

Sept. 27, 1960

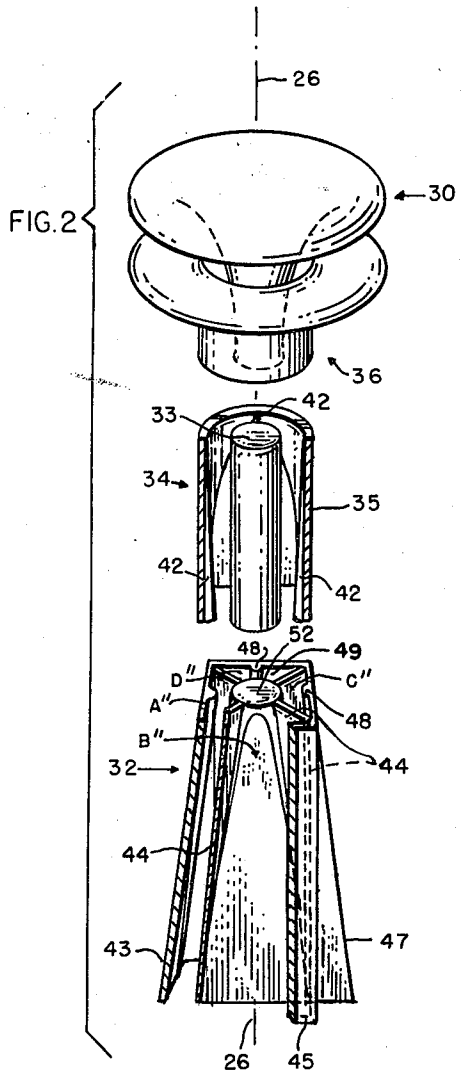
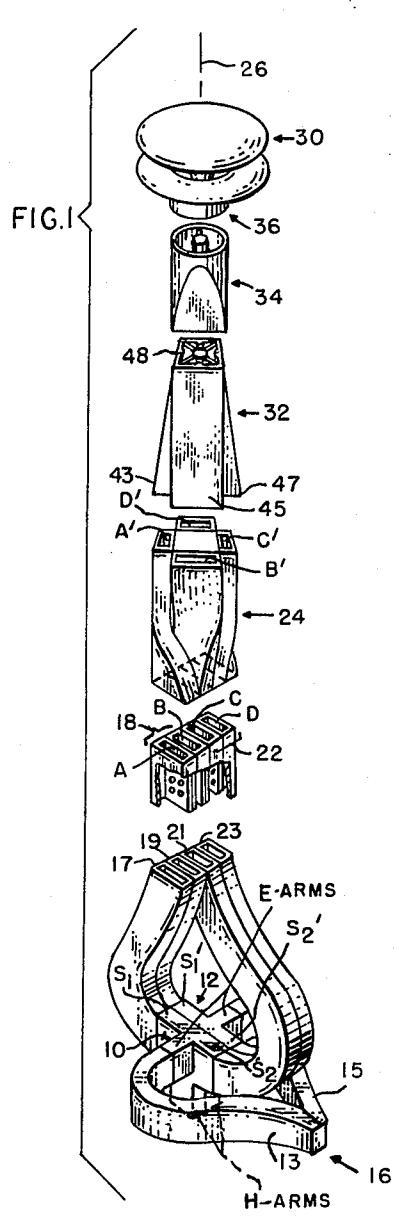
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2,954,558

OMNIDIRECTIONAL ANTENNA SYSTEMS

Filed March 20, 1958

2 Sheets-Sheet 1



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FIG. 3

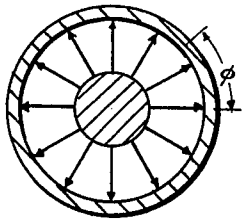


FIG. 4

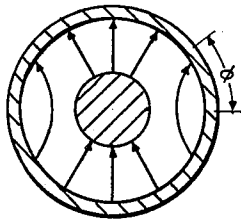
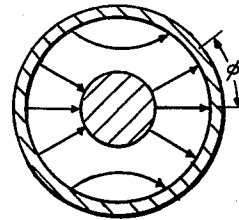


FIG. 5



COAXIAL LINE

FIG. 3a

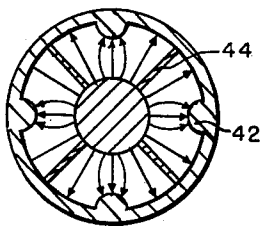


FIG. 4a

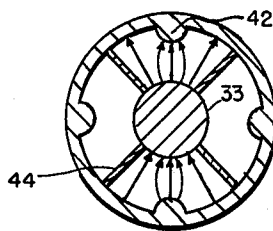
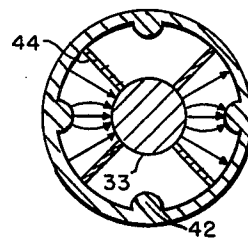


FIG. 5a



RIDGE WAVEGUIDES

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2,954,558

OMNIDIRECTIONAL ANTENNA SYSTEMS

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10 Claims. (Cl. 343-773)

The present invention relates to omnidirectional microwave antennas and more particularly to multiterminal omnidirectional antenna systems adapted for instantaneous direction finding over a relatively wide band of frequencies and especially suitable for multiplexing application.

The accuracy of a direction finding system is dependent upon the type of antenna employed in the system. The antennas presently employed in direction finding systems are limited by their narrow-band characteristics or utilize two separate antennas with concomitant complex circuitry. In the latter case, the indicated bearing is not only a function of the azimuth angle, but also a function of the elevation angle. It is an object of the present invention to provide an omnidirectional antenna system wherein the aforementioned limitations are overcome.

It is another object of the present invention to provide an omnidirectional antenna which is instantaneously responsive to signals arriving from any azimuth direction so that the direction of an incoming signal can be determined even if only one short pulse of energy is received.

It is still another object of the present invention to provide an omnidirectional antenna which may be operated over a very wide frequency range.

It is still a further object of the present invention to provide a multiterminal omnidirectional antenna system wherein the polarization and spacial distribution of the energy radiated by the antenna is independent of the particular input terminal excited.

It is still another object of the present invention to provide a multiterminal omnidirectional antenna wherein the input terminal pairs connected to the antenna structure are electrically isolated.

It is still another object of the present invention to provide a multiterminal omnidirectional antenna wherein all pairs of terminals provide the same polarization and essentially the same pattern in space.

In brief, one embodiment of the present invention provides an omnidirectional antenna system which may be used in connection with an instantaneous video direction-finder system. This antenna system includes a biconical type radiator having a prescribed axis and responsive to plane microwave radio-frequency energy for radial-line mode excitation. Also included are microwave energy propagating means coupled to the biconical radiator and responsive only to the excited TEM and TE_{10} radial-line modes whereby these radial-line modes are transformed respectively to TEM and TE_{11} coaxial-line modes. In addition, there are included four rectangular waveguides orthogonally positioned relative to each other and symmetrically arranged about the biconical radiator axis. Included further is a waveguide transition means interconnecting the four symmetrically arranged rectangular waveguides and the microwave energy propagating means whereby the TEM coaxial-line mode establishes equal amplitude and phase signals in each of the rectangular

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waveguides, and the TE_{11} coaxial-line mode establishes respective oppositely phased signals in mutually opposing pairs of the rectangular waveguides.

Another embodiment of the present invention provides an omnidirectional system which may be utilized either in connection with an instantaneous superheterodyne type direction-finder or as a wide-band multiplexed antenna. In brief, this system includes a biconical type radiator having a prescribed axis and responsive to plane microwave radio-frequency energy for radial-line mode excitation, and microwave energy propagating means coupled to the biconical radiator and responsive only to the excited TEM and TE_{10} radial-line modes whereby these radial-line modes are transformed respectively to TEM and linearly polarized TE_{11} coaxial-line modes. Also included are waveguide means symmetrically arranged about the prescribed biconical radiator axis for transforming the TEM coaxial-line mode and the linearly polarized TE_{11} coaxial-line mode into three orthogonal modes comprising the left-hand and right-hand circularly polarized TE_{11} coaxial-line modes, and the TEM coaxial-line mode. In addition, there are provided waveguide means for isolating the orthogonal modes from each other.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings in which:

Fig. 1 is an exploded view, shown in perspective, of the omnidirectional antenna system adapted for use as a multiplexed antenna or in connection with an instantaneous superheterodyne type direction-finder system;

Fig. 2 is an exploded view, with the elements partially cut-away, of the omnidirectional antenna system for use in connection with an instantaneous video type direction-finder system;

Figs. 3, 4 and 5 are illustrative diagrams showing the modes in the coaxial-line; and

Figs. 3A, 4A, and 5A are illustrative diagrams showing the corresponding modes in the four ridge-waveguide sections.

Referring now to Fig. 1, there is shown at 10 and 12 two identical symmetrical Magic-T waveguide couplers with their respective E-arms coupled to the symmetrically arranged series arms 13 and 15 of a series-T waveguide junction 16. As shown, the common termination of arms 13 and 15 forms a bifurcated waveguide opening of rectangular cross section, which together with the respective H-arms of Magic-T waveguide couplers 10 and 12 comprise the three ports, or terminals, of the antenna system. Corresponding side arms S_1 and S_1' of the Magic-T waveguide couplers are connected respectively to the two discrete inputs of a quadrature hybrid junction, or a 3-db multi-hole directional coupler, 18, through rectangular waveguides 17 and 19. Similarly, corresponding side arms S_2 and S_2' of the Magic-T waveguide couplers 10 and 12 are connected through respective rectangular waveguides 21 and 23 to the two discrete inputs of a quadrature hybrid junction, or a 3-db multi-hole directional coupler, 22, which is identical in construction to quadrature hybrid junction 18. It is to be noted that rectangular waveguides 17, 19, 21, and 23 are structurally identical and symmetrically arranged such that the waveguide paths from the respective side arms connecting to the hybrid junction terminals are of the same length and the free ends of the waveguides 17-23 are linearly aligned. The hybrid junctions 18 and 22, which may comprise a Hewlett-Packard X752A multi-hole directional coupler, each have the property that a signal fed into a terminal at one end will emerge from the two terminals

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at the other end with equal amplitude and a 90° phase difference. Thus for each input applied to hybrid junctions 18 and 22, there are provided two outputs of equal power but with 90° phase difference. For convenience, the two waveguides which comprise hybrid junction 18 have been labeled A and B, respectively, and the two waveguides comprising hybrid junction 22 have been labeled C and D, respectively. As shown, one end of each of the hybrid junction waveguides A, B, C, and D is connected to the respective free waveguide terminations of waveguides 17—23. The other end of each of the hybrid junction waveguides A, B, C, and D is connected to one end of a waveguide transition section 24, hereinafter referred to as the waveguide 45°-twist-section. It is the function of waveguide section 24 to provide a gradual transition from the linearly aligned hybrid junction waveguides A, B, C, and D, to four discrete waveguides orthogonally positioned relative to each other and symmetrically arranged about a prescribed antenna axis 26. The construction and operation of the 45°-twist-section 24 is described in the April 1956 issue of the IRE Transactions, vol. MTT-4, pages 131 and 132. The orthogonally positioned waveguides A', B', C', and D' of waveguide 45°-twist-section 24, which correspond respectively to the waveguides A, B, C, and D of hybrid junctions 18 and 22, are coupled to a biconical antenna 30 through respective waveguide transition section 32, coaxial transition section 34, and coaxial feed-line 36. As shown, the spaced elements comprising the antenna 30 are formed by flaring out both the inner and outer conductor of coaxial-line 36 so that the biconical radiator tapers into the coaxial-line at its center and the axis of the coaxial-line coincides with antenna axis 26. The parameters of the coaxial feed-line 36 are chosen such that it will propagate only the TEM and the TE₁₁ coaxial modes, all others being cut off. The transition sections 32 and 34 are so constructed and arranged that there is not only a gradual transition from the waveguide modes to the coaxial mode but, also, the symmetrical orthogonal relationship of the waveguide modes about the antenna axis 26 is maintained. The detailed construction of transition sections 32 and 34 are shown in Fig. 2 together with the biconical antenna 30.

Referring now to Fig. 2, the inner conductor 33 of coaxial transition section 34 is a continuation of the center conductor of coaxial feed-line 36 and the outer conductor 35 of coaxial transition section 34 tapers from the round or circular configuration of the outer conductor of coaxial feed-line 36 at the top, as shown on the drawing, to a square configuration at the bottom. Thus, in effect, the outer periphery of coaxial transition section 34 comprises a four sided figure with substantially flat surfaces. Affixed to each of the respective inner flat surfaces of the four sides along the centers thereof are longitudinal ridges 42 which taper from zero height at the top end of section 34, i.e., the end thereof adjacent to coaxial-line 36, to a prescribed maximum at the bottom thereof. Waveguide transition section 32 is an integrated structure comprising four identical hollow wedge-shaped structures 43, 45, 47, and 49 orthogonally positioned relative to each other and symmetrically arranged about axis 26. The cross section of coaxial transition section 34 at its junction with waveguide transition section 32 is divided into four identical ridge-loaded waveguides by inserting four identical fins 44 into waveguide section 32. These four fins extend from the corners of the square configuration of the outer conductor formed by the sloping walls of the wedge shaped structure 43—49 into the round center conductor 52 at the upper end of section 32. The edges of these fins are perpendicular to the antenna axis 26. The upper end of waveguide transition section 32 coincides in dimension with the configuration at the bottom of coaxial transition section 34, except for the introduction of the four fins 44. Within waveguide transition section 32, the four symmetrically-located, ridge-loaded waveguide

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channels, A'', B'', C'', and D'', formed by fins 44 taper to the four symmetrically-located, rectangular waveguide channels, A', B', C', and D'. This is done by tapering ridges 48 from the maximum thickness at the top of waveguide transition section 32, to match the ridges at the bottom of coaxial transition section 34, to zero thickness at the bottom, and by altering the cross-sectional shape of the inner conductor 52 from round at the top of waveguide transition section 32 to square at the bottom. The cross-section configuration at the bottom of transition 32 is identical to the cross-section configuration of the four symmetrical waveguides at the top of waveguide 45°-twist-section 24, to which it is attached as shown in Fig. 1.

The antenna structure shown in Fig. 2 comprising the biconical antenna 30, coaxial feed-line 36 and transition sections 32 and 34 can be utilized in connection with an instantaneous video type direction-finder while the complete antenna structure shown in Fig. 1 can be utilized as a wide-band multiplexed antenna and, also, in connection with an instantaneous superheterodyne type direction-finder. The video type direction-finder antenna will now be considered.

As is well known in the art, a plane wave incident on the antenna excites a large number of propagating radial-line modes in the antenna which are transformed into coaxial-line modes by the flared section between the biconical antenna 30 of the uniform coaxial-line 36. However, as hereinabove mentioned the parameters of the uniform coaxial-line 36 are such that it will propagate only the TEM and the TE₁₁ modes, all others being cut off. Thus, since the TEM radial-line mode is transformed into the TEM coaxial-line mode and the TE₁₀ radial-line mode is transformed into the TE₁₁ coaxial-line mode, only the behavior of these two modes will be considered in the following discussion. For the TEM mode, the amplitude of the electric field is independent of the azimuth angle ϕ while the electric field configuration characteristic of the TE₁₁ mode in the coaxial-line 36 is such that the electrical field intensity is proportional to the sine of the azimuth angle ϕ . The energy in the TEM mode and TE₁₁ mode in the coaxial-line 36 is split among the four ridge-loaded waveguides A'', B'', C'', and D'' symmetrically arranged about the axis 26 of the coaxial-line. Figs. 3, 4, and 5 show the electrical field configurations existing in the four ridge-loaded waveguide channels of transition sections 32 and 34 when the coaxial-line is excited by the TEM and TE₁₁ modes. From Fig. 3A, it is seen that the TEM mode establishes equal phase and amplitude signals in all four ridge-loaded waveguides. From Figs. 4A and 5A, however, it can be seen that the TE₁₁ mode sets up fields in opposite waveguide channels that are equal in amplitude but in opposing phase. Figs. 4A and 5A show the direction of the established electric field when the electric field varies as $\sin \phi$ and $\cos \phi$, respectively. It can readily be ascertained from Figs. 3, 4, and 5 that a signal incident on biconical antenna 30 from an azimuth direction ϕ will excite signals in the four ridge-loaded waveguides given by the vector sum of the TEM and TE₁₁ modes. With such an arrangement, the only additional equipment necessary to provide an instantaneous direction-finder are four suitable discrete square law detectors respectively responsive to the outputs of each of the four ridge-loaded waveguides, and a conventional oscilloscope. It is to be understood of course, that the square law detectors may be coupled to the discrete channels of waveguide transition section 32 by means of respective rectangular waveguides (not shown). The detectors provide video signals which measure the sum of the TEM and the TE₁₁ coaxial-line modes, and by taking the difference in the signals from opposite pairs of detectors, the following two video output signals

$$E_v = C \sin \phi \cos \phi$$

and

$$E_h = C \cos \phi \cos \delta$$

are obtained where ϕ is the angular bearing of the received signal, and δ is the net phase difference between the TEM mode and the TE_{10} radial-line and the TE_{11} coaxial-line modes due to their different phase velocities in antenna 30 and coaxial-line 36. If these two signals are applied to the vertical and horizontal plates of the oscilloscope, the angular position of the radial trace is a direct measure of the bearing angle. Since both E_v and E_h are proportional to $\cos \delta$, the video output of the difference signal goes to zero whenever $\cos \delta$ goes to zero. It is desirable therefore to maintain $|\cos \delta|$ as near unity as possible throughout the frequency band. This system was found to be very effective for determining the arrival of a received signal from any azimuth direction over a 1.5 to 1 frequency band.

The complete antenna structure shown in Fig. 1, provides signals which may be applied to phase comparison direction finding systems. The circuitry of Fig. 1 can best be understood by considering the transmitting case. It is to be assumed that conventional waveguide mode microwave energy can be applied to any of the three input terminals, i.e., the input of series-T waveguide junction 16 and the respective H-arms of Magic-T waveguide couplers 10 and 12. The waveguide mode energy applied to the input of series-T waveguide junction 16 will divide equally in the bifurcated waveguide arms 13 and 15 so that equal amounts of energy will be applied to the respective E-arms of Magic-T's 10 and 12. Since signals entering the E-arm of a Magic-T divide out-of-phase in the two side arms, it is apparent that the signals applied respectively through waveguides 17 and 19 to the terminals of the 3-db quadrature hybrid junction 18 are in phase. Similarly, the signals applied to the two terminals of hybrid junction 22 are in phase with each other, but out-of-phase with those applied to hybrid junction 18. Hence, after passing through hybrid junctions 18 and 22, the signals at the orthogonally arranged waveguide channels A', B', C', and D' of waveguide 45°-twist-section 24 will be in phase but symmetrically arranged about axis 26. As a result, the channeled signals arriving at antenna 30 and coaxial-line 36 through transition sections 32 and 34 will be in phase to excite only the TEM mode in coaxial-line 36 and antenna 30. Considering now the conventional waveguide mode microwave energy signal applied to the H-arm of Magic-T 10, it can be seen that the signals entering waveguide 17 through side arms S_1 will be in phase with the signal entering waveguide 21 through side arm S_2 . The energy applied to one terminal of 3-db hybrid junction 18 via waveguide 17 divides equally between output waveguides A and B, but with a 90-degree phase difference between them. Similarly, the energy applied to 3-db hybrid junction 22 via waveguide 21 divides equally between output waveguides C and D, but with a 90-degree phase difference between them. After going through the waveguide 45°-twist-section 24, these equal signals arrive at waveguides A', B', C' and D' with a progressive 90-degree phase difference around the periphery. This excites the circularly-polarized TE_{11} mode in coaxial transition section 34 and coaxial-line 36, which is transformed to the "spiral-phase" TE_{10} radial-line mode in antenna 30. This "spiral-phase" TE_{10} radial-line mode produces a figure-eight radiation pattern in space which rotates about the antenna axis 26 at the R-F. frequency. This rotating field distribution is termed a "spiral-phase" mode since a line of constant phase in the far-field radiation pattern forms a spiral. In an identical manner, if the conventional waveguide mode energy is applied to the H-arm of Magic-T 12, a figure-eight radiation pattern is produced by antenna 30 that rotates in the opposite direction at the R-F. frequency. The two circularly polarized components of the TE_{11} coaxial-line mode and the TEM

mode thus represent three orthogonal modes so that the respective H-arms of Magic-T's 10 and 12 and the series-T junction 16 input terminal may be considered to be three independent terminals. It can be shown that the two circularly polarized components have amplitudes of one-half the amplitude of the linearly polarized TE_{11} coaxial mode and that the power associated with each of the right-and-left circularly polarized components is equal to that of the TEM mode. The radiation patterns of the TEM mode and of the spiral-phase TE_{10} modes in the biconical antenna have amplitudes that are independent of azimuth angle, but with phase differences that are dependent only on azimuth angle. Thus the direction of arrival of a received signal may be determined with no ambiguity by measuring the phase difference between the TEM mode and either of the spiral-phase modes. Moreover, since the modes are orthogonal and since each radiates essentially the same omnidirectional power pattern, the antenna system can be used as a three terminal pair omnidirectional multiplexing antenna. Good isolation is assured between the several channels of this antenna system since each terminal couples to a mode in the biconical antenna 30 that is orthogonal to all the others. Moreover, each of the modes in the antenna have the same polarization and each have essentially the same far-field pattern.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An omnidirectional antenna system comprising, a biconical type radiator having a prescribed axis and responsive to plane microwave energy for radial-line mode excitation, microwave energy propagating means coupled to said radiator and responsive only to the TEM and TE_{10} radial-line modes whereby said radial-line modes are transformed respectively to TEM and TE_{11} coaxial-line modes, four rectangular waveguides orthogonally positioned relative to each other and symmetrically arranged about said prescribed axis, and waveguide transition means inter-connecting said four rectangular waveguides and said microwave energy propagating means whereby the TEM coaxial-line mode establishes equal amplitude and phase signals in each of said rectangular waveguides, and the TE_{11} coaxial-line mode establishes respective oppositely phased signals in mutually opposing pairs of said rectangular waveguides.

2. An omnidirectional antenna system comprising, a biconical type radiator having a prescribed axis and responsive to plane microwave energy for radial-line mode excitation, a uniform coaxial feed-line having its axis aligned with said prescribed axis and adapted to propagate only the TEM and TE_{11} coaxial-line modes, means for coupling said uniform coaxial-line to said biconical radiator whereby the TEM and TE_{10} radial-line modes excited in said radiator by the plane wave incident thereon are transformed to TEM and TE_{11} coaxial-line modes in said uniform coaxial-line, four rectangular waveguides orthogonally positioned relative to each other and symmetrically arranged about the coaxial feed-line axis, and waveguide transition means interconnecting said four rectangular waveguides and said uniform coaxial feed-line whereby the TEM coaxial-line establishes equal amplitude and phase signals in each of said rectangular waveguides, and the TE_{11} coaxial-line mode establishes respective oppositely phased signals in opposing pairs of said rectangular waveguides.

3. The antenna system in accordance with claim 2 wherein said waveguide transition means include four

discrete ridge-loaded waveguide channels symmetrically arranged about said coaxial feed-line axis.

4. An omnidirectional antenna system comprising, a biconical type radiator having a prescribed axis and responsive to plane microwave energy for radial-line mode excitation, microwave energy propagating means coupled to said radiator and responsive only to the TEM and TE_{10} radial-line modes whereby said radial-line modes are transformed respectively to TEM and linearly polarized TE_{11} coaxial-line modes, waveguide means symmetrically arranged about said axis for transforming said TEM coaxial-line mode and said linearly polarized TE_{11} coaxial-line mode into three orthogonal modes comprising the right-hand and left-hand circularly polarized TE_{11} coaxial-line modes, and said TEM coaxial-line mode, and means for isolating said orthogonal modes from each other.

5. An omnidirectional antenna system comprising, a biconical type radiator having a prescribed axis and responsive to plane microwave energy for radial-line mode excitation, microwave energy propagating means coupled to said radiator and responsive only to the TEM and TE_{10} radial-line modes whereby said radial-line modes are transformed respectively to a TEM coaxial-line mode and a linearly polarized TE_{11} coaxial-line mode, four rectangular waveguides orthogonally positioned relative to each other and symmetrically arranged about said prescribed axis, means including a pair of quadrature hybrid junctions responsive to the mode energy in said rectangular waveguides whereby there are produced three orthogonal modes comprising the left-hand and right-hand circularly polarized TE_{11} modes and said TEM coaxial-line mode, and means for isolating said orthogonal modes from each other.

6. An omnidirectional antenna system comprising, a biconical type radiator having a prescribed axis and responsive to plane microwave energy for radial-line mode excitation, a uniform coaxial feed-line having its axis aligned with said radiator axis and adapted to propagate only the TEM coaxial-line mode and the linearly polarized TE_{11} coaxial-line mode, means for coupling said uniform coaxial feed-line to said biconical radiator whereby the TEM and TE_{10} radial-line modes excited in said radiator are transformed to said TEM and TE_{11} coaxial-line modes, waveguide means symmetrically arranged about said axis for transforming said TEM coaxial-line mode and said linearly polarized TE_{11} coaxial-line mode into three orthogonal modes comprising the right-hand and left-hand circularly polarized TE_{11} coaxial-line modes and said TEM coaxial-line mode, and waveguide means for isolating said orthogonal modes from each other.

7. An omnidirectional antenna system comprising, a biconical type radiator having a prescribed axis and responsive to plane microwave energy for radial-line mode excitation, a uniform coaxial feed-line having its axis aligned with said radiator axis and adapted to propagate only the TEM coaxial-line mode and the TE_{11} coaxial-line mode, means for coupling said uniform coaxial feed-line to said biconical antenna whereby the TEM and TE_{10} radial-line modes excited in said radiator are transformed to said TEM and TE_{11} coaxial-line modes, four rectangular waveguides orthogonally positioned relative to each other and symmetrically arranged about said prescribed axis, a waveguide transition structure coupled between said rectangular waveguide and said coaxial feed-line whereby there is provided a gradual transition from said coaxial-line to each of the rectangular waveguides, said transition means including four ridge-waveguide channels symmetrically arranged about the radiator axis and adapted to propagate the TEM and TE_{11} coaxial-line modes from said coaxial-line to said rectangular waveguides such that the TEM coaxial-line mode establishes equal amplitude and phase signals in each of said rectangular waveguides and the TE_{11} coaxial-line mode establishes respective oppositely phased signals in opposing

pairs of said rectangular waveguides, means including a pair of quadrature hybrid junctions responsive to the mode energy in said rectangular waveguides whereby there are produced three orthogonal modes comprising the left-hand and right-hand circularly polarized TE_{11} coaxial-line modes and said TEM coaxial-line mode, and means for isolating said orthogonal modes from each other.

8. An omnidirectional antenna system comprising, a biconical type radiator having a prescribed axis and responsive to plane microwave energy for radial-line mode excitation, a uniform coaxial feed-line having its axis aligned with said radiator axis and adapted to propagate only the TEM coaxial-line mode and the linearly polarized TE_{11} coaxial-line mode, means for coupling said uniform coaxial feed-line to said biconical antenna whereby the TEM and TE_{10} radial-line modes excited in said radiator are transformed to said TEM and TE_{11} coaxial-line modes, four rectangular waveguides orthogonally positioned relative to each other and symmetrically arranged about said prescribed axis, a waveguide transition structure coupled between said rectangular waveguide and said coaxial-line whereby there is provided a gradual transition from said coaxial-line to the rectangular waveguides, said transition means including four ridge-waveguide channels symmetrically arranged about the radiator axis and adapted to propagate the TEM and TE_{11} coaxial-line modes from said coaxial-line to said rectangular waveguides such that the TEM mode establishes equal amplitude and phase signals in each of said rectangular waveguides and the TE_{11} coaxial-line mode establishes respective oppositely phased signals in opposing pairs of said rectangular waveguides, a first and second quadrature hybrid junction each comprising two waveguides, a second waveguide transition structure for coupling the mode energy in said rectangular waveguides to the quadrature hybrid junctions such that there are produced from said quadrature junctions three orthogonal modes comprising the left-hand and right-hand circular polarized TE_{11} coaxial-line mode and said TEM coaxial-line mode, and means for isolating said orthogonal modes from each other.

9. The antenna system in accordance with claim 8 wherein said last mentioned means comprises a first and second Magic-T waveguide coupler each having two side arms an H-plane and an E-plane arm, a series-T waveguide junction having two rectangular waveguide arms terminating in a common bifurcated waveguide junction, the free ends of said arms being connected respectively to the E-plane arms of said first and second Magic-T, discrete rectangular waveguides, of equal length, individually coupling corresponding side arms of said first and second Magic-T's to the respective waveguides comprising the first and second quadrature hybrid junctions the H-plane arms of said first and second Magic-T's being the respective isolated terminals for the left-hand and right-hand circularly polarized TE_{11} coaxial-line modes, and the common waveguide junction of said E-plane arms being the isolated terminal of the TEM coaxial-line mode.

10. The omnidirectional antenna system in accordance with claim 2 wherein said waveguide transition means comprises: a coaxial transition section having its inner conductor a continuation of the center of said coaxial feed-line, and having its outer conductor tapering from the circular configuration of the outer conductor of said coaxial feed-line to a square configuration such that the outer periphery of said coaxial transition section comprises a four sided figure with substantially flat surfaces, longitudinal ridges affixed to each of the respective inner flat surfaces of the four sides along the centers thereof, said ridges tapering from zero height at the end of said coaxial transition section adjacent said coaxial feed-line to a prescribed maximum at the other end of said coaxial transition section; and a waveguide transition structure comprising an integrated structure having four identical hollow wedge-shaped structures orthogonally positioned relative to each other and symmetrically arranged about said

axis, one end of said waveguide transition structure coinciding with the square configuration of said coaxial transition section and the other end of said waveguide transition structure having a cross-section configuration which coincides with the four orthogonally positioned waveguides. 5

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