

Oct. 4, 1966

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3,277,490

BROADBAND CONICAL SCAN FEED FOR PARABOLIC ANTENNAS

Filed Dec. 20, 1962

4 Sheets-Sheet 1

FIG. 1

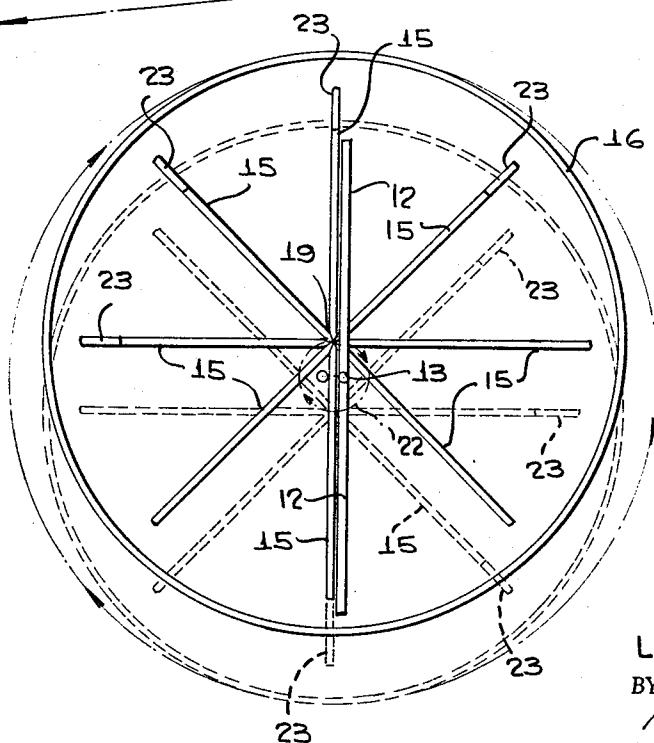
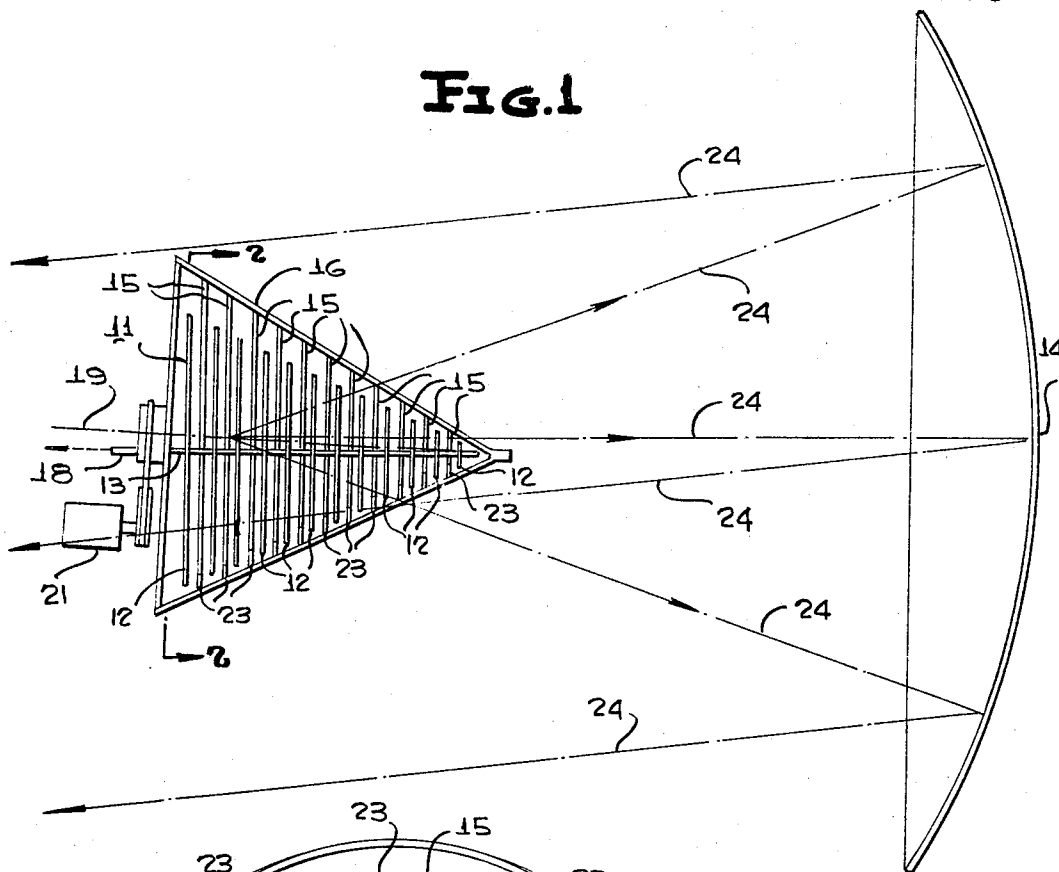


FIG. 2

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Fig. 4

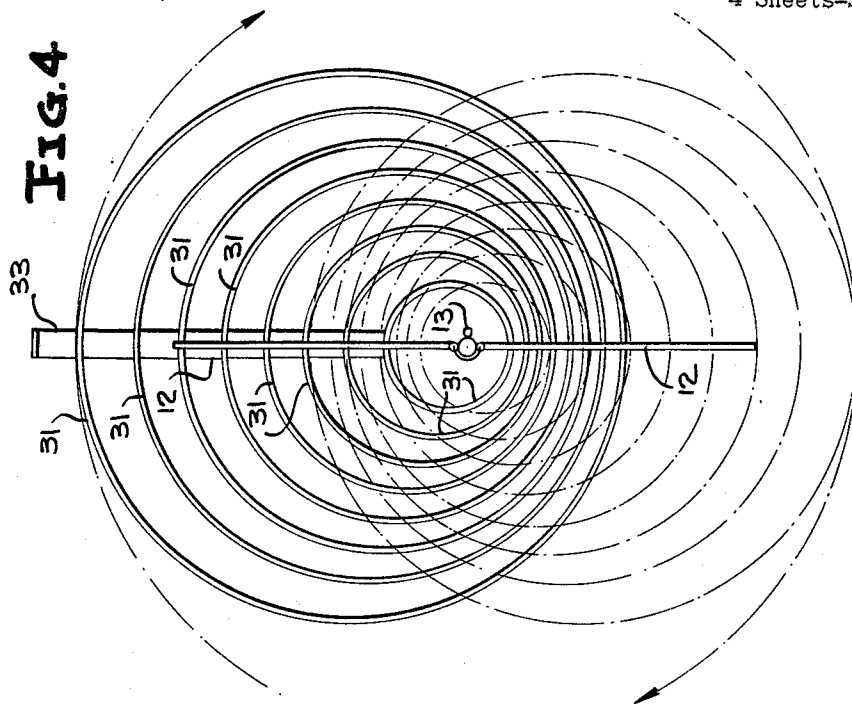
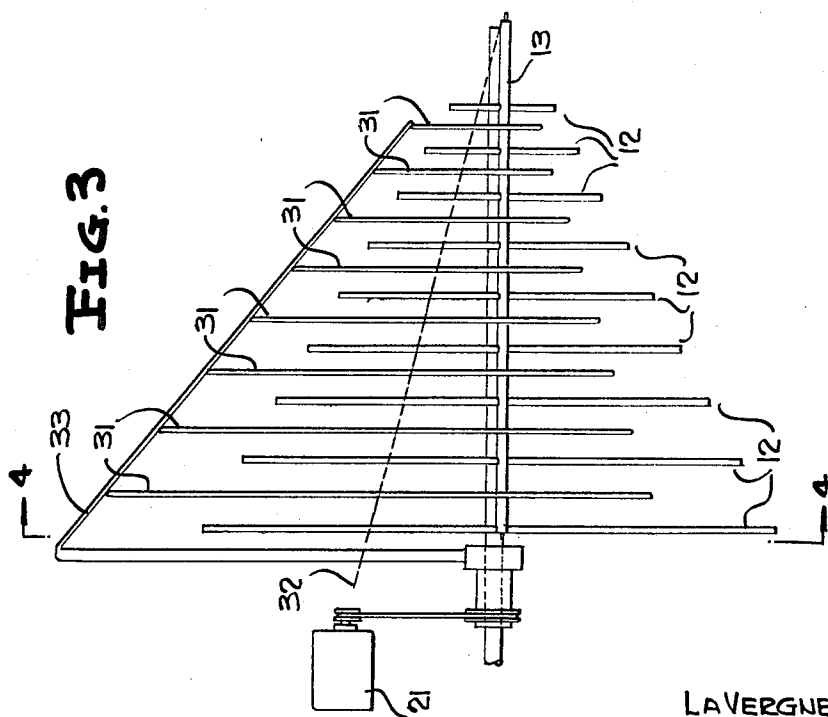


Fig. 3



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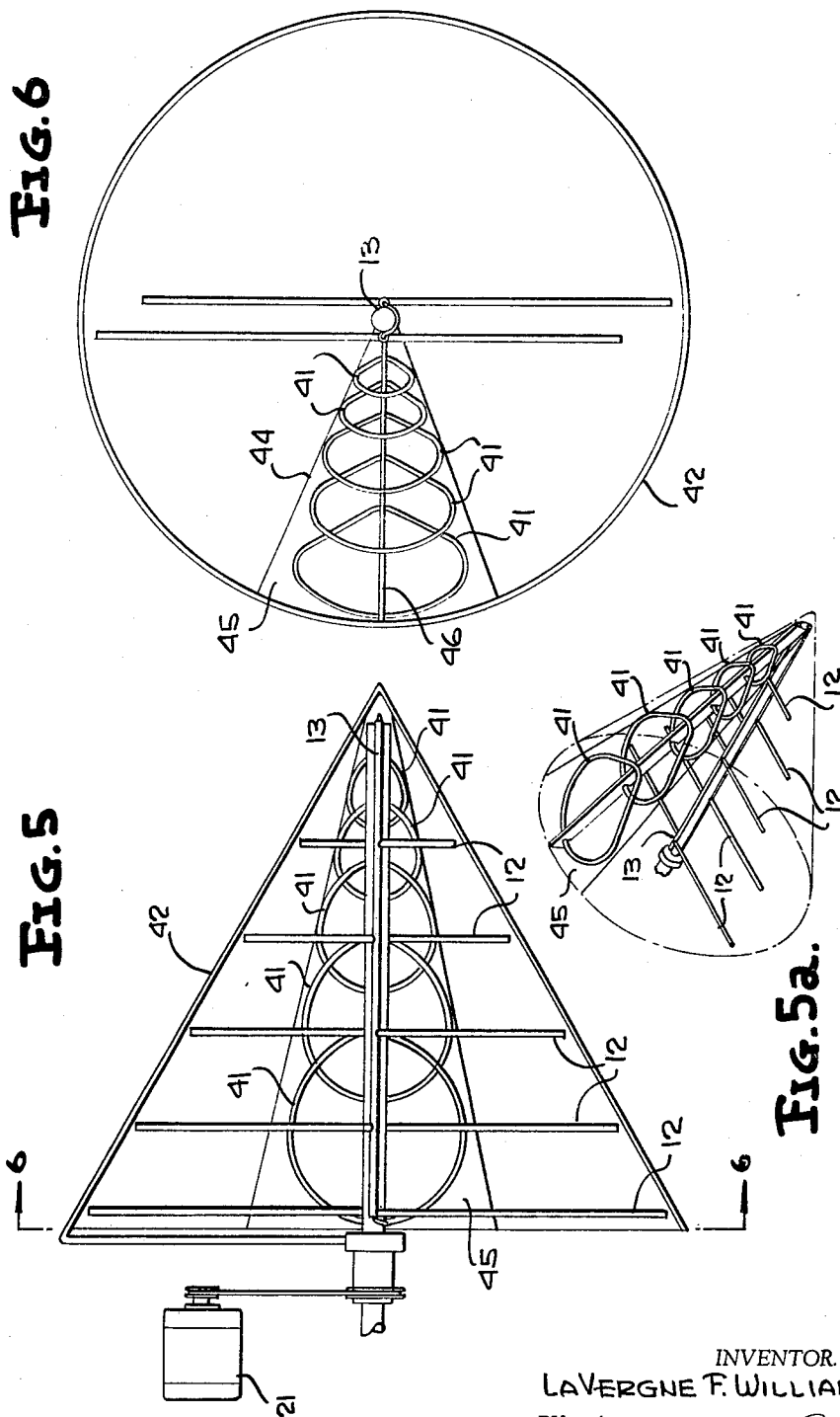
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FIG. 8

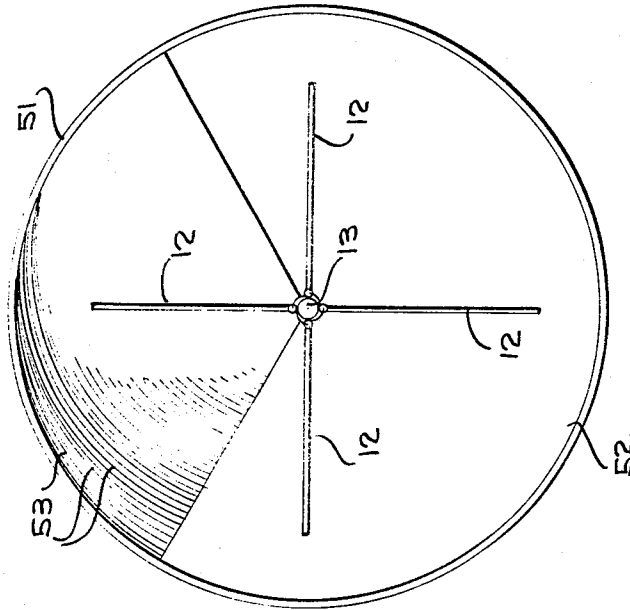
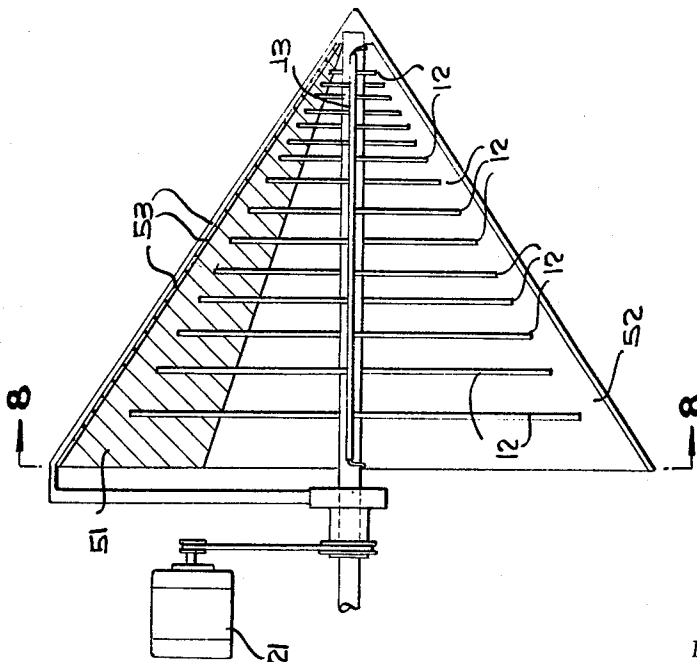


FIG. 7



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BROADBAND CONICAL SCAN FEED FOR PARABOLIC ANTENNAS

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The present invention relates generally to a conical scan antenna system and more particularly to a conical scan antenna system including a parasitic element that is rotatable relative to an active feed element which absorbs energy from the feed element and re-radiates it towards a parabolic reflector.

Previously, conical scan has generally been accomplished by rotating or nutating the entire feed, including the active element, in a circular motion. For single frequency operation, where existing rotating couplers are adequate, this approach is reasonably satisfactory. For broadband coverage utilizing multiple polarizations, all of the available broadband rotary joints introduce severe electrical and mechanical problems. Similarly, the slip rings associated with a rotating feed are undesirable because of the high noise factor they introduce into the signal. An approach of the prior art to obviate the need for a rotating feed is the utilization of rotating prisms. This structure cannot be changed once it is installed, and does not allow control of crossover depth, hence the on axis gain is reduced for many frequencies in a broadband system.

According to the present invention, the necessity for rotating the active feed element is completely obviated by utilizing a broadband, parasitic element that rotates about a stationary broadband active feed, e.g. a log periodic radiator. The parasitic element includes structures resonant at, above, and below the frequency of the active feed. In consequence, energy from the active feed is absorbed by the parasitic element and re-radiated thereby towards a parabolic reflector, having an axis on which the feed is located. As the parasitic element rotates about the active element, the apparent phase center of the feed is rotated and the secondary beam is squinted at an angle approximately equal and opposite to the instantaneous parasitic element off-set relative to the feed axis.

The parasitic element may take any one of several different forms, as long as the noted frequency criteria are satisfied. My experiments have shown that resonant logarithmically periodic structures, such as dipole elements or log periodic rings, are quite satisfactory. Carrying the concept of a log periodic structure to the limit, I have found that a metal section of a cone may be utilized for the parasitic element. The cone is such that an arc on its surface is resonant at the frequency of the active feed and its taper follows a mathematical definition similar to that of a log periodic element. Thereby, arcs on either side of the resonant arc serve as reflectors and directors of the energy absorbed and re-radiated by the resonant arc. The cone is preferable to the standard log periodic structure because of its relative mechanical simplicity.

With the present invention, it is possible to obtain a high gain conical scan over a decade frequency band with minimum mechanical and electrical design effort merely by selecting feed and parasitic elements of the required bandwidth. The feed system is capable of functioning with multiple polarizations, e.g. simple linear, orthogonal linear, and circular.

Accordingly, it is an object of the present invention to provide a new and improved conical scanning antenna system, particularly adapted for broadband signals.

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Another object of the present invention is to provide a new and improved broadband conical scan system which will function with multiple polarization.

A further object of the present invention is to provide a new and improved conical scanning system, particularly adapted for broadband operation, in which the necessity for rotary joints or slip rings is eliminated by maintaining the active feed element stationary.

An additional object of the present invention is to provide a broadband conical scanning system utilizing a stationary active feed wherein crossover depth of the pattern, is not fixed for all frequencies so that high gain is achieved for all frequencies in the band of interest.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is an elevation view, in section, of one embodiment of the present invention employing dipole log periodic parasitic elements;

FIGURE 2 is a front view of the cone of FIGURE 1, taken along the lines 2-2;

FIGURE 3 is a side sectional view of another embodiment of the present invention employing interleaved rings;

FIGURE 4 is a front view of FIGURE 3, taken along the lines 4-4;

FIGURE 5 is a side view of a further embodiment of the present invention employing log-periodic parasitic elements in the form of rings mounted outside of the active feed;

FIGURE 5a is a perspective view in phantom of the embodiment of FIGURE 5;

FIGURE 6 is a front view of FIGURE 5;

FIGURE 7 is a side sectional view of an additional embodiment of the present invention employing a segmented cone as the parasitic element; and

FIGURE 8 is a front view of FIGURE 7.

Reference is now made to FIGURES 1 and 2 of the drawings, wherein the reference numeral 11 denotes a linear log periodic driven element having a multiplicity of dipoles 12 spaced along and at right angles to rod 13. The number, length and spacing of dipoles 12 depends on the extent and location of the frequency band covered. The entire driven array is maintained stationary and is directly connected to a suitable source of R.F. energy, e.g. a radar set or receiving system, via non-rotating lead 18 obviating the need for any rotating couplers. As is well known, the dipole 12 which is resonant to the frequency of the R.F. energy serves as a radiator therefor while the adjacent longer and shorter dipoles function to reflect and direct the radiated energy, respectively. In consequence, it is possible to derive a unidirectional high gain beam from driven element 11 over a frequency range determined only by the physical lengths of the next to the longest and next to the shortest dipoles.

The axis of driven feed 11, along which rod 13 extends, coincides with that of parabolic reflector 14. The intersection of the shortest dipole 12 with rod 13 is approximately at the focus of reflector 14 so that some of the energy reflected from reflector 14 towards the system aperture travels along lines parallel to rod 13.

Positioned intermediate dipoles 12 are metallic, parasitic elements 15 each of which is of a different length, equal to the mean of the two adjacent driven dipoles 12. Because dipoles 12 are in a log periodic array, it follows that parasitic elements 15 are in similar configuration.

Parasitic elements 15 are mounted at various points around the perimeter of rotatable, electromagnetically

transparent, plastic cone 16, having its apex substantially coincident with the focus of reflector 14. Axis 19 of parasitic elements 15, the projection of their points of intersection, is inclined with respect to rod 13 and the axis of parabolic reflector 14 by an angle that controls the angular off-set of the conical scan phase center. This enables elements 15 to be rotated without contacting rod 13, as clearly viewed in FIGURE 2. As cone 16 is rotated by motor 21 about rod 13, axis 19 is rotated on the perimeter of circle 22.

To enable half of the shorter parasitic elements 15 to be located on either side of axis 19 it is necessary to attach each end to the surface of cone 16 via a plastic, electromagnetically transparent rod 23. The other parasitic elements have one conducting end directly fastened to cone 16 and the opposite end is connected via plastic rods 23 to the surface of cone 15 to increase their mechanical stability.

In operation, the parasitic element 15 resonant with the frequency emitted by driven dipoles 12, i.e. the one closest in length to one half wave length of the energy, absorbs and re-radiates the energy impinging thereon. The adjacent larger and smaller parasitic elements direct the re-radiated energy towards reflector 14 by reflecting and directing it, respectively. The phase center of the energy directed towards reflector 14 from the parasitic array thus lies along axis 19. With cone 16 in the position shown, axis 19 above rod 13, the re-radiated energy impinges on reflector 14 and the secondary beam is directed downwardly, as shown by wave paths 24. As cone 16 is rotated, axis 19 and the apparent phase center of the re-radiated energy is rotated to achieve the desired conical scan.

Reference is now made to FIGURES 3 and 4 of the accompanying drawings which shows another embodiment of the invention. In this embodiment, the log periodic feed is constructed and positioned identically as in FIGURE 1 so there is no need to describe the feed or illustrate the parabolic reflector. Interposed between adjacent dipoles 12 are log periodic circular rings 31. These rings are of varying diameter such that the resonant frequency of each is the median of the resonant frequency of its two adjacent dipoles 12. Each of the rings 31 lies in a plane orthogonal to rod 13 and their centers are displaced by a different amount from rod 13 but lie on line 32, which is considered axis of this parasitic structure.

Rings 31 are mechanically rigid, electrically conducting members attached to an elongated plastic support 33 which extends at an angle to rod 13 from the focus of parabolic reflector 14, FIGURE 1, to a point beyond the longest driven dipole 12. Rings 31 must be rigid so that they are maintained in a constant position relative to support 33, as the latter is rotated by motor 21.

The operation of the structure shown in FIGURES 3 and 4 is virtually identical to that illustrated on FIGURES 1 and 2. A certain one of the rings is resonant with the energy propagated from dipoles while the adjacent rings serve as a reflector and director for the re-radiated energy from the resonant ring. As support 33 is rotated, axis 32 of parasitic rings 31 is rotated to achieve the conical scan.

Reference is now made to FIGURES 5 and 6 of the drawings which discloses still a further embodiment of the present invention. In this embodiment the mechanically cumbersome, interleaved log periodic rings 31 of FIGURES 3 and 4 are replaced with log periodic metallic rings 41 mounted on the surface of rotatable plastic cone 42. The major and minor axes of each elliptical ring 41 is different but are related to each other and the rings are positioned relative to other so that points on their edges lie on lines which form the sides 43 and 44 of an imaginary segmented cone 45. It has been found that satisfactory results are attained even though rings 41 contact each other physically and electrically.

The major axes of log periodic rings 41 lie along the surface of cone 42 on line 46 which bisects the angle formed by sides 43 and 45 of segmented cone 45. As cone 42 is rotated by motor 21 while feed elements 12 remain fixed, the phase center of the energy re-radiated by rings 41 to reflector 14, FIGURE 1, rotates with axis 46 and the conical scan is achieved. In the same manner as rings 31 of FIGURES 3 and 4, a certain one of the rings 41 is resonant with the energy derived from driven dipoles 12 while the adjacent rings reflect and direct the re-radiated energy from the resonant ring.

In order to simplify the mechanical construction of the parasitic element, I investigated the possibility of extending the log-periodic structure of FIGURES 5 and 6 to its limit. This resulted in the structure shown in FIGURES 7 and 8 in which a metallic segmented cone 51 is secured to the surface of rotatable plastic cone 52. Cone 52 is positioned relative to driven feed elements 12 in exactly the same manner as cone 42 in the embodiment of FIGURES 5 and 6.

I have found that the electrical performance of this arrangement is quite satisfactory and that the shielding effect which normally is expected when a conducting member covers a driven radiator does not occur. This is because the edges of segmented cone 51 are similar in mathematical definition to those of the log periodic elements. Thus, certain arcs or surfaces on metal segmented cone 51 are resonant with the energy from driven feed 14 while other surfaces are resonant above and below the frequency of this energy. The surfaces having resonant frequencies above that of the energy are located between the resonant surface and the apex of segmented cone 5 and direct the re-radiated energy towards reflector 14. The surfaces having resonant frequencies less than the energy are located between the resonant surface and the base of segmented cone and reflect the re-radiated energy towards reflector 14.

As cone 52 is rotated about feed dipoles 12, the axis of parasitic element 51 (the bisector of the apex of segmented cone 51) is rotated to provide a conical scan having wave fronts 24, as illustrated in FIGURE 1.

I have found that the addition of metallic grid wires 53 extending from the interior surface of segmented cone 51 towards its base in a direction parallel to rod 13 equalizes the phase center displacement in the E and H planes without effecting the squint angle of the conical scan pattern.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variations of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

I claim:

1. A conical scan system comprising a parabolic reflector, a stationary active feed positioned approximately at the focus of said reflector and having an axis coincident with the axis of said reflector, a parasitic element rotatable about said feed and having an axis inclined with respect to the axis of said reflector, said parasitic element including a structure resonant at the frequency of the active feed pattern to absorb and re-radiate energy from the active feed pattern, said element including non-resonant structure for guiding the re-radiated energy towards said reflector.

2. A conical scan system comprising a parabolic reflector, a stationary, broadband active feed positioned approximately at the focus of said reflector and having an axis coincident with the axis of said reflector, a broadband parasitic element rotatable about said feed and having an axis inclined with respect to the axis of said reflector, said parasitic element including a structure resonant at the frequency of the active feed pattern to absorb and re-radiate energy from the active feed pattern,

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said element including non-resonant structure for guiding the re-radiated energy towards said reflector.

3. The system of claim 2 wherein said parasitic element comprises a log periodic structure.

4. The system of claim 3 wherein said structure includes a plurality of dipoles.

5. The system of claim 3 wherein said structure includes a plurality of rings.

6. The system of claim 5 wherein said rings are elliptical and have one of their axes coincident with the axis of said element.

7. The system of claim 5 wherein an axis of said rings extends orthogonally to the axis of said parabola.

8. The system of claim 2 wherein said parasitic element includes a segmented cone.

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9. The system of claim 8 wherein said parasitic element includes a multiplicity of conducting grid fingers.

10. An antenna scanning system comprising a reflector, an active feed, a parasitic element rotatable relative to said feed element and located between said reflector and said feed element, said parasitic element including a structure resonant at the frequency of the active feed pattern to absorb and re-radiate energy from the active feed pattern, said element including non-resonant structure for guiding the re-radiated energy towards said reflector.

No references cited.

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