

March 1, 1960

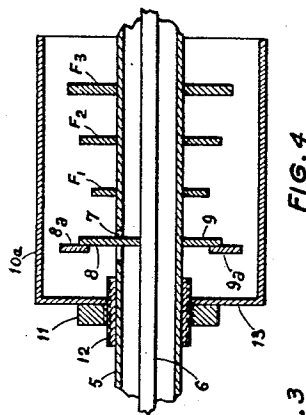
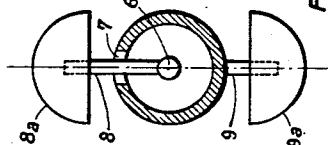
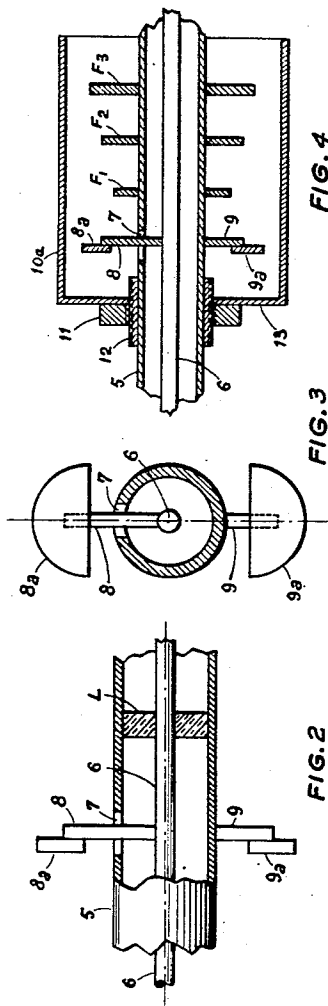
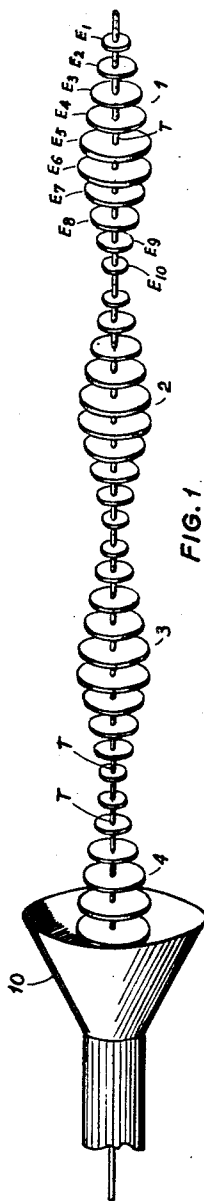
J. C. SIMON ET AL

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ULTRA-HIGH FREQUENCY WAVE RADIATING DEVICES

Filed April 23, 1954

2 Sheets-Sheet 1



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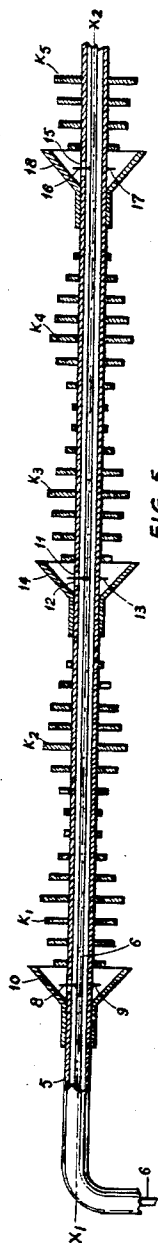


FIG. 5

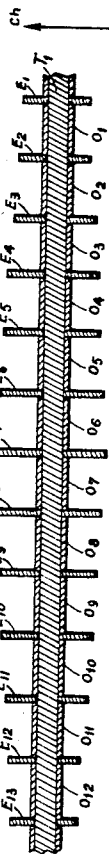


FIG. 6

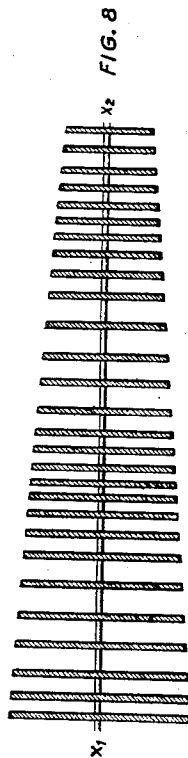


FIG. 8

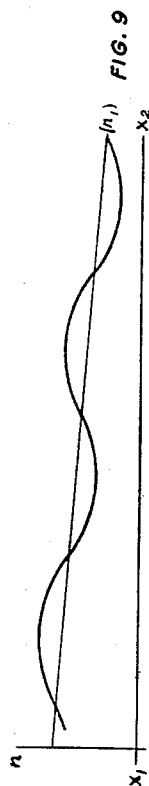


FIG. 9

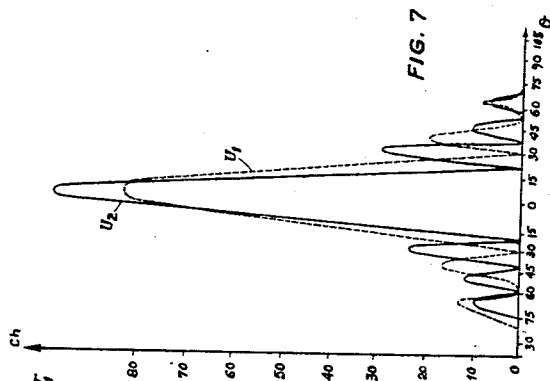


FIG. 7

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ULTRA-HIGH FREQUENCY WAVE
RADIATING DEVICES

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Application April 23, 1954, Serial No. 425,143

Claims priority, application France April 24, 1953

6 Claims. (Cl. 343—786)

The present invention relates to aerials for short or ultra-short electro-magnetic waves and, more particularly to dielectric antennas or to the artificial dielectric antennas of the type described in the copending U.S.A. patent application Serial Number 357,845 of May 27, 1953, now abandoned.

Dielectric rod antennas having an end-radiation pattern are known. Artificial dielectric rod antennas described in the above copending application are made up of metallic plates arranged parallel to one another along a common axis.

It is known that rod type antennas have radiation pattern which cannot be improved beyond a given limit, even if the length of the rod is increased.

One object of the invention is to provide an aerial of the above mentioned type, having greatly improved axial directivity.

The antenna according to the invention comprises a series of elements having a geometrical parameter which varies periodically or at least quasi periodically along its longitudinal axis, thus displaying alternate maxima and minima. Accordingly, it is a feature of the antenna according to the invention that the index of refraction of the medium which constitutes these elements varies along its axis, from one end to the other, with the corresponding curve of variation of said index plotted against the distance along the axis displaying a sequence of maxima and minima.

The invention will be best understood from the following description and the attached drawings showing, by way of non-limitative examples, some embodiments of the invention:

Fig. 1 shows, in perspective view, an artificial dielectric antenna, according to the invention.

Figs. 2 and 3 show respectively a longitudinal and an end-view section of an embodiment of the exciting system more particularly designed for aerial of Fig. 1.

Fig. 4 shows a longitudinal section through another embodiment of an exciting and impedance matching arrangement.

Fig. 5 shows in longitudinal section another embodiment of an artificial dielectric antenna according to the invention.

Fig. 6 shows, in a longitudinal section a portion of an artificial dielectric antenna according to the invention.

Fig. 7 shows radiating diagrams of the antenna according to the invention, in which the field intensity ch is plotted against the angular distance θ to the axis.

Fig. 8 shows schematically another embodiment of the antenna according to the invention.

Fig. 9 shows the variation of the refractive index of the antenna of Fig. 8 along its axis.

Fig. 1 shows an embodiment of the antenna of the invention, which is an artificial dielectric antenna formed by a succession of coaxial metal discs.

The discs E_1 and E_{10} , E_2 and E_9 , E_3 and E_8 , etc., are of equal diameters, the disc diameters increasing from E_1

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to E_5 and from E_{10} and E_6 . The antenna is made up of four identical "spindles" 1, 2, 3 and 4.

The discs are supported by a rod T.

The assembly is excited at the left-hand end of the spindle 4, while the radiation propagates in the direction of the rod T.

Experience shows that an end radiation is obtained with this antenna, provided that the diameters do not exceed

$$\frac{\lambda}{2}$$

The length of each "spindle" is of the order of a few wavelengths, 2 or 3 for instance. The distance between the elements of each "spindle" of Fig. 1 is of the order of one quarter of a wavelength.

As already mentioned, in the antenna of Fig. 1, the variation along the axis of the refractive index of the radiating element follows substantially the variation of the diameters of the transverse cross-sections of the antenna.

Such antennas have a radiation pattern which has a higher degree of directivity than rod antennas having the same length and the same diameter.

Figs. 2, 3 and 4 show various embodiments of exciting systems which may be used with the antenna of the invention. These include a coaxial guide comprising an outer conductor 5 and an inner conductor 6. A hole 7 is provided in the conductor 5, through which passes a metal rod 8 whose diameter is slightly less than that of the hole 7. This rod is welded at one end to the inner conductor 6, and supports at the other end a semi-circular metal plate 8a which is arranged as shown in Fig. 3, being perpendicular to the axis of the coaxial guide and having a diameter which is substantially the same as that of the conductor 5. Welded to the outer conductor 5 is a rod 9 supporting a plate 9a, the rod 9 and the plate 9a being identical to the rod 8 and to the plate 8a, respectively, and the assembly 8, 8a, 9, 9a being symmetrical about the axis of the coaxial guide.

The two conductors of the coaxial guide are insulated from each other by insulating washers L (Fig. 2). The coaxial guide is excited on its left-hand end. The rod T which supports the discs $E_1 \dots E_{10}$ (Fig. 1) is, in the particular embodiments of Figs. 2, 3, 4, 5, constituted by the outer conductor 5 itself. The inner conductor of the coaxial (Figs. 2 and 4) may be terminated by a metal adjustable matching termination conductor 5. In addition, the whole of the exciting device may be enclosed in a horn 10 (Fig. 1). This horn improves the radiation in the required direction; it also improves the matching of the impedances of the antenna and of the coaxial cable.

The arrangement shown in Fig. 4 comprises a metal cylinder 10a the function of which, the same as that of the horn 10 of Fig. 1—is to improve the matching of the antenna impedance and to eliminate the backward radiation. This cylinder 10 covers the exciting system as well as the initial discs F_1 , F_2 and F_3 of the first antenna spindle 4. At the left-hand end, this cylinder is sealed by a ring-shaped element 13 which is secured to a threaded sleeve 11. The latter is screwed on another sleeve 12 which is secured to the outer conductor 5. In this way, it is possible to adjust the position of the cylinder 10 by screwing and unscrewing the sleeve 11, thus obtaining satisfactory impedance matching. An additional impedance matching system can also be inserted into the antenna coaxial cable.

The device of Fig. 4 is more particularly used when the guide 5—6 extends from one end of the antenna to the other and is thus substituted for the rod T. In this case it supports the discs as shown in Figs. 5 and 6.

Such dielectric or artificial dielectric aerials may be

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still improved in so far as the directivity is concerned, if each spindle or each group of spindles is excited substantially in phase with the wave which propagates into the guide, along the axis. This will be obtained as shown in Fig. 5.

In this figure, the discs of spindles K_1 , K_2 , K_3 and K_4 are supported by the outer conductor 5.

The results obtained shall be made evident by means of two specific examples I and II. The corresponding aerias comprise, each of them, three spindles.

Each spindle (Fig. 6) includes thirteen metal discs $E_1 \dots E_{13}$ whose diameters are respectively: 20; 22.5; 25; 27.5; 30; 32.5; 35; 32.5; 30; 27.5; 25; 22.5; 20 mm. These discs are about 2 mm. thick. They are supported by a metallic rod T_1 and separated by identical, metallic tubular spacers, such as O_1 and O_2 , each of them being 15 mm. long and 8 mm. in diameter.

The results obtained are given in the following table and the corresponding radiation diagrams are shown, respectively in a dotted line and a solid line, in Fig. 7.

Example	I	II
Number of spindles	2	3
Field gain	3.2	3.7
Power gain	16	17.5
Half-power lobe angle	29	23
Side lobes	13	12
Backward radiation	30	30

Gains are given in relation to an isotropic source. These results were obtained with antennae excited by a circular guide.

The above examples show that the antenna gain increases with the number of spindles. Very high gains can be obtained with a large number of spindles, ten spindles for instance.

The antenna according to the invention could be realized with discs of equal diameters disposed along the axis x_1 , x_2 at variable spacings. Experience shows that the above described refractive index variation can be achieved in this way as well as by using discs of different diameters uniformly spaced along the axis. Further diameter variation can be combined with variation in spacing, as illustrated in Fig. 8.

Refractive index variations corresponding to the antennae of the invention have been plotted in the diagram of Fig. 9, against the distance along the axis x_1 , x_2 . The curve obtained displays a number of undulations while the mean value decreases progressively from the input end to the output end of the antenna. This value is inversely proportional to the disc diameters.

Of course, many variations of the antenna according to the invention could be devised by those skilled in the art without leaving the scope of the invention or departing from the spirit thereof. Thus, in artificial dielectric antennae, oval or polygonal elements could be used instead of discs.

What we claim is:

1. An antenna for radiating ultra-high frequency energy in a predetermined direction comprising a metallic

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elongated support member extending in said predetermined direction, a series of metallic plates centered over said member each of said plates having a thickness small relative to its diameter, at least one of the geometrical parameters determining the respective largest dimension of said plates and their respective distance to each other, varying continuously along all the length of said support member, this variation being in the form of a wave having a plurality of consecutive minima and maxima, whereby said member and the succession of said plates defines a dielectric medium, having a refractive index for said ultra-high frequency energy, whose value varies continuously along all the length of said support member, this variation following an undulatory law.

2. An antenna for radiating ultra-high frequency energy in a predetermined direction comprising a metallic elongated support member extending in said predetermined direction, a series of metallic discs centered over said member each of said discs having a thickness small relative to its diameter, said discs being regularly spaced over said rod, the diameters of said discs, varying continuously along all the length of said support member, the variation being in form of a wave, whereby said rod and the succession of said discs, defines a dielectric medium, having a refractive index for said ultra-high frequency wave, whose value varies continuously along all the length of said support member, this variation following an undulatory law.

3. Ultra high frequency device as claimed in claim 1 in which said member supporting said plates is hollow, and forms the outer conductor of a coaxial line in prolongation of a coaxial line feeding ultra-high frequency energy.

4. Device as claimed in claim 1, in which said plates form a series of spindle-shaped elements, feeding and matching means being provided for each group of adjacent spindles, each group comprising at least one spindle.

5. An antenna as claimed in claim 1, wherein said plates are circularly shaped, the distance between said plates varying continuously along said axis.

6. An antenna, as claimed in claim 5, wherein the diameters of said plates decrease continuously from one end of the antenna to the other.

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