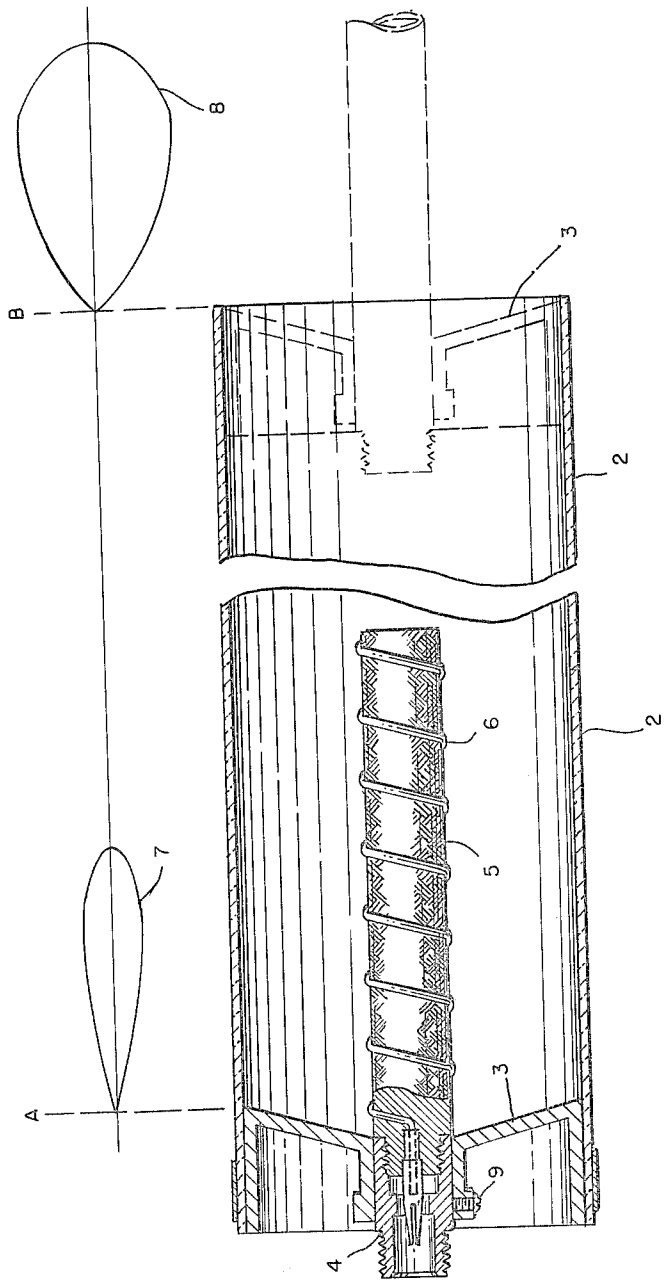
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VARIABLE BEAMWIDTH ANTENNA

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VARIABLE BEAMWIDTH ANTENNA

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The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

The present invention relates to microwave antennas and more particularly to a novel and useful high gain microwave antenna, the directivity of which is continually adjustable between certain limits.

The novel antenna of the present invention comprises in effect two diverse types of antennas, one of which has a substantially narrower beamwidth than the other. The antenna of wider beamwidth is slidably mounted within the other antenna and comprises the driven element for the narrow beamwidth antenna. By sliding the inner antenna relative to the outer one, the effective length of the latter is changed, resulting in a continuous increase in the beamwidth of the composite antenna. When the inner antenna is completely withdrawn from the outer one, the inner one becomes the sole radiator.

The structure and mode of operation of the invention will be better understood with reference to the following detailed description and drawing, the sole figure of which is a preferred embodiment of the novel antenna.

In the drawing, the cylindrical dielectric tube **2** comprises the outer antenna and may be molded of fiberglass, or other plastic material. Slidably and coaxially mounted within the dielectric tube **2** is a helical antenna **6** which is wound on insulated core **5**. Core **5** is in turn centrally held within tube **2** by metal support **3** which is adapted to slide within tube **2**. The helix is illustrated at the two extreme positions of its adjustment. Threaded plug **4** is adapted to receive a coaxial fed line from a transmitter or receiver, not shown. The inner end of helix **6** is connected to the center conductor of the feed line and metal support **3** is connected to the outer conductor thereof. The helix dimensions are chosen so that radiation in the beam or axial mode results therefrom at the desired operating frequency. The helix circumference, that is, the circumference of insulated core **5**, is made approximately equal to one wavelength of the operating frequency in free-space. Under these conditions the helix will radiate a directive circularly polarized beam having its maximum along the helix axis and toward the open or free end thereof. The sharpness of this directivity pattern depends on the helix circumference and electrical length of the helix. The beamwidth between half power points for a helix alone is given by the formula:

$$BW = \frac{52}{C\sqrt{L}} \text{ degrees} \quad (1)$$

wherein C is the helix circumference and L is the helix axial length, both in terms of free-space wavelengths. According to the present invention, the helix beamwidth is chosen to equal the widest beamwidth which is desired for the composite antenna and the dimensions of the dielectric tube are chosen to produce the narrowest beam desired therefor. In order to function effectively as an end-fire radiator, the diameter of dielectric tube **2** is made approximately equal to one wavelength. The half-power beamwidth of such a radiator can be approximated by the formula:

$$BW = \frac{60}{\sqrt{L}} \text{ degrees} \quad (2)$$

where L is the axial tube length in free-space wavelengths.

With the above-noted dimensions and with the helix fully retracted within the tube **2**, as shown in position A in the drawing, the helix in effect acts as the driven element for the tubular radiator **2** and the beam is highly directive, as shown by radiation pattern **7**, since nearly the entire length of the tube is effective. As the helix and its support are moved within the tube in the direction of propagation, that portion of tube **2** to the rear of the helix, or to the left in the drawing, becomes ineffective and the beamwidth continuously widens or increases in accordance with Formula 2. When the helix is fully extended from the forward end of tube **2**, as shown in dashed outline in the drawing at B the device becomes a simple helical antenna, the beamwidth of which is shown at **8**.

The helical radiator, being a slow-wave device, matches the slow-wave characteristics of the dielectric tube, resulting in efficient coupling of power thereto over a wide frequency range. Also, because most of the energy flows in the air space both within and outside of the dielectric tube, the power handling capacity of the antenna is not limited by the loss angle of the dielectric material, as is the case with solid dielectric radiators. The wall thickness of the tube **2** should be made as small as possible consistent with the required mechanical rigidity, in order to minimize the generation of spurious modes of radiation and losses therein. The wall thickness should be made less than 3% of the operating free-space wavelength for optimum performance.

Thus it can be seen that the disclosed invention combines two different antennas in such a way as to obtain continuously variable sharpness of directivity between predetermined limits. In an antenna constructed according to the teachings of the present disclosure, the tube **2** comprised a fiberglass tube of 1 meter length, 70 mm. diameter and wall thickness 1.5 mm., the helix was wound on an 18 mm. diameter plastic form and comprised 9 turns of axial length 115 mm. The experimentally measured half power beamwidths for positions A and B were 15° and 40.5°, respectively at 5000 mc. It should be noted that since both the helix circumference and the tube diameter are approximately one wavelength, the tube diameter will be approximately pi or 3 times the helix diameter. In practice, the tube may be made three to four times the helix diameter. Also, in order to achieve a wide range of beamwidth adjustment the tube must be substantially longer than the helix. In practice, the tube is made from five to fifteen times as long as the helix.

The present antenna achieves high directivity without the use of large metallic reflectors and hence is particularly useful for military applications wherein its lightweight make it easily portable. Also, the absence of large metal reflectors makes the antenna less susceptible to detection by hostile radar or infrared equipment. The simple design and absence of critical adjustments of the antenna result in inexpensive construction. Also, it has been found that there is no degradation in the antenna performance if it protrudes through the metal side of a vehicle or other structure. It should be noted that helix may be held stationary and tube **2** arranged to slide over metal support **3**. This permits the use of a rigid feed cable to the helix.

While a specific embodiment of the invention has been shown and described, it will be apparent that many modifications may be made therein by those skilled in the art, accordingly, the invention should be limited only by the scope of the appended claims.

What is claimed is:

1. A microwave antenna of adjustable beamwidth comprising a helical radiator mounted within and coaxially with a thin-walled cylindrical dielectric tube, said helical

radiator being adapted to slide along the axis of said tube, said helical radiator being dimensioned to radiate in the axial or beam mode, said dielectric tube being approximately pi times the diameter of said helical radiator and of such length as to produce a radiation pattern of substantially less beamwidth than that of said helical radiator.

2. A microwave antenna of adjustable beamwidth comprising a helix arranged to slide coaxially relative to a cylindrical dielectric tube, means to connect a feed line to one end of said helix, said helix being dimensioned to radiate in the axial or beam mode at the operating frequency, the diameter of said dielectric tube being from three to four times the diameter of said helical radiator, the length of said helical radiator being chosen to provide the widest desired beamwidth and the length of said dielectric tube being chosen to provide the narrowest desired beamwidth.

3. An adjustable microwave antenna comprising a helical radiator arranged to slide axially within a thin-walled dielectric tube, means to connect a feed line to one end of said helical radiator, said dielectric tube being approximately pi times the diameter of said helical radiator, said helical radiator having a circumference of approximately one free-space wavelength at the operating frequency of the antenna, said dielectric tube being substantially longer than said helical radiator.

4. An adjustable microwave antenna comprising a helix arranged to slide coaxially within a dielectric tube, said dielectric tube being approximately pi times the diameter

of said helix, means to connect a feed line to one end of said helix, said helix having a circumference of approximately one free-space wavelength at the operating frequency of the antenna, said dielectric tube being from five to fifteen times the axial length of said helix.

5. A microwave antenna comprising a helix slidably and coaxially mounted within a dielectric tube, means to connect a feed line to one end of said helix, said dielectric tube being from three to four times the helix diameter and from five to fifteen times as long as said helix.

6. A variable-beamwidth composite antenna comprising two diverse radiating elements slidably mounted one within the other, said one element comprising a slow-wave radiator adapted to launch a unidirectional wave longitudinally within said other element, said other element comprising a dielectric tube, the beamwidth of said dielectric tube being substantially less than that of said slow-wave radiator.

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