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[54] **BASE MOUNTED RE-ENTRY VEHICLE ANTENNA**

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[52] **U.S. Cl.** **343/708**, 343/769, 343/789

[51] **Int. Cl.** **H01q 1/28**

[58] **Field of Search** 343/705, 708, 770, 343/771, 769, 789

[56] **References Cited**

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[57] **ABSTRACT**

A space projectile such as a re-entry vehicle having an antenna comprising a plurality of concentric ring radiating elements at its base. Each radiating element is a plated dielectric loaded cavity having a circumferential radiating slot which extends around the greater part of the circumference of the element. The elements may be either rectangular or L-shaped in cross-section and may be excited out of phase with each other to produce a desired radiation pattern.

10 Claims, 4 Drawing Figures

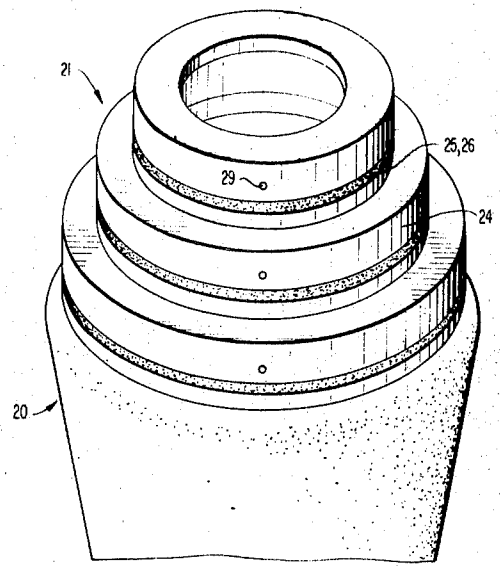


FIG. 1

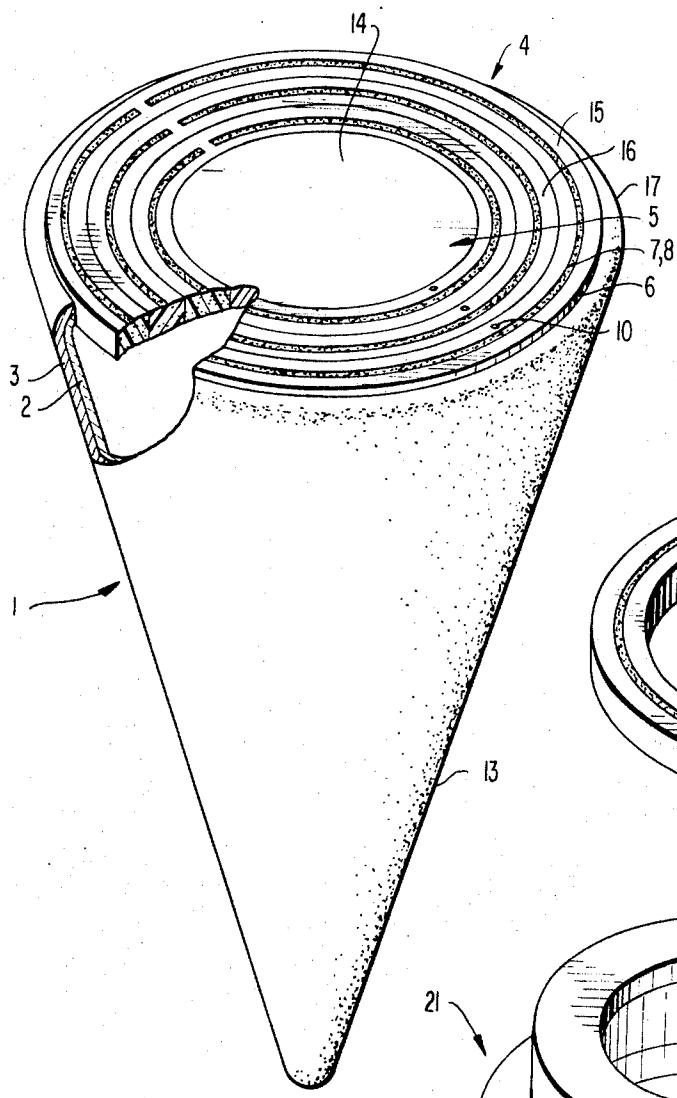


FIG. 2

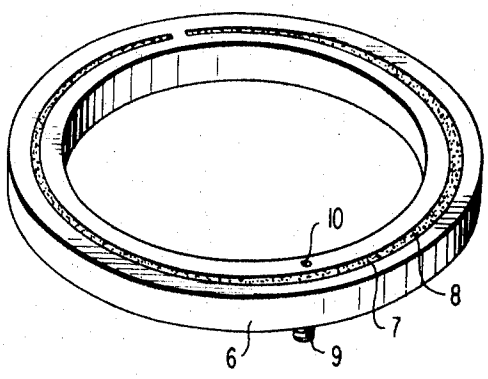


FIG. 3

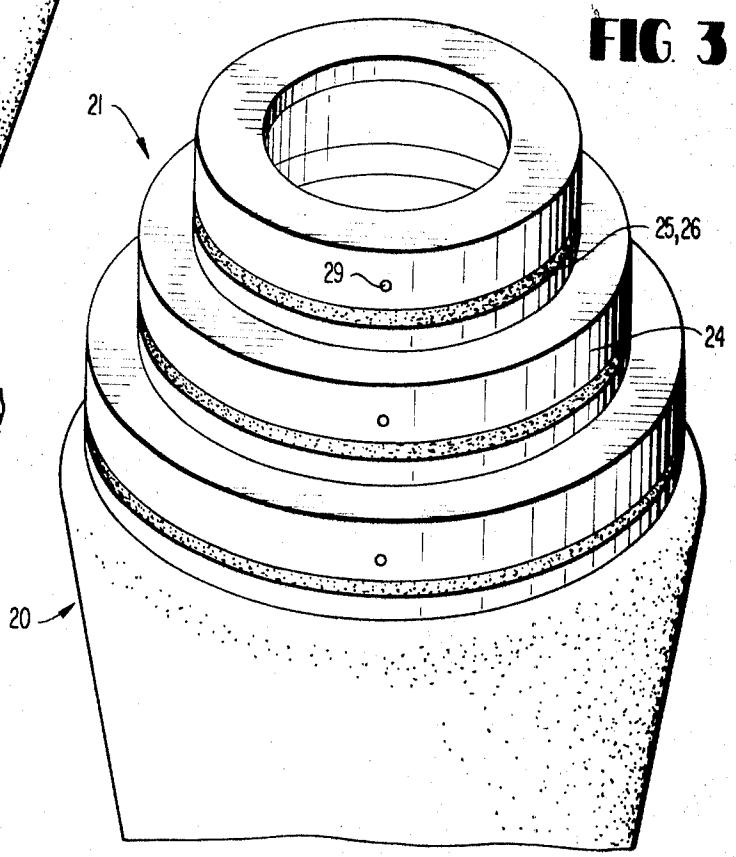
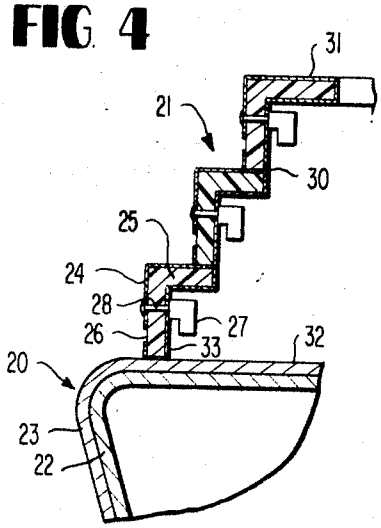


FIG. 4



BASE MOUNTED RE-ENTRY VEHICLE ANTENNA

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

This invention relates to an improved space projectile such as a re-entry vehicle and an antenna therefor which is mounted at the base of the projectile. In recent years spacecraft such as missiles and re-entry vehicles have been used with increased frequency in conjunction with the exploration of space. During their travel in space it is of paramount importance that these vehicles be able to transmit and/or receive radio signals, and it is therefore important that the vehicles be equipped with antennas which will be effective in the transmission and/or reception of radio signals.

Conventional antennas however have not sufficed for use with space projectiles such as missiles and re-entry vehicles. This is because conventional antennas when mounted on space projectiles according to the techniques of the prior art result in either projections or holes in the body portion of the projectile. These projections or holes in the body portion of the projectile interfere with aerodynamically true flight of the projectile and further adversely affect the electrical performance of the projectile. It has also been found that when conventional antennas are used on a re-entry vehicle, the ionized layer which surrounds the vehicle during the reentry period adversely affects radio transmission to and from the vehicle.

It is further desirable in a space projectile transmission system to be able to accurately control the direction of the radiated energy. For instance, in one application, it is important that the radiated energy be directed primarily along the axis of the projectile in the forward direction and that radiation in the rearward direction of the projectile be substantially suppressed.

It is therefore an object of the invention to provide a space projectile having an antenna which does not interfere with the aerodynamic or electrical performance of the projectile .

It is a further object of the invention to provide a space projectile having an antenna which is not adversely affected by the ionized layer which surrounds the vehicle during the re-entry period.

It is a further object of the invention to provide a space projectile having an antenna which is capable of producing radiated energy whose direction can be accurately controlled.

It is a further object of the invention to provide an antenna for use with a re-entry vehicle which does not interfere with the aerodynamic or electrical characteristics of the vehicle, which is not adversely affected by the ionized layer surrounding the vehicle during the re-entry period and which is capable of producing a radiation pattern whose direction can be accurately controlled.

The above objects are accomplished by the present invention by providing a space projectile such as a re-entry vehicle having an antenna mounted at the base of the projectile. The antenna is comprised of a plurality of concentric ring radiating elements, each element comprising a plated dielectric loaded cavity having a circumferential radiating slot.

In one embodiment the radiating elements have a rectangular cross-section and are flush-mounted in the base of the vehicle with the radiating slots facing rearwardly. The elements lie in the same plane and adjacent elements contact each other about their peripheral surfaces. Each radiating element has a different diameter but has the same thickness and volume. Because the antenna is comprised of a plurality of elements the elements may be excited in different phases to produce a desired radiation pattern.

In another embodiment of the invention the radiating elements are L-shaped in cross-section, are stacked one on top of the other and having radiating slots looking off to the side of the vehicle. The elements differ in diameter and horizontal width but the volume of each element is the same.

The invention will be understood in greater detail by referring to the following detailed description when taken in conjunction with the following FIGS. wherein:

FIG. **1** is a perspective view of a projectile such as a re-entry vehicle having a first embodiment of a novel antenna according to the invention mounted in its base.

FIG. **2** is a detailed perspective view of one radiating element of the antenna of FIG. **1.**

FIG. **3** is a perspective view of a projectile such as a re-entry vehicle having a second embodiment of a novel antenna according to the invention mounted in its base.

FIG. **4** is a detailed cross-sectional view of the radiating elements of the antenna shown in FIG. **3.**

Referring to FIG. **1,** projectile **1** is a space projectile such as a re-entry vehicle or missile. Projectile **1** is comprised of body portion **13** and base portion **5.** Body portion **13** if desired may be comprised of two layers **2** and **3,** the outside layer of which may be a heat resistant radome. Antenna **4** is flush-mounted in the base portion of projectile **1.** It may be either mounted on a base surface (not shown) or in the alternative, it may take the place of a base surface in which case the area **14** interior of inner radiating element **17** would be hollow.

Antenna **4** is comprised of a plurality of concentric radiating elements, one of which is shown in greater detail in FIG. **2.** Each radiating element is comprised of a plated dielectric loaded cavity having a circumferential radiating slot **8.** Dielectric material **7** is a low loss dielectric having a dielectric constant ϵ varying over the range from 2 to 9 de-pending on the volume available and bandwidth needed and may for instance be epoxy and silicone fiberglass materials having a value of $\epsilon \approx 3$. The metal cavity is plated on all four sides around the dielectric ring which is rectangular in cross-section. In a preferred embodiment of the invention the cavity was copper plated around the dielectric using electroless plating techniques which provide a strong dielectric to metal adherence. A slot **7** which extends around the greater part of the circumference of the ring but does not extend around the entire circumference of the ring is then cut into the top surface of metal so that when the ring elements are mounted in the base of the projectile, the radiating slots face rearwardly of the projectile. The radiating elements are mounted in the base of the projectile in the same plane and adjacent elements contact each other about their peripheral surfaces.

The elements may be secured in the base of the projectile with epoxy or other standard adherent and may be secured to each other by any standard adhering technique as is well known in the art. In the embodi-

ment shown in FIG. 1, three concentric radiating elements 15 and 16 and 17 are shown. However, it is to be understood that the use of any number of radiating elements is within the scope of the invention. As will be discussed later, the greater the number of radiating rings the greater is the number of phase options in which the rings may be excited and the greater is the amount of control which can be exerted on the direction of the radiated energy.

Each of the elements is fed from inside of the projectile by co-axial cable 9; the inner conductor of co-axial cable 9 penetrates through dielectric layer 8 and is soldered to the top surface of the radiating ring as is pictorially represented at 10 in FIGS. 1 and 2. The outer conductor of the coaxial cable may be soldered to the bottom surface of the radiating element.

In a preferred embodiment of the invention the outer radiating element has a mean diameter of approximately 12 inches, a width of about 1.1 inches and a thickness of 0.25 inch. All three of the radiating elements have the same volume and thickness but the diameter and width of the radiating elements is different.

The use of an antenna having a plurality of ring radiating elements enables elements to be excited out of phase with each other. This in turn enables the direction of the radiation emitted to be varied with changes in phase and to be accurately controlled. Thus, in one case, it is desirable to have primarily all of the radiation emitted in the axial direction of the projectile and in the forward direction. By varying the phases in which respective radiating elements are excited such a radiation pattern could be arrived at by one skilled in the art.

There thus has been provided a space projectile having an antenna which because it is mounted at the base of the projectile does not interfere with the aerodynamic or electrical characteristics of the projectile and is not adversely affected by the ionized layer which the projectile would encounter during re-entry period. Further, the antenna is comprised of a plurality of elements which can be excited out of phase with each other and which allow the direction of the radiated energy to be accurately controlled.

In another embodiment of the invention shown in FIGS. 3 and 4, the concentric ring radiators are L-shaped in cross-section and are stacked one on top of the other with the radiating slots facing off towards the side of the projectile. As shown in cross-section in FIG. 4, antenna 21 is mounted on base surface 32 of projectile 20 and each radiating element has a portion 30 which is disposed perpendicularly to base surface 32 and a portion 31 which is disposed parallel to base surface 32. L-shaped dielectric rings 25 which may be comprised of the same dielectric materials as the embodiment of FIGS. 1 and 2 is plated with a metal 24 such as copper. Radiating slots 26 as in the embodiment of FIGS. 1 and 2 extend around a greater part of the circumference of the rings but not around the entire circumference.

The radiating rings are stacked one upon the other as shown in FIGS. 3 and 4 and may be secured to the base 32 and to each other by any standard adhering technique known to those skilled in the art. While only three radiating elements have been shown, it is within the scope of the invention to use any number of radiating elements.

In a preferred embodiment of the invention, the total height of the three elements shown in FIG. 4 is less than 1 inch. The horizontal width and diameter of each element is different while the thickness and volumes of each of the elements is the same.

The elements are fed by co-axial cables 27 having center conductors 28 which extend through dielectric 25 and are soldered to the portion of the L-shaped element which is perpendicular to base surface 32. The outside conductor of the coaxial cable may be soldered to surface 33 shown in FIG. 4.

Typical dimension of the conical structure are approximately 80 inches long and a 15 inches diameter base. In FIGS. 3 and 4 the ring anetnnas are blown up out of portion. As suggested in the specification, the height of the three L-shaped antenna ring could be about 1 inch, therefore the overall height as it should appear in FIG. 3 would be considerably less.

It should be understood that the invention is not limited to the exact details of construction shown and described herein for obvious modifications will occur to persons skilled in the art.

I claim:

1. A space projectile having an antenna flush mounted in its base, said antenna comprising a plurality of concentric ring radiating elements, each ring radiating element comprising a metallic dielectric loaded cavity having a rectangular cross-section and a circumferential radiating slot which faces rearwardly of said projectile.

2. The projectile of claim 1 wherein said concentric ring radiating elements lie in the same plane and wherein adjacent elements contact each other about their peripheral surfaces.

3. The projectile of claim 2 wherein each of said plurality of ring radiating elements has a different diameter but wherein all of said elements have the same volume and thickness.

4. The projectile of claim 3 wherein each of said ring radiating elements is a copper-plated dielectric loaded cavity and wherein said dielectric is comprised of epoxy and fiberglass materials.

5. The projectile of claim 3 wherein said ring radiating elements are excited in different relative phases.

6. The projectile of claim 1 wherein said projectile further comprises a re-entry vehicle.

7. A space projectile having an antenna mounted at its base, said antenna comprising a plurality of concentric ring radiating elements, each ring radiating element comprising a metallic dielectric cavity having a circumferential radiating slot and being L-shaped in cross-section, said projectile comprising a re-entry vehicle having a bottom portion which terminates at the rear of the vehicle in a base, each of said L-shaped ring radiating elements having a first portion which is perpendicular to said base and a second portion which is parallel to said base, said circumferential radiating slot being located in said first portion and facing in the direction of the side of said re-entry vehicle, said ring radiating elements being stacked on each other so that said first portion of each radiating element above the bottommost element is mounted at the interior end of said second portion or the element immediately below it and said first portion of said bottommost ring radiating element being mounted on said base of said re-entry vehicle.

8. The projectile of claim 7 wherein the diameter and width of said second portion of each radiating element above the bottommost element are respectively smaller

and greater than the diameter and width of the second portion of the element immediately below, and wherein the volumes of all of said ring radiating elements are substantially equal.

9. The projectile of claim **8** wherein said circumferential radiating slots extend around the greater part of the circumference of said first portions of said ring radiating elements but do not extend around the entire circumference.

10. The antenna of claim **8** wherein said re-entry vehicle comprises a body portion which terminates at the rear of the vehicle in the base and said ring radiators are L-shaped in cross-section, each of said radiators having a first portion which is perpendicular to said base when said antenna is mounted and a second portion which is parallel to said base when said antenna is mounted, said circumferential radiating slots being located in said first portion and facing in the direction of the side of said re-entry vehicle when said antenna is mounted.

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