July 5, 1960 D. K. YEAROUT ET AL 2,944,258

DUAL-RIDGE ANTENNA

Filed July 25, 1958

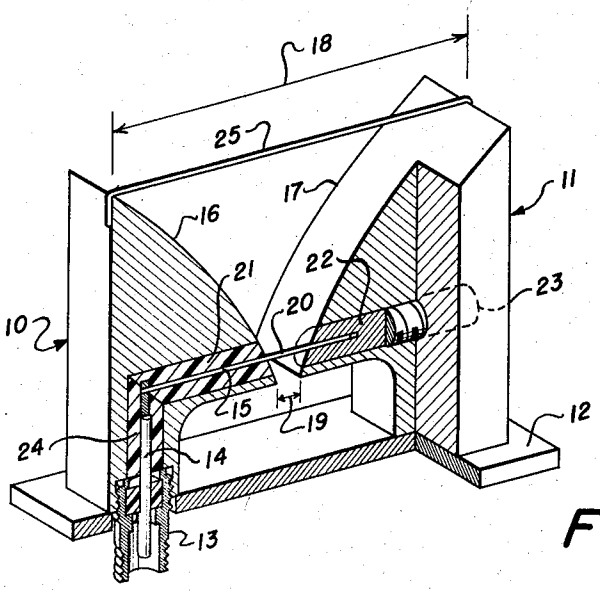

Fig. 1

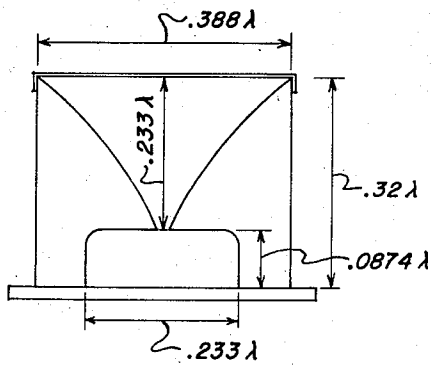

Fig. 2

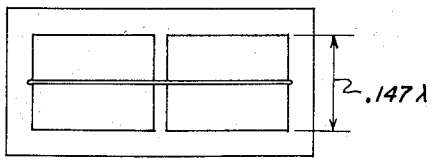

Fig. 3

INVENTORS:
Dean K. Yearout
Harvey L. Jergins

BY

Roland A. Anderson

Attorney

United States Patent Office

2,944,258

Patented July 5, 1960

2,944,258

DUAL-RIDGE ANTENNA

Dean K. Yearout, Sandia Park, and Harvey L. Jergins, Albuquerque, N. Mex., assignors, by mesne assignments, to the United States of America as represented by the United States Atomic Energy Commission

Filed July 25, 1958, Ser. No. 751,101

4 Claims. (Cl. 343—767)

The present invention relates to antennas and more particularly to a miniature dual-ridge transmitting and receiving radar antenna.

A principal object of the present invention is to provide a miniature antenna capable of transmitting and receiving radar signals.

A further object of this invention is to provide a miniature antenna having low voltage standing wave ratio operating in the microwave region.

A still further object of this invention is to provide a miniature antenna having broad bandwidth.

Another object of this invention is to provide a miniature antenna having an impedance equal to a conventional transmission line.

A further object of this invention is to provide miniature antenna capable of transmitting and receiving a broad radiation pattern.

Other and further objects will be hereinafter discussed and will be more particularly pointed out in the appended claims.

It is well known that radar systems are employed on missiles and airplanes, and with the changes in size and streamlining it has become necessary to design a miniature antenna with as good efficiency as larger antennas. By larger antennas, we mean those of the prior art such as the dipole, slot, horn, and many others which, because of their characteristics, must be of a definite size for specific wavelengths. In such antennas, if the frequency is specified, the wavelength of each element must be of a definite length. Certain elements may be a quarter of the wavelength and maintain good efficiency. This establishes a lower limit on antenna elements.

It is well known that an antenna of the correct length acts like a resonant circuit and presents pure resistance to the excitation circuit. An antenna having other than the correct length displays both resistance and reactance to the excitation circuit. Thus, if an antenna is made smaller than its resonant length, the input impedance becomes reactive. To correct for capacitive reactance in the input impedance, we add inductance in series with the antenna to bring it back into resonance, or, in other words, to increase the lengths of the antenna elements. This means that the above-mentioned antennas cannot be employed efficiently in broadband radar systems on missiles or airplanes where space requirement is at a premium.

It can be seen from the foregoing that the development of miniature antennas having all the characteristics of the larger prior art antennas is an important factor in present and further radar systems. By employing various microwave techniques, we have provided a miniaturized antenna having all the characteristics required for specific radar systems. The dual-ridge antenna of this invention takes approximately one-eighth the volume of the prior art antennas for the same radar system.

The ridge principle comes from an article by Seymour B. Cohn published in the Proceedings of the IRE for August 1947, page 783. In this article, Mr. Cohn points

out that by employing ridges in a waveguide, one can obtain broader bandwidths, and proper impedance match between waveguide and ordinary coaxial cable. Mr. Cohn further points out that ridge waveguide has been used for elements in wideband junctions between waveguide and coaxial line. Also the ridge waveguide has been employed as a matching transformer between a high impedance waveguide and an ordinary coaxial cable.

This information provides a background for the design of a miniature antenna having broad bandwidth and proper impedance match. It is obvious that an open end ridge waveguide is not an efficient radiator.

With the change in conventional configuration of the ridges and the elimination and addition of various elements to be described in detail, the antenna of the present invention complies with all of the requirements necessary for a broadband radar system to be employed on missiles and airplanes.

In its principal aspects, the present invention is a miniature antenna comprising a ground plane with a pair of oppositely disposed or matching directional elements herein referred to as ridges. These ridges extend perpendicularly from the ground plane and have facing inner curved surfaces which converge toward the ground plane and terminate at a predetermined distance from the ground plane and from each other. An exciter is connected between the ridges adjacent their point of maximum convergence or minimum separation. A suitable transmission line is connected to the exciter. Another conductor is connected across the two ridges at their point of maximum separation, in order to provide broader radiation and proper impedance.

A more thorough understanding of the invention may be secured from a study of the following description of several specific embodiments.

In the drawings:

Fig. 1 is a perspective view of the invention in preferred form, a part being broken away to illustrate details of construction.

Fig. 2 is a plan side view to illustrate relative size with respect to wavelength.

Fig. 3 is a plan top view to illustrate the width of the ridges with respect to wavelength.

In Fig. 1, the dual-ridge transmitting and receiving antenna is shown comprising ridges **10** and **11** supported on base **12**. Connector **13** is mounted on ridge **10** and extends through base **12**. Connector **13** provides coupling between an external transmission line (not shown) and conductor **14**, which is, in turn, connected to conductor **15**. The portion of conductor **15** which lies between ridges **10** and **11** constitutes exciter **20**.

Base **12** is not only a support for ridges **10** and **11**, but also provides a means for mounting the antenna in a ground plane. In the description, base **12** will also be referred to as the ground plane, since in actual installation base **12** is mounted flush with a larger surrounding metallic element which serves that function. The complete ground plane is not shown because its size and shape may vary for different antenna applications.

A definite relationship exists between the size of the ground plane and the directional elements or ridges for acceptable gain and effective radiation pattern. One example of the relative size of the ground plane and the ridges for good hemispherical radiation is a width ratio of three and one half to one. A relative change in ground plane or directional element size will vary these values.

In some cases, it is desirable to employ two complete radar systems in which two antennas are positioned in a single ground plane at right angles to each other. This prevents excessive coupling between systems. It can be seen that there is a definite advantage in using miniature

antennas in such a case because it makes it possible to keep the ground plane size to a minimum and yet maintain acceptable gain.

Conductive directional elements or ridges **10** and **11** are located perpendicular with respect to ground plane **12**. Each ridge **10** and **11** has a shape substantially defined by two parallel right angular sector-like surfaces. Each of the surfaces is bounded by two radii and an included arc with a rectangular cutout section located adjacent ground plane **12**. There are two mutually perpendicular rectangular surfaces individually joining like radii of the parallel sector-like surfaces. A curved surface **16** joins the arc of the sector-like surfaces. Curved surfaces **16** and **17** converge from what may be called the mouth **18** of the antenna to a narrow section which may be referred to as the throat **19** of the antenna. There is no exact mathematical formula that can be applied to calculating curvatures **16** and **17**. They must, however, be flared upwardly from the ground plane in accordance with an experimentally predetermined radius of curvature to obtain maximum bandwidth for given radiation requirements. Also, in developing curvatures **16** and **17**, the antenna impedance must be kept at the impedance of a selected transmission line. With an appropriate ground plane, the bandwidth is, for example, 4 to 1, and the radiation pattern is approximately 70° and the gain is approximately 7 db as compared to isotropic radiators. As shown in Fig. 1, each ridge **10** and **11** has a generally rectangular portion removed adjacent the ground plane. This creates a predetermined separation between the throat **19** and ground plane **12**, which provides a high impedance at the throat **19**. The antenna's exciting element **20** is that section of conductor **15** connected between ridges **10** and **11** at the throat **19**. The section of conductor **15** located in insulator **21** and in turn ridge **10** acts essentially as a transmission line and may be varied in diameter to serve as a quarter wave matching section. One end of conductor **15** is inserted in a friction tight cylinder of a threaded metallic plug **22**. This arrangement permits tuning the antenna by inserting a non-metallic screwdriver in cylinder **23** and adjusting plug **22** to slide over conductor **15**. The antenna is tuned for maximum efficiency at a predetermined center frequency. Then conductor **15** is soldered to plug **22**. The other end of conductor **15** is threaded and is turned into a threaded bore of conductor **14**. The threads of conductor **15** and the bore of conductor **14** are not shown.

Conductor **14** also provides the male terminal of connector **13** and is insulated from ridge **10** by insulator **24**. Insulators **21** and **24** are of a size to provide for proper transmission line impedance. Connector **13** is threaded into ridge **10** with an additional threaded portion extending below ground plane **12** for connecting a female connector of the transmission line from the radar system.

To obtain broader beam width and proper impedance, a conductor **25** is positioned across the mouth **18** of the antenna. Each end of conductor **25** is conveniently connected in the center of the width of ridges **10** and **11**.

Referring to Figs. 2 and 3, the dimensions of the antenna of this invention are expressed in fractional values of wavelength at any given frequency. These are typical figures which apply in the UHF or microwave region. An example is given below of the determination of actual antenna dimensions for a predetermined frequency applying these relative values, and assuming the transmission line between antenna and radar system is a conventional coaxial cable of 50 ohms impedance. The wavelength is found by applying the equation:

$$\lambda = \frac{C}{f_c}$$

where C is the velocity of radio waves in inches per second and f_c is the selected center frequency. If the center frequency f_c is selected as 500 mc., the wavelength will equal:

$$\lambda = \frac{1.181 \times 10^{10}}{5 \times 10^{8}} = 23.7 \text{ inches}$$

From the following table, the dimensions are given for an antenna according to this invention at a center frequency of 500 mc.

The distance from the throat to the mouth of the antenna is:

$$.223\lambda = (.233)(23.7) = 5.52 \text{ inches}$$

The distance from the highest vertical extent of one of the ridges to the ground plane is:

$$.32\lambda = (.32)(23.7) = 7.58 \text{ inches}$$

The distance across the mouth of the antenna is:

$$.388\lambda = (.388)(23.7) = 9.20 \text{ inches}$$

The vertical space between the throat and the ground plane is:

$$.0874\lambda = (.0874)(23.7) = 2.07 \text{ inches}$$

The horizontal space between the throat and the ground plane is the same as between the throat and the mouth or 5.52 inches.

The width of each ridge as shown in Fig. 3 is:

$$.147\lambda = (.147)(23.7) = 3.39 \text{ inches}$$

The relative wavelength values given above were determined experimentally for maximum antenna efficiency and therefore no antenna theory accounts for them exactly. It is emphasized, however, that these dimensions are in no sense to be regarded as a limitation and are shown for purposes of illustration only. The basic invention resides in the general configuration as shown in Fig. 1. The exact dimensions of the ridges and the curvature of their inner surfaces are determinable by those skilled in the art for given bandwidth, radiation pattern and other requirements prescribed for a particular installation.

What has been described is a miniature antenna having the necessary characteristic to operate efficiently with a radar system. This invention is not limited to the particular details of construction, materials and processes described, as many equivalents will suggest themselves to those skilled in the art. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

What is claimed is:

1. An antenna for transmitting and receiving radio waves of predetermined frequencies comprising a pair of similar oppositely disposed conductive ridges mounted perpendicular to a ground plane, a pair of curved surfaces on the facing inner ridge portions converging at a predetermined radius of curvature toward the ground plane and terminating a selected distance therefrom, thereby forming an antenna mouth and throat respectively, an exciter element parallel to the ground plane across the antenna throat, a conductor joining the ridges at the antenna mouth, an energy transferring connector mounted in one of said ridges, and a transmission line within said ridge joining said connector to the exciter element.

2. An antenna for transmitting and receiving radio waves of predetermined frequencies comprising a pair of similar oppositely disposed conductive ridges mounted perpendicular to a ground plane, a pair of curved surfaces on the facing inner ridge portions converging at a predetermined radius of curvature toward the ground plane and terminating a selected distance therefrom, thereby forming an antenna mouth and throat respectively, an exciter element parallel to the ground plane across the antenna throat, a conductor joining the ridges at the antenna mouth, an energy transferring connector mounted in the first of said pair of ridges, a transmission line within first said ridge joining said connector for the ex-

citer element, and tuning means located within the second ridge slidably connected to the exciter element.

3. An antenna for transmitting and receiving radio waves of predetermined frequencies comprising a ground plane, a pair of oppositely disposed conductive ridges mounted perpendicular thereto, each ridge having a substantially sector-like longitudinal section with a generally rectangular cutout portion adjacent the ground plane, a pair of curved surfaces on the facing inner ridge portions converging at a predetermined radius of curvature toward the ground plane and terminating a selected distance therefrom, thereby forming an antenna mouth and throat respectively, an exciter element parallel to the ground plane across the antenna throat, a conductor joining the ridges at the antenna mouth, an energy transferring connector mounted in one of said ridges, and a transmission line within said ridge joining said connector to the exciter element.

4. An antenna for transmitting and receiving radio waves of predetermined frequencies comprising a ground plane, a pair of oppositely disposed conductive ridges

mounted perpendicular thereto, each ridge having a substantially sector-like longitudinal section with a generally rectangular cutout portion adjacent the ground plane, a pair of curved surfaces on the facing inner ridge portions converging at a predetermined radius of curvature toward the ground plane and terminating a selected distance therefrom, thereby forming an antenna mouth and throat respectively, an exciter element parallel to the ground plane across the antenna throat, a conductor joining the ridges at the antenna mouth, an energy transferring connector mounted in one of said ridges, a transmission line within said ridge joining said connector to the exciter element, and turning means located wthin the second ridge slidably connected to the exciter element.

References Cited in the file of this patent

UNITED STATES PATENTS

2,531,454	Marshall	Nov. 28, 1950
2,691,731	Miller	Oct. 12, 1954
2,825,060	Ruze	Feb. 25, 1958
2,825,062	Lan Jen Chu et al.	Feb. 25, 1958