July 3, 1951 R. REULOS 2,559,092

DIRECTIONAL AERIAL

Filed Aug. 7, 1947 2 Sheets-Sheet 1

Fig.1.

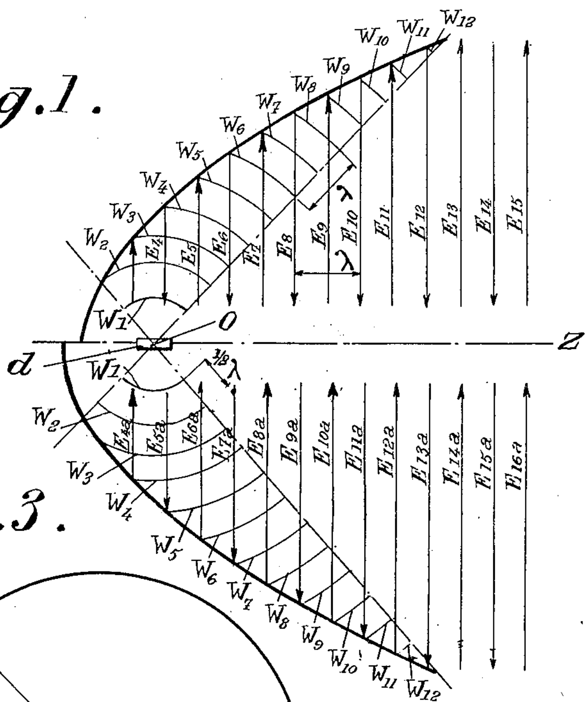


Fig.3.

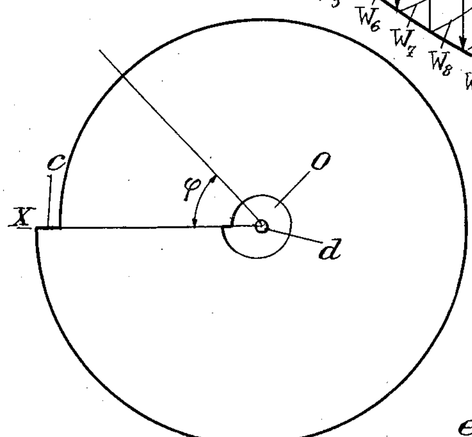


Fig.2.

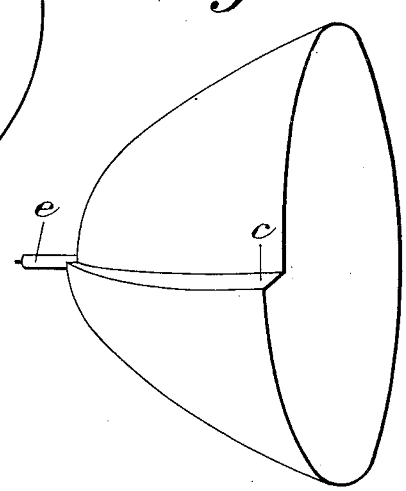


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Fig. 4.

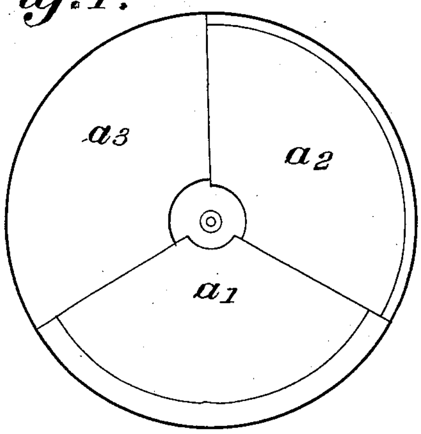



Fig. 5

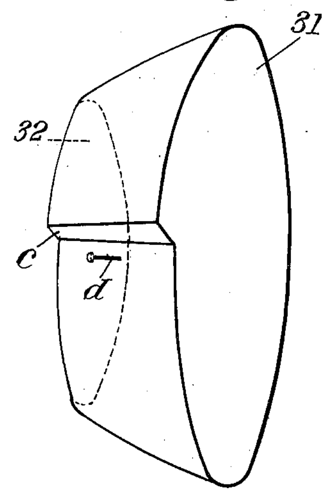
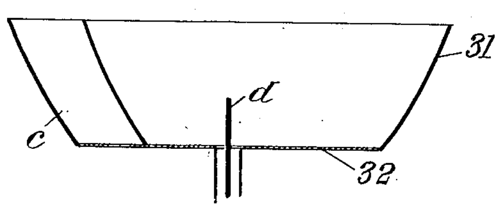



Fig. 6.

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# UNITED STATES PATENT OFFICE

2,559,092

## DIRECTIONAL AERIAL

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Section 1, Public Law 690, August 8, 1946
Patent expires February 29, 1960

5 Claims. (Cl. 250—33.65)

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The present invention relates to directional aerials.

The chief object of my invention is to provide a device capable of transforming spherical microwaves into a beam of substantially plane waves the electric field of which rotates in a substantially uniform manner as the waves are travelling forward.

Another object of my invention is to provide a device capable of picking up a beam of rotary field plane microwaves for reception purposes.

My device is essentially characterized by the combination of a short rectilinear antenna or doublet and of a wave reflecter surrounding said antenna and the inner surface of which is constituted by the juxtaposition of a plurality of sectors of paraboloids of revolution the respective axes of which coincide with that of said antenna and the planes of symmetry of which make equal angles with one another, all the parabolic axial sections of said reflector inner surface having their focus located at the same point of the rectilinear antenna, the parameter of the parabolic axial section of every sector being equal to the sum of that of the preceding sector and a quantity such that the difference between the parameter of the last paraboloidal sector and that of the first one is equal to one half of the wave length of oscillation of the antenna.

Preferred embodiments of my invention will be hereinafter described with reference to the accompanying drawings, in which:

Figs. 1 and 2 are an axial section and a perspective view respectively of a device according to my invention;

Fig. 3 is a front view of a reflector corresponding to that of Figs. 1 and 2 but slightly different;

Fig. 4 is a front elevational view of a modification;

Figs. 5 and 6 are a perspective view and an axial sectional view, respectively, of still another modification.

In order to obtain a homogeneous and little divergent microwave beam, according to my invention, I may proceed as follows.

I make use of a short rectilinear antenna or doublet oscillator and I transform by means of a special shaped reflector the rectilinear polarization spherical waves radiated from said antenna into plane waves the direction of the electric vectors of which rotates about the reflector axis as said waves are travelling along said axis. Of course a similar combination will make it possible to receive waves of this kind and transform them into spherical waves for the doublet antenna.

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My reflector is not a surface of revolution and can be considered (in the example of Figs. 1 to 3) as generated by the rotation about its axis of a variable half-parabola, the focus of which remains in fixed position and the parameter of which increases proportionally to the angle $\varphi$ made by the plane in which it is located with a fixed plane passing through the axis. The parameter, which is a linear function of said angle $\varphi$, increases by one half wave length when $\varphi$ varies from 0 to $2\pi$. It follows that the surface thus defined, and which may be called a "spiroidal paraboloid," has an axis and a focus, that the axial plane sections thereof are parabolas and that its sections perpendicular to the axis are spirals; such a surface has a line of discontinuity, a kind of step which is visible at *bc* on Fig. 2.

This arrangement is intended to create a phase difference which varies in a continuous manner between sectors of the wave corresponding to different values of angle $\varphi$, this phase difference being in fact equal to this angle. It follows that opposed sides of the reflector reflect portions of a plane wave that are in phase and that the geometrical line of discontinuity introduces no discontinuity in the structure of the wave, which is substantially plane and the vector fields of which, constant in magnitude, rotate about the direction of propagation in a uniform manner.

On the other hand, it results, from the axial position of the oscillator, that practically the whole of the radiation it transmits strikes the mirror and that the whole surface of the reflector (with the exception of a small zone surrounding the apex) is utilized.

On Fig. 1, O designates the focus of the reflector, OZ its axis, *d* the antenna or doublet placed at the focus and directed along this axis. Fig. 2 shows at *e* the line (illustrated by a tube with a coaxial conductor) which supplies high frequency current to the doublet. Each of the axial sections of this reflector has the shape of a half parabola, and as the parameter of this parabola increases continuously with the angle $\varphi$ made by the section plane with an origin axial plane XOZ (Figs. 1 and 3), all the cross sections of the reflector surface are spirals. The parameter increase, when $\varphi$ varies from O to $2\pi$, is chosen equal to one half of the length $\lambda$ of the wave transmitted by the doublet. In any axial section, the two corresponding half parabolas therefore have parameters that differ from each other by

$$\frac{\lambda}{4}$$

On Fig. 1, the circular arcs $W_1$, $W_2$, $W_3$, $W_4$, etc., indicate the successive positions of a wave transmitted by doublet *d*, at time intervals equal to one half of the period and straight lines $E_3$, $E_{4a}$, $E_4$, $E_{5a}$, $E_5$, $E_{a6}$, $E_6$, etc., indicate the corresponding positions and directions of the lines of force of the electric field of the plane wave that is produced after reflection.

Due to the parabolic shape of every longitudinal section of the reflector, the axial spacing of straight lines $E_3$, $E_{4a}$, $E_4$, $E_{5a}$, $E_5$, etc., is equal to the radial spacing

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

of the circular arcs and due to the increase of the parameter it will be seen every line of force for instance $E_{4a}$, starting from the lower half section of the reflector, is lagging by

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

with respect to that $E_4$ starting in the opposite direction from the upper half section and is thus in the same transverse plane as the line of force $E_3$ of the same direction starting from this upper half section and corresponding to the position $W_3$ of the wave on the preceding half period. This brings back into accordance the fields from the two opposed half sections. In a general manner, as the phase difference between two elementary half sections of the reflector is measured by the angle they make with each other, the direction of the lines of force of the electric field rotates through $2\pi$ as the wave moves forward a distance

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

in the axial direction. I thus obtain continuous rotary polarization.

In what precedes, no reference has been made to the phase change due to reflection, so as not unduly to complicate the description. As a matter of fact this change has no influence on the operation of the device, since it is the same at all points of the mirror.

Instead of forming a continuous spiroidal surface, the reflector may be constituted by a plurality of sectors each in the form of a portion of a paraboloid of revolution, said sectors having increasing parameters. For instance, the reflector of Fig. 4 comprises three sectors $a_1$, $a_2$, $a_3$, each of which extends over an angle of

$$\frac{2\pi}{3}$$

about their common axis OZ and the parameters of which are equal respectively to $p$,

$$p+\tfrac{1}{3}\frac{\lambda}{2},\ p+\tfrac{2}{3}\frac{\lambda}{2}$$

$p$ being arbitrary, that is to say without any relation to $\lambda$, but remaining of course substantially



larger than $\lambda$, ($\lambda$ being the wave length of the spherical waves emitted by the doublet). In this case, the vibration reflected by each sector has a phase difference of

$$\frac{2\pi}{3}$$

with those reflected by the adjoining sectors.

If the reflector includes $n$ sectors of the same kind each having a parameter equal to the preceding one plus

$$\frac{1}{n}\frac{\lambda}{2}$$

I likewise obtain a series of vibrations in phase difference of

$$\frac{2\pi}{n}$$

and the electric field of the plane wave still rotates as the wave is moving forward.

When $n$ becomes infinite, I obviously obtain the form of Figs. 1, 2 and 3. The surface is spiral form and its edges are joined by a radial step *c*.

In all cases, the central portion of the reflector (or "apex") which is the only one not to be efficient, can be cut away as shown on Figs. 3 and 4.

In particular, in the modification of Figs. 5 and 6 the apex portion of the parabolic surface which is removed is maximum and is replaced by a plane reflecting surface **32** located close to the focus.

In what precedes, the word plane wave is used, not in its absolute meaning (this expression then having an ideal and very accurate meaning), but rather in opposition with spherical waves which grow weaker and weaker as they disperse. Rotary field waves are not necessarily plane waves in the narrow meaning of this term.

What I claim is:

1. A directional aerial system which comprises, in combination, a rectilinear oscillator of small length and a wave reflector surrounding said oscillator and the inner surface of which is constituted by a plurality of adjacent paraboloidal sectors each of revolution and limited by axial planes, the respective axes of revolution of which sectors coincide all with the line along which said oscillator is located and the middle planes of which make equal angles with one another, all the axial parabolic sections of this reflector surface having the same focus, located on said rectilinear oscillator, the parameter of the axial parabolic section of each sector being equal to the sum of that of the preceding sector and of a fixed length such that the difference between the parameter of the last paraboloidal sector and that of the first one is equal to one half of the wavelength of oscillation of the rectilinear oscillator.

2. A directional aerial system according to claim 1 in which the number of paraboloidal sectors is infinite, so that each of them is reduced to a generatrix and the cross sections of the reflector surface are spirals.

3. A directional aerial system according to claim 1 in which the number of paraboloidal sectors is three.

4. A directional aerial system according to claim 1 in which the apex portion of the paraboloidal sectors is replaced by a plane reflecting surface at right angles to the common axis of the paraboloidal sectors.

5. A directional aerial system according to claim 1 in which the number of paraboloidal

sectors is infinite, so that each of them is reduced to a generatrix and the cross sections of the reflector surfaces are spirals, the apex portion of the parabolic surface being replaced by a plane reflecting surface at right angles to the common axis of the paraboloidal sectors.

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