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Jones, Jr. et al.

[11] **3,845,488**

[45] **Oct. 29, 1974**

[54] **REARMOUNTED FORWARD-LOOKING RADIO FREQUENCY ANTENNA FOR PROJECTILES**

[75] Inventors: **Howard S. Jones, Jr.**, Washington, D.C.; **Arthur R. Sindoris**, Arlington, Va.

[73] Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, D.C.

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[52] **U.S. Cl.** **343/708**, 343/792

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

[58] **Field of Search** 343/711, 712, 713, 792, 343/845, 846

[56] **References Cited**

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Primary Examiner—Eli Lieberman

Attorney, Agent, or Firm—Nathan Edelberg; Saul Elbaum

[57] **ABSTRACT**

A new radio frequency antenna which is mounted on the rear of the nose cone of a projectile which generates a forward-looking radiation pattern is provided. The antenna comprises the hollow metal nose cone of the projectile with a flat metal base attached. This is electromagnetically excited by an RF source connected to a hollow metal L-shaped cylindrical tube having a wire coaxially extended therethrough. One end of the wire is connected to the radio frequency source along with the hollow tube. The other end of the wire is connected to another similarly shaped solid metal L-shaped cylindrical rod wherein both said L-shaped rod and said L-shaped tube form a U-shaped structure wherein the end faces of said structure are attached to the nose cone. The wire extending through said hollow tube is surrounded by dielectric material and is isolated from said tube throughout. The wire extending through the tube extends beyond the tube and attaches to the rod in such a fashion as to form a gap between the end face of said tube and the end face of said rod. The radio frequency source is attached to the coaxial wire-tube assembly by means of a standard RF connector.

10 Claims, 7 Drawing Figures

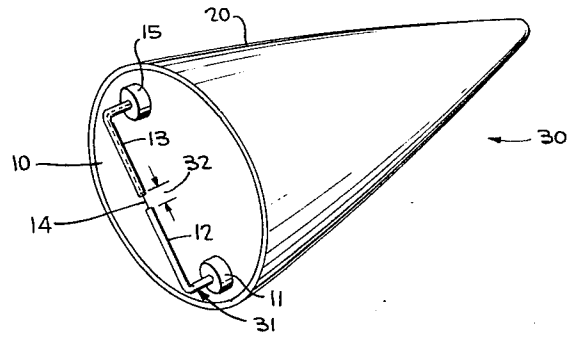


FIG. 1a

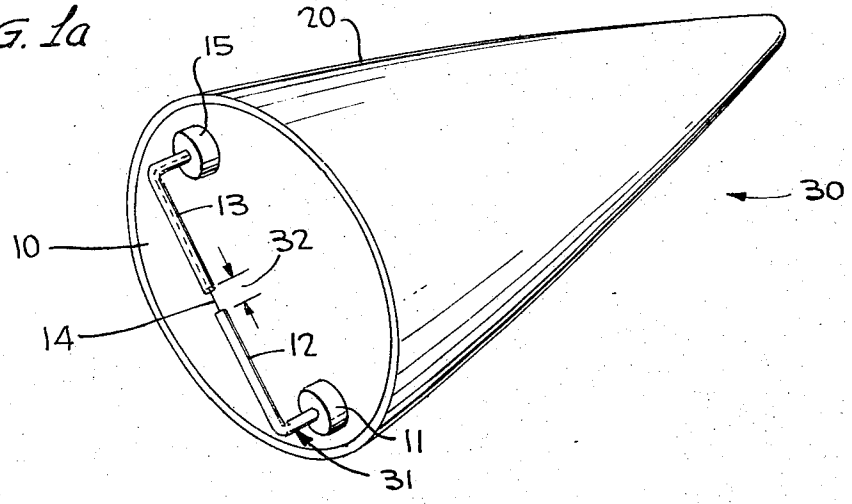


FIG. 1b

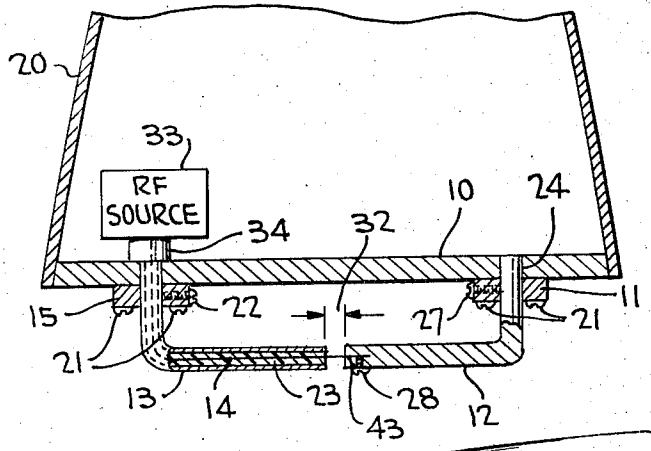


FIG. 2a

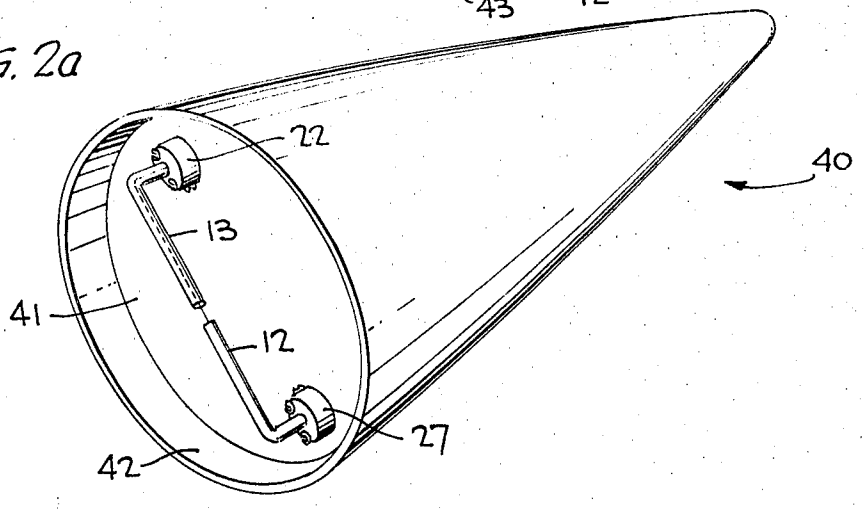


FIG. 2b

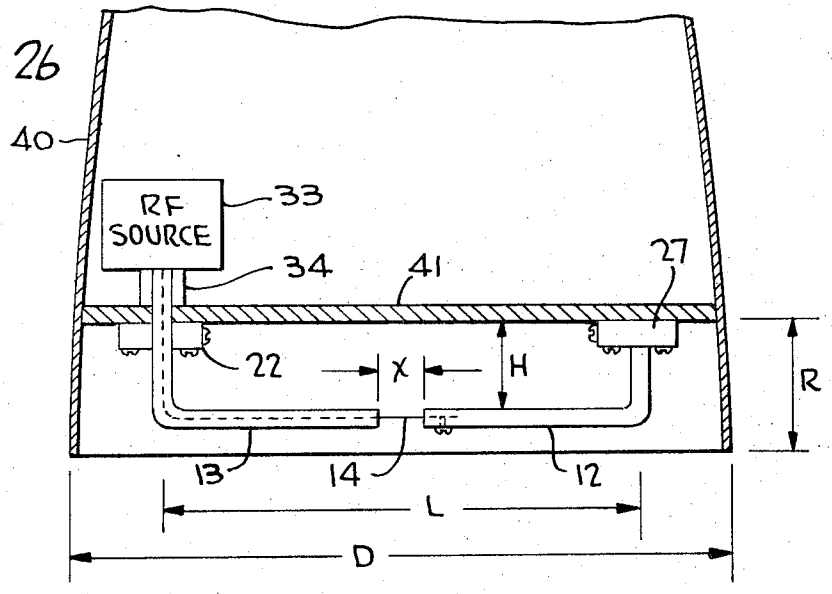

40
RF SOURCE
33
34
41
27
22
X
H
R
13
14
12
L
D

FIG. 4

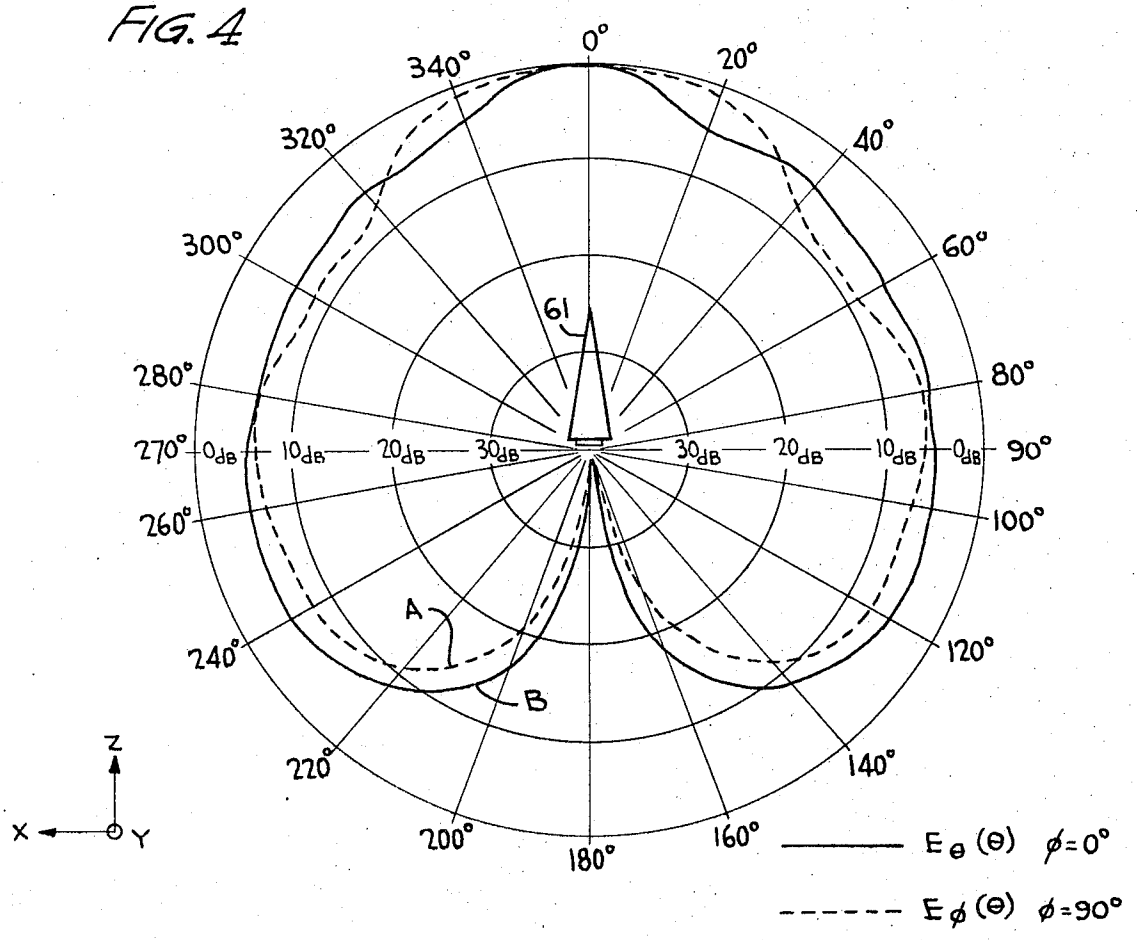

0°
20°
40°
60°
80°
90°
100°
120°
140°
160°
180°
200°
220°
240°
260°
270°
280°
300°
320°
340°
61
A
B
0dB
10dB
20dB
30dB
30dB
20dB
10dB
0dB
Z
X
Y
Eθ (θ) φ=0°
Eφ (θ) φ=90°

FIG. 3

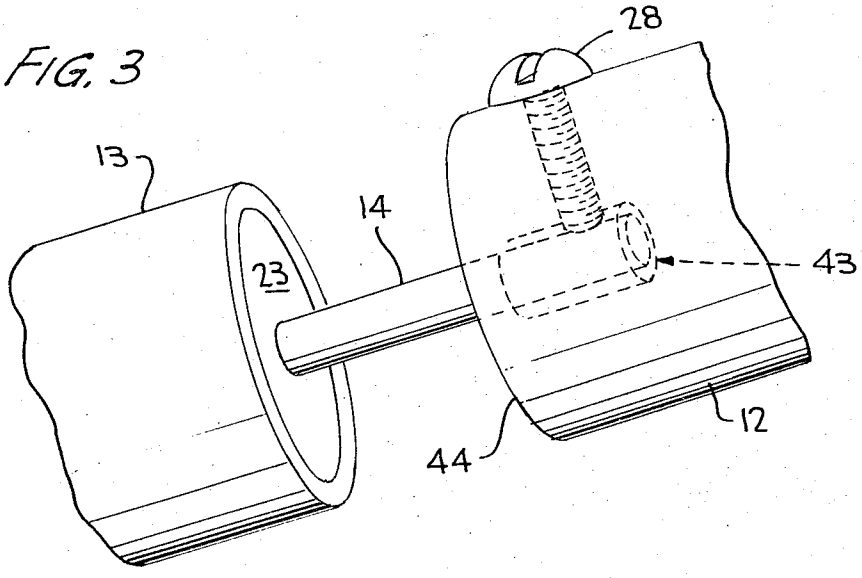
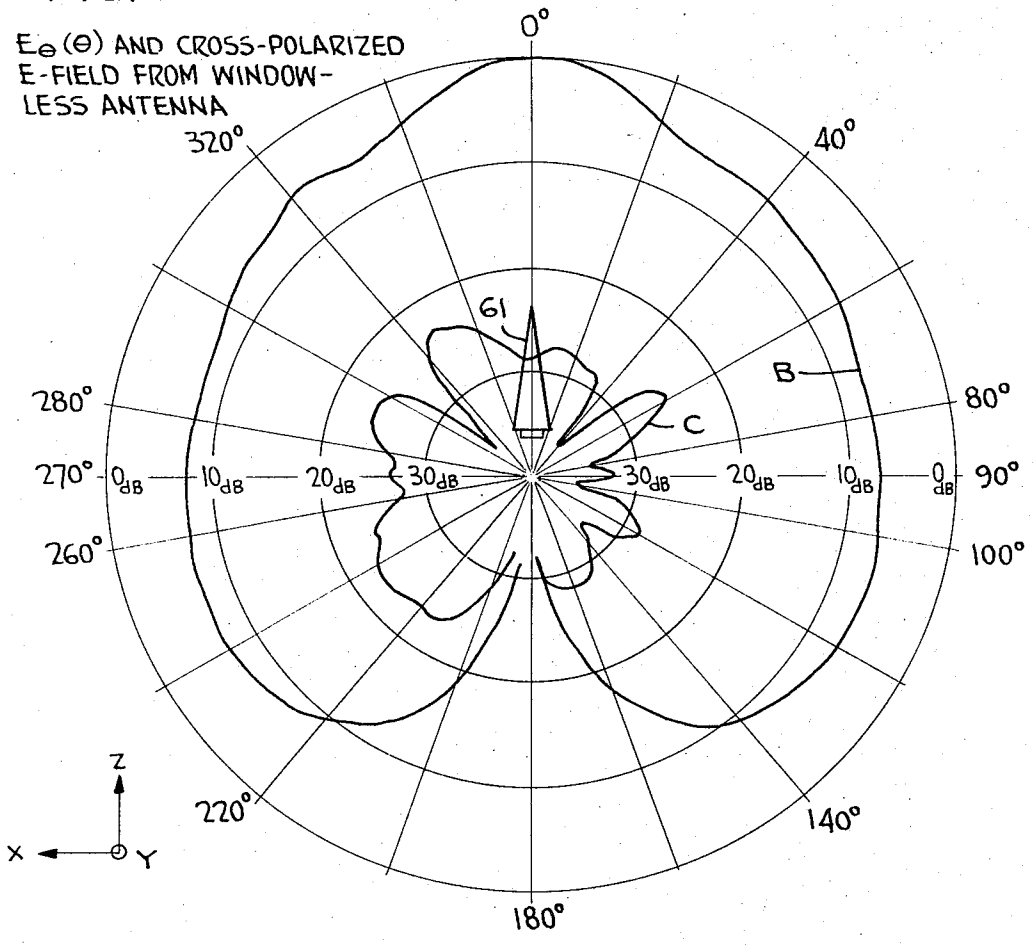

28
13
14
23
43
12
44

FIG. 5


$E_\theta(\theta)$ AND CROSS-POLARIZED E-FIELD FROM WINDOW-LESS ANTENNA
0°
40°
80°
90°
100°
140°
180°
220°
260°
270°
280°
320°
61
B
C
0dB
10dB
20dB
30dB
30dB
20dB
10dB
0dB
Z
X
Y

REARMOUNTED FORWARD-LOOKING RADIO FREQUENCY ANTENNA FOR PROJECTILES

RIGHTS OF THE GOVERNMENT

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

BACKGROUND OF THE INVENTION

Antennas of conventional design for use on projectile nose cones require cutouts and dielectric windows through which the electromagnetic radiation from the antennas mounted inside the projectile, or at the surface of the projectile, can be transmitted. Until now, this has been the only method by which a forwardlooking radiation pattern could be achieved. For a lightweight, high velocity projectile the required cutouts for conventional designed antennas for projectile nose cones are undesirable. These cutouts on the surface of said nose cones structurally weaken the rigidity of the cone. In addition, it is well known that dielectric material mounted on projectile nose cones or forming a part thereof ablates. The ablation rate of the material forming the body of the projectile and the material forming the dielectric antenna windows in most cases are different. These non-uniform ablation rates are known to cause aerodynamic instabilities during high speed endoatmospheric flight.

Until now, the idea of locating and mounting a radio frequency antenna on the base of a projectile nose cone and obtaining an adequate forward-looking radiation pattern has been totally rejected. Heretofore, this type of radiation pattern from a base mounted antenna has been considered difficult, if not impossible, to achieve. Since high frequency electromagnetic radiation tends to propagate along a line of sight path and since an antenna mounted on the base of a cone cannot be seen when viewing a projectile nose cone head on, little radiation in the forward direction is expected. In fact, the opposite is normally expected; most of the electromagnetic radiation should be directed to the rear.

A typical approach to obtaining a forward-looking radiation pattern with a rear mounted antenna is to attach a center-fed half wavelength dipole to the rear of the nose cone. One problem with the center-fed dipole is that it is inherently unbalanced and requires a balun for proper operation and coupling to the RF source.

Other conventional antennas mounted on the rear of a nose cone typically give a front to back power ratio of 0 to −10 dB, that it, a rearward looking antenna.

It is therefore an object of this invention to provide a new antenna which although mounted on the base of a projectile nose cone generates an excellent forward-looking radiation pattern.

It is another object of this invention to provide a radio frequency antenna for projectiles which eliminates the need for cutouts and dielectric windows on the projectile nose cone.

It is another object of this invention to provide a new and novel rear mounted forward-looking radio frequency antenna for projectiles which is inherently balanced and therefore obviates the need for a balun.

It is yet another addition object of this invention to provide a rear mounted forward-looking radio frequency antenna for projectiles which is mounted on a recessed base of the projectile nose cone and thereby provides thermal protection for the active elements.

It is still another additional object of this inventionn to provide a rear mounted forward-looking radio frequency antenna mounted on a recessed base of the projectile nose cone whereby the radio frequency currents which contribute to the forward-looking radiation pattern are concentrated on the trailing edge region of the cone.

Another additional object of this invention is to provide a forward-looking radio frequency antenna whose front-to-back ratio is not affected by the shape of the dielectric coating on the forward portion of the projectile nose cone.

These and other objects of the present invention will become more fully apparent with reference to the following specifications and drawings which relate to two preferred embodiments of the present invention.

SUMMARY OF THE INVENTION

In accordance with the disclosure herein presented this invention provides a new and novel forward-looking radio frequency antenna for a projectile wherein the active radio frequency element is mounted on the rear of the projectile nose cone. The antenna comprises a U-shaped cylindrical structure having the end faces of its two arms attached to the metal base of a hollow metal nose cone. The U-shaped structure consists of an L-shaped solid metal rod and an L-shaped hollow metal tube. The hollow metal tube has a metal wire extending coaxially therethrough. The end termination of the wire nearest the middle of the U-shaped structure is attached to the solid metal rod. A radio frequency power source is connected across the other end termination of the wire and the hollow tube by means of a conventional coaxial connector. The invention further comprises a gap between the end face of the arm of said tube and the end face of the arm of said rod located on the same axis of symmetry. In this gap the wire is exposed whereas the space inside said hollow tube and around said wire is filled with a dielectric material.

BRIEF DESCRIPTION OF THE DRAWINGS

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 drawings, in which:

FIG. 1*a* is a perspective view of the rear mounted forward-looking radio frequency antenna.

FIG. 1*b* is a cross-sectional view of the excitation element of the rear mounted forward-looking radio frequency antenna showing the radio frequency source and means for mounting.

FIG. 2*a* is a perspective view of the rear mounted forward-looking radio frequency antenna wherein the active radio frequency excitation element is mounted on a recessed base of the nose cone.

FIG. 2*b* is a cross sectional view of the forward-looking radio frequency antenna wherein the rear mounted radio frequency excitation element is attached to a recessed base on the nose cone.

FIG. 3 is a perspective view of the radio frequency excitation element of the forward-looking radio frequency antenna showing the detail structure of the gap connection.

FIG. 4 is a graph of the E_θ and E_ϕ components of the radiation pattern of the antenna.

FIG. 5 is a graph of the E_θ and cross-polarized E component of the antenna radiation pattern.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention disclosed herein may be understood with respect to its broad aspects by reference to FIG. 1*a* wherein there is shown a perspective view of an embodiment of the antenna. The structure **30** shown in this figure is a projectile nose cone **20** comprising a conductive metal and having a conductive metal base **10** sealing the rear of said cone **20.** In this embodiment the radio frequency excitation part of the antenna is bilaterally and axisymmetrically mounted on to the base **10.** This radio frequency excitation element is U-shaped and has its arms mounted to the base **10** by means of mounting blocks **11** and **15.** The U-shaped excitation member shown generally at **31** consists of two L-shaped members **12** and **13.** One L-shaped member is a solid metal rod **12** the other L-shaped member is a hollow metal tube **13** having a wire **14** extending coaxially therethrough. L-shaped conductive metal tube **13** is connected to the base **10** by means of connection block **15.** L-shaped solid rod **12** is connected to base **10** by means of connection block **11.** The arm of the L-shaped hollow tube **13** not attached to the base **10** and the arm of the L-shaped solid metal rod **12** are both located on the same axis of symmetry and have a gap **32** therebetween. The gap **32** exposes a portion of the wire **14.**

In FIG. 1*b* is shown a cross section of the antenna displayed generally at FIG. 1*a*. In this figure, the radio frequency source **33** is shown connected to the hollow metal cylindrical tube **13** by means of standard radio frequency connector **34.** The hollow metal cylindrical tube **13** is mounted onto the base **10** by means of mounting block **15** having screws **21** attaching the mounting block thereto. The hollow metal cylindrical tube **13** is held in place and electrically connected by means of mounting screw **22** in the side of mounting block **15.**

Another mounting block **11** having screws **21** therein is attached to the base of the nose cone **10.** The solid metal cylindrical L-shaped rod **12** is electrically attached to the base **10** by means of screw **27** located in the side of the mounting block **11.** A small hole **43** is at the end face of the unattached arm of the L-shaped solid cylindrical rod **12.** This hole is for receiving the wire **14** and the L-shaped solid rod **12** has a screw **28** mounted in the side of said unattached arm for the purpose of securing the metal wire **14** in said hole. This wire **14** extends coaxially through the hollow metal cylindrical L-shaped tube **13** and is connected to radio frequency source **33** via standard RF connector **34.** The wire **14** is isolated from the hollow metal cylindrical L-shaped tube **13** by means of a plastic dielectric material **23** filling the space inside of said hollow metal cylindrical L-shaped tube **13** and around metal wire **14.**

In FIG. 2*a* is shown a perspective view of another embodiment of the invention herein wherein the radio frequency excitation element for exciting the metal nose cone is mounted onto the recessed base of said cone. The nose cone **40** of this embodiment has a recessed metal base **41.** On this base **41** is mounted the U-shaped excitation element comprising L-shaped members **12** and **13,** as previously disclosed, attached by means of mounting blocks **22** and **27.** In FIG. 2*b* is shown a cross section of this specific embodiment of this invention wherein the element for exciting the nose cone is mounted on a recessed base of said nose cone. The only difference between this specific embodiment and that of FIG. 1*b* is that a new base **41** is recessed within a new nose cone **40.** The distance of the recession is R; all the various parts and the construction for the excitation element are the same. The excitation element consists of a hollow metal L-shaped cylindrical rod **13** and solid metal L-shaped cylindrical rod **12,** said hollow tube **13** having extended therethrough said wire **14.** A specific embodiment of this version of the invention having the dimensions as shown in FIG. 2*b* wherein R is the distance of the recession of the base **41.** L is the length of the base of the U-shaped excitation member consisting of L-shaped members **13** and **12.** X is the dimension of the gap between the L-shaped members **12** and **15.** H is the length of the arms of the L-shaped members which are attached to the base **41.** D is the diameter of the base of the nose cone **40.** For the specific operating frequency of **261** megaHertz the dimensions for this specific recessed version of the invention are as follows:

D	105.0 cm
x	0.2 cm
H	16.0 cm
R	17.8 cm
L	87.0 cm

FIG. 3 is a diagram showing the details of the interconnection between the hollow metal tube **13** and the solid metal tube **12.** In this figure the wire **14** is shown mounted within a hole **43** in the end face **44** of the solid metal cylindrical L-shaped rod member **12** by means of screw **28.** The portion of the wire **14** extending through the hollow metal L-shaped tube **13** is surrounded by a dielectric material **23.** The dielectric material **23** may be any standard dielectric commonly used in the radio frequency art for coaxial tubing. Typical examples of dielectric material **23** are polyurethane foam, polyethylene, and Teflon.

FIG. 4 shows both the E_θ and E_ϕ plots of the radiation pattern for this rearmounted forward looking antenna **61.** Curve A represents the E plots in the plane at θ equal to 90°. Curve B represents the E_θ at θ equal to 0°. The antenna **61** is oriented along the z-axis and the U-shaped element is oriented in the $x - z$ plane. Directive gain for the specific embodiment used for this radiation pattern and having the above specified dimensions measures 7.2 dB. This is moderately high for an antenna of such simple design as herein presented. The front-to-back ratio of this version of the antenna exceeds 35 dB. The L-shaped rod and the L-shaped tube each measure 3.5 mm in diameter. The 1 millimeter gap between the two half sections of the active element comprises an RF voltage gap. The radio frequency signal is transmitted to this gap through the hollow cylindrical L-shaped tube. This hollow tube and wire assembly with the dielectric material filled therein forms a 50 ohm coaxial transmission line.

The configuration of the active element of this antenna resembles what is known in scientific literature as a sleeve dipole. The particular dipole used herein when operated at the second resonance is inherently

balanced and the current and phase distributions on each half section are equal. This inherent balance obviates the need for a balun, which is required to balance a center-fed half-wave dipole. Operation of the antenna herein disclosed at the first resonance provides an unwanted inherently high impedence mismatch. Moreover, operation of this antenna at the first resonance tends to provide a backward looking radiation pattern. The U-shaped sleeve type dipole element for this rear-mounted conical antenna is therefore most efficiently operated near the frequency of the second resonance. At this frequency the total length of the two half sections, is a full wavelength.

All of the specifications above are for the recessed version of the antenna. The unrecessed version or exposed version of the active element operates similarly with only a slight increase in frequency.

The radio frequency currents which contribute to the forward-looking radiation pattern are mainly concentrated on the trailing edge region of the cone. Hence, any unusal shape or distortion, or dielectric coating on the forward portion of the projectile has little effect on the front-to-back ratio of the antenna's radiation pattern. Only the details of the side lobe structure are slightly changed.

This antenna also produces excellent linear polarization. The cross polarized component is on the average down 27 dB from the level of the main component in the forward direction. In FIG. **5**, curve C is a graph of the cross-polarized E field radiation pattern of the antenna herein presented. Again, curve B is the E_θ of the field radiation pattern of the antenna.

It is to be understood that the inventor does not desire to be limited to the exact detail of construction shown and described for obvious modifications will occur to a person skilled in the art pertaining hereto.

What is claimed is:

1. A forward-looking radio frequency antenna for projectiles comprising:

a. a hollow metal nose cone having a metal base;

b. a solid metal L-shaped cylindrical rod having a first end face and a second end face, said first end face attached to said base at a first point;

c. a hollow metal L-shaped cylindrical tube having a first open end face and a second open end face, said first open end face attached to said base at a second point;

d. a metal wire attached at one end to said solid rod and extending through said hollow tube;

e. a source of radio frequency power connected across said hollow tube at said base and the other end of said wire at said base;

f. a dielectric material filling the space inside said hollow tube and around said wire therein; and

g. the end face of said tube and the end face of said rod being disposed opposite one another across a gap, the arms of said rod and said tube being located on the same axis of symmetry.

2. The forward-looking radio frequency antenna of claim **1** wherein said second end face of said rod has a coaxial hole therein for receiving said first termination of said wire rod.

3. The forward-looking radio frequency antenna of claim **2** wherein said first point of attachment and said second point of attachment are located such that said L-shaped rod and said L-shaped tube are diametrically and bilaterally disposed about the central axis of symmetry of said cone.

4. The forward-looking radio frequency antenna of claim **3** wherein said gap is a radio frequency voltage gap.

5. The forward-looking radio frequency antenna of claim **1** wherein the length from the first end face of the L-shaped rod to the first end face of the L-shaped tube is equal to one wavelength of the radiated electromagnetic energy from said antenna.

6. The forward-looking radio frequency antenna of claim **5** further comprising annular mounting blocks attached to said base and through one of which extends said rod and through another of which extends said tube.

7. The forward-looking radio frequency antenna of claim **6** further comprising means for rigidly holding said tube and said rod in said mounting blocks.

8. The forward-looking radio frequency antenna of claim **7** wherein said wire extends across said gap.

9. The forward-looking radio frequency antenna of claim **8** wherein the base of said cone is recessed.

10. The forward-looking radio frequency antenna of claim **9** wherein said cone comprises a trailing edge which extends beyond said base and is substantially cylindrical.

* * * * *