ABSTRACT OF THE DISCLOSURE

In this disclosure is described a quarter wave length ring antenna developed to either telemeter information from active fuzes or to serve as the transmitting and receiving antenna for the active fuse on an artillery round. The antenna comprises a conducting strip electroplated on the outer surface of a dielectric ring whose inner surface has been plated with a ground plane consisting of a continuous conducting area. The conducting strip is open at one end and connected to the ground plane at the other end. At a frequency having a wavelength in the dielectric utilized of four times the length of the conducting strip, parallel resonance occurs. By driving the conducting strip at the proper point a variety of real impedances may be obtained.

Background of the invention

In the design of more efficient and more effective artillery devices it is often necessary to test the operation of such devices by attaching telemetering equipment to the artillery device under test so that data concerning the operating characteristics of the device while in flight may be obtained. In attaching such telemetering equipment to the artillery device under test it has been necessary with prior art devices to extensively modify the artillery device so that the data obtained from the test has not always been completely accurate. A primary source of such inaccuracies has been the antenna, the radiated energy from which would often cause interference with the fuse operation. Prior art telemetering equipment, especially the antenna, has been extremely inconvenient to attach to the body of the artillery device under test and has been relatively costly. Furthermore, because of the wide disparity between the sizes and shapes of the bodies of the artillery devices which might be tested, the performance of prior art telemetering equipment, especially the antenna, has been quite unpredictable.

In designing a quarter wave length antenna which may be adapted either to be used as an antenna which will transmit data while the artillery device is in flight or which may be used as the antenna for the fuse those skilled in the art will realize that the physical and aerodynamic characteristics of fuze-carrying missiles generally impose strict limitations upon the antenna. Such an antenna must be small, rugged enough to withstand high velocities and temperatures, and still give a radiation pattern which will produce the desired target sensitivity. In terms of cost and convenience it is highly desirable to have a fuze antenna that would require no modification when used on various types of projectiles. Two common prior art fuse antenna types are the loop antenna and the cap antenna. Use of a cap antenna for vehicle excitation generally results in satisfactory radiation, but the size and shape of the vehicle have a great influence upon the radiation pattern and the frequency used. Loop antennas which operate as a part of the tank circuit of the oscillator present complicated design problems because the use of a loop antenna requires suitable loop dimensions and an operating frequency which must be chosen for efficient operation and desired impedance values.

It is, therefore, an object of our invention to provide a quarter wave length antenna for use with artillery devices which is adaptable to either be used as a telemetry antenna or a fuze antenna on a wide variety of projectiles while requiring minimum modification to the projectile on which the antenna is used.

Another object of our invention is to provide an antenna which will meet the strict limitations imposed by the physical and aerodynamic characteristics of fuse-carrying projectiles.

Still another object of our invention is to provide an antenna which when used as the antenna for telemetry equipment on a projectile in flight will cause a minimum amount of radiation interference with the active fuse.

A further object of our invention is to provide an antenna having performance characteristics which will be relatively independent of the body upon which it is mounted and will withstand the maximum conditions of a gun-launched projectile environment.

A still further object of our invention is to provide an antenna which is independent of the vehicle length and can be tuned to the frequency desired with no dimensional restrictions.

Summary of the invention

As herein described the foregoing and other objects may be obtained by using a quarter wave length ring antenna which is electroplated on a dielectric ring said ring being placed on a sleeve between the fuse and the body of the projectile under test.

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:

FIGURE 1 is a view of the ring antenna of our invention mounted on an artillery device to be tested.

FIGURE 2 is an isometric view of the antenna of our invention.

FIGURE 3a is the antenna field strength pattern taken vertically from the projectile.

FIGURE 3b is the antenna field strength pattern taken horizontally from the projectile.

Description of the preferred embodiment

In FIGURE 1 is shown the antenna of our invention mounted on an unmodified mortar shell 10. Ring antenna 12 is mounted on a sleeve between the active fuse 14 and the body of the shell 11. As is readily apparent no modification of the shell is necessary, and there are no protrusions or projections from the shell which will in any way effect its performance.

In FIGURE 2 is shown the new quarter wave length ring antenna of our invention 12. The antenna consists of a dielectric ring 21 made of epoxy-fiber glass the inner surface of which is completely electroplated with a copper layer to form ground plane 22. Conducting strip 24 is formed by electroplating a copper layer in a groove cut in the outer surface of dielectric ring 21. It will be noted that the ends of conducting strip 24 are not joined and are separated by about 2/30 inch break. A lateral groove is cut across the top of ring 21 and electroplated, as previously described, so that the grounded end 26 of conducting strip 24 will be directly connected to ground plane 22 by ground strap 27. Semi-rigid coaxial cable is connected through a hole drilled in the wall of the ring to the appropriate driving point 29, the method of choosing the location of which will be described in greater detail hereinafter.

An understanding of the quarter wave length ring antenna of our invention can best be achieved through refer-
ence to strip transmission line theory which is well known to those skilled in the art. The specific antenna of our invention may be considered as a shorted termination strip transmission line. At a frequency having a wave length four times the electrical length of the transmission line, a parallel resonant situation exists. The input impedance of the line is high and purely real, consisting of a sum of the line losses and a resistance that represents the radiated power dissipation factor. Moving the driving point away from the input lowers the impedance measured at the driving point, and this value, relative to the high value of the input impedance, is a function of the ratio of driving point length (measured from the shorted end) to total line length. Thus, a variety of real impedance values is available by the proper selection of driving point locations. For the specific antenna described in FIGURE 2 an impedance of 50 ohms was chosen since this value was compatible with the widest range of laboratory instruments and co-axial cables. Neither separation between plates nor the strip width will determine the resonant frequency of a fixed length of strip line. Strip length solely determines the resonant frequency of the line. Because the wave length at the resonant frequency is directly proportional to the velocity of propagation which in turn is inversely proportional to the square root of the dielectric constant of dielectric ring 21, and because the dielectric loaded line length may be shortened by a factor which is inversely proportional to the square root of the dielectric constant of dielectric ring 21 relative to an air dielectric line, a fixed physical dimension may be made compatible with a desired electrical length by selecting a material with a suitable dielectric constant.

The radiation of energy from a transmission line can be analyzed in an effort to maximize this phenomenon for antenna applications. In the ideal case, and if spacing between the conducting strip and the ground plane is less than ½ wave length, only the TEM mode is present. Under these conditions, radiated power \( P_r \) relative to power transmitted in the line \( P \) is expressed as:

\[
\frac{P_r}{P} = \frac{K_4}{K_3} \left( \frac{h}{\lambda} \right)^2
\]

thus

\[
\frac{P_r}{P} = \frac{K_4 h a}{K_3 \lambda^2}
\]

where,

\[
Z_0 = \text{characteristic line impedance,}
\]

\[h = \text{height of conducting strip above the ground plane,}
\]

\[a = \text{conducting strip width,}
\]

\[K_4 \text{ and } K_3 = \text{constants, and}
\]

\[= \text{wave length of propagated wave in the strip transmission line. It can therefore be stated that a change in a strip width or spacing will cause a directly proportional change in radiated power relative to input power.}
\]

Power flow between conducting and ground planes is restricted to an area in the immediate vicinity of the transmission line. It is the standard practice in analysis of strip transmission lines to consider a ground plane infinite in width if it is greater than three times the width of the conducting strip. This implies that a strip transmission line radiator is virtually independent of its surroundings. The property of relative independency of the body upon which it is mounted is characteristic of this family of antennas.

In discussing antennas made from strip transmission line it is necessary to consider the power loss that occurs due to transverse coupling effects. The proximity of the conducting strip to either ground or other conducting strips leads to coupling of the transverse components of the energy. By maximizing the distance of the conducting strip from conductors parallel to the direction of propagation the transverse coupling effect may be made negligible.

Therefore, from the above analyses, several conclusions can be drawn which in turn will be characteristics of the antenna of our invention. Wave length and resonance are strictly functions of the strip or strip array dielectric. Radiated power increases directly with increasing dimensions of strip width or spacing above the ground plane. Power flow is restricted to the area in the immediate vicinity of the line implying that only limited excitation of the surroundings will occur. Spacing of the center conductor with respect to the conducting area is parallel to plane of the center conductor is such that transverse coupling effects are avoided.

In FIGURES 3a and 3b are shown the field strength patterns of the antenna of our invention. These patterns were arrived at by comparing the performance of the antenna herein described with standard dipoles and similar reference radiators. The field strength patterns shown are relative to a standard dipole at zero dB, were transmitted at 227 megahertz, and measured with a helical receiving antenna. In FIGURE 3a the field strength pattern is taken from the projectile vertical position or is the pattern seen by an observer looking directly at either the nose or tail of the projectile upon which the antenna is mounted. The field strength pattern 31 of the antenna of our invention from a projectile vertical position indicates the very uniform circular azimuthal field strength pattern which is of major significance in both telemetry and fuse applications. In FIGURE 3b the field strength pattern is taken from the projectile horizontal position which might be described as the pattern an observer would see looking directly down on the body of the projectile. Of particular interest here is the fact that no radiation of power occurs in the nose region of the projectile implying that telemetry transmission should not interfere with the active fuse. The wide three dB angle of dispersion which is about 60° for this antenna is of great value for telemetry applications, since it permits greater flexibility in the position of receiving stations while maintaining uniform received signal levels.

While our invention has been described in terms of a particular embodiment used on a mortar shell using particular dielectric and conductor materials it will be apparent to those skilled in the art that the embodiment shown is 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. We claim:

1. A new ring antenna comprising a
   (a) dielectric ring,
   (b) first conductor means extending around and adhering to the entire inner surface of said ring,
   (c) second conductor means having two ends, and extending substantially around and adhering to the outer surface of said dielectric ring,
   (d) third conductor means adhering to a lateral surface of said ring and connecting an end of said second conductor to said first conductor, and
   (e) an input terminal connected to said second conductor.

2. The ring antenna of claim 1 wherein the position of said input terminal is selected to determine the driving point impedance, said driving point impedance being the ratio of the length of said second conductor from said end connected to said third conductor to said input terminal to the entire length of said second conductor.

3. The ring antenna of claim 1 wherein said first, second and third conductor means are electroplated on said dielectric ring.

4. A new ring antenna for use with an active fuse or for telemetering data from projectiles in flight which will require only slight modifications to the projectile when mounted therein, comprising in combination with a projectile, a dielectric ring mounted perpendicular to the axis of said projectile and conforming to the circumferential dimensions and shape of said projectile and mounted on
said projectile so that the shape of said projectile is not disturbed, a first conductor extending around the entire circumference of and adhering to the inner surface of said dielectric ring, a second conductor having two ends and extending substantially around and adhering to the outer surface of said dielectric ring, third conductor adhering to a lateral surface of said ring and connecting an end of said second conductor to said first conductor, and an input terminal connected to said second conductor.

5. The ring antenna of claim 4 wherein the position of said input terminal is selected to determine the driving point impedance, said driving point impedance being the ratio of the length of said second conductor from said end connected to said third conductor to said input terminal to the entire length of said second conductor.

6. The ring antenna of claim 4 wherein said first, second and third conductor means are electroplated on said dielectric ring.

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