Feb. 14, 1956 R. KRAUSZ ET AL 2,735,093

AIRBORNE BEACON ANTENNA

Filed Jan. 2, 1952 4 Sheets-Sheet 1

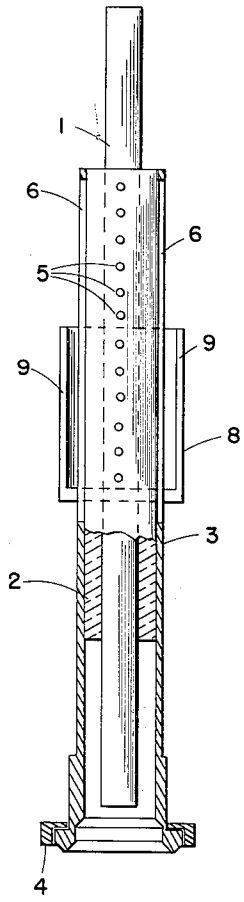

FIG. 1

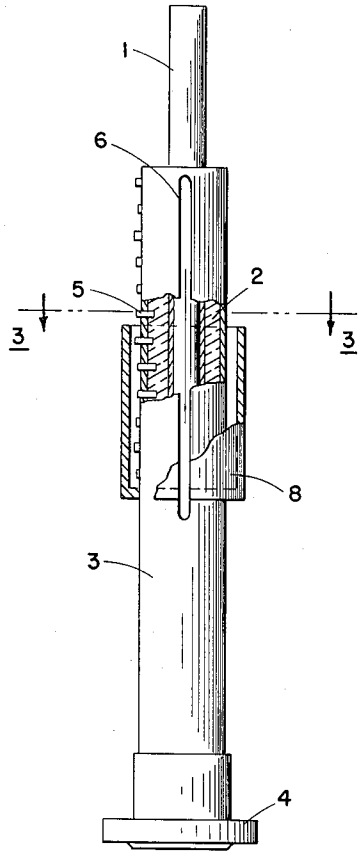

FIG. 2

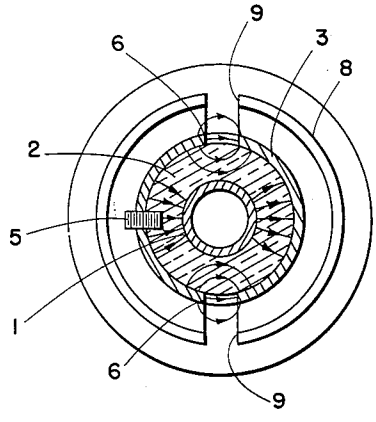

FIG. 3

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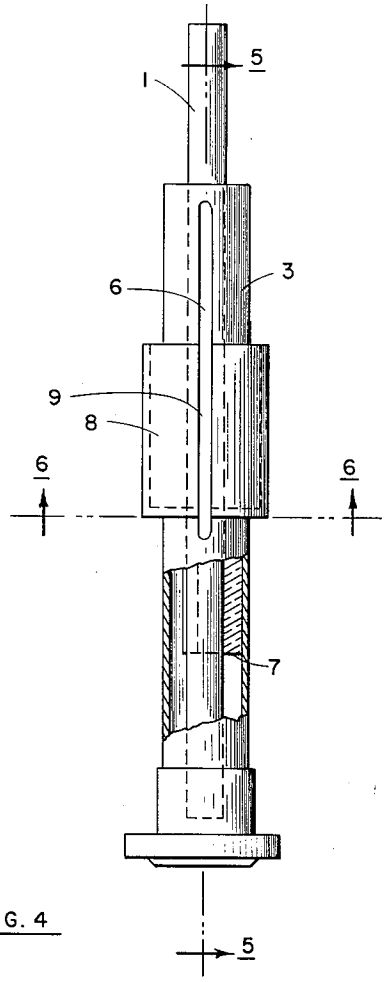

FIG. 4

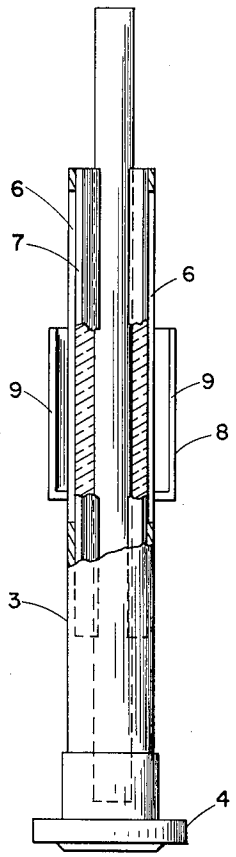

FIG. 5

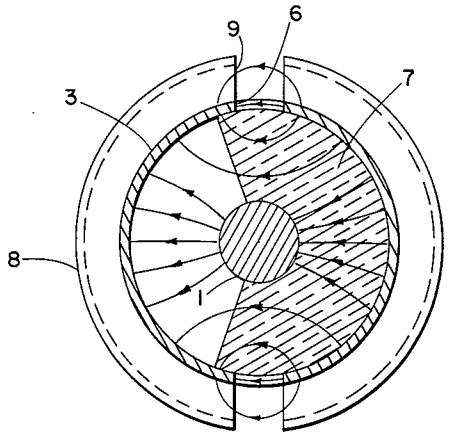

FIG. 6

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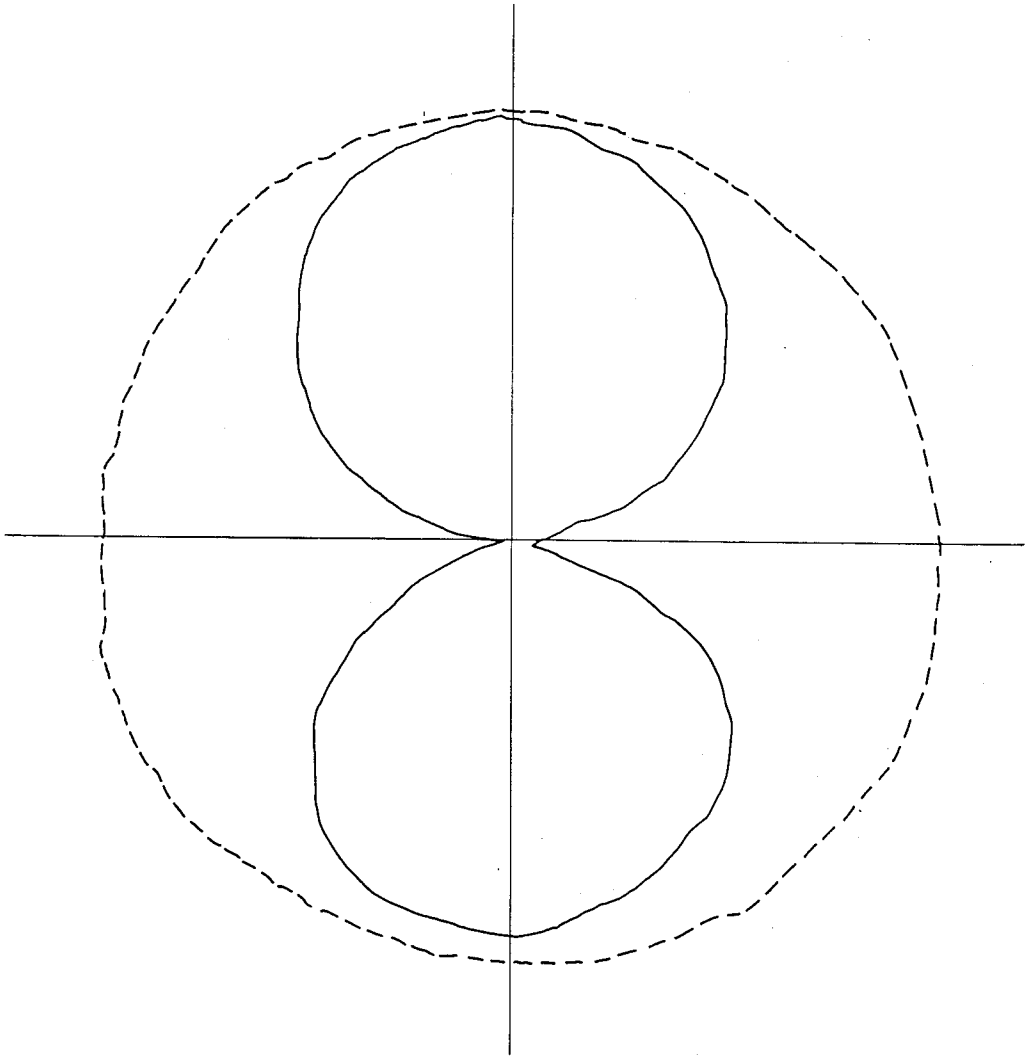

FIG. 7

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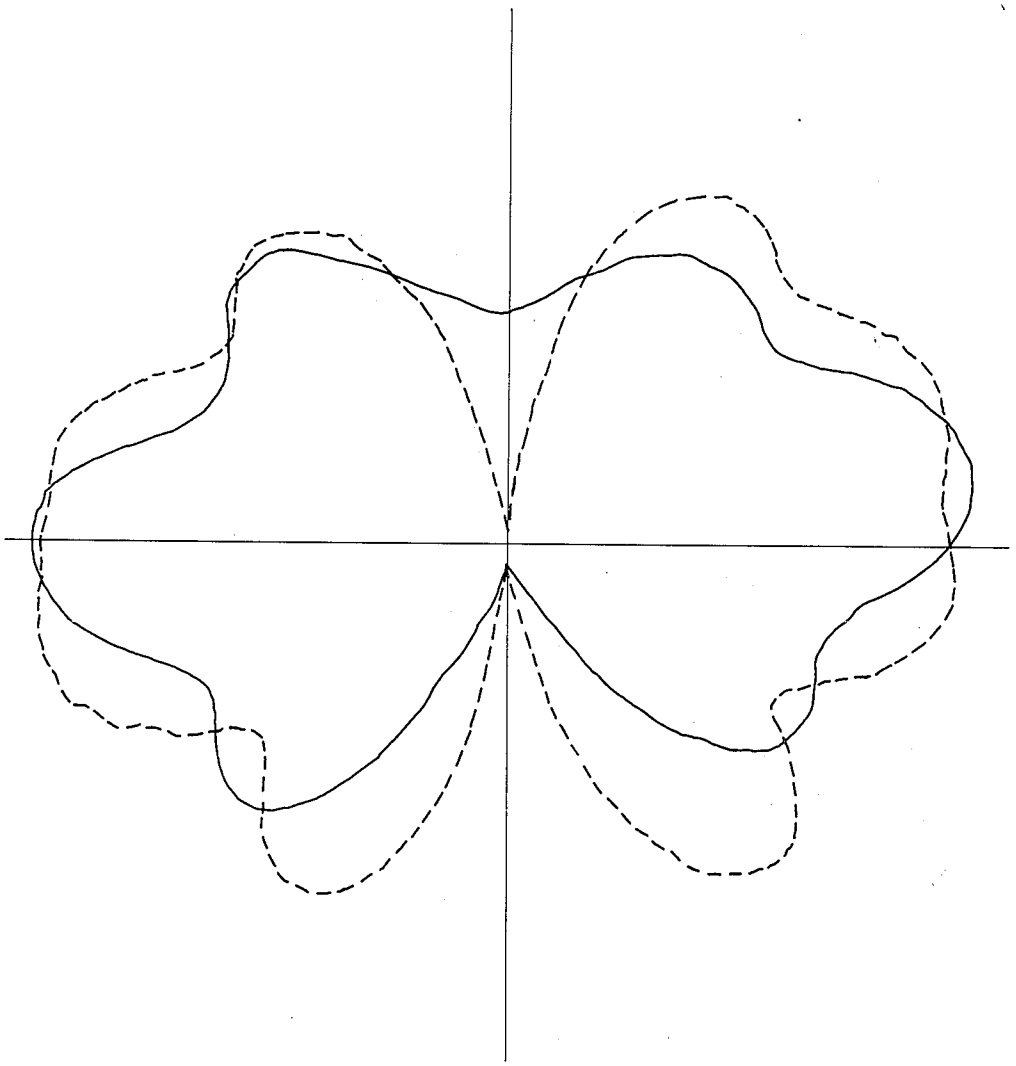

FIG. 8

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Application January 2, 1952, Serial No. 264,481

9 Claims. (Cl. 343—725)

This invention relates to beacon antennae for propagation of microwave electromagnetic energy, and particularly to a beacon antenna adapted to propagate circularly polarized electromagnetic waves.

Airborne beacon antennae must be designed to operate in conjunction with ground radar. Since ground radar devices may employ either circularly polarized radiation or plane polarized radiation with orientation upon which it is desired not to place any limitation, the beacon must respond to and must propagate circularly polarized electromagnetic waves. Since an aircraft carrying a beacon must be capable of detection from any direction in the horizontal plane, the pattern of propagation must be such as to cause substantially uniform propagation from any direction of observation of the aircraft, and the pattern of propagated circularly polarized waves must be as large as possible.

This invention contemplates an antenna for propagating electromagnetic waves with a substantially toroidal pattern.

It is an object of this invention to provide a beacon antenna adapted to propagate circularly polarized electromagnetic waves over a considerable portion of its propagation pattern.

Other objects of invention will become apparent from the following description taken in connection with the accompanying drawings, in which

Fig. 1 is an elevational view of the invention partly in section;

Fig. 2 is a side view of the invention;

Fig. 3 is a sectional view of the device shown in Fig. 1 taken at 3—3 in Fig. 2;

Fig. 4 is an elevational view partly in section of a second embodiment of the invention;

Fig. 5 is a side view of the device shown in Fig. 4;

Fig. 6 is a sectional view taken at 6—6 in Fig. 4;

And Figs. 7 and 8 are plots of the radiation pattern achieved by the invention.

Referring now to the drawings, and particularly to Fig. 1, there is shown a coaxial wave guide consisting of a cylindrical conductor 1 surrounded by a hollow dielectric cylinder 2 which in turn is encased in a tubular conductor 3. Tubular conductor 3 is connected to a fitting 4 which is adapted to be connected to a coaxial wave guide not shown. Tubular conductor 3 has cut in its periphery a pair of longitudinal diametrally opposed slots 6 having a length equal to approximately half the wave length of the electromagnetic waves to be propagated by the device. Attached to tubular conductor 3 and extending through dielectric cylinder 2 are a number of conducting pins 5 which extend radially toward conductor 1. Cylindrical skirt 8, having slots 9 of substantially the same dimensions as slots 6, is provided to prevent the flow of longitudinal currents upon the outer surface of tubular conductor 3 below the upper end of the skirt. Conductor 1 extends beyond the end of conductor 3 to form a dipole with conductor 3.

In operation, a coaxial wave guide is connected to fitting 4 to supply electromagnetic energy transmitted through the guide in the TEM mode. This energy is conducted

upon the inside surface of tubular conductor 3 and upon the outside surface of conductor 1 in the same mode. When the energy reaches pins 5, nonsymmetrical modes of the electromagnetic energy are generated, and approximately one-half of the energy is radiated from slots 6. The energy radiated from slots 6, of course, is polarized in a horizontal direction since electric fields exist across the slots. The remainder of the electromagnetic energy proceeds to the ends of the two conductors and is radiated with vertical polarization from the dipole elements 1 and 3. The distance between the end of conductor 1 and the end of tubular conductor 3 is made one-quarter of the wave length of the electromagnetic energy being transmitted. Likewise, the distance between the upper end of skirt 8 and the end of tubular conductor 3 is approximately one-quarter wave length. Slots 6 are located as near as practicable to the dipole in the interest of compactness. Consequently, the energy radiated by the slots is in phase-quadrature with the energy radiated by the dipole. This arrangement results in circularly polarized waves radiated in that portion of a plane perpendicular to the axis of the two conductors which is opposite the two slots. The circular polarization of the electromagnetic waves adjacent one slot is opposed in sense to the polarization adjacent the other slot. Since pins 5 present a discontinuity to electromagnetic waves transmitted within tubular conductor 3 it is necessary to adjust the penetration of pins 5 and their position along conductor 3 in order to prevent an impedance mismatch which would result in the reflection of energy back through the coaxial wave guide. Actually, each such pin causes a reflection, but by proper spacing of the pins in relation to the wave length of the energy being transmitted, the reflections may be caused to substantially cancel out at or near the operating frequency.

In order to simplify the problem of impedance matching in the device shown in Figs. 1 and 2, the embodiment of the invention shown in Figs. 4, 5, and 6 has been devised. In Fig. 4, the invention has been modified by substitution of a sector of a hollow dielectric cylinder for hollow dielectric cylinder 2 shown in Fig. 1. Sector 7, as shown in Fig. 6, extends from a point near slots 6 to a point on the opposite side of tubular conductor 3 such that the axis of symmetry of the sector is normal to a plane bisecting the slots longitudinally. The electric field is then distorted, as shown in Fig. 6, and radiation from slots 6 results as shown. Pins 5, of course, are no longer necessary, since no coupling means other than the sector is required to radiate energy from the slots. To assure a proper impedance match between the wave guide and the antenna it is necessary only to vary the length of dielectric sector 7. With this arrangement it has proved possible to achieve a frequency bandwidth of 1½% at an operating frequency of 3000 megacycles, the frequency bandwidth being understood to mean the range of frequencies in which the voltage standing wave ratio is less than 1½ to 1, and the voltage axial ratio of ellipticity is less than 2 to 1 off the slots.

Referring to Fig. 7, there is shown a plot of the radiation pattern of the invention in a plane normal to the axis of the wave guide with the abscissa aligned with the plane of the slots. The radiation pattern of the slots is shown as a solid line, whereas the radiation pattern of the dipole is shown as a dotted line. Thus, circular polarization occurs opposite the slots and over a considerable angle on either side thereof.

The radiation pattern of the device in a plane including the axis of the wave guide and the slots is shown in Fig. 8. Here, the substantially toroidal shape of the radiation pattern is demonstrated. Thus it is evident that the device is capable of propagating electromagnetic waves in a sub-

stantially toroidal pattern with circular polarization thereof over a considerable portion of the pattern. If it is desired to restrict the area in which circular polarization occurs to the region opposite only one of the slots, it is necessary only to eliminate one of the slots and make a slight adjustment of the exciting means. The radiation pattern from the single slot is then that of Fig. 7 with but one lobe from the slot.

Although the invention has been described and illustrated in detail, it is to be clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of this invention being limited only by the terms of the appended claims.

We claim:

1. Means for radiating circularly polarized electromagnetic waves comprising a coaxial wave guide, a tubular conductor connected to said wave guide at one end and having near its free end an axial slot of length equal to one-half the wave length of said electromagnetic waves, a cylindrical conductor centered within said tubular conductor and protruding from the free end thereof, a spacer of dielectric material between said conductors, and means for coupling half the electromagnetic energy in said wave guide out said slot the remainder being propagated from the end of said cylindrical conductor with polarization in phase-quadrature with the electromagnetic waves propagated from said slot whereby circularly polarized energy is radiated.

2. A beacon antenna for propagating electromagnetic waves in a substantially toroidal pattern said waves being circularly polarized over a considerable portion of said pattern comprising a coaxial wave guide for transmitting electromagnetic waves in the TEM mode, a dipole at the end of said wave guide oriented to propagate electromagnetic waves with a plane polarization parallel to the axis of said guide, an axial slot cut in the outside of said coaxial wave guide and situated near said dipole, and means for exciting said slot to thereby propagate from said slot electromagnetic waves plane polarized normal to the axis of said guide and in phase-quadrature with waves propagated from said dipole whereby circularly polarized waves are propagated from said antenna over an area opposite said slot.

3. A device as recited in claim 2 and further comprising a second slot cut in said coaxial wave guide and diametrally opposed to said first slot to thereby propagate circularly polarized waves opposite both said slots.

4. A device as recited in claim 2 in which said exciting means comprises a plurality of discontinuities in the interior of said guide adjacent said slot to thereby distort the electric and magnetic fields to cause propagation of electromagnetic waves from said slot.

5. A device as recited in claim 2 in which said exciting means comprises two complementary sectors of a cylinder filling said coaxial wave guide, said sections being of material having differing dielectric constants arranged symmetrically with respect to the electromagnetic waves transmitted in said guide are distorted to cause propagation from said slot.

6. An antenna for propagating electromagnetic waves in a substantially toroidal pattern, said waves being circularly polarized over a considerable portion of said pattern, comprising a coaxial wave guide including two coaxial conductors separated by a dielectric hollow cylinder, a dipole at the end of said wave guide oriented to propagate electromagnetic waves with a plane polarization parallel to the axis of said guide and in a substantially toroidal pattern, a longitudinal slot in the outer conductor of said coaxial wave guide situated near said dipole, and a plurality of pins adjacent said slot and extending from said outer conductor radially toward said inner conductor for exciting said slot to propagate electromagnetic waves in phase-quadrature with the electromagnetic waves propagated by said dipole whereby plane polarized electromagnetic waves are propagated in a toroidal pattern centered on the axis of said guide and circularly polarized electromagnetic waves are propagated in a region opposite said slot.

7. An antenna for propagating electromagnetic waves in a substantially toroidal pattern, said waves being circularly polarized in a substantial portion of said pattern, comprising a coaxial wave guide including two coaxial conductors, a dipole at the end of said wave guide oriented to propagate electromagnetic waves with plane polarization parallel to the axis of said guide and in a substantially toroidal pattern, a pair of diametrally opposed longitudinal slots in the outer of said two conductors situated near said dipole, and a non-uniform dielectric medium separating said conductors in the region of said slots for causing said slots to propagate electromagnetic waves in phase-quadrature with the electromagnetic waves propagated by said dipole whereby plane polarized electromagnetic waves are propagated in a toroidal pattern centered on the axis of said guide and circularly polarized electromagnetic waves are propagated in regions opposite said slots.

8. An antenna for propagating electromagnetic waves in a substantially toroidal pattern with circular polarization throughout a substantial portion of said pattern comprising a coaxial wave guide including two coaxial conductors, a dipole at the end of said wave guide oriented to propagate electromagnetic waves with plane polarization parallel to the axis of said guide, a pair of diametrally opposed longitudinal slots in the outer of said two conductors situated near said dipole, and a plurality of radially disposed pins extending inwardly from said outer conductor in the vicinity of said slots to cause said slots to propagate electromagnetic waves in phase-quadrature with the electromagnetic waves propagated from said dipole without an impedance mismatch with said guide whereby plane polarized waves are propagated in a toroidal pattern centered on the axis of said guide and circularly polarized electromagnetic waves are propagated opposite said slots.

9. An antenna for propagating electromagnetic waves in a substantially toroidal pattern with circular polarization throughout a portion of said pattern comprising a coaxial wave guide including two coaxial conductors, a dipole at the end of said wave guide oriented to propagate electromagnetic waves with plane polarization parallel to the axis of said guide, a longitudinal slot in the outer of said two conductors situated near said dipole, and a nonuniform dielectric medium separating said conductors to cause said slot to propagate electromagnetic waves in phase-quadrature with the electromagnetic waves propagated from said dipole without an impedance mismatch with said guide whereby plane polarized waves are propagated in a toroidal pattern centered on the axis of said guide and circularly polarized electromagnetic waves are propagated opposite said slot.

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