

Aug. 30, 1949.

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2 Sheets-Sheet 1

FIG. 1

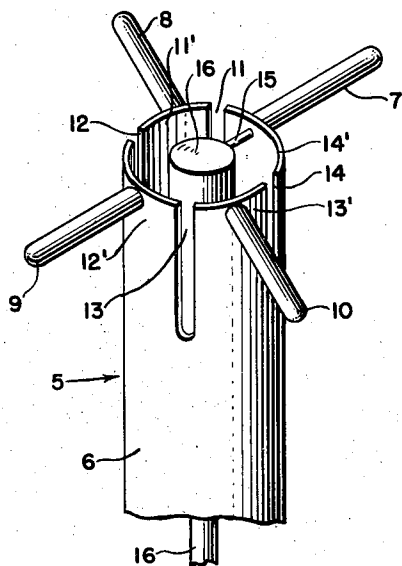
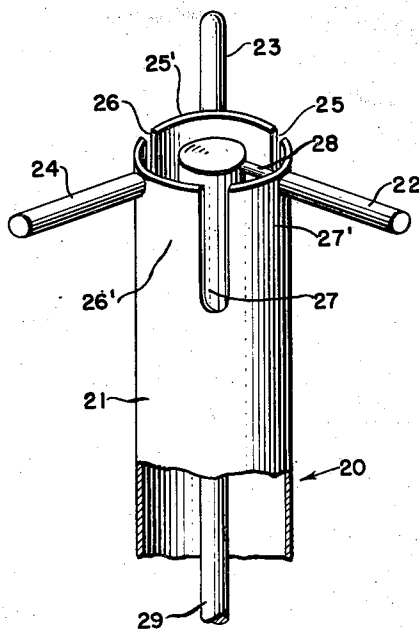


FIG. 2



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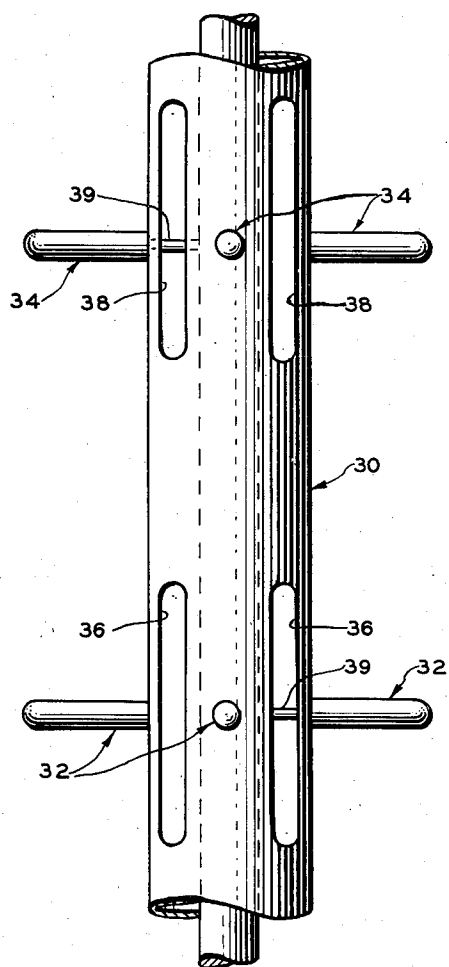


FIG. 3.

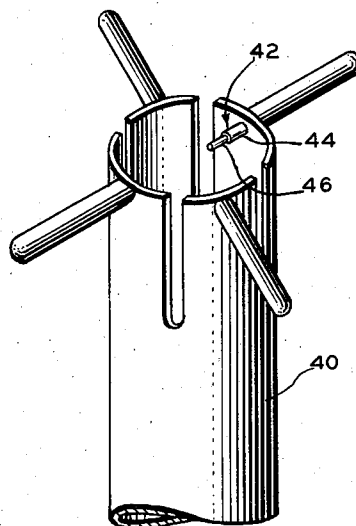


FIG. 4.

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8 Claims. (Cl. 250—33)

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This invention relates to antennae and more particularly to antennae which radiate circularly polarized electromagnetic waves.

It is frequently desirable to have circularly polarized waves in electromagnetic radiation. Such radiation has no definite line of polarization, but displays an equal signal strength regardless of the orientation of a receiving dipole in the plane of a wave front.

One object of this invention is to provide an antenna which will radiate circularly polarized electromagnetic waves.

Another object of the invention is to provide such an antenna which is compact in structure and easily manufactured.

Other objects, advantages, and novel features of the invention will be apparent from the description herein.

In the drawings:

Fig. 1 displays a preferred embodiment of the invention; and

Fig. 2 displays another preferred embodiment of the invention.

Fig. 3 illustrates a variation of the invention illustrated in Fig. 1.

Fig. 4 illustrates another embodiment of the invention.

Referring now to Fig. 1 wherein is displayed a perspective view of one preferred embodiment of the invention, circularly symmetric coaxial cable 5 is used to conduct or guide energy to the antenna proper. Near the terminus of coaxial cable 5 and electrically connected to its outer conductor 6 are four radiating elements 7, 8, 9, and 10 extending radially outward from conductor 6 and spaced at substantially equal angular intervals of 90°. Radiating elements 7 and 9 are paired and constitute a dipole, as also are radiating elements 8 and 10. Between the radiating elements in outer conductor 6 are cut longitudinal slots 11, 12, 13, and 14 forming inter-slot portions 11', 12', 13', and 14'. Thus, a radiating element is connected to and extends radially outwards from each inter-slot portion 11', 12', 13', or 14'.

In order to provide a means for efficiently driving radiating elements 7 to 10 inclusive, an electrically conductive feed element 15 connects inner conductor 16 of cable 5 to the inside of the inter-slot portion 14' of the outer conductor from which radiating element 7 extends. It has been found that connecting the inner and outer conductors by a radial member 15 as shown is satisfactory.

The length of slots 11 to 14 inclusive affects the phasing of radiation from elements 7 to 10 in-

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clusive. In general, the best results for circularly polarized radiation have been obtained by having one diametrically opposed pair of slots, for example 11 and 13 substantially greater than one-quarter wavelength, and the other diametrically opposed pair 12 and 14 substantially shorter than one-quarter wavelength.

The length of slots may be computed to produce a desired result, but it has been found more convenient and satisfactory to obtain the requisite lengths by experiment.

In the structure displayed in Fig. 1, it has been found that maximum radiation is directed with very low gain in the direction of the longitudinal axis of coaxial cable 5. Consider now radiation reaching a point in space some distance from the antenna but generally along the extended axis of cable 5. It will be observed that paired elements 7 and 9 from one dipole and paired elements 8 and 10 form another dipole. Each dipole radiates energy which, due to the orientation thereof, is substantially in space quadrature. Adjustment of the length of slots 11 to 14 inclusive alters the phasing of radiation from each of said dipoles, and also results in variation in the relative intensity thereof. By appropriate adjustment, it is possible to achieve phase quadrature and to substantially equalize the intensity of radiation from each of said dipoles. Radiation in both space and phase quadrature with equal amplitude is thereby provided. The resultant radiation is thus circularly polarized.

Referring now to Fig. 2, a second embodiment is shown in which a coaxial cable 20 has connected to its outer conductor 21 three radiating elements 22, 23, and 24 which extend radially outward from cable 20, angularly spaced at substantially 120° intervals in a plane perpendicular to the axis of cable 20. Slots 25, 26, and 27 in outer conductor 21 are spaced between elements 22 to 24 inclusive, forming inter-slot portions 25', 26' and 27'. Element 22 is driven by a short metallic feed element 28 connecting inter-slot portion 27' of outer conductor 21 to inner conductor 29 of cable 20. To obtain circular polarization, it has been found convenient to make the length of slot 23, that slot lying between inter-slot portions 25' and 26' to which respectively are connected radiating elements 23 and 24 which are not directly driven, to be substantially one-quarter wavelength, whereas one of the other slots, say 25, is substantially less than one-quarter wavelength and the remaining slot 27 is substantially greater than one-quarter wavelength.

An observer measuring radiation from the antenna of Fig. 2 at a great distance removed therefrom along its axis would find in general elliptically polarized radiation. This is because radiation from radiating elements 22 to 24 inclusive may be considered as having a polarization aligned with the respective radiating elements, each of which might be viewed as components along two previously chosen mutually perpendicular axes normal to the line of sight of the antenna. It is possible under certain conditions to have circular polarization, and the conditions are substantially realizable by adjustment of the length of the slots. Although these lengths may be computed to give the desired effect, it has been found more satisfactory to make experimental observations and adjustments.

Although the embodiments illustrated in Figs. 1 and 2 show the radiating elements located near the terminus of a coaxial cable, the cable may extend beyond the radiating elements. The cable may be terminated by a stub support, that is, a continuation long enough to act electrically as an effective open support but closed at its end, or, as illustrated in Fig. 3, the cable 30 may be continued a greater distance and a multiplicity of sets of radiating elements 32, 34 may be included spaced along the cable to give "end fire" effects and thereby increase the directivity of radiation. If the cable is continued, the best results for feeding the radiating elements have been obtained by extending slots 36 and 38 longitudinally an equal distance on each side of the plane of the radiating elements, that is, the lengths of the slots are substantially doubled, but they are closed at both ends. Feed elements 39 correspond to the feed elements 15, 28 in the embodiments shown in Figs. 1 and 2. The radiating elements thus may extend substantially from the longitudinally central part of the inter-slot portions thus formed in the outer conductor. Various adjustments of the lengths of the slots and the lengths of the radiating elements result in the radiation having a polarization of differing degrees of ellipticity.

A further variation of the invention is effected by employing a hollow pipe wave guide 40, Fig. 4 rather than a coaxial cable. Thus, the invention is applicable to any inclosed transmission line including a coaxial cable or a hollow pipe wave guide. In the event that a hollow pipe wave guide is utilized, the feed element 42, may be made adjustable in length in its inward extension from the wave guide 40 toward the axis thereof, and is excited and transmits energy by the electromagnetic fields within the pipe. This adjustment may be effected, for example, by using a feed element 42 having telescoped sections 44, 46 or by having the feed element threaded into and through the outer conductor (or pipe wall) so that the portion of feed element extending outwardly from the outer conductor of the line is inserted into a hollowed out portion of a radiating element. In the hollow pipe wave guide variation, adjustment of the length of the feed element will affect both phasing and impedance match, and this same type of adjustment may be utilized in the coaxial cable variation in which the feed element transmits energy derived from the fields in the inclosed transmission line without necessarily physically contacting the inner conductor.

It will be apparent to those skilled in the art that many other variations of the invention are possible than those described herein and therefore it is not desired to limit the scope of the in-

vention other than in the manner indicated in the accompanying claims.

What is claimed is:

1. In an antenna, the combination including
5 a coaxial cable having a longitudinal axis and having an outer conductor with three longitudinal slots therein at substantially equal angular intervals about said axis forming three inter-slot portions of said conductor, three radiating elements
10 electrically connected to said inter-slot portions and extending radially outward therefrom substantially in one plane at substantially equal angular intervals, and a feed element electrically connected to one of said inter-slot portions and extending radially inward therefrom.

2. In the antenna of claim 1 adapted for use at a contemplated operating wavelength, the combination of claim 1 wherein one of said slots adjoining the said one inter-slot portion to which
20 is connected said feed element is substantially greater than one-quarter said wavelength measured in one longitudinal direction from said plane, the other of said slots adjoining said one inter-slot portion is substantially less than one quarter said wavelength measured in a like direction, and
25 the third said slot is substantially equal to one quarter said wavelength measured in a like direction from said plane.

3. In an antenna, the combination including
30 a coaxial cable having a longitudinal axis and having an outer conductor with four longitudinal slots therein at substantially equal angular intervals forming four inter-slot portions of said conductor, four radiating elements electrically connected to said interslot portions and extending
35 radially outward therefrom substantially in one plane at substantially equal angular intervals and a feed element electrically connected to one of said inter-slot portions and extending radially inward therefrom.

4. In the antenna of claim 3 adapted for use at a contemplated operating wavelength, the combination of claim 3, wherein two said slots diametrically opposed to each other are substantially equal to each other and less than one quarter
45 said wavelength measured in one longitudinal direction from said plane, and the other two of said slots are substantially equal to each other and greater than one quarter said wavelength measured in a like direction from said plane.

5. An antenna comprising a wave guide having a longitudinal axis and having at least three longitudinal slots formed therein at substantially equal angular intervals about said axis forming
55 at least three inter-slot portions, at least three radiating elements electrically connected to said inter-slot portions and extending radially outwardly therefrom substantially in one plane at substantially equal angular intervals, and a feed
60 element electrically connected to one of said inter-slot portions and extending inwardly therefrom.

6. The device according to claim 5 wherein one of said slots adjoining the inter-slot portion to which said feed element is connected is substantially greater than one quarter of the operating wave length measured in a longitudinal direction from said plane, the other of said slots adjoining
65 said inter-slot portion is substantially less than one quarter of said wave length measured in the same direction, and the third said slot is substantially equal to one quarter of said wave length measured in the same direction from said plane.

7. An antenna comprising a wave guide having
75 a longitudinal axis and having four longitudinal

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slots formed therein at substantially equal intervals forming four inter-slot portions, four radiating elements electrically connected to said inter-slot portions and extending radially outwardly therefrom substantially in one plane at substantially equal angular intervals, and a feed element electrically connected to one of said inter-slot portions and extending radially inward therefrom.

8. The device according to claim 7 wherein two of said slots that are diametrically opposed to each other are substantially equal to each other and less than one quarter of the operating wave length measured in one longitudinal direction from said plane, and the other two diametrically opposed slots are substantially equal to each other and greater than one quarter of said wave length measured in a like direction from said plane.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,275,646	Peterson -----	Mar. 10, 1942
2,298,449	Bailey -----	Oct. 13, 1942
2,417,895	Wheeler -----	Mar. 25, 1947
2,444,320	Woodward -----	June 29, 1948
2,455,403	Brown -----	Dec. 7, 1948
2,462,881	Marchetti -----	Mar. 1, 1949
2,465,245	Mabry -----	Mar. 22, 1949