Sept. 11, 1951 G. B. LITCHFORD 2,567,220

SCALLOPED LIMACON PATTERN ANTENNA

Filed Oct. 29, 1947

Fig. 1.

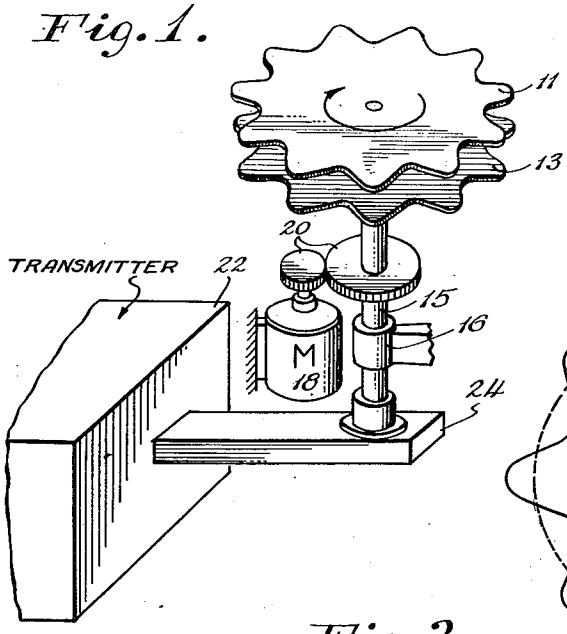


Fig. 2.

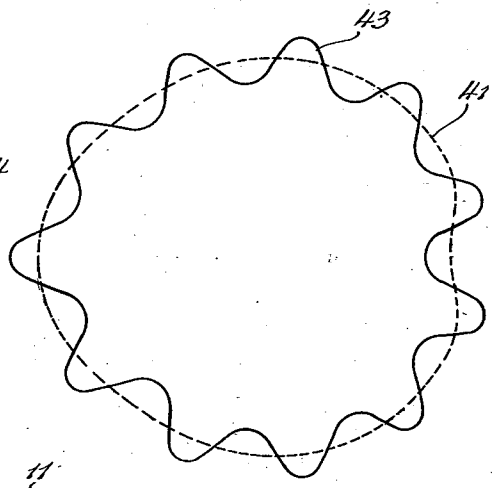
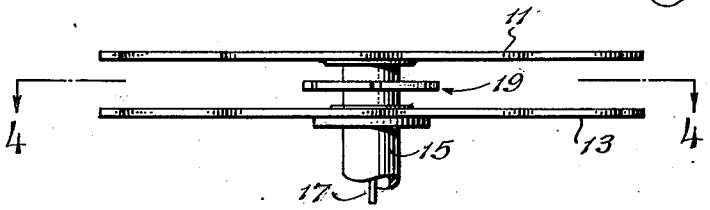


Fig. 3.



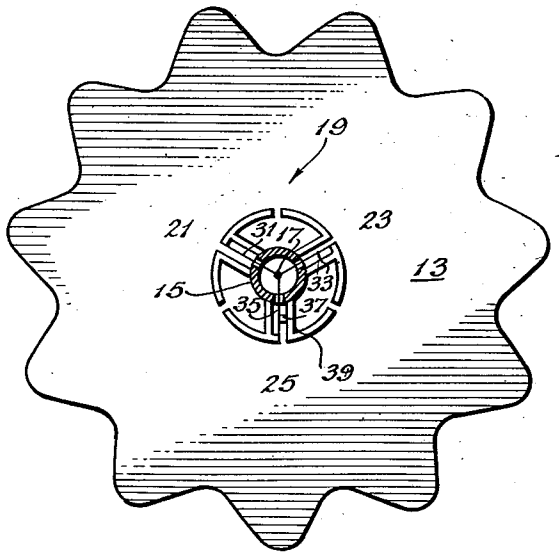


Fig. 4.

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SCALLOPED LIMACON PATTERN ANTENNA

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10 Claims. (Cl. 250—33.65)

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The present invention is concerned with directive antennas for producing a multi-fingered azimuthal directive pattern having a general limacon shape, suitable for high accuracy navigational reference systems.

In copending application for Omni-Azimuth Guidance System, S. N. 782,722 filed concurrently by George B. Litchford and Joseph Lyman, and assigned to the assignee of the present application, an improved omni-azimuth guidance system of very high directional accuracy is described and claimed. This system achieves high accuracy through use of a regularly rotated transmitting antenna so arranged as to produce a general limacon azimuth directivity pattern modified by a scalloped or multi-fingered outline. Through the rotation of this special antenna pattern, a craft at some point remote from the rotating antenna system receives energy therefrom which appears as an amplitude-modulated wave having a low frequency modulation component and a high frequency modulation component. Low- and high-frequency phase reference signals are transmitted for comparison with these respective components in a craft direction indicating system. The craft direction indicator is brought into the approximate angular setting by the phase comparison between the low frequency signals, and thereafter is controlled precisely by the phase comparison between the high frequency signals.

It is an object of the present invention to provide an improved rotatable antenna system especially suited for use in an omni-azimuth guidance system of the type described above.

Moreover, the present invention is directed toward an arrangement of such an antenna system wherein great mechanical strength and low windage loss permit very high speed rotation, the antenna system being of such character as to make the system simple and inexpensive to manufacture.

In accordance with an important feature of this invention, a limacon-pattern inner antenna element is provided between the central regions of two parallel discs having their axes aligned along a common vertical axis. The discs are provided with scalloped or multi-fingered outlines, having n projections in each disc regularly spaced therearound for producing n fingers in the directivity pattern, and the maximum radius points on each disc are aligned with those on the other. The zone thus defined between the peripheries of the discs is a cylindrical locus having longitudinal corrugations.

Ultra-high-frequency energy passing radially outward from the antenna element at the central region of the discs emerges in a phase distribution pattern of such character that the desired fingers are superimposed upon the limacon-like azimuth directive pattern of the inner antenna unit. An important advantage of this arrangement is its high structural strength and suitability for rotation at very high angular velocity

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in view of the freedom from requirement of masses attached to the discs near their peripheries, and hence, the freedom from requirement of parts likely to be dislodged by centrifugal forces. Furthermore, the present antenna arrangement is particularly suited for high speed rotation by the relatively low windage loss resulting from its physical outline.

An embodiment of the present invention is illustrated in the drawings, wherein:

Fig. 1 is an oblique general view of the antenna system;

Fig. 2 is a polar intensity plot of the azimuthal directivity pattern of the antenna; and

Figs. 3 and 4 are elevation and sectional views of the antenna system illustrating the arrangement of the center antenna unit for determining the general limacon shape of the directivity pattern of Fig. 2.

Referring to Figs. 1, 3 and 4, an upper disc 11 and a lower disc 13 are arranged in substantially parallel orientations on the outer sleeve 15 of a coaxial transmission line having an inner conductor 17. The outer conductor 15 of the transmission line preferably is a rigid cylinder of relatively hard metal borne in a vertical-axis journal 16 to provide for rotation of the system 11, 13, 15, 17. A motor 18 is coupled to the rigid tubular outer conductor 15, as through gears 20. The discs 11 and 13 are provided with n fingers regularly spaced therearound, the number n being an odd number. This number n is taken as 11 in the illustrations.

A central antenna unit 19 is provided between discs 11 and 13. This unit comprises three dipole or doublet antenna portions 21, 23 and 25 (see especially Fig. 4), each having two arcuate arms rigidly supported on parallel arms extending outward from the outer conductor 15. Alternate arcuate arms, e. g., the clockwise arcuate arms of the dipoles 21, 23, 25 are connected by radial conductors 31, 33 and 35 to the inner conductor 17 of the coaxial transmission line. These radially extending conductors pass through clearance holes in the outer conductor 15.

Ultra-high-frequency energy for radiation through the antenna system is provided by a transmitter 22, through a wave guide 24 into which extends the inner conductor of the coaxial transmission line 15, 17.

A shorting bar 37 is provided for affording a current path between radial conductor 35 and the substantially radial rigid arm 39. Without such a bar 37, the three arcuate dipole systems 21, 23 and 25 would be energized cophasally and in equal intensities, producing a generally circular intensity pattern. The shorting bar 37 is provided for distorting the radiation pattern of the inner antenna unit 19, to reduce the intensity in the direction of conductor 35, and to give the radiation pattern a general limacon-like character. The nature of the radiation pattern produced by the inner unit 19 alone is

illustrated in dotted line at 41, Fig. 2, the minimum-radius portion thereof corresponding to the direction of the radial conductor 35.

The discs 11 and 13 are formed with very much larger diameters than the diameter of the inner antenna unit 19, and are spaced apart by an axial dimension of the order of one wavelength at the frequency of the energy supplied by transmitter 22. By virtue of the mutually aligned fingers or scallops around the peripheries of the discs 11 and 13, the directivity pattern is provided with a corresponding number of scallops or fingers, as illustrated in the resultant intensity distribution curve 43 in Fig. 2. This is the desired ultimate directivity pattern for the omni-azimuth transmitting system discussed above.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. Antenna apparatus comprising two conductive discs rigidly spaced apart in substantially parallel relation, a conductor extending between said discs and substantially perpendicular thereto at their centers, said conductor connecting the centers of said discs together, said discs having scalloped outlines characterized by maximum radii and minimum radii angularly spaced around concentric circles therein, and radiator means between the central regions of said discs.

2. Antenna apparatus as defined in claim 1, wherein said radiator means is directive and provides a directive pattern characterized by opposite directions of maximum and minimum radiation strength, the plane of polarization of said radiator means being parallel to the planes of said discs.

3. Antenna apparatus as defined in claim 2, wherein the spacing between said two discs is small compared to their diameters, and said discs are equally scalloped and the maximum radius fingers thereof are arranged in mutual alignment.

4. Antenna apparatus as defined in claim 1, wherein said radiator means comprises three dipole elements with the doublet arms of each arranged in a respective arc, said arcs lying in a common circle, means for exciting two of said dipole elements with equal intensities, and means exciting said third element with a different intensity.

5. Antenna apparatus comprising a coaxial transmission line having an inner conductor and a rigid tubular outer conductor, two scalloped conductive discs fixed to said tubular outer conductor coaxially therewith and in spaced relation thereon, a plurality of arcuate radiator elements supported by and encircling said tubular outer conductor between said discs, and at least one conductor extending between said inner conductor and one of said arcuate radiator elements and providing an ultra-high-frequency current path therebetween.

6. Antenna apparatus comprising a coaxial transmission line having an inner conductor and a rigid tubular outer conductor, two scalloped conductive discs fixed to said tubular outer conductor coaxially therewith and in mutually spaced relation thereon, a plurality of arcuate radiator elements supported by and encircling said tubular outer conductor between said discs, at least one radial conductor extending from said inner conductor to one of said arcuate radiator elements and providing an ultra-high-frequency current path therebetween, journal means supporting said tubular outer conductor for rotation about an axis, and motive means coupled thereto for providing regular rotation thereof.

7. Antenna apparatus comprising a coaxial transmission line having an inner conductor and a rigid tubular outer conductor, two scalloped conductive discs fixed to said tubular outer conductor coaxially therewith and in mutually spaced relation thereon, a plurality of arcuate dipoles supported by and encircling said coaxial transmission line in a plane between said discs, means connecting alternate arcuate arms of said dipoles to said outer conductor, and means on at least one of said dipoles for providing asymmetrical current distribution among said dipole elements.

8. Antenna apparatus comprising an ultra-high-frequency energy conduit having a rigid tubular conductor, a pair of discs fixed to said conductor perpendicular to the axis thereof and spaced apart thereon, a plurality of antenna arms extending at least part way around said tubular conductor in the region between said spaced discs, at least one of said arms being connected to said tubular conductor, conductor means connected to at least one of said arms and extending into the interior of said tubular conductor, and at least one of said discs having a scalloped outline for introducing a multi-fingered characteristic in the directivity pattern of ultra-high-frequency transmitted between said antenna arms and external space.

9. Antenna apparatus including radiator means polarized substantially in a single plane, a pair of conductive surfaces on opposite sides of said radiator means and substantially parallel to said plane of polarization, corresponding elements of said conductive surfaces coacting as wave guides radially disposed from said radiator means as a center, the peripheries of said surfaces being shaped to make the elementary radial wave guides formed thereby of different lengths in different directions whereby the directive pattern of the combination includes maxima and minima defining lobes corresponding to the different lengths of said elements.

10. The invention as set forth in claim 9 wherein said radiator means is directive and provides a limacon-like pattern, and means rotating said conductive surfaces about their respective centers.

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