Dec. 1, 1964 D. L. HINGS 3,159,839

DRIVEN DIPOLE COUPLED TO A COLINEAR ARRAY SPACED WITH RESPECT TO THE FIRST FRESNEL ZONE

Original Filed July 7, 1955 3 Sheets-Sheet 1

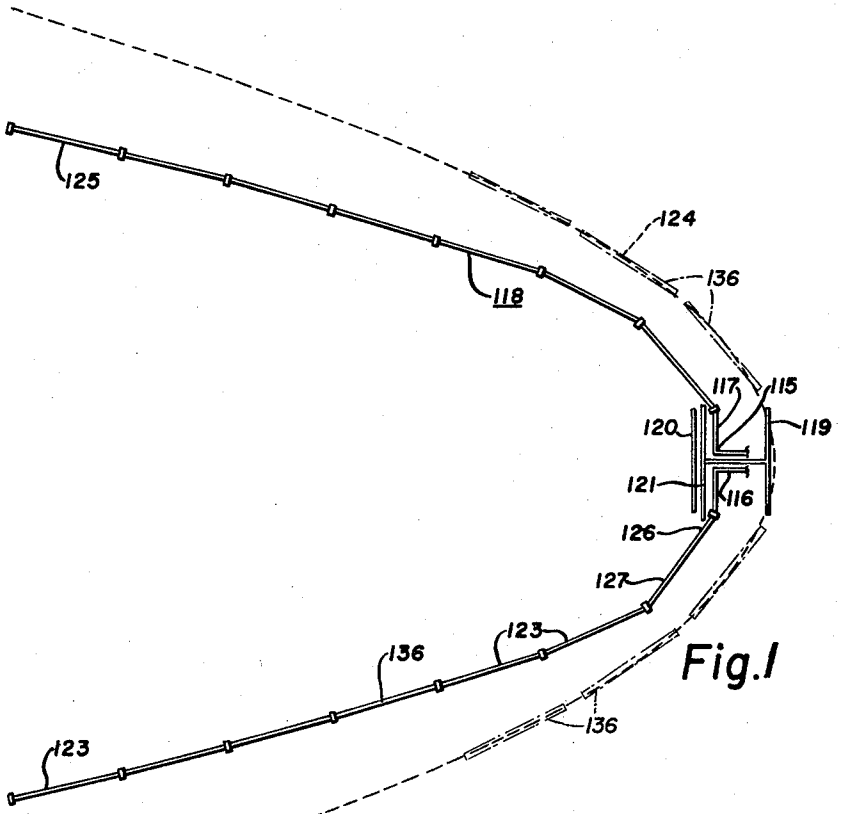


Fig.1

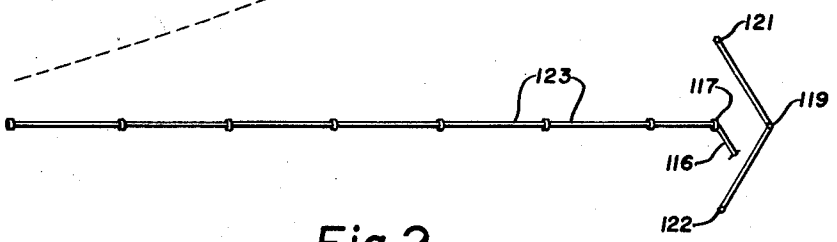


Fig.2

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Original Filed July 7, 1955 3 Sheets-Sheet 2

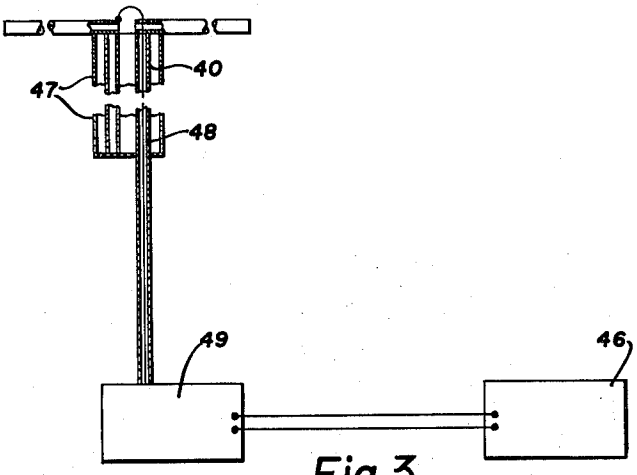


Fig.3

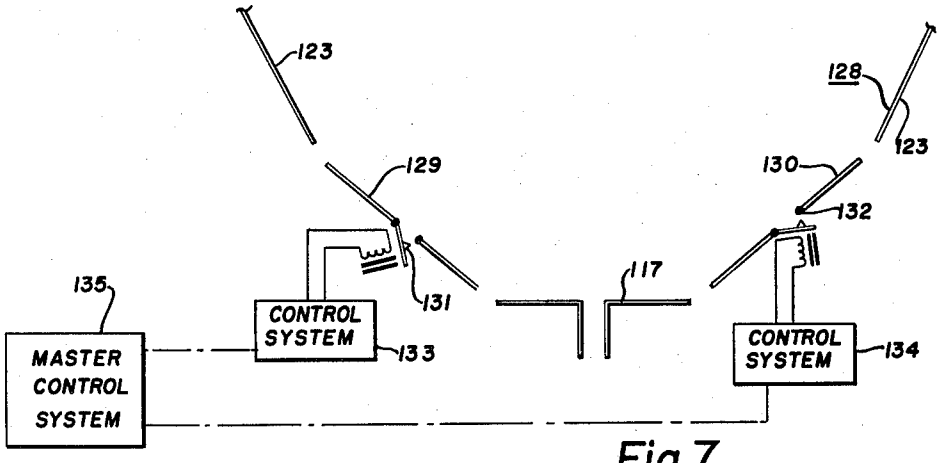


Fig.7

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DRIVEN DIPOLE COUPLED TO A COLINEAR ARRAY SPACED WITH RESPECT TO THE FIRST FRESNEL ZONE

Original Filed July 7, 1955 3 Sheets-Sheet 3

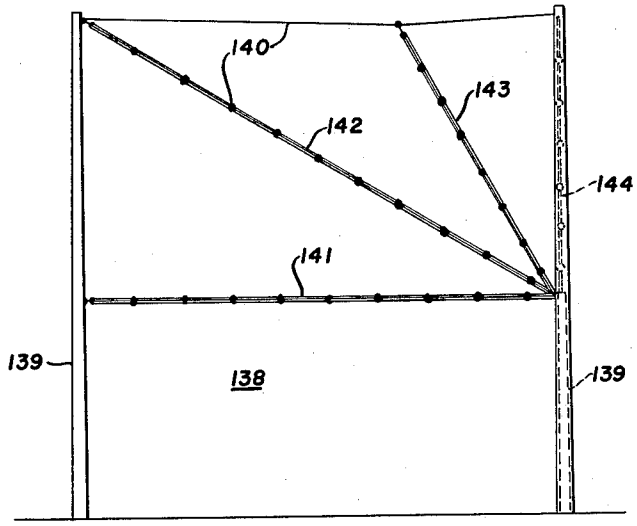


Fig.4

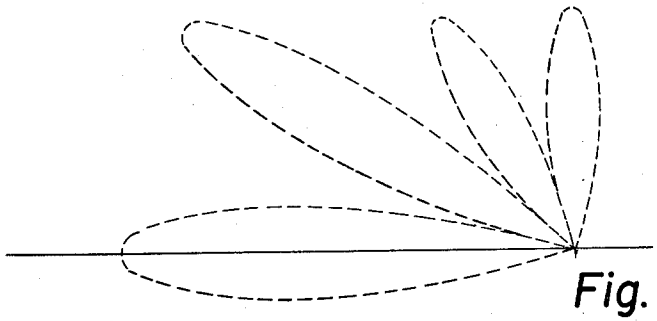


Fig. 5

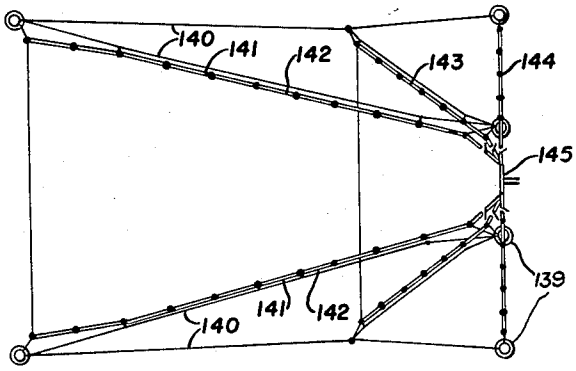


Fig.6

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United States Patent Office 3,159,839 Patented Dec. 1, 1964

3,159,839

DRIVEN DIPOLE COUPLED TO A COLINEAR ARRAY SPACED WITH RESPECT TO THE FIRST FRESNEL ZONE

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Original application July 7, 1955, Ser. No. 520,606, now abandoned. Divided and this application May 5, 1959, Ser. No. 811,035

19 Claims. (Cl. 343—819)

The invention relates in general to the reception of electromagnetic waves and more particularly to an antenna system which may be made highly directional and which may be electrically scannable. The antenna in this system may be used either as a transmitting or receiving antenna, and may be termed a focal point or point source radiator or collector, which is the closest approach to the theoretical isotropic antenna or elemental length dipole. This provides a spot or point source for the radiated waves so that the radiated waves have a definite phase at a point in space at any given instant of time.

An object of the invention is to provide an antenna system capable of achieving a directed beam which may be scanned or swept through the sky in any desired direction.

Another object of the invention is to provide a highly directional antenna array which may be easily used in the VHF or UHF spectrum and which antenna array may be arranged along radials generally from a focal point so that the radiated beam of the complete antenna system may be electrically switched to achieve a scanning of the effective beam of the entire antenna system.

Another object of the invention is to provide an antenna array which utilizes a resonant driven element and which has parasitic collector elements with high impedance coupling to the ends of the driven element to increase the gain and directivity of the driven element.

Another object of the invention is to provide an antenna array which utilizes antenna elements which may be termed collector elements positioned generally parallel to the elliptical Fresnel zones of the antenna array, considering this antenna array to have Fresnel zones with respect to another antenna, with one antenna being a transmitter and the other being a receiver.

Other objects and a fuller understanding of this invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a plan view of a directive antenna array of this invention;

FIGURE 2 is a side view of the antenna of FIGURE 1;

FIGURE 3 is a diagram of the connections of the antenna to radio apparatus;

FIGURE 4 is a side view of an antenna system using antenna arrays similar to those of FIGURE 1;

FIGURE 5 is an elevational view of the beam patterns obtainable with the antenna of FIGURE 4;

FIGURE 6 is a plan view of the antenna of FIGURE 4; and

FIGURE 7 is a circuit diagram showing how the antenna array of FIGURE 1 may be effectively switched in and out.

The FIGURES 1 and 2 show a directive antenna array which is quite suitable for the VHF spectrum, and even the HF and UHF spectrums. The antenna utilizes a driven element which has been shown as a resonant one-half wave dipole 117 and which is a focal point radiator. This dipole 117 may be connected as shown in FIGURE 3, that is, by means of a Balun 47 to a coaxial feed line 48 and then to a preamplifier 49 which in turn is connected to the input of the detector 46. This is one

possible connection of the dipole 117 to radio apparatus 46–49 which is receiving apparatus. If the antenna is to be used as a transmitting antenna, then the apparatus 46 may be a transmitter. The dipole has its length determined so as to be resonant at the operating frequency of the entire antenna array 118. A reflector 119 may be used which may conveniently be the Yagi type reflector and which typically is cut to be longer than the dipole 117. The reflector 119 is, of course, positioned to the rear of the dipole 117, relative to the radiation pattern of the antenna. An element 120 may be positioned in front of the dipole 117, and this element may be considered a director or an impedance matching element. It has been found most effective when positioned in the order of one-tenth wave length from the dipole 117 and has a length less than the length of the dipole 117 to thus be similar to director elements used in a Yagi type antenna array. Additional reflector elements 121 and 122 are positioned above and below the dipole 117 in ninety degree space-phase relationship thereto. These reflector elements narrow the beam in a vertical direction.

A novel feature of the antenna array 118 is the inclusion therein of antenna elements which are termed collector elements 123. These have been found most effective when having a length equal to one-half wave length of the operating frequency so as to be resonant with the dipole 117. These collector elements co-linearly extend along a curved line which appears to be an ellipse and which appears to be generally parallel to and inside of the ellipse of the first Fresnel zone 124. This first Fresnel zone 124 is known to pass one-quarter wave length to the rear of the dipole 117, and generally passes through the reflector 119. The positioning of the reflector element 119 is roughly one-quarter wave length to the rear of the dipole 117, although this may vary slightly depending upon the impedance match of the antenna to the feed line, for example. This spacing may be .28 of the operating wave length yet remains ninety degrees in space-phase relationship to the dipole 117.

The first Fresnel zone may be defined as a cylindrical surface of revolution, having the direct path from the transmitting to receiving antennas as the axis thereof, and possessing a contour such that the distance from the transmitting antenna to a point on the surface plus the distance from this point to the receiving antenna is one-half wavelength longer than the direct path length. This is, in essence, a definition of an ellipsoid of revolution, considering the ellipse to be in a plane containing the direct path, and rotating the ellipse about the direct path as the axis to form the ellipsoid of revolution. One definition of an ellipse is that the sum of the focal radii of a point on an ellipse is a constant, and is equal to the length of the major axis. Thus, the above definition of the first Fresnel zone shows it is really defining an ellipse, and considered in three dimensions it is more properly an ellipsoid of revolution.

Under the Yagi principle, a reflector one-quarter wavelength behind the transmitter antenna, for example, will cause addition of the wave received at the receiver location, additive to the direct wave. This is because the reflected wave path moves backward from the transmitter driven element and is displaced 90 degrees in phase by the time it is reflected from the reflector, there it receives a 180 degree phase shift in being reflected and then as it is traveling forward to the plane of the driven element there is an additional 90 degree phase shift, for a total of 360 degrees, so this reflected wave is then additive to the direct wave. If a reflector is placed at any point along the first Fresnel zone, say at a point midway between the transmitter and receiver antennas, this first Fresnel zone is so spaced from the direct path that the reflected

wave path from transmitter to receiver will be one-half wave length longer and, thus, again the reflected wave will be additive to the direct wave at the receiver.

It has been observed that elements **136**, shown in phantom in FIGURE 1, which are cut to be reflector elements may be positioned along and tangent to this first Fresnel zone **124** and are effective to somewhat increase the gain of the entire antenna array **118**. The position of such reflector elements would indicate that the first Fresnel zone **124** diverges from the position of the collector elements **123** at the front end or open end **125** of the antenna array **118**. Thus, the collector elements **123** may be considered to be generally parallel to and within the first Fresnel zone **124**.

The collector elements **123** may be supported in any suitable manner and are preferably supported at the mid-points, such as the mid-point **136**, where the current would be maximum but the voltage would be minimum. The ends of the collector elements are adjacent the next co-linear collector element for a high impedance or capacity coupling. It has been found that a closer spacing, that is, a higher capacity coupling, is desirable for the collector elements near the front end **125** than for those near the dipole **117**. It has also been observed that the exact spacing between the near ends **126** of the first collector element **127**, relative to the end of the dipole **117**, is much more critical than is the spacing between ends of collector elements at the front end **125**. The spacing between the near end **126** and the end of the dipole **117** has been found to be most effective when approximately .02 wave length. It has also been found that the collector elements near the front end **125** may be slightly overlapped lengthwise, yet spaced, and this permits a slight reduction in overall length of the complete array.

The entire array with a total of twenty collector elements **123** in conjunction with the reflectors **119**, **121**, and **122**; and the element **120** has been observed to have about twenty db gain over the resonant dipole **117** alone. If all the collectors **123** are removed yet retaining the reflectors and director **120**, the db gain is only about nine db. This means that the collectors, when added to the antenna array, produce a signal increase of approximately ten times.

The driven element **117** is, of course, connected at the center at a feed point **115** to a feed line, so as to act either as a transmitting or receiving antenna. The connection to the feed line is made in any suitable manner, such as by a matching stub **116**, and the feed point may be considered to be a reference point on the generally elliptical path of the collector elements **123**. The plane of the entire array contains this reference point, and the driven element may be considered to be a means for coupling the matching stub to the co-linear sets of collector elements **123** on each side of this driven element or matching stub.

The FIGURE 7 shows a portion of an antenna array **128** which may be quite similar to the antenna array **118**. Again the resonant dipole **117** is used together with the collector elements **123**. However, collector elements **129** and **130** are used immediately adjacent the dipole **117** which are special elements comprised of an open dipole. The open dipoles **129** and **130** are identical and each may be considered as formed from two co-linear quarter wave length elements. Electrically operated high dielectric switches **131** and **132** are provided at the middle of each of these open dipoles **129** and **130**, respectively, with these electrically operated switches controlled by control systems **133** and **134**, respectively, each in turn connected to a master control **135**. When the switches **131** and **132** are closed, the elements **129** and **130** are effectively a half wave element which acts the same as the other collector elements **123** and thus renders effective the entire antenna array **128**. When the electrically operated switches **131** and **132** are open, this destroys the resonant feature of the elements **129** and **130** and minimizes the coupling between the dipole **117** and the co-linear collector elements **123** on the open end of the antenna array **128**.

The FIGURES 4, 5, and 6 show a scannable directional antenna system **138**. Supporting towers **139** may be used to support non-conductive cables **140** on which the entire system may be carried. The FIGURES 4 and 6 show that the entire antenna system **138** includes four antenna arrays **141** through **144**, each of which may be generally similar to the antenna array **128** shown in FIGURE 7. Only a single driven element **145** is used with all four antenna arrays **141** through **144**. This driven element will effectively feed each of the four antenna arrays. The antenna arrays **141–144**, being similar to the antenna array **128** of FIGURE 7, may be controlled by the electrically operated switches **131** and **132**. The two switches in each of the four antenna arrays may be individually closed to obtain a lobe switching of the entire antenna system. If these switches were all simultaneously closed, it would form a fan-shaped beam from horizontal to vertical. The control systems **133** and **134** and the master control system **135** may be applied to the antenna system of FIGURES 4 and 6 to control this lobe switching which is therefore a form of beam scanning, and the FIGURE 5 is an elevation view of the beams attainable by each of the arrays **141–144** in the antenna system **138**.

The use to which the antenna system **138** may be put will often require a longer beam or lobe toward the horizon than toward the zenith, and this antenna system **138** accomplishes this by providing more collector elements **133** in the antenna array **141** than in the upwardly directed arrays **143** and **144**.

The antenna array **141** of FIGURE 4 shows a convenient way to build such array either for the HF or UHF spectrums. The antenna elements may simply be metallic tubes and insulator beads alternately strung on a non-conductive cable or cord, such as nylon or glass fiber cables, with support cables running to the insulator beads as required to pull the entire array into the desired generally elliptical shape.

Also, the entire antenna system of FIGURES 4 and 6 may be approximately doubled, with additional arrays to the right, as viewed in these figures, to produce an antenna system capable of scanning from horizon to horizon through the zenith.

This application is a division of my application Serial Number 520,606, filed July 7, 1955, now abandoned, which in turn is a continuation-in-part of my application Serial Number 347,871, filed April 10, 1953, now Patent Number 2,886,813.

Although this invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. A directional antenna comprising, a driven element having a first Fresnel zone, and a plurality of parasitic elements each substantially resonant to the frequency of said antenna and spaced along a curved line lying generally parallel to and space-phased approximately ninety degrees on the inner side of said first Fresnel zone.

2. A directional antenna comprising, a driven element having a first Fresnel zone, a plurality of parasitic elements each substantially resonant to the frequency of said antenna and spaced along a curved line lying generally parallel to and space-phased approximately ninety degrees on the inner side of said first Fresnel zone, and high impedance coupling means between said parasitic elements.

3. A directional antenna comprising a driven element having a first Fresnel zone, a plurality of parasitic elements each substantially resonant to the frequency of said

antenna and spaced approximately half a wave length apart along a curved line lying generally parallel to and space-phased approximately ninety degrees on the inner side of said first Fresnel zone, and high impedance coupling means between said parasitic elements.

4. A directional antenna comprising, a driven element having at least a first Fresnel zone, a directional antenna comprising, a resonant matching stub, first and second pluralities of parasitic collector elements co-linearly extending generally along a curved line off opposite sides of said matching stub, said curved line lying generally parallel to and space-phased approximately ninety degrees from the inner side of the first Fresnel zone of said antenna, and each said parasitic collector element being substantially resonant to the frequency of said antenna.

5. A directional antenna comprising, a driven element having at least a first Fresnel zone, first and second pluralities or parasitic collector elements co-linearly extending generally along a curved line off the two ends of said driven element in a plane substantially containing said driven element, said curved line lying generally parallel to and space-phased approximately ninety degrees from the inner side of said first Fresnel zone of said antenna, and each said parasitic collector element being substantially resonant to the frequency of said driven element.

6. A directional antenna comprising, a driven element having at least a first Fresnel zone, first and second pluralities of parasitic collector elements co-linearly extending generally along a curved line off the two ends of said driven element in a plane substantially containing said driven element, said curved line lying generally parallel to and space-phased approximately ninety degrees from the inner side of said first Fresnel zone of said antenna, each said parasitic collector element being in the order of one-half wave length long and high impedance coupled at the ends thereof to the adjacent co-linear element.

7. A directional antenna comprising, a resonant radiator, a parasitic reflector parallel to said radiator and spaced on one side of said radiator a distance approximately one-fourth wave length and approximately on the first Fresnel zone of said radiator considering said one side of said radiator to be the rear thereof, first and second pluralities of parasitic collector elements co-linearly extending generally along a curved line off the first and second ends of said radiator in a plane substantially containing said radiator and reflector, said curved line lying generally parallel to and space-phased approximately ninety degrees from said first Fresnel zone, each said parasitic collector element being in the order of one-half wave length long and capacity coupled at the ends thereof to the adjacent co-linear element.

8. A directional antenna comprising, a half-wave dipole radiator, a parasitic director parallel to said radiator and spaced on one side of said radiator a distance approximately one-tenth wave length, a parasitic reflector parallel to said radiator and spaced on the opposite side of said radiator a distance approximately one-fourth wave length and approximately on the first Fresnel zone of the radiator considering said first side of said radiator to be the front thereof, first and second pluralities of parasitic collector elements extending generally along a curved line off the first and second ends of said radiator in a plane substantially containing said director, radiator and reflector, said curved line lying generally parallel to and spaced approximately one-fourth wave length from said first Fresnel zone, each said parasitic collector element being in the order of one-half wave length long and capacity coupled at the ends thereof to the adjacent co-linear element.

9. An antenna array for connection to a transmission line at a reference point, said antenna being primarily effective in a reference plane passing through said reference point, a plurality of co-linear collector elements arranged along a generally elliptical path substantially in said plane extending from said reference point in said reference plane, and coupling means between said collector elements and said reference point.

10. A directional antenna for connection to a feed line at a feed point, said antenna being primarily effective in a reference plane passing through said feed point, a plurality of collector elements co-linearly arranged along a generally elliptical path substantially in said plane extending from said feed point in said reference plane, and coupling means between said collector elements and said feed point.

11. A directional antenna for connection to a feed line at a feed point, said antenna being primarily effective in a reference plane passing through said feed point, a plurality of collector elements co-linearly arranged along a generally elliptical path substantially in said plane in said reference plane, and coupling means including a driven element between said collector elements and said feed point with said collector elements extending in two directions from said driven element.

12. An antenna system comprising, support means having an axis, a driven element on said support means and resonant to an operating frequency, a plurality of antenna arrays with each array lying in a plane radiating from and containing said axis, each of said antenna arrays having first and second pluralities of parasitic collector elements co-linearly extending generally in an elliptical path in the respective radial plane, and control means to selectively couple said first and second pluralities of collector elements to the ends of said driven element to thus render selectively effective each of said antenna arrays.

13. An antenna system comprising, support means having an axis, a driven element on said support means on said axis and resonant to an operating frequency, a plurality of antenna arrays with each array lying in a plane radiating from and containing said axis, each of said antenna arrays having first and second pluralities of parasitic collector elements co-linearly extending generally in an elliptical path in the respective radial plane from the two ends of said driven element, each of said collector elements being substantially resonant to said operating frequency, the collector element in each of said pluralities immediately adjacent said driven element being divided in two halves, a pair of electrically operable switches to electrically connect together said divided collector halves in each antenna array, control means to selectively render operative and inoperative a given antenna array by the closing and opening, respectively, of the pair of switches in said given antenna array, and means to sequentially actuate said pairs of switches to effectively sweep a beam of said antenna system within a plane substantially perpendicular to said axis.

14. An antenna being primarily effective in a reference plane comprising, in combination, a driven element having a first Fresnel zone substantially in said plane, and a plurality of co-linear antenna elements spaced along a curved line substantially in said plane lying generally parallel to and spaced from said first Fresnel zone.

15. An antenna being primarly effective in a reference plane comprising, in combination, a driven element having a first Fresnel zone substantially in said plane, and a plurality of co-linear parasitic elements each substantially resonant to the frequency of said antenna and spaced along a curved line substantially in said plane lying generally parallel to and spaced from said first Fresnel zone.

16. An antenna array being primarily effective in a reference plane, comprising, in combination, a driven element having a first Fresnel zone in said plane, and a plurality of co-linear collector elements arranged along a general elliptical path substantially in said plane extending from the ends of said driven element and spaced from said first Fresnel zone.

17. A directional antenna being primarily effective in a reference plane comprising, in combination, a resonant element having a first Fresnel zone in said plane, and a plurality of collector elements co-linearly arranged along

a generally elliptical path substantially in said plane extending from the ends of said resonant element and spaced from said first Fresnel zone.

18. A directional antenna being primarily effective in a reference plane, comprising, in combination, a driven element having a first Fresnel zone, and at least one co-linear parasitic element substantially resonant to the frequency of said antenna and spaced along a curved line substantially in said plane lying generally parallel to and space-phased approximately ninety degrees on the inner said of said first Fresnel zone.

19. A directional antenna being primarily effective in a reference plane, comprising, in combination, a driven element having a first Fresnel zone, a reflector element positioned to the rear of said driven element and generally on said first Fresnel zone, first and second pluralities of parasitic elements, each of said second elements being of reflector length and each of said first elements being substantially resonant to the frequency of said antenna,

said second parasitic elements co-linearly spaced generally along said first Fresnel zone, and said first parasitic elements co-linearly lying along a curved line substantially in said plane to the front of said second parasitic elements.

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