

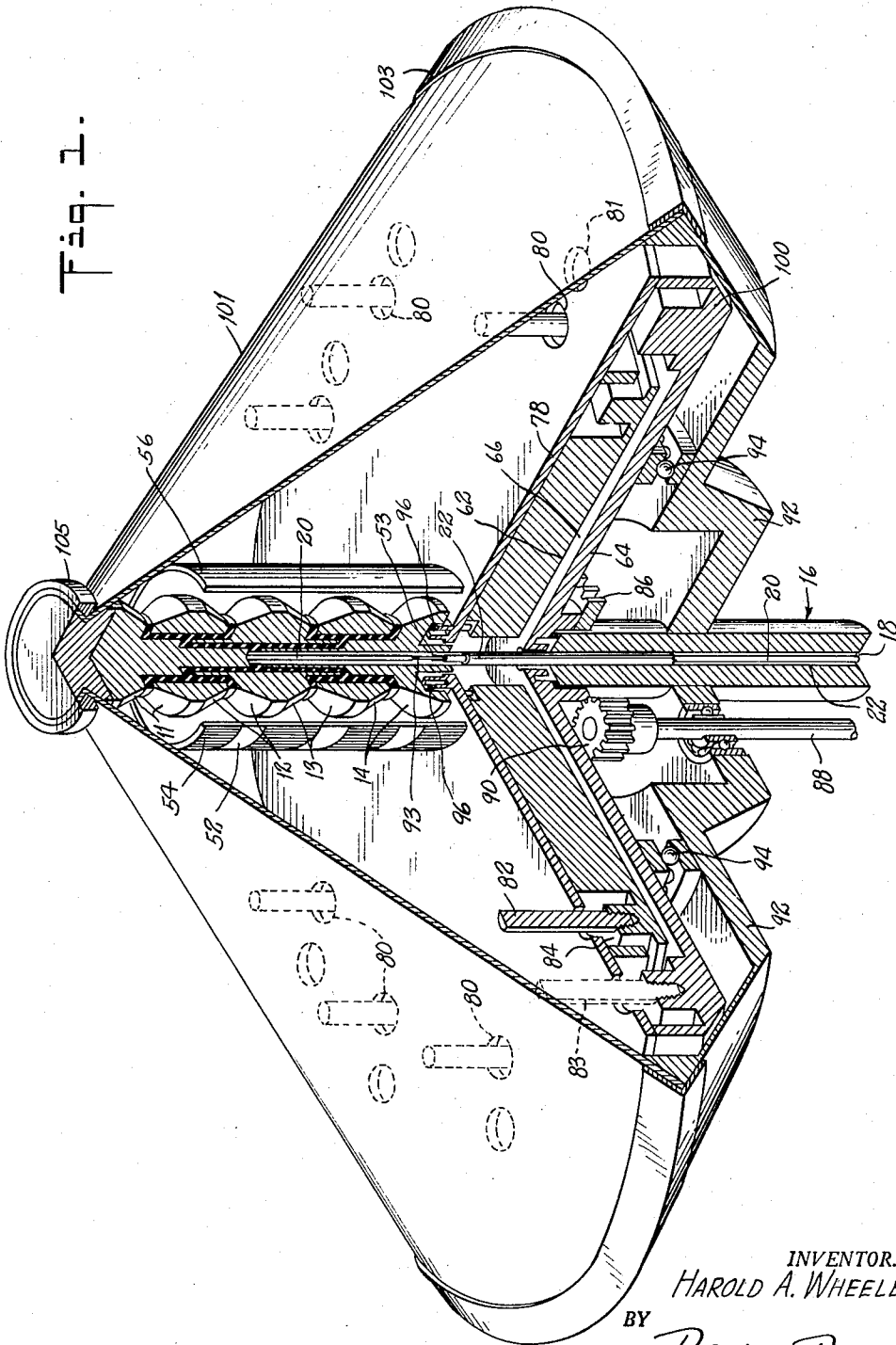
Sept. 29, 1959

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ROTATING BEACON ANTENNA

2,907,032

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2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 2.

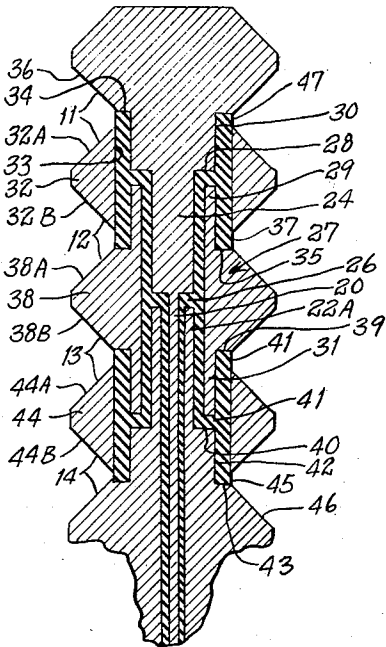


Fig. 3.

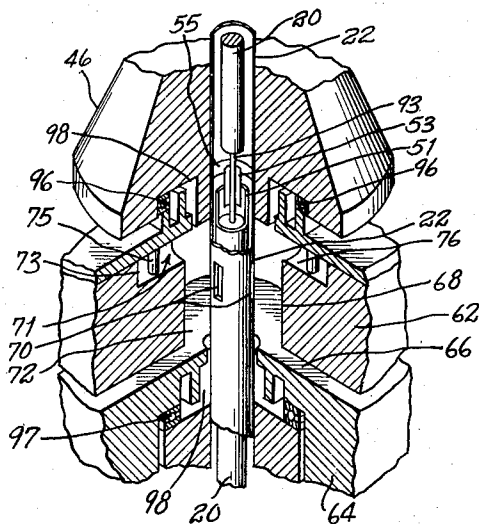


Fig. 4.

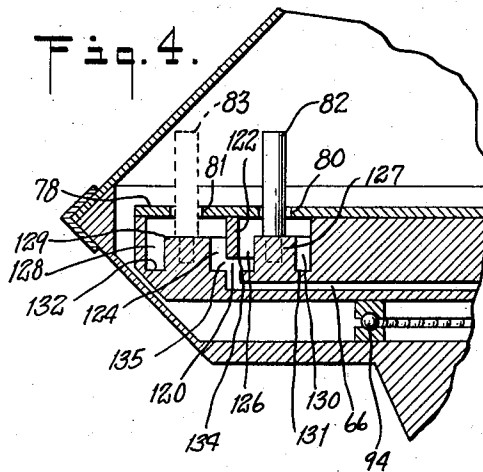
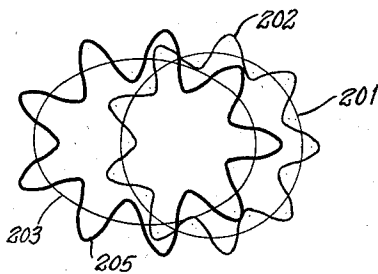


Fig. 5.



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ROTATING BEACON ANTENNA

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20 Claims. (Cl. 343-758)

The present invention relates to improvements in radio beacon antennas and particularly to an antenna device producing and radiating into space vertically polarized electromagnetic energy having a directivity pattern formed with convolutions and rotating to provide a double amplitude modulated signal at a reception point. Such rotating-directivity pattern radiators are often used in omni-directional radio range systems for determining the direction from the point of radiation to any point of reception within receiving distance therefrom.

It is a principal object of the present invention to provide an omni-directional range beacon antenna of the above described type operable at microwave frequencies and providing a symmetrical rotating-directivity pattern with the desired convolutions or scallops in a simple and efficient manner.

It is another object of the present invention to provide antenna means of the above type having good directivity in the vertical plane and having simple means for rotation to obtain the desirable directional characteristics.

Other objects and advantages of the present invention will become more fully apparent from the following description of a preferred embodiment thereof, taken in conjunction with the appended drawings, in which

Fig. 1 shows an isometric view partly in cross section of a preferred form of the present invention.

Fig. 2 shows an axial cross sectional view of a portion of Fig. 1 illustrating the manner of feeding the antennas of Fig. 1.

Fig. 3 is a fragmentary perspective view, partly in section, of a portion of the device of Fig. 1 showing the rotating coupler thereof.

Fig. 4 is a fragmentary radial elevational cross sectional view of a portion of the device of Fig. 1.

Fig. 5 shows several radiation patterns useful in explaining the operation of the present invention.

In its essential aspects, the present invention comprises a vertical array of biconical horns with vertical axis fed in like phase to radiate in all azimuth directions with sharply defined vertical directivity. Reflector means are provided to enhance radiation in one direction and to give a major axis of directivity. At the same time energy is supplied to a plurality of vertical rod antennas circularly disposed about the axis of the biconical array to provide a convoluted directivity pattern by interference or reinforcement with the waves radiated from the biconical array. The entire antenna assembly is then continuously rotated about its vertical axis to sweep the convoluted directivity pattern in azimuth as is desired.

Referring to the drawings, the entire antenna is supported from a post or mast 16. Energy is supplied at the lower end of a fixed coaxial line 18 within post 16 and having an inner conductor 20 and an outer conductor 22 coaxially surrounding the inner conductor 20. The line 18 is coupled to a vertically stacked array of four biconical horns 11, 12, 13 and 14 by means of a rotary coupler shown in more detail in Fig. 3 and by folded coaxial line sections shown most clearly in Fig. 2, pro-

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viding equal wave-travel-time and phase shift from line 18 to each of the horns.

As indicated in Fig. 2, the outer conductor 22 terminates in a thin-wall section 22A through which the inner conductor 20 passes. Joined at the upper end of inner conductor 20 is an enlarged section 24 thereof having a diameter the same as the outer diameter of the outer conductor section 22A and spaced therefrom coaxially to form an annular gap 26. Surrounding both the enlarged section 24 and the section 22A is a conductive element 27 having a concentric cylindrical bore which forms a coaxial line section with section 24 and a further coaxial line section with section 22A. From the configuration shown in Fig. 2, it will be clear that line sections 24, 27 and 22A, 27 are effectively in series with line section 20, 22.

At its upper end, element 27 is provided with a thin-walled cylindrical portion 29. Element 24 at its upper end is provided with an annular step 28 to provide a cylindrical surface 30 of the same diameter as the outer diameter of portion 29. Surrounding both of these cylindrical surfaces 30 and 29 and insulatedly separated therefrom is a member 32 having an inner bore 33 which forms coaxial line sections with the cylindrical surfaces 30 and 29. Here again, the line sections 30, 33 and 29, 33 are effectively in series with line section 24, 29.

Element 27 also has a lower thin-walled cylindrical portion 31 surrounding element 22A. Element 22A is provided with a lower step 40 to form a cylindrical surface 42 of the same diameter as the outer diameter of portion 31 of element 27. Coaxially surrounding both of these is an element 44 with an inner cylindrical bore forming further coaxial line sections 31, 44 and 42, 44 therewith. As in the previous instances, line sections 31, 44 and 42, 44 are effectively in series with line section 22A, 31.

Element 30 is provided with a step 34 at its upper end, forming an annular gap 47 with element 33. Element 27 has a step 35 at the lower end of its portion 29 to form a similar gap 37 with element 33. A similar step 39 is formed at the upper end of portion 31, to form another annular gap 41 with element 44. Element 42 also has a step shoulder 43 forming an annular gap 45 with element 44. The energy supplied to each of the four annular gaps 47, 37, 41 and 45 from line 18 is caused to be in the same line phase by making line sections 30-33, 29-33, 31-44 and 42-44 all equal, and by making line sections 24-27 and 22A-27 to be equal.

For the purpose of radiating the energy appearing at each of these gaps 47, 37, 41, 45, axially symmetrical biconical horns, 11, 12, 13, 14, are provided each flaring outwardly from a respective one of the gaps. Thus, flaring outwardly from shoulder 34 is a conical surface portion 36, and element 32 is formed with a connecting conical surface 32A. These surfaces 32A, 36 form horn 11 fed by gap 47.

Element 32 has a second conical surface 32B cooperating with a conical surface 38A on element 38 to form biconical horn 12 fed from gap 37.

Element 38 has a second conical surface 38B cooperating with conical surface 44A on element 44, to form horn 13 fed from gap 41. Similarly, element 44 has a second conical surface 44B cooperating with similar surface 46 adjacent step shoulder 43 to form horn 14 at gap 45.

The four horns 11, 12, 13, 14 are thus stacked vertically and constitute a broadside array for radiating omnidirectionally in azimuth. In a vertical plane, this array has a major lobe extending outwardly and upwardly. The first null elevation angle of this lobe may be substantially increased above 60 degrees elevation by tapering the energy fed to the respective horns so that a major

amount is supplied by the lowest horn and each horn above that radiates a successively lesser amount of energy. Such tapering is effected by properly proportioning the characteristic impedances of the branch line sections discussed above. As indicated above, the two primary branch lines are of equal length, and each in turn separates into two secondary branches, with all of the secondary branches being of equal length. Each pair of secondary branches is effectively in series and accordingly energy will be fed to them in reverse proportion to their impedances. This impedance for each secondary branch consists of the radiation impedance of the horn (which is effectively the terminating impedance for the secondary branch line) combined with the characteristic impedance of the secondary branch line itself. Hence, the resulting impedance for the uppermost secondary branch line section is made smallest, so it will radiate least energy, and the successive lower branches have successively higher impedances to properly taper or graduate the radiation from the four horns. Similarly, the two primary branch lines are in series and their impedances are determined by the resultant impedance of each pair of secondary branch lines at the terminus of the primary branch line taken together with the characteristic impedance of the primary branch line. These impedances are selected by designing the dimensions of the line sections in well known manner to apportion the flow of energy to the respective branches as desired.

The space between the elements just described is preferably filled with dielectric material or dielectric spacers for maintaining their separation and insulation.

The line 18 shown in Fig. 1 is joined to the biconical horn array described above by means of a folded line section shown most clearly in Fig. 3, the purpose of the folded line section being to increase the electrical length of the line 18 to the proper value for permitting correlation between the radiation from the horn array and from the post or rod antennas 82 described below. As seen in Fig. 3, the inner conductor 20 of line 18 terminates in a sleeve 51 closed at its bottom by the end of conductor 20. The inner conductor 20 is continued as a reduced diameter section 93 concentric with sleeve 51. A further sleeve 53 is interposed between sleeve 51 and inner conductor section 93 and is spaced from the bottom of sleeve 51. This latter sleeve 53 is connected to the outer conductor 22 by a disk 55 spaced from the upper end of sleeve 51. As a result, the line 20, 22 is continued as a line section 51, 53, which in turn is continued as a line section 53—93 to which is connected the main line 22, 20 leading to the horns. By means of this arrangement the electrical length of the line exceeds the physical length by the added sections 51, 53 and 53—93, which are correlated to have the length indicated below. Preferably each of these added sections has the same characteristic impedance as that of the main line.

Surrounding the biconical array 11—14 are a plurality of post or rod antennas 82 or 83 arranged in respective rings. As indicated below, the ring of antennas 82 is used alternatively with the ring of antennas 83, to provide the convolutions referred to above. These antennas 82, 83 are supplied with energy from line 18 by means of a radial parallel-plate transmission line or wave guide arrangement 66 formed by a pair of parallel conductive plate-like members 62, 64 having a uniform gap therebetween. The manner of excitation of radial line 66 is illustrated in Fig. 3. Element 62 is formed as a member of substantial coaxial length or thickness whose inner surface 68 is cylindrical and coaxial with the outer conductor 22 of line 18 to form a short coaxial line section therewith. Conductor 22 of input line 18 is provided with a plurality of axially extending slits 70 symmetrically disposed therearound. Three to eight of these slits may be used, as may be desired. These slits form a directional coupler between the coaxial line 18 and coaxial line 68, 22, in the manner described in U.S.

Patent No. 2,606,974 for "Directional Coupler" granted to H. A. Wheeler on August 12, 1952. As therein described, these slots are substantially one-quarter wavelength long at the center of the operating band and are dimensioned to pass only a few percent of the total energy flowing along line 18.

At its upper end, line 68, 22 communicates with a short parallel-plate radial line 71 short-circuited at its radially-outward end 73 and containing a plurality of terminating impedance elements 75 which absorb all energy travelling upward in line 68, 22 to line 71, whereby wave reflections and standing waves in line 66 are avoided. The energy supplied from line 18 through slits 70 is therefore fed through the parallel plate line 66 radially outward from the axis of the device.

The upper surface of member 62 is formed as a flat conductive sheet 78 having the characteristics of a ground plane. Sheet 78 is provided with a set of circular apertures 80 arranged symmetrically about the axis of the device and equi-distant from each other. By way of example, nine of these apertures may be provided. Extending through each of the apertures 80 is a circular antenna rod 82 spaced from the edge of the aperture 80 and extending therethrough.

The manner of exciting the rod antennas 82 from the radial line 66 is shown most clearly in Fig. 4 which is a fragmentary radial sectional view of the rod antenna arrangement. As seen in Fig. 4, the radial line 66 terminates in an annular chamber 120 having a cylindrical partition 122 which divides the chamber 120 into two parts 124 and 126, each of annular shape. Chamber 126 communicates with the series of apertures 80 adapted to receive the rod antennas 82. Also communicating with the apertures 80 is a further annular chamber 130. The rod antenna 82 extends upwardly from the partition 127 between chambers 126 and 130, through the ground plate 78 and is designed to have an electrical length above the ground plate 78 of substantially one-quarter wavelength at the center of the operating frequency band in which the rod antennas 82 are used. The chamber 130 is essentially a coaxial line section short-circuited at the lower end 131 and in parallel with the antenna 82 at the opening 80. It is also a quarter wavelength long at the same center frequency. The chamber 126 extending between the antenna 82 and the end of the radial line 66 is also a coaxial line section supplying energy from the radial line 66 to antenna 82. Because the chamber 130 is one-quarter wavelength long, it presents a high impedance at the antenna 82 and has substantially no effect on the antenna 82.

A second ring of apertures 81 are formed in ground plate 78 concentric with and radially opposite apertures 80, and communicating with chamber 124. A further annular chamber 128 is formed concentric with chamber 124 and separated therefrom by cylindrical wall 129, on which antenna rods 83 are adapted to be mounted, extending concentrically through apertures 81.

Antennas 83 are preferably used alternatively to antennas 82. It has been found that the band width desirable for the present device may be of the order of 25%. However, any one ring of rod antennas such as 82 will give practically satisfactory results only for a band width of the order of 12%. Accordingly, two rows of rod antennas are used alternatively, to cover the full 25% band width. It will be noted that the antennas 82 are closer to the central horn array than antennas 83 and are hence used in the higher frequency portion of the total band.

Antennas 83 are also designed to be substantially one-quarter wavelength long at the center of their operating band, and chamber 128 is of like length, thereby forming a coaxial line section of very high impedance in parallel with antennas 83, and having little effect upon radiation from antennas 83.

Chamber 124 also forms a coaxial line section, which

when added to section 128 forms substantially a half-wavelength line at the center frequency of antennas 82. This line is short-circuited at its end 132, and presents a very low impedance at its input end 135. Similarly, line section 126 in combination with line section 130 forms a short circuited half-wave line at the frequency of antennas 83. Hence, when antennas 82 are used (antennas 83 then being absent), line sections 128 and 124 prevent energy from passing to apertures 81, while when antennas 83 are used (antennas 82 then being absent), line sections 126 and 130 prevent energy from passing to apertures 80. Therefore for each half of the operating band, energy will pass only to the respective ring of antennas 82 or 83 used for that portion of the band.

As thus far described, the biconical horn array will radiate omni-directionally, with an essentially circular radiation pattern, such as 201 in Fig. 5. The effect of the antennas 82 or 83 is to inject radiation locally into the radiation emitted from the horn array. This injected radiation will partially reinforce and partially interfere with the radiation from the horns, and the net result will be a scalloped or convoluted radiation pattern such as shown at 202 in Fig. 5.

To provide substantially pure amplitude modulation without appreciable phase modulation, the energy radiated from the antennas 82 or 83 should be in phase coincidence with the energy radiated from the horn array. For this purpose, the length of the folded line arrangement shown in Fig. 3 is selected so that the energy at the foot of the horn array is in phase with the energy at the antennas 82, 83.

For the purpose of producing amplitude modulation of the energy received at any point spaced from the axis of the device, rings of antennas 82 and 83 are made to rotate about the axis of the horns. For this purpose, the members 62 and 64 forming the radial line 66 are formed as a turntable having a spur gear 86 at the center thereof, which gear is driven from a pinion 90 on a drive shaft 88 rotated by a motor in conventional manner. The turntable 100 may be supported from the fixed base 92 by means of bearings 94. Further bearings 96, 97, as seen in Fig. 3, may be interposed between the turntable 100 and the horn array, and between the turntable and line 18. Annular choke joints of conventional design indicated at 98 may be interposed to reduce the effect of bearing gap on the transfer of energy from the fixed coaxial line 18 to the line 66 carried by the turntable 100.

Since both the antennas 82 or 83 are continuously rotated at constant speed, such as, for example, 900 r.p.m. or 15 r.p.s., the entire radiation pattern 202 of Fig. 5 will rotate 15 times per second. By using nine antennas 82 or 83 distributed about the axis of the device, there will be nine fluctuations in amplitude of energy received at any reception point for each cycle or revolution of the complete pattern and, accordingly, an antenna at the reception point will receive energy amplitude modulated at 135 cycles per second.

In some cases it is also desirable to produce an amplitude modulation at the receiver at the actual frequency of rotation (i.e., 15 c.p.s.). For this purpose the biconical horn array is surrounded by a dielectric cylinder 56 which is permeable to radiation from the horns. Coated or superposed on cylinder 56 are bands of radiation-reflective material, such as metal paint. Each band has its center in substantially the same horizontal plane as the gap or throat of a respective horn, and the bands extend only partially around the circumference of the cylinder 56. For example, they may have arcuate extensions of between 100 and 180 degrees. The purpose of these bands is to inhibit radiation from the horns in the directions in which the bands may be located and to reinforce radiation in the opposite directions, thereby causing the radiation pattern produced to have a uni-directional aspect. As indicated, cylinder 56 is support-

ed on turntable 100 and continuously rotates with the other turntable structure described.

Alternatively, the reflective bands may be aligned with the outward tips of the biconical horns, leaving arcuate slits aligned with the horn throats. This will slightly inhibit radiation in that direction as compared to the opposite direction. Where desired, such slits may vary in width around the dielectric cylinder so as to obtain a desired shape of basic directivity pattern.

The entire structure is enclosed in a conical dielectric radome 101 sealed at its periphery 103 to the base and also sealed at its top at 105. The configuration of the entire antenna device is such that it can fit readily in a compact carrying case or shipping container of cubical form, with the plane of the turntable 100 as a diagonal plane of the container, thereby conserving space for packing and shipping. According to one design, the entire unit will fit into an approximately 41 inch cubic space, with an outer diameter of 50 inches for the radome.

Since many changes could be made in the above described 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 above described or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A beacon antenna system comprising an omni-azimuthal radiator for radiating vertically polarized radiant energy, a plurality of vertical rod antennas arranged in a ring about said radiator, a supply transmission line, means coupling said line to said radiator, and non-radiating means coupling said rod antennas to said supply line to be excited therefrom in equal phase.

2. An antenna system as in claim 1 further comprising means for uniformly rotating said ring of rod antennas about said radiator.

3. An antenna system as in claim 1, wherein said non-radiating coupling means includes means for exciting said rod antennas and said radiator in like phase.

4. A beacon antenna system comprising a vertically stacked array of omni-azimuthal biconical horns, a supply transmission line, means coupling said horns to said line, a plurality of vertical rod antennas arranged in a ring about said horn array, non-radiating means coupling said rod antennas to said supply line to be excited therefrom in predetermined phase relationship with the excitation of said horns and means uniformly rotating said ring of rod antennas about the axis of said array.

5. A beacon antenna system comprising a vertically stacked array of omni-azimuthal biconical horns, a supply transmission line, means coupling said horns to said line for cophasal excitation of said horns from said line, a reflector partially encircling said horns, a plurality of vertical rod antennas arranged in a ring about said horn array, non-radiating means coupling said rod antennas to said supply line to be excited therefrom in predetermined phase relationship with the excitation of said horns and means uniformly rotating said reflector and said ring of rod antennas about the axis of said array.

6. A beacon antenna system comprising a vertically stacked array of omni-azimuthal biconical horns, a supply transmission line, means coupling said horns to said line for cophasal excitation of said horns from said line with the amplitude of excitation graduated from a maximum at the bottom horn of said array to a minimum at the top horn, a reflector partially encircling said horns, a plurality of vertical rod antennas arranged symmetrically in a ring about said horn array, non-radiating means coupling said rod antennas to said supply line to be excited therefrom substantially cophasally with said horn array and with an amplitude of excitation of the order of magnitude of a few percent of the excitation of said horn array, and means uniformly rotating said

reflector and said ring of rod antennas about the axis of said array.

7. A beacon antenna system comprising a vertically stacked array of omni-azimuthal biconical horns, a supply transmission line, means coupling said horns to said line for cophasal excitation of said horns from said line with the amplitude of excitation graduated from a maximum at the bottom horn of said array to a minimum at the top horn, a reflector partially encircling said horns, a plurality of vertical rod antennas arranged symmetrically in a ring about said horn array, non-radiating means coupling said rod antennas to said supply line to be excited therefrom substantially cophasally with said horn array and with an amplitude of excitation of the order of magnitude of a few percent of the excitation of said horn array, and means uniformly rotating said reflector and said ring of rod antennas about the axis of said array, said transmission line being a coaxial line having inner and outer conductors, and said last coupling means comprising a conductive member having a cylindrical bore coaxially and rotatably surrounding said outer conductor, said outer conductor having a plurality of slots of length substantially equal to a quarter wave length adjacent the center of the operating frequency range and forming a directional coupler with said member, terminating impedance means coupled between said member and said outer conductor at one end of said bore, said member having a flat conductive portion surrounding said line and extending radially outward therefrom, a conductive plate adjacent and parallel to said flat conductive portion and forming a radial parallel plate transmission line therewith, and means coupling said rod antennas to said radial line.

8. A beacon antenna system as in claim 7 wherein said last named coupling comprises a ground plate parallel to said radial line, and having a plurality of antenna-receiving apertures disposed in a circle therearound, means for supporting said rod antennas projecting through but spaced from the edges of said apertures, a first coaxial line section between said radial line and said ground plate coupling said radial line to said ring of antennas and ground plate and a second short-circuited coaxial line section concentric with said first section also coupled to said ring of antennas and ground plate.

9. A beacon antenna system as in claim 8 further including a second like plurality of antenna-receiving apertures in said ground plate disposed in a circle therearound and concentric with said first circle, means for supporting a further row of rod antennas projecting through and spaced from the edges of said latter apertures, a third coaxial line section between said radial line and said ground plate coupling said radial line to said latter antenna-supporting means, and a fourth short-circuited coaxial line section concentric with said third section and also coupled to said latter antenna-supporting means, said first and third coaxial line sections being coupled in series to said radial line, said first and second coaxial line sections having a combined length forming a low impedance at said series coupling point at a frequency in the upper portion of the operating frequency range, and said third and fourth coaxial line sections having a combined length forming a low impedance at said series coupling point at a frequency in the lower portion of said range.

10. A beacon antenna system as in claim 8 further including a second like plurality of antenna-receiving apertures in said ground plate disposed in a circle therearound and concentric with said first circle, means for supporting a further row of rod antennas projecting through and spaced from the edges of said latter apertures, a third coaxial line section between said radial line and said ground plate coupling said radial line to said latter antenna-supporting means, and a fourth short-circuited coaxial line section concentric with said third section and also coupled to said latter antenna-supporting

means, said first and third coaxial line sections being coupled in series to said radial line, said first and second coaxial line sections having a combined length forming a low impedance at said series coupling point at a frequency in the upper portion of the operating frequency range, and said third and fourth coaxial line sections having a combined length forming a low impedance at said series coupling point at a frequency in the lower portion of said range, wherein said second short-circuited coaxial line section has a length of substantially one-quarter wavelength at said lower portion frequency, and said fourth short-circuited line section has a length of substantially one-quarter wavelength at said upper portion frequency.

11. An antenna system comprising a supply transmission line of the coaxial type having inner and outer conductors, a plurality of vertical rod antennas arranged symmetrically in a ring about a vertical axis, a conductive member having a cylindrical bore coaxially and rotatably surrounding said outer conductor, said outer conductor having a plurality of slots of length substantially equal to a quarter wave length adjacent the center of the operating frequency range and forming a directional coupler with said member, terminating impedance means coupled between said member and said outer conductor at one end of said bore, said member having a flat conductive portion surrounding said line and extending radially outward therefrom, a conductive plate adjacent and parallel to said flat conductive portion and forming a radial parallel plate transmission line therewith, and means coupling said rod antennas to said radial line.

12. An antenna system as in claim 11 further comprising a ground plate parallel to said radial line and having a plurality of antenna-receiving apertures disposed in a circle therearound, means for supporting said rod antennas projecting through but spaced from the edges of said apertures, a first coaxial line section between said radial line and said ground plate coupling said radial line to said ring of antennas and ground plate and a second short-circuited coaxial line section concentric with said first section also coupled to said ring of antennas and ground plate.

13. An antenna system as in claim 12 further comprising a second like plurality of antenna-receiving apertures in said ground plate disposed in a circle therearound and concentric with said first circle, means for supporting a further row of rod antennas projecting through and spaced from the edges of said latter apertures, a third coaxial line section between said radial line and said ground plate coupling said radial line to said latter antenna-supporting means, and a fourth short-circuited coaxial line section concentric with said third section and also coupled to said latter antenna-supporting means, said first and third coaxial line sections being coupled in series to said radial line, said first and second coaxial line sections having a combined length forming a low impedance at said series coupling point at a frequency in the upper portion of said range, and said third and fourth coaxial line sections having a combined length forming a low impedance at said series coupling point at a frequency in the lower portion of said range.

14. An antenna system as in claim 13, wherein said second short-circuited coaxial line section has a length of substantially one-quarter wavelength at said lower portion frequency, and said fourth short-circuited line section has a length of substantially one-quarter wavelength at said upper portion frequency.

15. An antenna system comprising a supply transmission line, a plurality of vertical rod antennas arranged symmetrically in a ring about a vertical axis, and means coupling said rod antennas to said supply line to be excited therefrom comprising a pair of parallel conductive surfaces parallel to the plane of said ring of antennas, said conductive surfaces being spaced from one another in the direction perpendicular to the plane of said ring

and forming a radial parallel plate line, means coupling said radial line at its center to said supply line, and means coupling said rod antennas to said radial line.

16. An antenna system comprising a supply transmission line, a plurality of vertical rod antennas arranged symmetrically in a ring about a vertical axis, and means coupling said rod antennas to said supply line to be excited therefrom comprising a pair of parallel conductive surfaces parallel to the plane of said ring of antennas and forming a radial parallel plate line, means coupling said radial line at its center to said supply line, means coupling said rod antennas to said radial line, a ground plate parallel to said radial line and having a plurality of antenna-receiving apertures disposed in a circle therearound, means for supporting said rod antennas projecting through but spaced from the edges of said apertures, a first coaxial line section between said radial line and said ground plate coupling said radial line to said ring of antennas and ground plate and a second short-circuited coaxial line section concentric with said first section also coupled to said ring of antennas and ground plate.

17. An antenna system as in claim 16 comprising a second like plurality of antenna-receiving apertures in said ground plate disposed in a circle therearound and concentric with said first circle, means for supporting a further row of rod antennas projecting through and spaced from the edges of said latter apertures, a third coaxial line section between said radial line and said ground plate coupling said radial line to said latter antenna-supporting means, and a fourth short-circuited coaxial line section concentric with said third section and also coupled to said latter antenna-supporting means, said first and third coaxial line sections being coupled in series to said radial line, said first and second coaxial line sections having a combined length forming a low impedance at said series coupling point at a frequency in the upper portion of said range, and said third and fourth coaxial line sections having a combined length forming a low impedance at said series coupling point at a frequency in the lower portion of said range.

18. An antenna system as in claim 17 wherein said second short circuited coaxial line section has a length of substantially one-quarter wavelength at said lower portion frequency, and said fourth short-circuited line section has a length of substantially one-quarter wavelength at said upper portion frequency.

19. An antenna adapted for operation in either of two frequency ranges, comprising a ground plate having a

pair of antenna-receiving apertures, means for supporting a respective rod antenna projecting through but spaced from the edge of each of said apertures, a supply line, a first line section coupled at one end to one of said antenna-supporting means and said ground plate, a second line section coupled at one end to the other of said antenna-supporting means and said ground plate, said first and second sections being connected in series across said supply line, means coupled to said first section to cause said first section to present a low impedance at said series connection at a first frequency in one of said ranges, and means coupled to said second section to cause said second section to present a low impedance at said series connection at a second frequency in the other of said frequency ranges.

20. An antenna adapted for operation in either of two frequency ranges, comprising a ground plate having a pair of antenna-receiving apertures, means for supporting a respective rod antenna projecting through but spaced from the edge of each of said apertures, a supply line, a first line section coupled at one end to one of said antenna-supporting means and said ground plate, a second line section coupled at one end to the other of said antenna-supporting means and said ground plate, said first and second sections being connected in series across said supply line, means coupled to said first section to cause said first section to present a low impedance at said series connection at a first frequency in one of said ranges, and means coupled to said second section to cause said second section to present a low impedance at said series connection at a second frequency in the other of said frequency ranges, said last means comprising a line section coupled between said last-named antenna-supporting means and said ground plate and of a length substantially one-quarter wave long at said first frequency and said means coupled to said first section comprising a line section coupled between the other antenna-supporting means and said ground plate and of a length substantially one-quarter wavelength at said second frequency.

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