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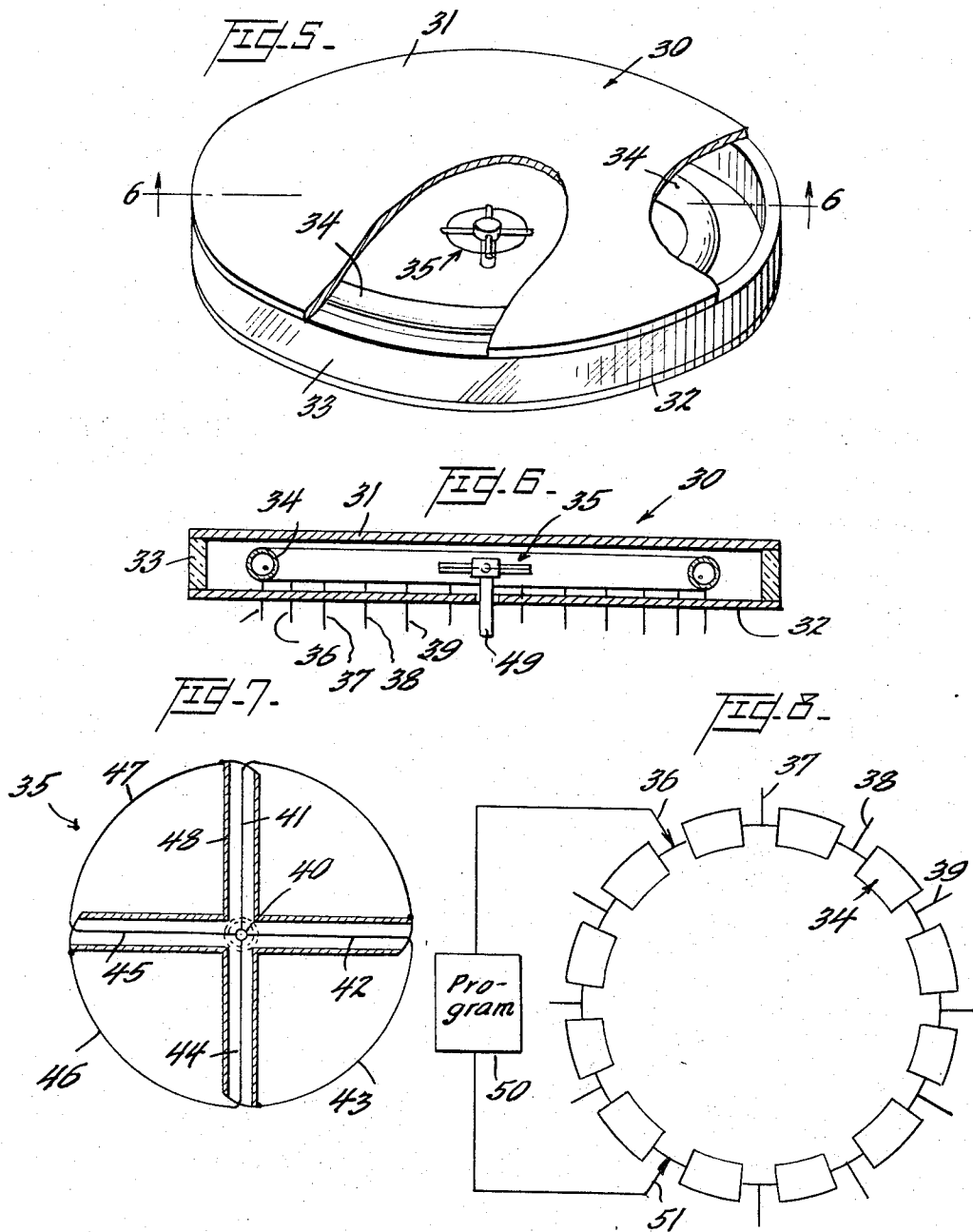
March 26, 1968

F. E. BURNHAM
SCANNING REFLECTOR

3,375,519

Filed May 19, 1960

3 Sheets-Sheet 2



INVENTOR

Fred E. Burnham,
Alfred B. Levine
Seymour M. Rosenberg
Robert H. Lantz
ATTORNEYS

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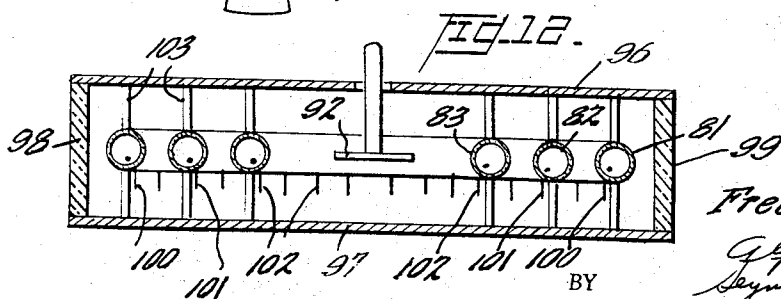
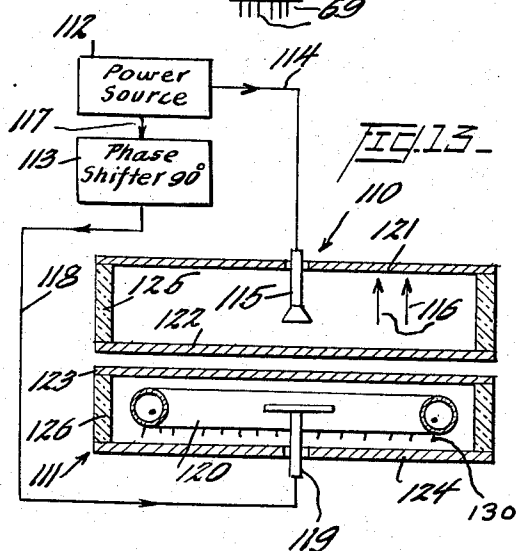
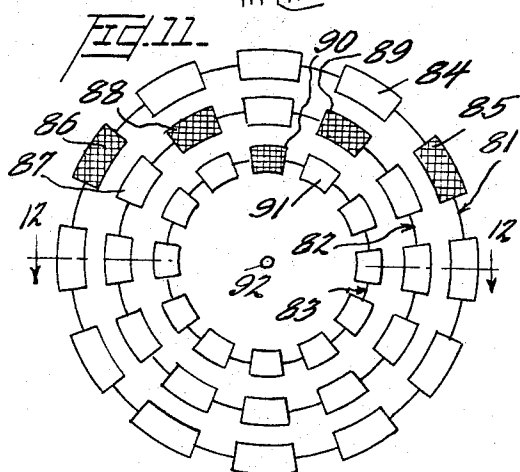
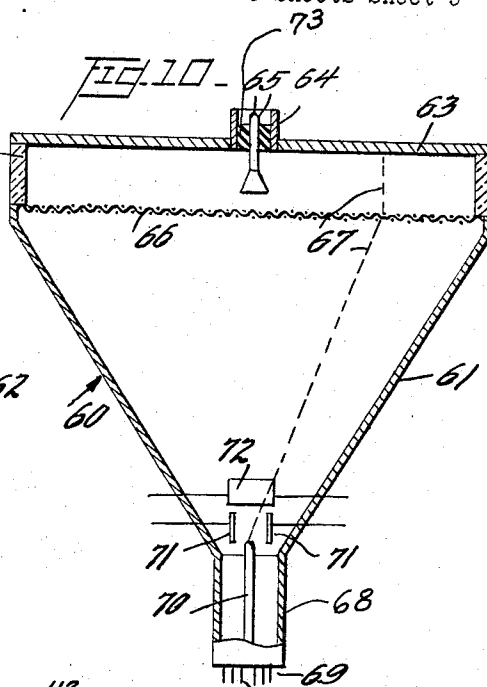
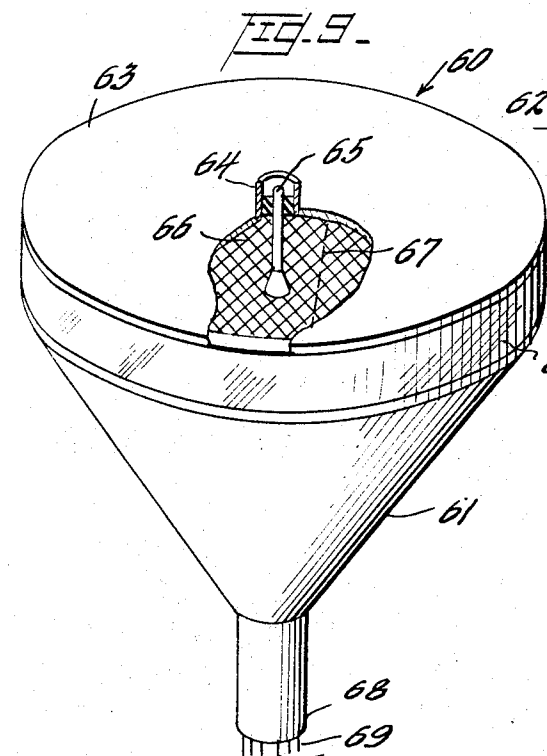
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SCANNING REFLECTOR

Fred E. Burnham, Silver Spring, Md., assignor to
Litton Industries of Maryland, Incorporated, College Park, Md.

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This invention generally relates to multifunction antennas and is more particularly concerned with such antennas wherein the beam position and beam shape are controllable by an electronically variable reflector means to provide a versatile antenna structure useful for inertialess scanning purposes and many of other functions.

In the prior art, it is known that electric discharges or otherwise obtained ionized particle clouds will refract, reflect, or diffuse an electromagnetic or radio beam, and various types of antenna structures have been proposed employing this principle. However, most known devices of this type have not found widespread acceptance or even extensive use in limited applications but instead have been employed mostly for purposes of laboratory study since suitable means have not heretofore been found for producing and controlling an ionized beam or cloud in an efficient and controllable manner comparable to conventionally constructed antennae employing metallic reflectors and the like.

Considering the problem in greater detail, it is known that to obtain sufficient range for either propagation or reception purposes without the need for excessive power requires that the antenna possess a high gain characteristic wherein the energy is efficiently collimated into a rather narrow beam. In an ionized or particle cloud antenna, this requirement necessitates that the ionized cloud be formed and controlled in a predetermined or shaped manner and that the composition and characteristics of the cloud be maintained substantially constant during use. For tracking, position locating, scanning, and other antenna functions, it is also necessary that the ionized cloud be physically displaced from position to position while maintaining the same spacial configuration of the cloud since otherwise the beam pattern or shape is undesirably varied during displacement of the cloud. These and other problems have seriously limited the application of known ionized type antenna structures to the point where they have presently found little use for most practical purposes.

According to the present invention, there is provided an antenna structure that overcomes many of these difficulties by employing an electronic reflection means whose shape may be either accurately maintained or rapidly varied as desired to provide a wide variety of beam patterns and wherein the electronic reflector may also be physically displaced from position to position, either with or without change in shape, to permit scanning of the beam over wide arcs in space extending to 360° or greater. According to further features of the invention, the beam pattern may also be polarized in any desired spacial plane and/or in more than one plane, either simultaneously or sequentially. Still further modifications of the invention permit the scanning or displacement of the beam over a plurality of orthogonal planes providing such functions as spacial searching over wide spherical areas.

It is accordingly a principal object of the invention to provide a high gain scanning antenna that may be controlled completely electronically with no physically moving parts.

A still further object is to provide such an antenna employing an ionized particle reflector.

A further object is to provide such an antenna whose beam shape may also be controlled electronically.

A still further object is to provide a high gain antenna capable of efficiently functioning over a broad frequency band.

Still another object is to provide such an antenna of reduced complexity, lower weight and smaller overall volume.

A further object is to provide such an antenna capable of rapid scanning rates and/or rapid variation in beam shape.

A still further object is to provide such an antenna possessing high gain and efficiency.

Still another object is to provide such an antenna having a fixed feed and a variable ionized or conducting reflector permitting rapid change in either beam position or beam shape, or both either sequentially or simultaneously.

A still further object is to provide a scanning antenna capable of producing a polarized beam of either narrow or broad shape and varying configurations.

Other objects and many additional advantages will be more readily understood by those skilled in the art after a detailed consideration of the following specification taken with the accompanying drawings, wherein:

FIG. 1 is a perspective view partially in section illustrating one preferred embodiment of the invention,

FIG. 2 is a sectional view taken along lines 2-2 of FIG. 1,

FIG. 3 is an enlarged sectional view of a preferred gas tube structure employed in the embodiments of FIGS. 1 and 2,

FIG. 4 is a diagrammatic plan view of the antenna of FIG. 1 for illustrating its functional operation,

FIG. 5 is a perspective view, partially in section, illustrating an alternative construction, according to the invention,

FIG. 6 is a side sectional view taken along lines 6-6 of FIG. 5,

FIG. 7 is an enlarged plan view of the antenna feed means for the antenna of FIG. 5,

FIG. 8 is a diagrammatic view, schematically illustrating the gas tube arrangement of FIG. 5 and the manner of firing portions thereof,

FIG. 9 is a perspective view, partially in section, illustrating still another embodiment of the invention,

FIG. 10 is a sectional view of the antenna structure of FIG. 9,

FIGS. 11 and 12 are a cross-sectional plan view and a transverse sectional view, respectively, illustrating a modified form of the antenna of FIGS. 5 and 6, and

FIG. 13 is a sectional view of a further modification of the invention, illustrating an arrangement for obtaining polarized beams in two orthogonal planes.

Referring now to the drawings, there is shown in FIGS. 1 to 4 details of one preferred embodiment of the invention in the general form of a transmission line antenna having an electrically ionizable reflector means whose position and/or shape may be varied as desired both to displace the beam over scanning arcs extending to 360° or greater, or vary the beam shape in any desired configuration.

As shown, the antenna structure preferably comprises a pair of stationary and parallel arranged upper and lower spaced conducting plates 11 and 12, which may be circular flat plates, as shown. Located at the central axis and disposed between the plates, there is provided an upright energizable antenna feed, generally indicated as 13, which may be of the hollow door knob type. With this arrangement energization applied to, or received from the feed 13 provides wave energy in the TEM mode,

which wave is directed radially outward between the plates and omnidirectionally about the central antenna feed 13.

For collimating the beam to provide the desired gain and directivity, there is provided between the plates and transversely arranged with respect thereto, a plurality of gas tube cylinders, generally indicated at 16 and 17, with the gas tubes being spaced apart from one another in a predetermined pattern, as will be more fully described hereafter.

In the absence of any reflecting means between the spaced plates 11 and 12, the beam being produced or received by the antenna feed 13 is directed omnidirectionally outward from the feed over a full 360° arc. However, if transversely disposed spaced conductors are provided between the plates and are spaced apart from one another at a given distance relative to the frequency of the propagated wave, a reflector is provided which serves to collimate the beam and direct it outwardly over a given portion of this arc. For example, if a series of spaced conductors are arranged between the plates in a parabolic curve arrangement, as indicated in FIG. 4 by the conductors "X" numbered 16, and if these individual conductors "X" are spaced from one another at less than about one-half wave length at the operating frequency, such conductors 16 function as an efficient parabolic reflector serving to collimate the beam and direct it outwardly to the right in a focused manner. Similarly, if such a parabolic arrangement of spaced conductors are rotated to a different angular position referenced to the feed 13, as shown by the delta shaped conductors numbered 25 in FIG. 4, a collimated beam of the same wave-shape is then directed outwardly at a different scanning angle than is provided by the conductors 16.

According to the present invention, this technique is employed to provide a variable reflector whose shape and angular location between the plates 11 and 12 may be varied electrically thereby to focus and/or scan the beam over wide arcs in space either continuously, sequentially, or in any other predetermined manner, as is desired.

To provide such an electronically variable reflector between the plates, there is supplied a plurality of gas filled tubes such as 16, 17 and 24 fixedly positioned between the plates and permanently affixed thereto. Each of said gas tubes in its un-ionized condition does not provide an electrical conductor between the plates, but when suitably triggered into its ionized condition, it forms an ionized conducting path, whereby a series of such tubes fired in a group, such as in the parabolic arrangement 16 of tubes "X" in FIG. 4, forms an ionized parabolic reflector for collimating the beam.

According to the invention, a relatively large number of such gas tubes, such as 16, 17, and 24 are provided between the plates 11 and 12, with each adapted to be individually fired or ionized by an outside triggering source (not shown) to provide an individual column of ionized gas at that position between the plates 11 and 12. A suitable commutator or programming means (not shown) may be provided to fire different series of these tubes in predetermined groups, such as the groups of tubes 16 or 25 in FIG. 4, whereby the shape and/or position of the ionized reflecting surface may be varied as desired. Since the ionized column in each conducting gas tube is confined in space within that cylindrical tube, and since each tube may be individually controlled into a conducting or non-conducting state, an infinite variety of reflector surface configurations may be synthesized for any one given angular position of the beam to produce either wide or narrow columnated beam patterns, and such reflector surfaces may be identically reproduced at any angular position about the central feed 13 over a full 360° arc. Consequently, this antenna structure can provide an infinite variety of beam shapes in the horizontal plane and rapidly scan a selected beam continuously or discontinuously over arcs extending to 360° or greater.

This antenna structure may also be employed over a wide range of frequencies, limited only by the dimensions of the plates 11 and 12 and the number and spacing of the gas tubes, since as noted above the spacing of the gas tubes for any reflecting surface should be positioned apart not greater than about one half wavelength at the frequency involved.

Returning to FIG. 1 and to FIG. 3, each of said gas tubes, such as tube 17, is preferably comprised of a hollow sealed cylindrical body containing an ionizable gas 18 therein and being formed with a cylindrical wall of a non-conducting material, such as quartz, together with a top plate 20 and a bottom plate 21 of electrically conducting material, each being hermetically sealed to the quartz tube wall 19. The top and bottom plates 20 and 21 are in turn physically and electrically connected to the antenna upper plate 11 and lower plate 12, respectively, whereby when the gas tube 17 is triggered into its ionized conducting condition, an ionized conducting path or column exists at the position of that tube between the upper and lower antenna plates 11 and 12.

For individually triggering the gas tubes, each tube is also provided with a control electrode 22 positioned within the sealed tube and energizable by a voltage pulse to render the tube conducting. The electrode 22 is provided with a lead 22a that passes outwardly from the tube through a hermetically sealed and non-conducting joint 23 enabling each tube to be individually triggered into a conducting condition by an outside triggering source (not shown).

Returning to FIG. 4, it is noted that a relatively few gas tubes 24 may be positioned closely about the antenna feed 13. By selectively ionizing these tubes 24, a 90° beam pattern can be provided in any of the four quadrants which together form the 360° arc in the azimuth plane.

By horizontally positioning the antenna plates 11 and 12, variable beam shaping and scanning is obtainable in the azimuth plane whereas, by vertically positioning the plates, the electronic reflector operates in the elevation plane. Consequently, a pair of such antennas (not shown) arranged transversely to one another can provide scanning in two orthogonal planes.

In the arrangement of FIGS. 1 to FIG. 4, the beam pattern being produced is necessarily polarized in the direction of the gas filled tubes since a beam having an electric vector transverse to the columnar discharge is substantially unaffected by the spaced discharges and will not be reflected by the spaced ionized columns. Consequently, with the antenna plates 11 and 12 being disposed in the horizontal plane, the antenna beam is vertically polarized.

In FIGS. 5 to 8, there is shown a modification of the reflector structure suitable for producing a horizontally polarized beam pattern. In this modification, the outer parallel plates of the antenna are substantially the same as in FIGS. 1 to 3 and comprise a pair of circular conducting plates 31 and 32 that are spaced apart by an endless side ring or band 33 of material that is transparent to electromagnetic waves. As shown, the band 33 interconnects the plates about their peripheral edges providing a rigid support for the plates and sealing the antenna feed 35 and reflecting means 34 within the hollow antenna structure provided.

Within this sealed enclosure, there is centrally supported the antenna feed 35 which is constructed to transmit and receive a horizontally polarized wave in the TM mode; and concentrically about this feed 35, there is located a series-connected circle of short gas tubes 34, as best shown in FIG. 8; which tubes 34 are all horizontally disposed in the same plane as the antenna feed 35 and suitably suspended between the upper and lower plates 31 and 32.

A programmer device 50 supplies triggering voltages to the junctions, such as 36, 37, 38, 39 . . . , between the

tube sections thereby to fire different ones and groups of these tube sections 34, and provide a horizontally disposed ionized column reflector whose position may be angularly shifted over arcs extending to 360° or greater by firing different ones and groups of the gas tube sections. This horizontally disposed discharge column reflects the horizontally polarized beam as desired. In this embodiment, the ionized reflector 34 is circular and the antenna is fed at the center instead of at the focal point, as in the embodiment of FIGS. 1 to 4. Consequently, in this case, the antenna does not possess the gain that is obtainable with the vertically polarized embodiment of FIGS. 1 to 3 unless the aperture dimensions are apportioned accordingly. To increase the gain obtained with this embodiment, some correction may be obtained by varying the velocity of propagation of the wave as by additionally employing a dielectric lens, or by varying the spacing between the upper and lower conducting plates 31 and 32.

FIG. 7 illustrates further details of the antenna feed means for the arrangement of FIG. 5. As shown, the feed line elements may be introduced between the plates by either a coaxial line or by a waveguide (not shown) that projects centrally through the lower plate 32. The upper end of the feed 49, being located between the antenna plates 31 and 32, carries a cruciform shaped group of hollow tubes, generally designated 48, which contain the horizontally disposed radiating element lines 41, 42 and 44, 45, respectively. The ends of such lines are horizontally looped between the ends of tubes 48 to provide the radiating elements for each of the four quadrants of the antenna feed.

FIGS. 11 and 12 diagrammatically illustrate a further modification of the horizontally polarized antenna arrangement of FIG. 5 for the purpose of obtaining a greater variety of reflector shapes. In this arrangement a plurality of concentrically arranged circles of series connected gas tubes 81, 82, and 83 are provided between the upper and lower plates 96 and 97 and are concentrically positioned about the central antenna feed 92. As best illustrated in FIG. 11, different ones of the gas tubes in each circular series may be simultaneously fired either singly or in pairs or other groupings, such as tube 90 in the inner circle of tubes 83; tubes 88 and 89 in the middle circle 82; and tubes 86 and 85 in the outer circle 81, all to provide a greater variety of reflector shapes and locations than with the single circle tube series arrangement 34 of FIG. 5. As generally mentioned above, each of the gas tubes in each circular series is individually provided with an energizable lead such as 100, 101, 102 . . . , leading to a firing grid or the like whereby the tubes may be individually or collectively triggered into ionization in predetermined groups by manual controlling means or automatically by a programmer for scanning the antenna beam or varying its shape as desired.

FIG. 13 generally illustrates a combined antenna construction employing both the vertically polarized antenna arrangement of FIGS. 1 to 3 and the horizontally polarized antenna arrangement of FIG. 5 or FIG. 12 being operated together for the purpose of obtaining a beam pattern that is polarized in a plane other than the vertical or horizontal planes. The upper antenna portion 110 is similar to that of FIG. 1 and is arranged to produce a vertically polarized pattern as indicated by the vectors 116, and the lower antenna portion 111 is similar to that of FIG. 5 and employs a horizontal ionized reflector 120 and feed 119 for horizontal polarization. For simultaneously operating both antenna portions, the power source 112 (or receiver during reception) is connected to energize the feeds 115 and 119 of both antenna portions 110 and 111 thereby producing both polarized beams simultaneously. A variable phase shifter 113 is also interposed in the lines 117 and 118 feeding the lower antenna 111 whereby the relative phase of the signals energizing the two antenna portions may be varied as desired to

vary the resulting plane and type of polarization produced by the combined beams of the two antenna portions.

For obtaining a randomly variable polarization, each of the antennas 110 and 111 of FIG. 13 may be fed by a separate transmitter, with the two transmitters (not shown) operating a different frequencies. The phase shift between the two antenna feeds would therefore vary at a rate proportional to the difference in frequency, and the polarization of the combined beam would, therefore, vary at the same rate. For example, if the difference in frequency between the two feeds were one megacycle, then the polarization of the resulting beam varies through all types or planes at the rate of one million times each second providing the random polarization desired. It is, of course, understood that the gas tube reflector means of both antennas 110 and 111 are operated together so that the beams being generated by both antennas scan or otherwise vary in the same fashion.

FIG. 9 illustrates a further means for providing an electronic or ionized reflector whose position and configuration may be varied as desired to change the direction and shape of the beam. In this embodiment, the radial transmission line is incorporated as part of the structure of a cathode ray tube 60. Specifically, referring to FIG. 9, the cathode ray tube antenna structure is comprised of an outer flat face plate 63 of conducting material forming the upper plate of a radial transmission line antenna and an inner conducting screen or grid 66 within the tube envelope and positioned parallel to and spaced from the upper plate 63 to supply the lower member of the antenna.

The upper plate 63 is provided with a central sealed opening therethrough for accommodating an antenna feed means, indicated as members 64 and 65, that is introduced into the tube 60 from outside the envelope and serves to feed the electromagnetic energy between the upper plate 63 and lower grid or screen 66. The mesh of the lower grid or screen 66 is relatively fine relative to the wavelength at the frequency range of operation of the antenna whereby the lower screen 66 effectively operates as a continuous metal plate to provide a radial transmission line antenna as in FIG. 1.

The upper side portion or side surface 62 of the cathode ray tube envelope existing between the upper conducting plate 63 and grid 66 is of material such as glass or the like that is transparent to the passage of electromagnetic beam therethrough. The remaining outer portions of the tube envelope 61 may be of metal or other sufficiently strong and suitable material, as desired. As thus far described, therefore, the outer plate 63, inner mesh 66 and central antenna feed means 64 and 65 function as in the above embodiments to produce or receive an omnidirectional beam pattern radially outwardly from the antenna feed means between the plate 63 and grid 66.

For focusing and scanning the antenna beam, there is generated between the plate 63 and grid 66 an ionized cloud or electron beam 67 in a desired pattern configuration or shape. This electron cloud is produced by means including an electron gun 70 and deflecting plates, such as 71 and 72, positioned near the neck of the tube 60. The electron gun 70 within the cathode ray tube emits electrons, and these are accelerated by means of accelerating potentials toward the screen 66 and end face 63 of the tube. These electrons are focused in a concentrated beam 67 and deflected along either or both the "X" and "Y" axis by electrostatic fields generated by deflecting plates 71 and 72 or by magnetic deflection means (not shown). Since the lower plate portion of the transmission line antenna, according to this embodiment, is in the form of a fine mesh or screen 66, the electron beam 67 may pass through the open mesh and provide an electron cloud serving as a reflector for the antenna. This beam may be swept in any desired two dimensional pattern or displaced to any angular position between the plate 63 and grid 66 whereby the synthesized reflector being formed may be varied in shape or scanned in position as desired.

By providing a sufficiently concentrated electron cloud 67 in the manner, the antenna wave is reflected therefrom in essentially the same manner as in the embodiments discussed above thereby to enable rapid scanning or beam shaping as is desired.

In the embodiments of FIGS. 1, 5, 12 and 13, the means for providing the desired electron beam reflecting columns or segments are disclosed as being gas tubes or gas tube sections that may be individually fired or collectively fired in pairs or in predetermined groups to synthesize the shape and position of the beam reflector as desired. It is to be understood, however, that the invention is not intended to be limited in this manner since other known means may be employed to provide a plurality of spaced conducting paths or electron beam path in varying arrangements. For example, when using this antenna structure for receiving applications involving low power requirements, semi-conductor devices of known varieties may be substituted for the gas tubes and in such receiving applications where low noise conditions are desirable, such semi-conductors would be preferred. Since these and other changes may be made by those skilled in the art in the light of the present invention, this invention should be considered as being limited only by the following claims.

What is claimed is:

1. In a transmission line antenna comprised of two spaced conducting plates symmetrically disposed about a central transverse axis and an energizable antenna feed positioned between said plates and proximate said central axis, controllable means forming a plurality of spaced paths that are selectively renderable conductive and nonconductive in the spaced defined between said plates with each path being displaced in position from said feed to form an increment of a reflector, and selectively energizable means for said controllable means to provide energization of different ones of said paths to vary the position and configuration of said incremental reflectors thereby to electrically provide displacement of said reflector to different positions within the plates and variation of the reflecting surface configuration to vary the antenna beam pattern.

2. In the antenna system of claim 1, said controllable means comprising a plurality of electronic switches fixedly positioned between the antenna plates and said energizable means including a commutator for selectively actuating predetermined different groups of said switches thereby to displace said spaced conducting path reflector.

3. In the antenna system of claim 2, said electronic switches comprising a plurality of gas tubes positioned in a spaced predetermined pattern between the antenna plates and means for selectively energizing predetermined groups of said gas tubes to render the same conducting.

4. In a radial transmission line antenna comprised of two spaced electrically conducting plates symmetrically disposed about a central transverse axis and an energizable antenna feed positioned in-between said plates and proximate said central axis, controllable means between said plates forming a plurality of conducting paths in selectively predetermined patterns, and means selectively energizing said controllable means to vary the position and configuration of said pattern of conducting paths thereby to selectively vary the beam pattern and beam position.

5. In the antenna of claim 4, said controllable means comprising a plurality of space discharge devices fixedly positioned within the area defined by said plates and said energizing means comprising means to selectively trigger preselected groups of said space discharge devices to render the same conducting.

6. In the antenna of claim 4, said plates being part of a cathode ray tube device having a controllable means including an electron beam gun portion for providing a scannable beam of electrons between said plates in a series of predetermined pattern configurations in different posi-

tions with respect to the feed, and said controlling means including an electron beam focusing and deflecting portion that is energizable to vary the position of said scanned beam of electrons.

7. A cathode ray tube antenna comprising an outer face plate of conducting material and an inner plate positioned therefrom, said inner plate having a plurality of discrete positions thereon that are transparent to the transmission of an electron beam therethrough, whereby an electron beam may be injected in-between said plates at spaced positions to provide a plurality of spaced electron beam conducting paths between the plates as the electron beam is scanned over the inner plate, and energizable deflecting means for the tube for displacing said electron beam in predetermined patterns across the surface of the inner plate.

8. In an antenna, an upper and a lower electrically conducting member spaced apart from one another, an antenna feed disposed between said members and normally adapted to omnidirectionally radiate and observe outwardly between said members, and an electrically variable reflecting means disposed between said members and spaced from said feed, said means being variable both in surface configuration and in relative position with respect to said feed to vary both the beam shape and beam position, and controllable means for energizing said reflecting means to synthesize the reflector shape and position desired.

9. In the antenna of claim 8, said reflecting means including a plurality of normally nonconducting devices, each being physically spaced from the others and forming a nonconducting path between the upper and lower conducting members, and each being individually energizable by said controllable means to provide a conducting path between the upper and lower members.

10. In the antenna of claim 8, said reflecting means including a plurality of normally nonconducting devices, with certain of said devices being connected to other said devices, and said devices being energizable individually and in predetermined groups by said controllable means to synthesize different reflector shapes and to provide different reflector positions with respect to said antenna feed.

11. In the antenna of claim 8, said electrically variable reflecting means including a plurality of gas tubes.

12. In the antenna of claim 8, said antenna feed being energizable in the TEM mode and said electrically variable reflecting means comprising a plurality of spaced apart conductor devices, each being fixed in position to contact the upper and lower members and each being normally nonconducting electrically, and said controllable means including means for selectively rendering selected ones and groups of said devices conducting thereby to provide predetermined configurations of different spaced conducting paths between the members.

13. In the antenna of claim 8, said antenna feed being energized in the TM mode and said electrically variable reflecting means including a series of interconnected devices disposed in an arcuate path about the feed, said devices being normally nonconducting and being energizable by said controllable means to selectively render preselected ones and groups of said devices conducting.

14. A plurality of antennas as in claim 8 with the feed means of one of said antenna being energized in the TEM mode and the electrically variable reflecting means of said antenna being vertically polarized, and with another of said antenna being energized in the TM mode and the reflecting means thereof being horizontally polarized.

15. A plurality of antennas as in claim 8 with the feed means of each antenna being energized in the same mode and the reflecting means of all antennas being polarized in the same direction.

16. A plurality of antennas as in claim 8 with the feed means of different ones of said antennas being energized in different modes and the reflecting means of different

ones being polarized in different directions, and means for commonly energizing and commonly receiving energy from the feed means of different antennas at the same frequency but in an out-of-phase relationship thereby to provide randomly polarized antenna structure.

17. In the antenna of claim 8, means for energizing said feed means in the TM mode, and said reflecting means including a concentrically arranged arcuate device about the feed means, said device being normally nonconductive and being responsive to said energizing means to become selectively conductive along different portions of its arcuate length.

18. In the antenna of claim 17, a plurality of said arcuate devices concentrically positioned with respect to each other and with said feed means.

19. A variable beam shape and scanning antenna comprising a fixed antenna feed, an electron beam producing means, and a deflecting means for said electron beam to form a two dimensional grouping of electrons of variably controllable surface configuration spaced from said feed, and means energizing said deflecting means for angularly adjusting said grouping of electrons with respect to said feed to deflect the grouping to any desired angle within a 360° arc.

20. In the antenna of claim 19, said antenna comprising a pair of spaced conducting members with the antenna feed being positioned between the members to omnidirectionally observe outwardly between the members, one of said members being permeable to the passage of electrons therethrough, and means for deflecting said electron beam to selectively scan both arcuate and planar paths through said permeable member and at any angular position with respect to said feed over a complete 360° arc.

21. A two dimensional antenna beam focusing mechanism that is electrically variable both in configuration and in spatial orientation with respect to an antenna feed comprising: a support, a plurality of discrete members spaced

apart from one another in fixed positions with respect to said support over a two dimensional region, each member being normally nonconducting and being individually energizable to become conducting, an antenna feed means fixed in position with respect to said support, and switch control means for selectively energizing different ones of said members in preselected groups to variably synthesize both the shape of the antenna beam and the orientation of the beam in space.

22. A radio beam reflector that is variable both in surface reflecting configuration and in space orientation with respect to an antenna feed to adjustably vary both the beam pattern and its spatial angle of radiation comprising: a plurality of individual conductor-nonconductor means spaced apart from one another over a given region, each member being selectively energizable and deenergizable to selectively provide a conductive and nonconductive path at that position with respect to the antenna feed, each such member when energized forming an incremental portion of a reflecting surface, programming means for selectively energizing a plurality of such members in different groups of less than all of said members, thereby to synthesize different reflector surface configurations and different reflector spatial orientations with respect to the feed means.

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RODNEY D. BENNETT, *Primary Examiner*.

CHESTER L. JUSTUS, *Examiner*.

W. S. PYLES, H. C. WAMSLEY, *Assistant Examiners*.