

April 29, 1947.

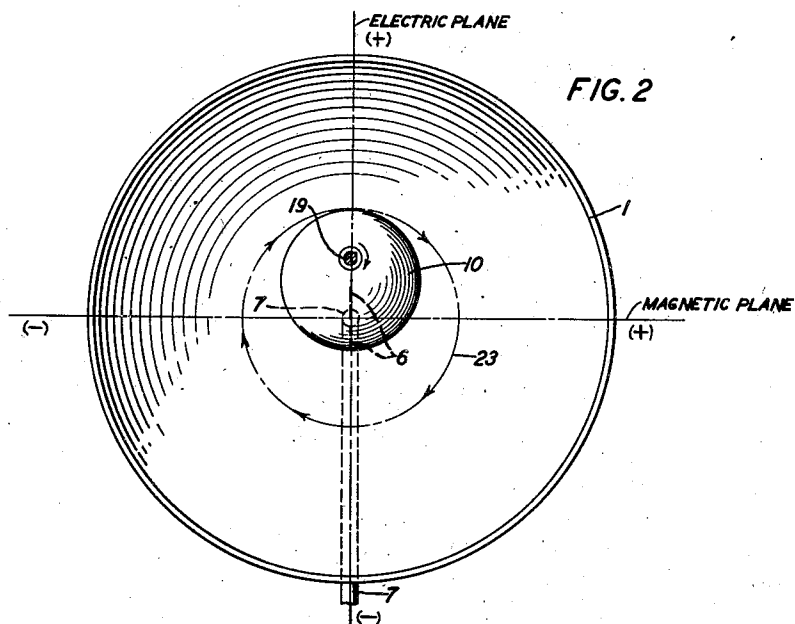
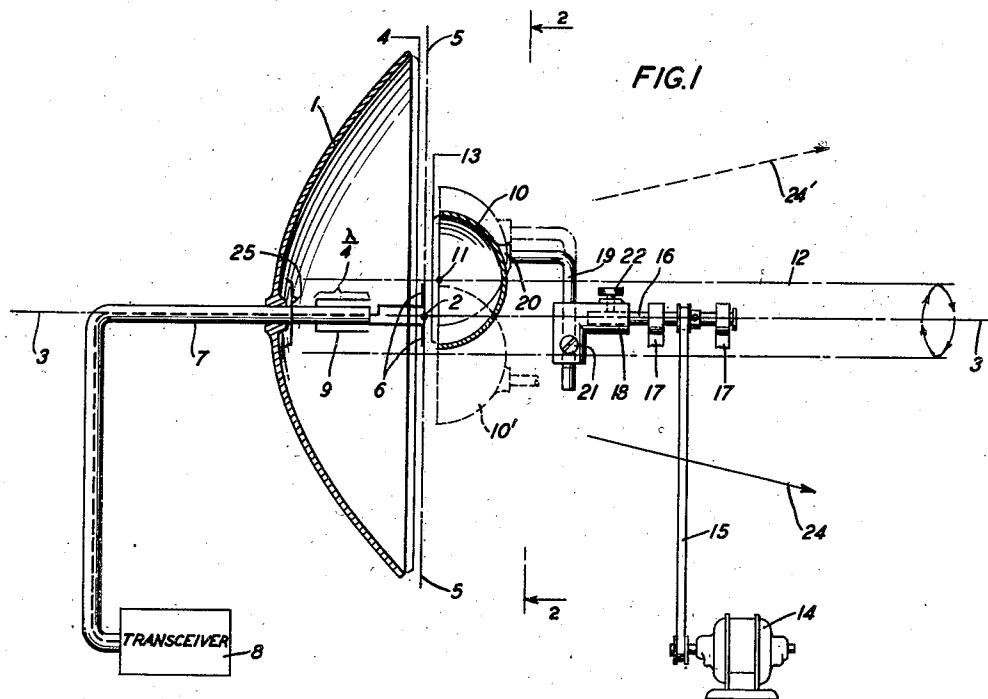
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2,419,556

SCANNING ANTENNAS

Filed July 22, 1942

2 Sheets-Sheet 1



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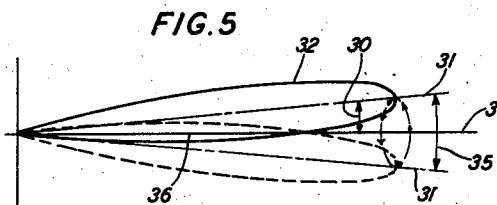
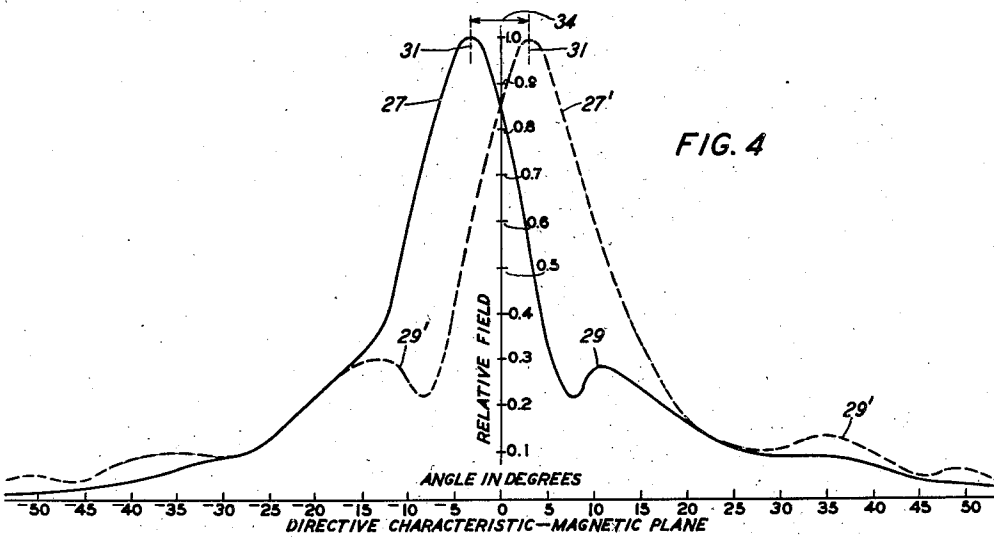
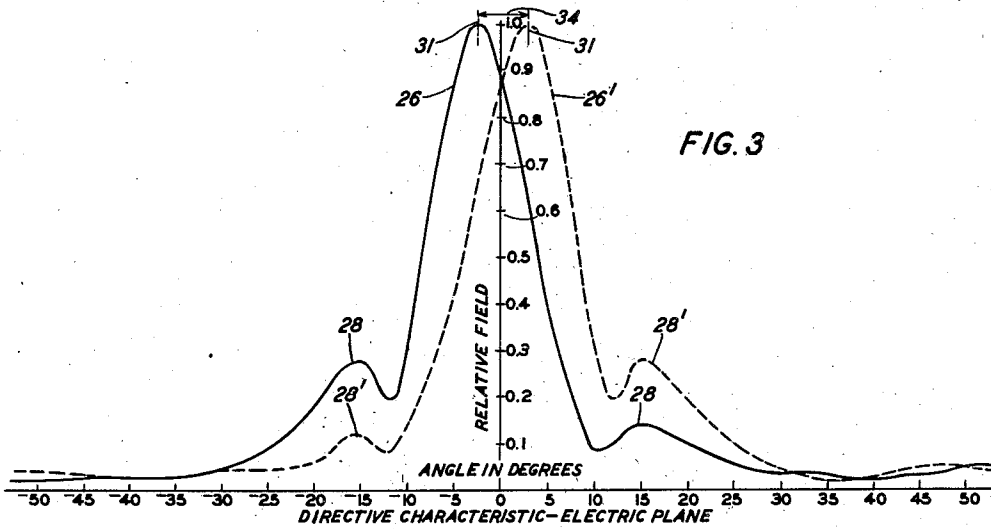
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SCANNING ANTENNAS

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2 Sheets-Sheet 2



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SCANNING ANTENNA

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This invention relates to directive antennas, and more particularly to directive antennas of the type used in direction finding and radio scanning systems.

As is known, the peak of the maximum lobe, considered in the solid, of even the most highly unidirectional antenna unit at present in use for signal or intelligence communication, is relatively blunt or flat over an angular range including a large number of distinct paths or linear wave directions. The lobe is therefore ordinarily not sufficiently pointed or sharp to secure the high degree of directive selectivity required for direction determination in airport landing, radar and scanning systems. In order to secure a more accurate wave direction determination, than is obtainable with the prior art antennas of the signal type, at least three distinct types of antenna arrangements have been suggested for use in the short wave and ultra-short scanning or object-locating field. Thus, Patent 2,002,181 to W. Ilberg illustrates a "lobe switching" arrangement; Fig. 3 of Patent 2,083,242 to W. Runge illustrates a "lobe sweeping" multiunit array, and Fig. 2 of the aforementioned Runge patent illustrates a "lobe rotation" antenna system. The present invention relates primarily to antennas of the lobe rotation type and, while scanning antennas of this type have been used in the past with some success in the short and ultra-short wave fields, it now appears desirable to utilize this type of scanning antenna in the microwave field and to obtain an improved lobe rotation antenna system having certain distinct mechanical and electrical features not found in the prior art arrangements.

It is one object of this invention to increase the directive sensitivity of an antenna.

It is another object of this invention to determine accurately the propagation direction of a transmitted or received radio wave.

It is still another object of this invention to utilize, in a lobe rotation antenna system, simple lightweight apparatus for producing the lobe rotation.

It is a further object of this invention to adjust or vary, in a lobe rotation system, the angle between the maximum lobe of the antenna and the antenna axis.

It is an additional object of this invention to provide, in a lobe rotation antenna system, means for adjusting the shape of the maximum lobe and the intensity relation of the maximum and minor lobes.

In accordance with the preferred embodiment of the invention, the antenna system comprises a

large paraboloidal reflector, a dipole at the focus thereof, and a small semispherical reflector facing the paraboloidal reflector and having its opening spaced slightly from the focal plane of the paraboloidal reflector. A translation device, such as a radio range transceiver, is connected to the dipole. Means are provided for rotating the spherical reflector in a manner such that its principal axis revolves about the principal axis of the paraboloidal reflector and its electro-optical focus describes, in effect, a circle. Rotation of the spherical reflector produces conical rotation of the maximum directive lobe of the antenna, the angle between the axis of the paraboloidal reflector and the principal axis of the maximum lobe being maintained at a constant value during the lobe rotation, so that the principal lobe axis describes in space a cone having its apex at the center point of the antenna, substantially. If desired, the spacing between the axes of the two reflectors, may be adjusted for the purpose of changing the conical searching range. If the spacing is relatively small, the conical angle is small and the lobe rotates about the axis of the paraboloidal reflector so that, assuming the minor lobe axis is aligned with a target, the reflected signals are of the same intensity. If the spacing is large the conical angle is large. In addition, the spacing between the reflector openings may be adjusted for the purpose of securing an optimum gain or an optimum directive characteristic.

The invention will be more fully understood from a perusal of the following specification taken in conjunction with the drawing on which like reference characters denote elements of similar function, and on which:

Figs. 1 and 2 are, respectively, a cross-sectional view, taken in elevation, and a front view of the preferred embodiment of the invention;

Figs. 3 and 4 are curves illustrating the measured directive patterns of the preferred embodiment; and

Fig. 5 is a diagram used in explaining one feature of the invention.

Referring to Figs. 1 and 2, reference numeral 1 designates a metallic paraboloidal reflector having a finite focus 2, a principal axis 3, and an opening 4 which may or may not coincide with the focal plane 5. Numeral 6 denotes a half-wave dipole which is positioned at the focus 2, substantially, and is connected by the coaxial line 7 to a translation device 8. The device 8 may be a transmitter or receiver, or it may be a transceiver of the type employed in conventional radio range systems of the pulse type. Numeral 9 designates

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a coaxial quarter-wave sleeve which functions to match the unbalanced coaxial line 7 to the balanced dipole 6.

Numeral 10 denotes a rotating metallic semi-spherical reflector having a center 11, a principal axis 12, and an opening 13. The dish-shaped reflector 1 and the cup-shaped reflector 10 face each other, their openings 4 and 13 being coincident or spaced. Reflector 10 is rotated by means described below in a manner such that the openings 4 and 13 are always parallel, the axes 3 and 12 are always parallel, and the center 11 describes a circle about the focus 2, substantially. The means for rotating reflector 10 comprises a motor 14, belt 15, driving shaft 16 supported on bearings 17, the stationary tubular elbow member 18, and the movable L-shaped rod 19 which is connected to the rear of reflector 10 at a point 20 spaced from the axis 12. The L-shaped rod 19 extends through the vertical portion of the elbow member 18 and is adjustably connected thereto by means of a set-screw 21, so that the spacing between the axes 3 and 12, corresponding to the radius of rotation of reflector 10, may be altered. Also, the shaft 16 extends through the horizontal portion of elbow 18 and is adjustably connected thereto by means of set-screw 22, whereby the spacing between the reflector openings 4 and 13 may be changed.

In operation, assuming the antenna system is used for transmitting pulses in a microwave radio scanning or radar system, pulses are supplied by device 8 over line 7 to dipole 6. At the same time the spherical reflector is rotated by motor 14 in a clockwise direction about the axis 3 of the paraboloidal reflector, as indicated by the circular arrow 23, Fig. 2. In the plane perpendicular to the dipole, hereinafter called the "magnetic" plane, the energy is radiated non-directionally by dipole 6. In the plane of the dipole, hereinafter called the "electric" plane and corresponds to the plane of the drawing (Fig. 1), the radiation is not completely non-directional but may be considered to be so, since the dipole is positioned in the focal plane 5 of reflector 1 and is relatively small compared to the reflectors. Considering any plane passing through the focus 2, certain of the wavelets emitted by the dipole pass directly to the paraboloidal reflector and, in a manner well understood in the art, these particular wavelets are reflected so that their propagation directions extend in substantially parallel lines. Certain other wavelets emitted by the dipole 6 impinge upon the semispherical reflector, are reflected thereby so as to strike the paraboloidal reflector and are then projected into the ether medium through the opening 4 of paraboloidal reflector 1. Since many of these last-mentioned wavelets do not pass through the focus of the paraboloidal reflector, the wavelets reflected by both the spherical and the paraboloidal reflectors combine with the wavelets reflected only by the paraboloidal reflector to produce a maximum lobe or beam having its principal axis at an angle to the axes 3 and 12 of the reflectors. Thus, for example, with the spherical reflector 10 in the top position, as shown by the full-line illustration of this reflector in Fig. 1, the principal axis of the maximum lobe is pointed downwards as illustrated by arrow 24. With the reflector 10 in the bottom position, as illustrated by the dotted line representation 10', the principal axis is directed upwards as shown by arrow 24'. Hence the rotating spherical reflector causes the longitudinal axis and the peak of the maximum lobe to

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rotate about the axis 3, the base of the lobe being fixed roughly at the mid-point 25 of the paraboloidal reflector. In other words, the reflector rotation causes the principal axis of the lobe to describe in space a cone-shaped figure.

Referring to Figs. 3 and 4 of the drawing, Fig. 3 illustrates the shape and the two positions, as measured in the electric plane, of the directive pattern; and Fig. 4 illustrates the shape and the two positions of the pattern, as measured in the magnetic plane, for a system constructed in accordance with the invention. Numerals 26 and 26', Fig. 3, denote the two positions of the maximum electric plane lobe and numerals 27 and 27', Fig. 4, designate the two positions of the maximum magnetic plane lobe. Thus, the full-line and dotted-line curves 26 and 26' correspond, respectively, to the top and bottom positions of the rotating reflector 10; and curves 27 and 27' correspond to the right and left positions of reflector 10. In the system actually tested, an aluminum paraboloidal reflector having a focal length of 8.66 inches and a diameter of thirty inches, and a copper semispherical reflector having a six inch diameter were used, the spacing between the axis 3 and the point 20 of connection between rod 19 and reflector 10, being about one inch. In other words, in accordance with the invention, the ratio of the paraboloidal reflector diameter to the semispherical reflector diameter is in the order of five whereby, as shown on the drawing, the minor electric plane lobes 28 and 28' and the minor magnetic plane lobes 29 and 29' are rendered negligible.

Referring to Fig. 5, the conical angle 30 between the principal axis 31 of the maximum lobe 32 and the axis 3 may be altered, if desired, by sliding the vertical rod or arm 19 within the elbow member 18 and securing these elements together by the set-screw 21. In other words, referring to Figs. 3 and 4, the spacing 34 between the two positions for the principal axis 31 of the maximum lobe, may be changed by adjustment of rod 19. For accurate direction determination, the spacing between the center 11 and axis 3, Fig. 1, is preferably made relatively small, whereby a small conical angle 35, Fig. 5, is obtained. The maximum lobe 32 or its principal axis 31 is, in effect, rotated about a subordinate radius 36 of the maximum lobe and, assuming the radius or line 36 is aligned with a target, the received reflected pulses have a constant intensity. If desired, the entire antenna assembly including the two reflectors may be moved vertically and/or horizontally as in conventional radar or scanning systems. Also, referring to Fig. 1, if desired, the shape of the nose of the maximum lobe may be altered, that is, sharpened or flattened, and the optimum ratio of the intensities of the maximum to minor lobes may be obtained, by adjusting shaft 16 relative to the fixed elbow member 18 and thereby adjusting the horizontal spacing between dipole 6 and the reflector 10.

Although the invention has been explained in connection with a certain embodiment, it should be understood that it is not to be limited to the embodiment described inasmuch as other apparatus may be utilized in successfully practicing the invention. Thus, in place of the dipole and associated coaxial line an open wave guide having its aperture at the focus 2 may be employed for emitting or collecting the wavelets impinging on the reflectors 1 and 10. Also, if desired, a cylindrical parabolic or other concave reflector

may be used in place of the paraboloidal reflector.

What is claimed is:

1. In combination, a translation device, an antenna system comprising a spherical reflector having a principal axis, an antenna member connected to said device and spaced from the reflector axis in the plane of the reflector opening, and means for moving the reflector axis relative to said member, whereby steering of the maximum directive lobe is effected.

2. In combination, a translation device, an antenna system comprising a spherical reflector having a principal axis, an antenna member connected to said device and spaced from said reflector axis in the plane of the reflector opening, and means for rotating the reflector axis about said member, whereby the directive lobe of said antenna system is rotated.

3. In combination, a paraboloidal reflector, an antenna positioned at the focus thereof, a semispherical reflector facing said paraboloidal reflector, and means for rotating the axis of said semispherical reflector about the axis of the paraboloidal reflector.

4. In combination, a parabolic reflector, a dipole at the focus thereof, a spherical reflector facing said parabolic reflector and means for rotating said spherical reflector so as to cause its electro-optical focus to describe a circle about the axis of the parabolic reflector.

5. In combination, a parabolic reflector, a transceiver, an antenna connected to said transceiver and positioned at the focus of said reflector, a semispherical reflector, said reflectors facing each other, the axes of said reflectors being parallel and spaced from each other, whereby maximum radio action occurs at an angle to said axes.

6. In combination, an antenna system comprising a first concave reflector having a focus and a principal axis, an antenna element for

emitting and absorbing energy positioned at said focus, means for causing rotation of the directive lobe of said system comprising a second concave reflector completely facing the first-mentioned concave reflector and having a principal axis positioned parallel to the first mentioned principal axis, and means for rotating the axis of the second reflector about said first mentioned principal axis.

7. A radio scanning system comprising a pair of concave metallic reflectors having their openings facing each other and each having a principal axis, an antenna included between said reflectors, and means for rotating the axis of one reflector about the axis of the other reflector and maintaining said axes parallel.

8. In combination, a paraboloidal reflector, an antenna element located at the focus thereof, a semispherical reflector, the principal axes of said reflectors being parallel and spaced a given amount, and means for changing the spacing between said axes.

9. In combination, a paraboloidal reflector, an antenna element at the focus thereof, a semispherical reflector, said reflectors facing each other, and means for changing the spacings between the openings of said reflectors.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,173,897	Clavier	Sept. 26, 1939
2,083,242	Runge	June 8, 1937
2,043,347	Clavier et al.	June 9, 1936

FOREIGN PATENTS

Number	Country	Date
370,135	British	Apr. 7, 1932