stripline circuit **18** which is shown in FIG. **3** is located between cloths **11** and **14** with the fingers **19** of the stripline circuit connected or soldered to the slots **17**. Cloths **11** and **14** have their dielectric sides bonded together and their copper layers connected together by copper rivets **20** to form cavities **21** between the copper layers. A radio frequency connector **22** extends through cloth **14** and is soldered to the stripline circuit **18** at feed point **23**.

In FIG. **4**, there is shown a cylindrical section **25** of a spacecraft with the embodiment of the invention **26**, as disclosed in the FIGS. **1–3**, attached to the spacecraft and covered with a layer of ablation material **27**. The radio frequency connector **22** extends through the walls of the spacecraft to provide a single connection to the antenna.

The fabrication of an extremely thin array in accordance with this invention composed of eight circumferential slots will now be discussed. This antenna was fabricated for use on a cylindrical section of a spacecraft having a length of **6** inches and a diameter of 8.61 inches. Layers **11** and **14** were constructed from 2-oz. copper-clad dielectric cloth having a dielectric constant of 2.10 which is commercially available.

The dielectric layers were cut to the proper size and each layer was rolled into a 9-inch diameter cylinder. This diameter allowed a sufficient amount of overlap prior to cutting each layer to the exact circumferential length. The inside layer was rolled or formed with the dielectric side on the outside and the copper surface inside. A butt joint was formed with the inside layer by soldering a copper strip across the joint on the copper side of the layer. The joint was later filled with an epoxy adhesive. Prior to rolling the outside layer, the layer with the copper surface on the outside and the dielectric surface inside, the slots were formed by cutting away the copper surface.

The slots were made 2.4 × 0.10 inches which is slightly longer than the 2.26 inch lengths specified by test results using a single-coated slot. It was believed that this additional length would compensate slightly for tolerance effects, and length could be easily shortened later after preliminary array measurements were concluded. The dimensions of each cavity were also outlined prior to rolling the outside layer. The outline would be the rivet line and the rivets would be placed in after the two layers were bonded together. In order to obtain a smooth surface on both sides of the flight antenna, copper countersunk rivets were used instead of bolts. The outside layer was then rolled into a 9-inch diameter cylinder.

The stripline circuit was bonded to the dielectric side of the outside layer, and the feed loops were then placed through holes 0.60 inch from the end of the slot. A hole 0.50 inch in diameter through the outside layer was provided at the feedpoint location. This hole would facilitate soldering the stripline to the radio frequency connector later.

Since the inside layer was in the form of a cylinder but was not close to 8.61 inches in diameter, a 0.125 inch diameter hole for the feed connector was drilled 0.5 inches from one edge of the layer. The connector would be placed there later. The outside layer, also being in the form of a cylinder, was positioned so that the stripline feed would aline properly with the connector hole on the inside layer. The layers were then bonded together and a copper strap was soldered across the joint on the outside surface. Both dielectric surfaces were chemically treated to facilitate bonding. After the bond was sufficiently cured, pilot holes were drilled along the rivet line on the outside surface and copper countersunk rivets were then placed in the holes approximately 0.30 inch apart. These rivets thereby formed the individual cavities for the slots as well as for the rectangular transmission line. The countersunk rivets were placed through the two layers and peened over on the inside to form a fairly smooth surface inside and outside. The antenna was then ready to be bonded to the payload cylindrical section.

Since the antenna had been rolled to a slightly larger diameter it could slide over one end of the cylinder. A hole large enough to accommodate the feed connector had already been drilled in the payload cylinder. The antenna was then bonded to the payload cylinder under a vacuum to eliminate air bubbles in the epoxy adhesive. After bonding the feed connector

was soldered in place on the inside antenna surface, and the hole in the outside surface provided a means of soldering the strip-line circuit to the center conductor of the feed connector. A patch of copper-clad dielectric material was placed in the outside hole and soldered securely in place. The feed lines for the individual slots were then soldered in place and the array was ready for testing. After testing, indicated adjustments were made to the slots. Then the array was ready for coating with a heat-protective ablation material.

The advantages of this invention are numerous. It provides an antenna array which provides an omnidirectional radiation pattern in the plane of the array and a near-omnidirectional pattern in the planes perpendicular to the array for S-band applications. It is extremely light and requires very little space on the spacecraft. It is fed by providing a single hole through the spacecraft structure for a radio frequency connector.

It is to be understood that the form of the invention herewith shown and described is to be taken as a preferred embodiment. Various changes may be made in the shape, size and arrangement of parts. For example, equivalent elements may be substituted for those illustrated and described herein, parts may be reversed and certain features of the invention may be utilized independently from the use of other features, all without departing from the spirit or scope of the invention as defined in the subjoined claims. The embodiment of the invention disclosed shows an array of eight antennas. However, many more or many less than eight could be used without departing from this invention. Also the embodiment is shown in a cylindrical form; whereas other shapes of the array could be made without departing from the invention. For example, the array could be put on a flat surface and instead of having a plurality of antennas only one could be used.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A microwave array antenna comprising:
first and second sheets of material with each including a layer of electrically conducting material and a layer of electrically nonconducting material;
said first and second sheets placed together such that their nonconducting layers are together;
a plurality of slots cut into said layer of electrically conducting material of said first sheet;
circuit means connected to each of said slots and extending through said second sheet; and
electrically conducting means connecting the electrically conducting material layers of said first and second sheets together around each of said slots to form a cavity back of each of said slots whereby a plurality of microwave antennas are formed which can be fed by a single source.

2. A microwave array antenna according to claim 1 wherein said first and second sheets of material are sheets of copper-clad dielectric cloth.

3. A microwave array antenna according to claim 1 wherein said circuit means includes a stripline circuit.

4. A microwave array antenna according to claim 1 wherein said electrically conducting means are copper rivets.

5. A microwave array antenna according to claim 1 where two sides of said first and second sheets are attached together to form a cylinder with said first sheet on the outside of said cylinder, with said second sheet on the inside of said cylinder and with said slots on a circumference of said cylinder whereby said antenna will produce an omnidirectional radiation pattern.

6. A microwave array antenna according to claim 5 wherein the inside of said cylinder is attached to a cylindrical section of a spacecraft and said circuit means extends through the wall of said spacecraft.

7. A microwave array antenna according to claim 6 with the outside of said cylinder coated with an ablation material.

8. A microwave antenna comprising:
first and second sheets of material with each including a layer of electrically conducting material and a layer of electrically nonconducting material;
said first and second sheets placed together such that their nonconducting layers are together;
a slot cut into said layer of electrically conducting material of said first sheet;
circuit means connected to said slot and extending through said second sheet; and
electrically conducting means connecting the electrically conducting material layers of said first and second sheets together around said slot whereby a cavity-backed slot antenna is formed.

9. A microwave antenna according to claim 8 wherein said first and second sheets of material are sheets of copper-clad dielectric cloth.

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