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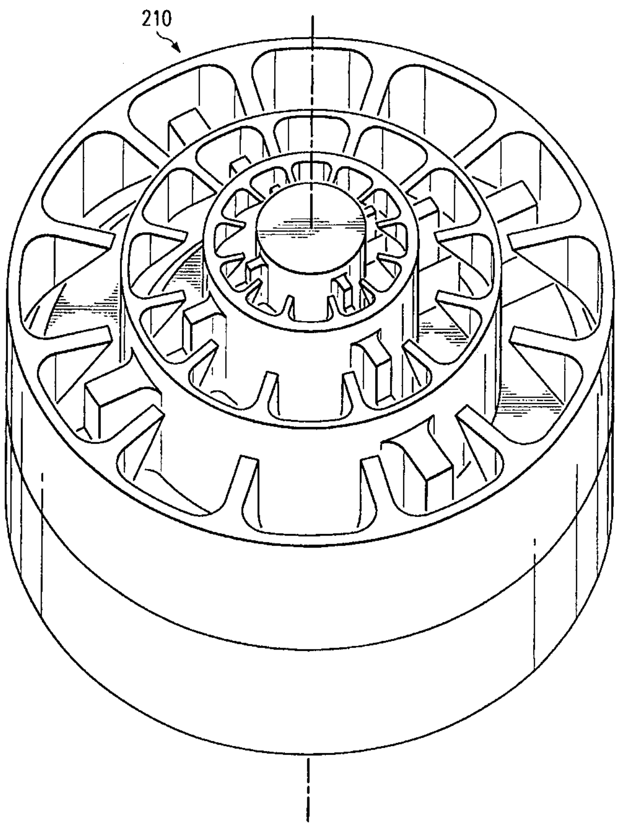
(54) Title: COAXIAL CAVITY ANTENNA

(57) Abstract

A coaxial cavity antenna including a cylindrical inner conductor sized for propagation of electromagnetic signals in a preselected frequency range. The coaxial antenna also includes a cylindrical outer conductor positioned coaxial with the inner conductor, and having a diameter larger than the inner conductor. The outer conductor has an aperture ring disposed at an end of the outer conductor. The outer conductor is positioned with respect to the inner conductor to form a cavity between the inner conductor and the outer conductor. The cavity is sized for propagating electromagnetic signals in the preselected frequency range. The coaxial cavity antenna also includes a plurality of aperture teeth radially oriented and disposed around the aperture ring, and an iris ring positioned inside the cavity at a predetermined distance from the aperture ring. In addition, the coaxial cavity antenna includes a plurality of septums coupled to the inner conductor and the iris ring, and a plurality of cable supports coupled to the outer conductor.



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COAXIAL CAVITY ANTENNA

TECHNICAL FIELD OF THE INVENTION

This invention relates generally to antennas and more particularly to a coaxial cavity antenna.

BACKGROUND OF THE INVENTION

Coaxial antennas have been produced for some time. However, they have all suffered from electrical plane ("E-plane") and magnetic plane ("H-plane") pattern differences. Specifically, in a typical coaxial radiator, differences in the aperture distributions of the E & H planes cause the E-plane pattern to narrow as frequency increases. This narrowing is not desirable in a dual polarized antenna, that is, the net result is wide azimuth/narrow elevation for one sense of polarization and narrow azimuth/wide elevation for the other sense of polarization. For the case of the dual circularly polarized coaxial antenna, this is undesirable as it results in unacceptable axial ratio performance. Similarly, for a dual linearly polarized coaxial antenna, E & H plane pattern differences result in unacceptable differences in field of view coverage. The differences in the E & H plane patterns also limits the useful operating bandwidth.

Previous coaxial antenna technology has approximately a 30% usable bandwidth. This is achieved by employing various combinations of inner to outer diameter conductors, radial aperture stubs, and miscellaneous other feeding schemes and arrangements.

SUMMARY OF THE INVENTION

Accordingly, a need has arisen for a polarization diverse, high gain, wide bandwidth antenna with low dispersion properties. The present invention provides a coaxial cavity antenna that addresses shortcomings of prior systems and methods.

According to one embodiment of the invention, a coaxial cavity antenna includes a generally cylindrical inner conductor sized for propagation of electromagnetic signals in a predetermined frequency range. The coaxial antenna also includes a generally cylindrical outer conductor formed generally coaxial with the inner conductor, and having a larger diameter than the inner conductor. The outer conductor includes an aperture ring disposed at an end of the outer conductor. The outer conductor is positioned with respect to the inner conductor to form a cavity between the inner conductor and the outer conductor. The cavity is sized for propagating electromagnetic signals in a predetermined frequency range. The coaxial cavity antenna also includes a plurality of aperture teeth disposed around the aperture ring, and an iris ring disposed inside the cavity at a predetermined distance from the aperture ring. Furthermore the coaxial cavity antenna includes a plurality of septums coupled to the inner conductor and the iris ring, and a plurality of cable supports coupled to the outer conductor.

The invention provides numerous technical advantages. For example, the problem of a narrow E-plane has been minimized in an antenna in accordance with the present invention. The antennas of the present invention exhibit substantially symmetric E-plane and H-plane performance over reasonably wide angles, such as ±60 degrees, and over reasonably wide frequency bandwidths, such as an octave per sub-band. Another advantage of the present invention is that the antennas are scalable, and through the appropriate choice of inner to outer cavity sizes and depths can be nested in a concentric configuration to provide multi-octave performance.

Other advantages offered by the present invention are dual polarization, high gain, relatively small size and weight, wide bandwidth, and excellent amplitude and phase response in terms of pattern control, phase/amplitude tracking, and cross polarization. All of these are over a field of view greater than or equal to ±60 degrees. Antennas in accordance with the present invention have been constructed having bandwidths of 0.5 to 2.0 GHz, 2.0 to 8.0 GHz, and even the whole 2.0 to 18.0 GHz range.

Antennas in accordance with the present invention have applications as elements in interferometers, polarimetry antennas, and as various types of reflector feeds. Antennas incorporating the present invention have excellent dispersion properties making them excellent time domain antennas for use in very wideband systems. Antennas in accordance with the present invention can be arrayed in vertical stacks in order to provide increased directivity (gain) by narrowing the elevation beamwidth. In addition, antennas in accordance with the present invention have few mechanical parts, and are relatively simple to machine and assemble, and have proven to be repeatable.

In summary, the present invention provides a novel, wideband, high gain antenna capable of producing dual linear and/or dual circular polarization simultaneously. Desirable symmetric E & H plane patterns over broad bandwidths, heretofore unknown in coaxial antennas, have been achieved through the physical composition of the invention.

Other technical advantages are readily apparent to one skilled in the art from the following figures, descriptions, and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and the advantages thereof, reference is now made to the following descriptions taken in connection with the accompanying drawings in which:

FIGURE 1 is an isometric view of a coaxial cavity antenna representing an embodiment of the present invention;

FIGURE 2 is an isometric view of a multi-band coaxial cavity antenna also representing an embodiment of the present invention;

FIGURE 3 is an isometric view of multi-band coaxial cavity antenna representing yet another embodiment of the present invention;

FIGURE 4 is an isometric view of the inner portion of the coaxial cavity antenna of FIGURE 1;

FIGURE 5 is an isometric view of the outer portion of the coaxial cavity antenna of FIGURE 1;

FIGURE 6 is a diagram illustrating an antenna feed network for use in conjunction with an antenna of the present invention;

FIGURE 7 is an exploded view of a coaxial cavity antenna representing an embodiment of the present invention; and

FIGURE 8 is a cross sectional view of a coaxial cavity antenna in accordance with the present invention.

FIGURE 9 is a schematic illustration of a coaxial cavity antenna in accordance with the present invention identifying the dimension of an antenna;

FIGURES 10A and 10B are schematic illustrations of the aperture teeth and the iris ring septums, respectively, for a coaxial cavity antenna of the previous Figures;

FIGURE 11 is an isometric view of a coaxial cavity antenna representing an embodiment of the present invention for radiating non-circular patterns;

FIGURE 12 is an isometric view of a vertical array of coaxial cavity antennas represented by the embodiments of FIGURES 1-3; and

FIGURE 13 is an isometric view of a line array of coaxial cavity antennas represented by the embodiments of FIGURES 1-3.

DETAILED DESCRIPTION OF THE INVENTION

Embodiments of antennas in accordance with the present invention and advantages of the antennas are best understood by referring to FIGURES 1 through 13 of the drawings, like numerals being used for like and corresponding parts of the various Figures.

FIGURE 1 is an illustration of a coaxial cavity antenna 10 representing one embodiment of the present invention. Coaxial cavity antenna 10 includes a hollow, cylindrical inner conductor 12 and a cylindrical outer conductor 14 having opposite ends 16 and 18. In the illustrated embodiment, inner conductor 12 is closed at an end 16. However, inner conductor 12 can also be open at end 16, and this open space could serve as a circular waveguide antenna. In addition, although the illustrated embodiment incorporates a hollow inner conductor 12 to reduce the weight of coaxial cavity antenna 10, the inner conductor 12 could also be solid. Outer conductor 14 is disposed around and generally concentric with inner conductor 12 about axis 50. The annulus between the inner conductor 12 and the inner diameter of outer conductor 14 forms cavity 20.

Inner conductor 12, outer conductor 14, and cavity 20 are sized for effectively propagating electromagnetic waves in a range of frequencies. In the embodiment of an antenna of the present invention shown in FIGURE 1, the end of inner conductor 12 extends outward along axis 50 from the end of the outer conductor 14. However, in other embodiments the end inner conductor 12 and the end outer conductor 14 are equal along the axis 50. All elements of the antenna illustrated in FIGURE 1 can be scaled either larger or smaller to effectively propagate electromagnetic waves of lower or higher frequencies, respectively.

As illustrated, the outer conductor 14 includes an aperture ring 22 and a base 15. Aperture ring 22 can be formed integral with base 15 or it can be a separate part and detachable from base 15. In the illustrated embodiment, aperture ring 22 has an outer diameter equal to the outer diameter of base 15. In addition, in the embodiment wherein the aperture ring 22 is a separate part and detachable from the base 15, aperture ring 22 and base 15 are formed such that aperture ring 22 can be securely attached to base 15. An exploded view of such an embodiment is illustrated in FIGURE 7.

Aperture ring 22 includes a plurality of aperture teeth 24 that are radially oriented and disposed around the inside diameter of the aperture ring. In the embodiment of the antenna of the present invention illustrated in FIGURE 1, aperture teeth 24 are triangular in shape, and are equally spaced around the inside diameter of aperture ring 22 with each aperture tooth oriented generally radially towards axis 50 of the coaxial cavity antenna 10. One purpose of aperture teeth 24 is for pattern control.

More specifically aperture teeth 24 function to make the E-plane and H-plane performance substantially symmetric over reasonably wide angles such as ±60 degrees.

Coaxial cavity antenna 10 further includes an iris ring 26, best illustrated in FIGURES 4 and 7. Iris ring 26 has an inner diameter approximately equal to the outer diameter of inner conductor 12. However, the outer diameter of iris ring 26 is less than the inner diameter of outer conductor 14. The iris ring 26 is attached to the inner conductor 12 inside cavity 20, but does not contact an inner wall 28 of outer conductor 14.

In addition, coaxial cavity antenna 10 includes a set of four aperture blocks or septums 30. In the embodiment of the present invention shown in FIGURE 4, septums 30 resemble steps. In order to more clearly illustrate the configuration and placement of septums 30, an isometric view of inner conductor 12, iris ring 26, and septums 30 is shown in FIGURE 4. Septums 30 are attached to iris ring 26 and inner conductor 12. Septums 30 are positioned around inner conductor 12 at ninety degree intervals, and are attached to inner conductor 12 such that a plane passing through opposed septums includes axis 50. One function of septums 30 is for pattern control in conjunction with the aperture teeth 24. Another function of septums 30 is impedance matching.

All of the elements described above are preferably fabricated out of a conductive material. Aluminum offers a fairly lightweight and inexpensive option. However, for more weight-sensitive applications, conductive composite materials can be used.

Coupled to the inner wall 28 of outer conductor 14 are a plurality of cable supports 32, shown in FIGURE 5. The number of cable supports 32 equals the number of coaxial cables (not explicitly shown) that are required to receive and transmit signals. In the embodiment shown in FIGURES 1 and 5, there are four cable supports 32. A conventional coaxial cable comprises an inner conductor and outer conductor that are insulated from each other. The coaxial cables are fed from end 18 of coaxial cavity antenna 10 through cable supports 32. The outer conductor of the coaxial cable is terminated to a cable support 32 and the center conductor protrudes past the cable support and into the iris ring 26, which is connected to inner conductor 12, as described above. It should be noted that iris ring 26 and cable supports 32 are not in contact, although in close proximity.

Referring to FIGURE 7, there is shown an exploded view of a coaxial cavity antenna 10 embodying the present invention, and FIGURE 8, where there is shown a cross sectional view of the coaxial cavity antenna embodying the present invention.

The computation to determine the diameters of inner conductor 12 and outer conductor 14 and the use of iris ring 26 in conjunction with cable supports 32, septums 30 and aperture teeth 24 is discussed below. As mentioned previously, the feed cables come up through and are grounded to cable supports 32 with the center conductors of the coaxial cables extending to the iris ring 26. The radial dimension between opposed feed cables as well as the size of cable support 32, the spacing between cable support 32 from iris ring 26, the diameter and thickness of iris ring 26, and the separation of iris ring 26 from end 18 all play a role in providing an efficient transition from the coaxial feed cables to the antenna. The transition is characterized in terms of impedance matching and/or voltage standing wave ratio (VSWR). Septums 30 and aperture teeth

24 provide additional matching support but serve mainly to equalize the E & H plane patterns. Finally, the overall depth of cavity 20 also influences the pattern performance of the antenna. The antenna as described above provides an efficient impedance match over a wide frequency range.

Polarization diversity is achieved through the use of a feed network. An example of feed networks 310 and 320 are illustrated in FIGURE 6. The use of a feed network can produce either two orthogonal linear polarizations or both senses of circular polarization (right-handed and left-handed). As illustrated in FIGURE 6, two 180 degree hybrids 340 are utilized for either case, and a 90 degree hybrid 350 is added behind hybrids for feed network 320 to get dual circular polarization. Specifically, the TE11 coaxial mode is excited by feeding signals from oppositely spaced coaxial feed terminals 330a and 330b with equal amplitude and a 180 phase shift relative to one another into 180 degree hybrids 340. The output of 180 degree hybrids 340 each provide one sense of linear polarization. The delta port is terminated. In this manner, using 180 degree hybrids 340, the signals from the four coaxial feed terminals are translated into two orthogonal linear polarizations. By definition, the two orthogonal linear polarizations are offset 90 degrees from each other. Depending on the orientation of the antenna, this can be horizontal and vertical polarization, two slant linear polarizations (oriented at ±45 degrees), or some other combination.

Subsequently, connecting these outputs through a 90 degree hybrid 350 produces both left and right circular polarization at the output ports of 90 degree hybrid 350. It should be noted that although feed networks 310 and 320 are for use with a single coaxial cavity antenna as illustrated in FIGURE 1, such networks can be modified to work with a coaxial cavity antenna with multiple sub-bands, as described below in conjunction with FIGURES 2 and 3. In this case, the feed networks are simply replicated for each respective sub-band.

Referring to FIGURES 2 and 3, there is illustrated multi-band coaxial cavity antennas 110 and 210 representing additional embodiments of the present invention. As mentioned above, the size of coaxial cavity antenna 10, illustrated in FIGURE 1, is scalable. In other words, it can be sized to operate over different frequency bands. In addition, coaxial cavity antennas representing embodiments of the present invention can be nested to provide multi-band performance. Such scaling and nesting are illustrated by coaxial cavity antennas 110 and 210. Coaxial cavity antenna 110 comprises two coaxial cavity antennas. The smaller, higher frequency antenna is nested inside the larger, lower frequency antenna. Similarly, coaxial cavity antenna 210 comprises three coaxial cavity antennas. Antennas of the present invention are not limited to those illustrated in FIGURES 1, 2 and 3. Both the number and size of the antennas can be varied to form various configurations of antennas of the present invention.

The components of each nested antenna of coaxial cavity antennas 110 and 210 are similar in form to those of coaxial cavity antenna 10, described in conjunction with FIGURE 1. The various components only differ in size. Therefore, each component of the antennas of FIGURES 2 and 3 will not be described again. In order to nest a plurality of antennas, the outer conductor of the innermost antenna serves as the inner conductor for the next surrounding antenna. This is repeated for each successive antenna. In addition each nested antenna has a separate set of four coaxial cables (not explicitly shown) and four coaxial feed terminals (not explicitly shown). Such coaxial cables are connected to each nested antenna as described above in conjunction with coaxial cavity antenna 10.

Referring to FIGURE 9, there is shown an illustration identifying the dimensions for scaling an antenna to effectively propagate electromagnetic waves of lower or higher frequencies. The various parts of the antenna illustrated in FIGURE 9 are identified with like numerals as used in FIGURE 1 describing in detail the various parts of the antenna 10. A description of each of the dimensions illustrated in FIGURE 9 are given by Table 1.

TABLE 1

Dimensions	
R1 -	Outer Cavity Inside Radius
R2 -	Inner Cavity Outer Radius
R3 -	Radius to Outside Edge of Feed Probe Center Conductor
R4 -	Radius to Center of Feed Probe Center Conductor
R5 -	Radius to Feed Probe Shelf
F -	Feed Ring Thickness
G -	Feed Ring to Feed Probe Gap Width
H -	Cavity Base to Top of Feed Probe Height
I -	Top of Feed Probe to Aperture Height

Referring to FIGURE 1 and FIGURE 9 along with Table 1, dimensions for a single sub-band coaxial cavity antenna 10 is given by Table 2.

TABLE 2

FREQ. RANGE (GHz)		*2.50-4.50*
Cavity Wall radius	R1	1.1758
Cavity Wall radius	R2	0.6930
Probe Iris radius	R3	1.0164
Rad to Coax C/L	R4	1.0095
Rad to shelf edge	R5	0.8266
Probe Iris Thickness	F	0.1156
Probe Iris to Shelf gap width	G	0.0578
Cavity Base to top of Shelf Height	H	0.7970
Top of Shelf to Aperture Height	I	1.0834
Cavity Height	H+I	1.8804

With reference to FIGURE 1, the dimensions illustrated are for a single sub-band coaxial cavity antenna operating in a frequency range from 2.50 GHz to 4.50 GHz. The dimensions are illustrated in FIGURE 9 and explained in Table 1.

With reference to FIGURE 10A, there is illustrated one of the twelve teeth 24 as shown in FIGURE 1 and also illustrated for the two sub-band coaxial cavity antenna 110 of FIGURE 2. FIGURE 10B is an illustration of the two parts of a septum 30 as shown in FIGURE 1 for the coaxial cavity antenna 10 and also illustrated in FIGURE 2 for the two sub-band coaxial cavity antenna 110. With reference to Table 3, there is given the dimension for each of the teeth 24 for the single sub-band coaxial cavity antenna 10 of FIGURE 1 operating in a frequency range of 2.50 GHz to 4.50 GHz. Table 4 gives the dimensions of the two parts of the septum 30 for the single sub-band antenna operating in a frequency range of 2.50 GHz to 4.50 GHz. For other frequencies, the dimensions given in Tables 2, 3 and 4 are adjusted as required.

TABLE 3

A =	0.3232
B =	0.4620
C =	0.0694

TABLE 4

A =	0.2
B =	0.3
C =	0.265
D =	0.2
Width =	0.1

Also given by way of example in Tables 5, 6 and 7 are the dimensions of a two sub-band coaxial cavity antenna 110, as illustrated in FIGURE 2. The dimensions given in Tables 5, 6 and 7 are for a two sub-band antenna operating in a frequency range of 0.50 GHz to 2.00 GHz, with the lower sub-band operating in a frequency range of 0.50 GHz to 1.00 GHz and the upper sub-band operating in a frequency range of 1.00 GHz to 2.00 GHz. Reference is also made to FIGURES 9, 10A and 10B and Table 1 for illustrating the relationship between the dimensions of Tables 5, 6 and 7 and the two sub-band coaxial cavity antenna 110 of FIGURE 2. Note that with reference to Tables 6 and 7, the first or upper set of dimensions in each of these Tables is for the lower sub-band in a frequency range of 0.50 GHz to 1.00 GHz and the lower set of dimensions in Tables 6 and 7 is for the sub-band in the range of 1.00 GHz to 2.00 GHz. Again, the dimensions are scaled for antennas operating in higher or lower frequency ranges than is given by Tables 5, 6 and 7.

TABLE 5

FREQ. RANGE (GHz)		*0.50-1.00*	*1.00-2.00*
Cavity Wall radius	R1	5.3192	2.6596
Cavity Wall radius	R2	3.1350	1.5675
Probe Iris radius	R3	4.5980	2.2990
Rad to Coax C/L	R4	4.5668	2.2834
Rad to shelf edge	R5	3.7392	1.8696
Probe Iris Thickness	F	0.5229	0.2614
Probe Iris to Shelf gap width	G	0.2614	0.1307
Cavity Base to top of Shelf Height	H	3.6054	1.8027
Top of Shelf to Aperture Height	I	3.8562	1.9281
Cavity Height	H+I	7.4617	3.7308

TABLE 6

A = 1.4622

B = 2.0900

C = 0.3139

A = 0.7311

B = 1.0450

C = 0.1569

TABLE 7

A =	1.0000
B =	1.5000
C =	1.3248
D =	1.0000
Width =	0.5000
A =	0.5000
B =	0.7500
C =	0.6624
D =	0.5000
Width =	0.2500

Referring to FIGURE 11, there is shown an embodiment of the coaxial cavity antenna of the present invention providing a shaped propagated electromagnetic wave. The coaxial cavity antenna 410 of FIGURE 11 includes an elliptical-shaped inner conductor 412 and a similar elliptical-shaped outer conductor 414. The shaped coaxial cavity antenna 410 of FIGURE 11 includes the circumferentially distributed aperture teeth as described with reference to FIGURE 1 and also the aperture blocks or septums (also shown in FIGURE 1.) Also included in the shaped coaxial cavity antenna 410 are the cable supports 32 as illustrated in FIGURES 5 and 7. Thus, the variation of the antenna of FIGURE 11 from the antenna of FIGURE 1 is found in the elliptical-shaped inner conductor 412 and the similarly elliptically-shaped outer conductor 414.

It should also be noted with reference to FIGURE 11 that multi-band coaxial cavity antennas such as illustrated in FIGURES 2 and 3 may have elliptically-shaped inner conductors and outer conductors to propagate a shaped electromagnetic wave.

Referring to FIGURE 12, there is shown an embodiment of the invention incorporating coaxial cavity antennas in a vertical array. As illustrated, a single sub-band coaxial cavity antenna 510 is vertically positioned with reference to a single sub-band coaxial cavity antenna 512. A vertical array of the coaxial cavity antennas of the present invention provide increased directivity (gain) by narrowing the elevation beam width. Although FIGURE 12 illustrates only two single sub-band antennas as illustrated and described with reference to FIGURE 1 in a vertical array, additional such antennas may be vertically arrayed to further increase directivity. In addition, the multi-band coaxial cavity antennas of FIGURES 2 and 3 may also be vertically arrayed to provide enhanced directivity to propagation of electromagnetic waves. It should be noted that the antennas 510 and 512 include the various parts described with reference to the antenna of FIGURE 1.

Referring now to FIGURES 13 and 14, there is illustrated a line array of coaxial cavity antennas in accordance with the present invention. Although the antennas of FIGURES 13 and 14 are illustrated as reflector feeds, this is given by way of example only and not by way of limitation. As illustrated, the line array includes a horizontal line of received coaxial cavity antennas 610 and a horizontal line of transmit coaxial cavity antennas 612. The line array of antennas 610 and 612 are mounted to a support 614 and spaced from a reflector 616.

The coaxial cavity antennas 610 and 612 comprise the single sub-band antenna 10 as illustrated and described with reference to FIGURE 1. The antennas are scaled for the frequency band width of the operating system.

The various antennas of the present invention described above have numerous applications. These applications include use as a wideband, frequency scalable, high gain, and polarization diverse antenna. The coaxial antenna can be used as an element in an interferometry array for performing precision direction finding. The antenna can also be used as a radar warning receiver antenna. The unique pattern performance of the coaxial antenna enables use as a very high precision polarimetry antenna for characterizing emitter polarization. Furthermore, the circular symmetry of the antenna provides substantially equal azimuth and elevation pattern performance.

For some applications, such as platforms at long stand off ranges, it may be desirable to have wide azimuth and narrow elevation pattern performance. This can be accomplished by distorting the antenna shape into an elliptical or rectangular shape such as illustrated in FIGURE 11. The elongated dimension provide narrower field of view coverage and also increase the directivity of the antenna. This can also be accomplished by stacking two coaxial antennas vertically.

The wideband coaxial antennas of the present invention can also be arrayed and implemented as a feed for reflector antennas as illustrated in FIGURES 13 and 14 in addition to use as individual antenna elements. Coaxial antennas incorporating the teachings of the present invention exhibit flat phase response over a wide frequency range and a minimum of 120 degrees, centered about zenith, in field of view. This response is in addition to a flat amplitude response. This allows the antenna to be used as a wideband and ultra-wideband antenna for the reception and transmission of extremely fast pulses. The coaxial antenna of the present invention when used as a reflector of the cassegrain, gregorian, corner, parabolic, or cylindrical type exhibits high gain across the full band of operation.

Single reflector antennas of both the cassegrain and cylindrical type have been built. The gain of the cassegrain, over the band of operation is at least 30 dB minimum. The reflector uses a coaxial antenna configured for a single polarization or for all polarizations via the incorporated feed network. With the incorporated feed network, the resultant reflector antenna receives or transmits in all polarizations, including the four basic polarizations of horizontal, vertical, right hand circular and left hand circular.

The antennas of the present invention are also useful as a feed for any type of reflector. However, for cylindrical applications, the antennas are placed in a line feed array and scanned electronically in the non-varying plane of the reflector. Offset line arrays are placed next to the primary banded line array resulting in the reflector antenna useful over multiple bands of operation in the same aperture area.

Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions, and alterations can be made therein without departing from the spirit and scope of the present invention as defined by the appended claims.

WHAT IS CLAIMED IS:

1. A coaxial cavity antenna, comprising:

a cylindrical inner conductor for propagation of electromagnetic signals in a preselected frequency range;

at least one cylindrical outer conductor positioned coaxial with the inner conductor, each successive outer conductor having a diameter larger than an adjacent outer conductor, and having an aperture ring as a part of thereof, one of the at least one outer conductors positioned with respect to the inner conductor to form a cavity between the inner conductor and the adjacent outer conductor, each successive pair of outer conductors positioned to form a cavity, each cavity sized for propagating electromagnetic signals in a preselected frequency range;

a plurality of aperture teeth radially oriented and disposed around each aperture ring;

an iris ring positioned inside each cavity and;

a plurality of septums coupled to each iris ring.

2. The coaxial cavity antenna of Claim 1, wherein each cavity includes four septums spaced equidistant around the iris ring.

3. The coaxial cavity antenna of Claim 1, further comprising:

a coaxial cable coupled at a first end to an iris ring.

4. The coaxial cavity antenna of Claim 1, wherein the aperture ring for each of the at least one outer conductors comprises a part detachable from the at least one outer conductor.

5. The coaxial cavity antenna of Claim 1, wherein the inner conductor comprises a closed end cylinder.

6. The coaxial cavity antenna of Claim 1 further comprising a plurality of cable supports attached to each outer conductor.

7. A coaxial cavity antenna of Claim 1 wherein the interconductor, each of the at least one outer conductors, the plurality of aperture teeth, the iris ring positioned inside each cavity and the plurality of septums coupled to each iris ring comprise an aluminum material.

8. A coaxial cavity antenna of Claim 1 wherein the interconductor, each of the at least one outer conductors, the plurality of aperture teeth, the iris ring positioned inside each cavity and the plurality of septums coupled to each iris ring include a structural plastic coated with a metal.

9. The coaxial cavity antenna of Claim 1, wherein the preselected frequency range comprises a bandwidth of 0.50 to 2.0 GHz.

10. The coaxial cavity antenna of Claim 1, wherein the preselected frequency range comprises a bandwidth of 2.0 to 8.0 GHz.

11. The coaxial cavity antenna of Claim 1, wherein the preselected frequency range comprises a bandwidth of 2.0 to 18.0 GHz.

12. A coaxial cavity antenna, comprising:

a cylindrical inner conductor sized for propagation of electromagnetic signals in a preselected frequency range;

a cylindrical outer conductor positioned coaxial with the inner conductor, and having a diameter larger than the inner conductor, the outer conductor having an aperture ring as a part thereof, the outer conductor positioned with respect to the inner conductor to form a cavity between the inner conductor and the outer conductor, the cavity sized for propagating electromagnetic signals in the preselected frequency range;

a plurality of aperture teeth radially oriented and disposed around the aperture ring;

an iris ring positioned inside the cavity;

a plurality of septums coupled to the inner conductor and the iris ring; and

a plurality of cable supports attached to the outer conductor.

13. The coaxial cavity antenna of Claim 12, wherein each of the plurality of septums comprises a substantially stair-step outline configured for impedance matching.

14. The coaxial cavity antenna of Claim 12, wherein the plurality of septums comprise an outline configuration selected for impedance matching.

15. The coaxial cavity antenna of Claim 12, wherein each aperture ring includes from 8 to 12 aperture teeth equally spaced around the aperture ring.

16. A coaxial cavity antenna, comprising:

an inner conductor sized for propagation of electromagnetic signals in a preselected frequency range;

at least one outer conductor positioned generally coaxial with the inner conductor, each successive outer conductor having a diameter larger than the adjacent outer conductor, one of the at least one outer conductors positioned with respect to the inner conductor to form a cavity between the inner conductor and the adjacent outer conductor, each successive pair of outer conductors positioned to form a cavity, each cavity sized for propagating electromagnetic signals in the preselected frequency range; and

an iris ring positioned inside each cavity.

17. The coaxial cavity antenna of Claim 16, wherein the inner conductor and each of the at least one outer conductors comprises an elliptical configuration having a major and minor access selected to provide a selected narrow field of view coverage.

18. The coaxial cavity antenna of Claim 16, wherein the inner conductor and each of the at least one outer conductors comprise a rectangular configuration with the length and width dimensions selected to provide a preselected narrow field of view coverage.

19. A coaxial cavity antenna, comprising:

an inner conductor sized for propagation of electromagnetic signals in a preselected frequency range;

at least one outer conductor positioned coaxial with the inner conductor, each successive outer conductor having a diameter larger than the adjacent outer conductor and having an aperture ring as a part thereof, one of the at least one outer conductors positioned with respect to the inner conductor to form a cavity between the inner conductor and the adjacent outer conductor, each successive pair of outer conductors positioned to form a cavity, each cavity sized for propagating electromagnetic signals in a preselected frequency range;

a plurality of aperture teeth radially oriented and disposed around each aperture ring;

an iris ring positioned inside each cavity; and

a plurality of septums coupled to each iris ring.

20. The coaxial cavity antenna of Claim 19, wherein each cavity includes four septums spaced equidistant around the iris ring.

21. The coaxial cavity antenna of Claim 19 further comprising:

at least one coaxial cable individually coupled at a first end to an iris ring.

22. The coaxial cavity antenna of Claim 19, wherein the aperture ring for each of the at least one outer conductors comprises a part detachable from the at least one outer conductor.

23. The coaxial cavity antenna of Claim 19, wherein the inner conductor comprises a closed end configuration.

24. The coaxial cavity antenna of Claim 19 further comprising a plurality of cable supports coupled to each of the outer conductors.

25. A coaxial cavity antenna, comprising:

an inner conductor sized for propagation of electromagnetic signals in a preselected frequency range;

an outer conductor positioned coaxial with the inner conductor, and having a diameter larger than the inner conductor, the outer conductor having an aperture ring as a part thereof at an end of the outer conductor, the outer conductor positioned with respect to the inner conductor to form a cavity between the inner conductor and the outer conductor, the cavity sized for propagating electromagnetic signals in the preselected frequency range;

a plurality of aperture teeth radially oriented and disposed around the aperture ring;

an iris ring positioned inside the cavity; and

a plurality of septums coupled to the inner conductor and the iris ring.

26. The coaxial cavity antenna of Claim 25, wherein the inner conductor and each of the at least one outer conductors comprises an elliptical configuration having a major and minor access selected to provide a selected narrow field of view coverage.

27. The coaxial cavity antenna of Claim 25, wherein the inner conductor and each of the at least one outer conductors comprise a rectangular configuration with the length and width dimensions selected to provide a preselected narrow field of view coverage.

28. A vertical stacked coaxial cavity antenna array, comprising:

a first coaxial cavity antenna having a longitudinal access and size for propagation of electromagnetic signals in a preselected frequency range;

at least one additional coaxial cavity antenna each size for propagation of electromagnetic signals in the preselected frequency range, each of said at least one additional coaxial cavity antenna having a longitudinal axis aligned with the longitudinal axis of said first coaxial cavity antenna;

wherein each coaxial cavity antenna of the vertical array comprises:

an inner conductor sized for propagation of electromagnetic signals in a preselected frequency range;

an outer conductor positioned coaxial with the inner conductor, and having a diameter larger than the inner conductor, the outer conductor having an aperture ring as a part thereof at an end of the outer conductor, the outer conductor positioned with respect to the inner conductor to form a cavity between the inner conductor and the outer conductor, the cavity sized for propagating electromagnetic signals in the preselected frequency range;

a plurality of aperture teeth radially oriented and disposed around the aperture ring;

an iris ring positioned inside the cavity; and

a plurality of septums coupled to the inner conductor and the iris ring.

29. The coaxial cavity antenna of Claim 28, wherein the inner conductor and each of the at least one outer conductors comprises an elliptical configuration having a major and minor access selected to provide a selected narrow field of view coverage.

30. The coaxial cavity antenna of Claim 28, wherein the inner conductor and each of the at least one outer conductors comprise a rectangular configuration with the length and width dimensions selected to provide a preselected narrow field of view coverage.

31. The vertical stacked coaxial cavity antenna array of Claim 28, wherein the inner conductor and the outer conductor comprise a closed end cylinder.

32. A linear coaxial cavity antenna array, comprising:

a first coaxial cavity antenna having a longitudinal axis and size for propagation of electromagnetic signal in a preselected frequency range;

at least one additional coaxial cavity antenna sized for propagation of electromagnetic signals in the preselected frequency range, each of said at least one coaxial cavity antenna having a longitudinal axis in parallel alignment with an adjacent coaxial cavity antenna;

wherein the first coaxial cavity antenna and each of the at least one additional coaxial cavity antenna comprises:

an inner conductor sized for propagation of electromagnetic signals in a preselected frequency range;

an outer conductor positioned coaxial with the inner conductor, and having a diameter larger than the inner conductor, the outer conductor having an aperture ring as a part thereof at an end of the outer conductor, the outer conductor positioned with respect to the inner conductor to form a cavity between the inner conductor and the outer conductor, the cavity sized for propagating electromagnetic signals in the preselected frequency range;

a plurality of aperture teeth radially oriented and disposed around the aperture ring;

an iris ring positioned inside the cavity; and

a plurality of septums coupled to the inner conductor and the iris ring.

33. The coaxial cavity antenna of Claim 32, wherein the inner conductor and each of the at least one outer conductors comprises an elliptical configuration having a major and minor access selected to provide a selected narrow field of view coverage.

34. The coaxial cavity antenna of Claim 32, wherein the inner conductor and each of the at least one outer conductors comprise a rectangular configuration with the length and width dimensions selected to provide a preselected narrow field of view coverage.

35. The vertical stacked coaxial cavity antenna array of Claim 32, wherein the inner conductor and the outer conductor comprise a closed end cylinder.

36. A coaxial cavity antenna system, comprising:

a coaxial cavity antenna comprising:

a cylindrical inner conductor sized for propagation of electromagnetic signals in a preselected frequency range;

a cylindrical outer conductor positioned coaxial with the inner conductor, and having a diameter larger than the inner conductor, the outer conductor having an aperture ring as a part thereof, the outer conductor positioned with respect to the inner conductor to form a cavity between the inner conductor and the outer conductor, the cavity sized for propagating electromagnetic signals in the preselected frequency range;

a plurality of aperture teeth radially oriented and disposed around the aperture ring;

an iris ring positioned inside the cavity;

a plurality of septums coupled to the inner conductor and the iris ring;

a plurality of cable supports attached to the outer conductor;

an antenna feed network, comprising:

a first 180° hybrid receiving vertical probe inputs and providing a vertical probe output;

a second 180° hybrid receiving horizontal probe input and providing a horizontal probe output; and

a 90° hybrid receiving the vertical probe output of the first 180° hybrid and the horizontal probe output from the second 180° hybrid, said 90° hybrid generating a left circular polarization signal connected to selected ones of the plurality of cable supports and generating a right circular polarization signal applied to selected other of said plurality of cable supports.

37. A coaxial cavity antenna system, comprising:

a coaxial cavity antenna comprising:

a cylindrical inner conductor sized for propagation of electromagnetic signals in a preselected frequency range;

a cylindrical outer conductor positioned coaxial with the inner conductor, and having a diameter larger than the inner conductor, the outer conductor having an aperture ring as a part thereof, the outer conductor positioned with respect to the inner conductor to form a cavity between the inner conductor and the outer conductor, the cavity sized for propagating electromagnetic signals in the preselected frequency range;

a plurality of aperture teeth radially oriented and disposed around the aperture ring;

an iris ring positioned inside the cavity;

a plurality of septums coupled to the inner conductor and the iris ring;

a plurality of cable supports attached to the outer conductor;

an antenna feed network, comprising:

a first 180° hybrid receiving vertical probe pair inputs and generating a vertical linear polarization signal applied to a selected plurality of said cable supports; and

a second 180° hybrid receiving horizontal probe pair inputs and generating a horizontal linear polarization signal applied to selected others of the plurality of cable supports.

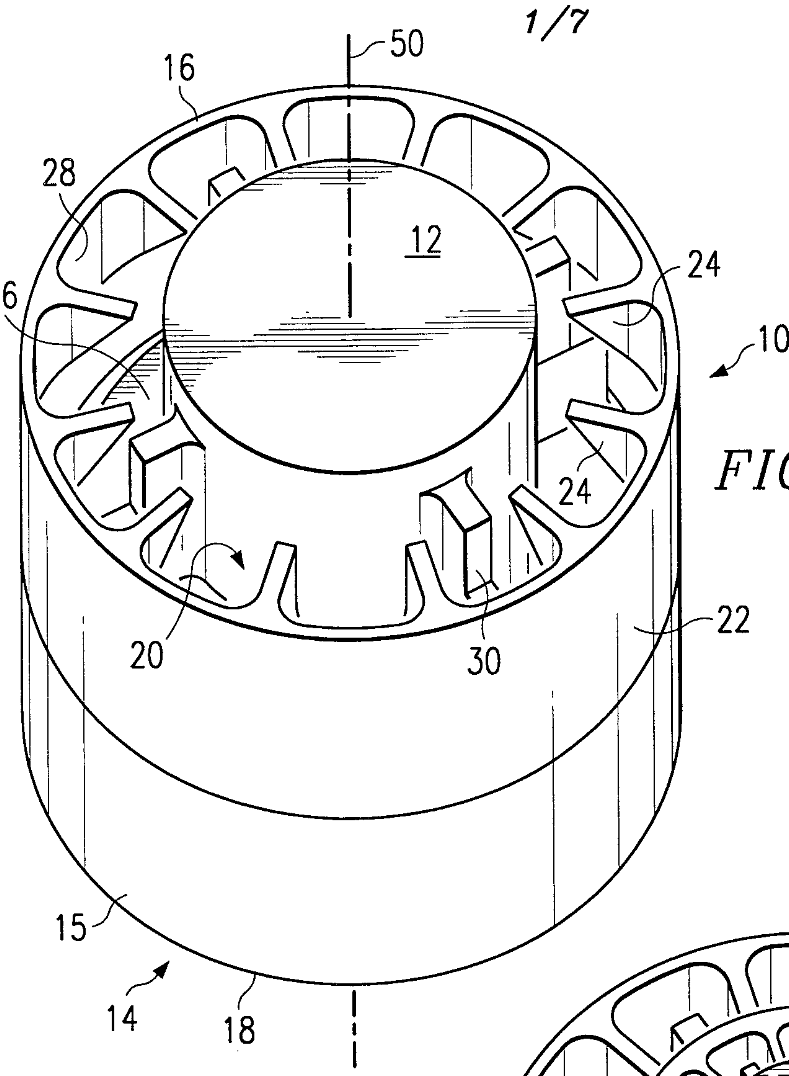


FIG. 1

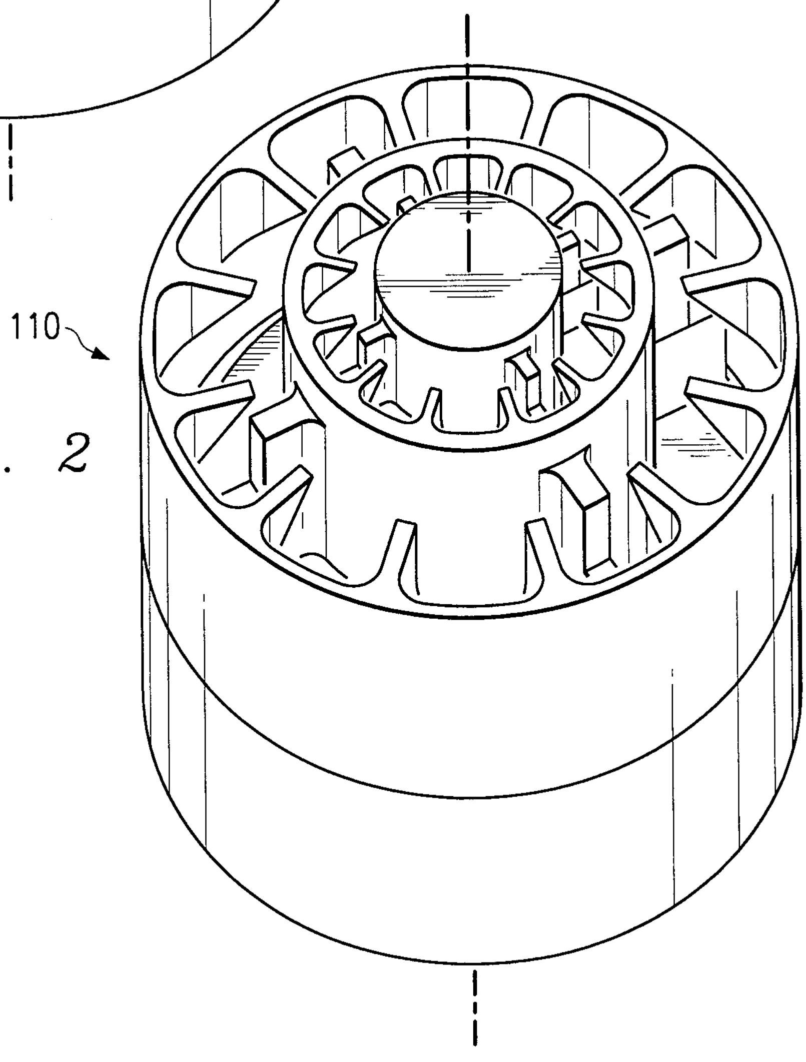


FIG. 2

FIG. 3

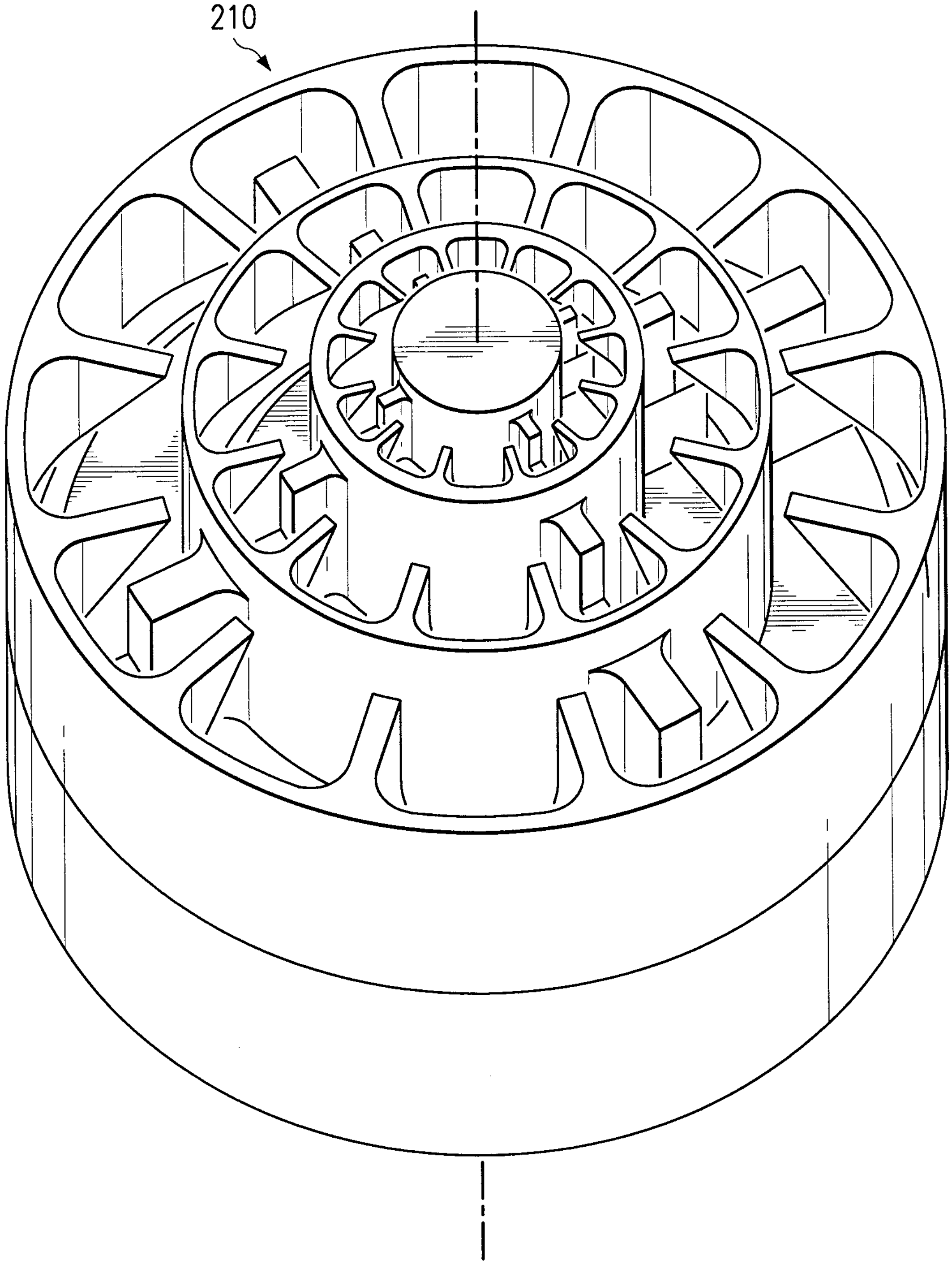


FIG. 4

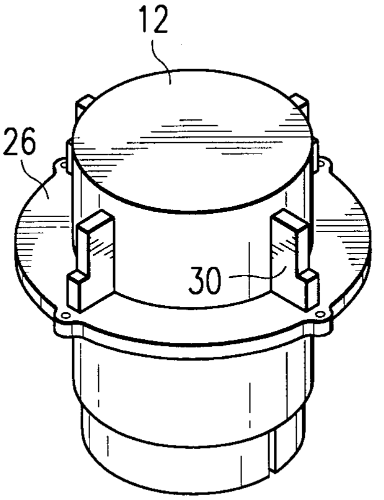


FIG. 5

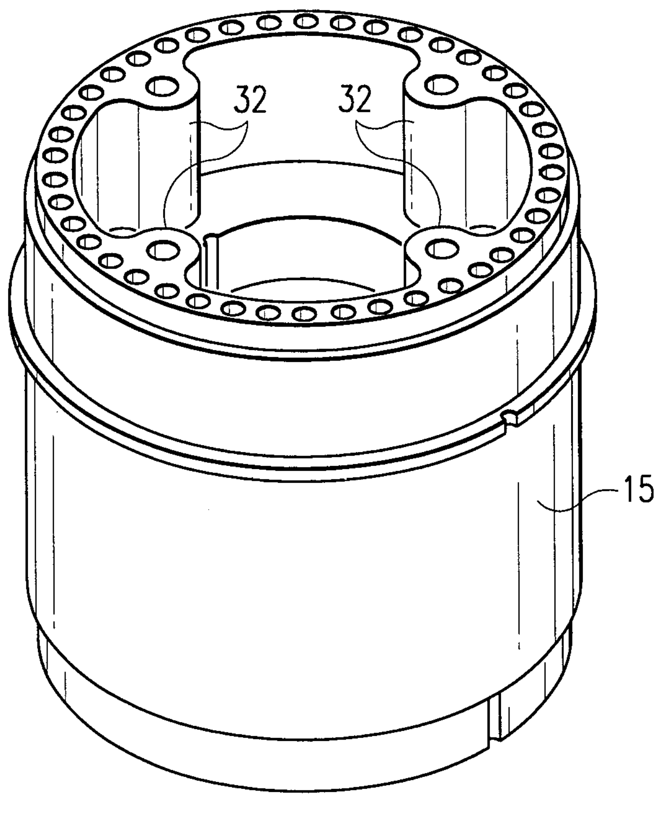
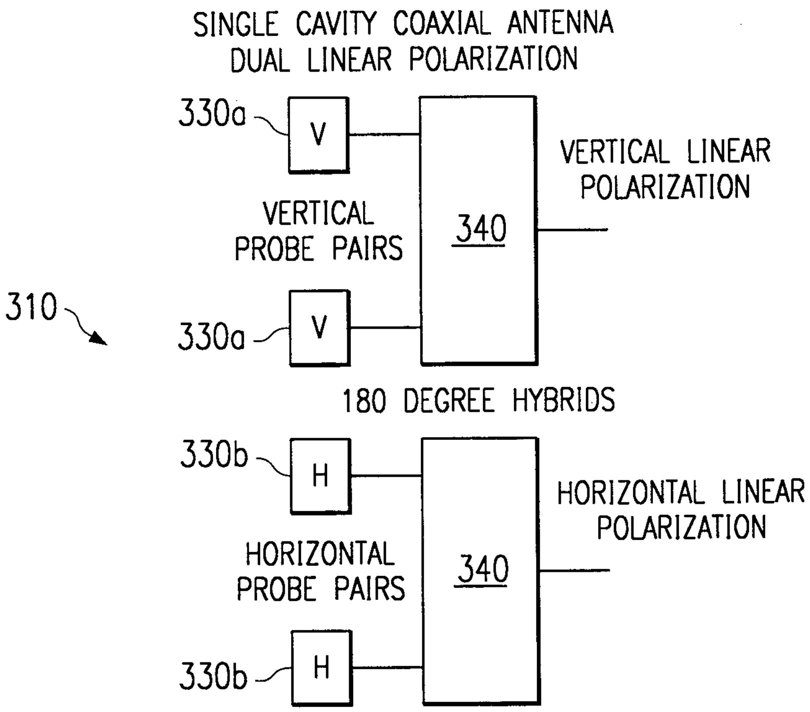


FIG. 6A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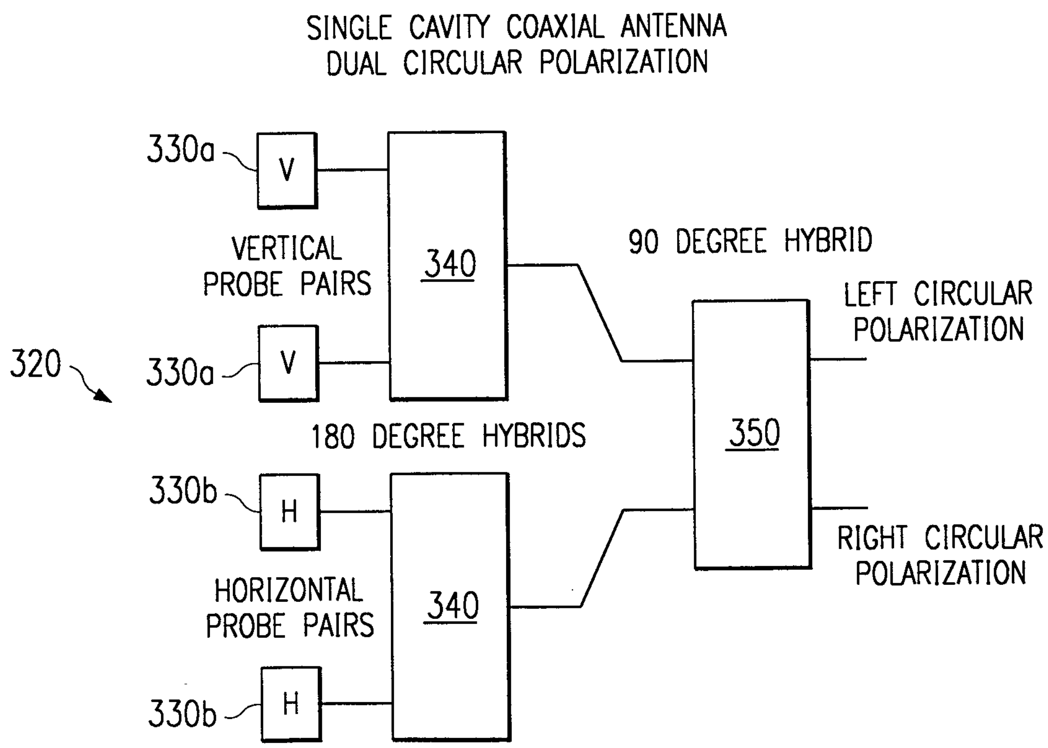
DUAL LINEAR POLARIZATION
330a
V
VERTICAL
PROBE PAIRS
340
VERTICAL LINEAR
POLARIZATION
310
330a
V
180 DEGREE HYBRIDS
330b
H
HORIZONTAL
PROBE PAIRS
340
HORIZONTAL LINEAR
POLARIZATION
330b
H

FIG. 6B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DUAL CIRCULAR POLARIZATION
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90 DEGREE HYBRID
LEFT CIRCULAR
POLARIZATION
320
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350
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RIGHT CIRCULAR
POLARIZATION
HORIZONTAL
PROBE PAIRS
340
330b
H

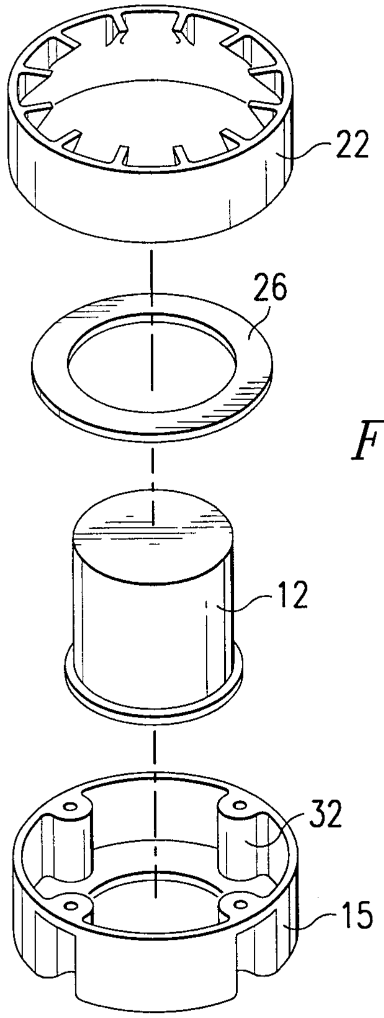


FIG. 7

FIG. 8

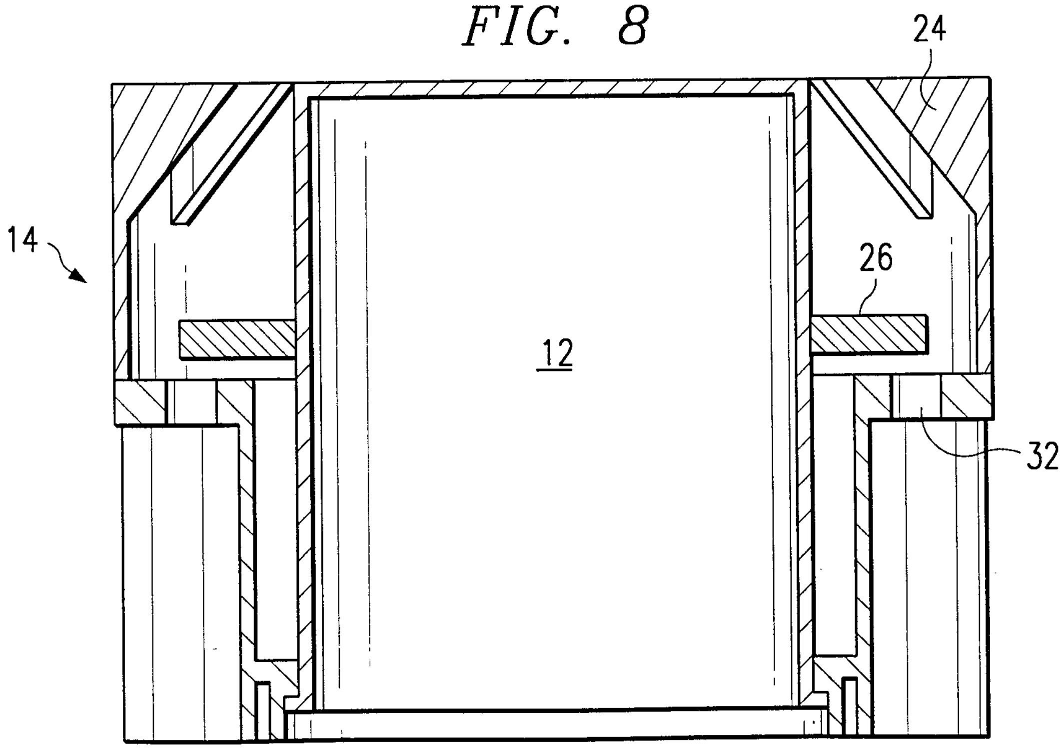


FIG. 9A

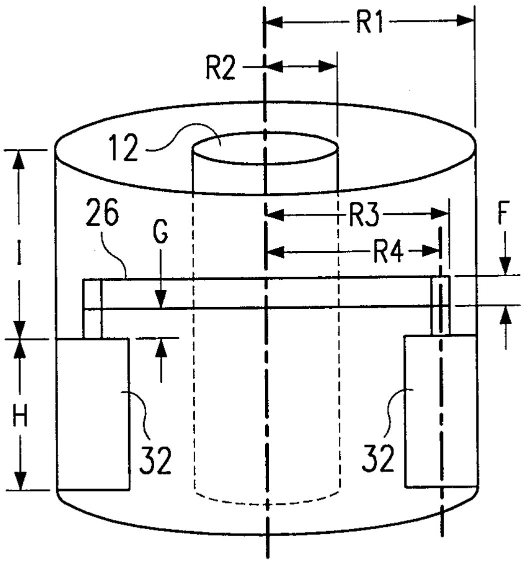


FIG. 10A

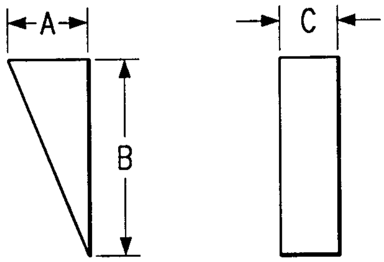


FIG. 10B

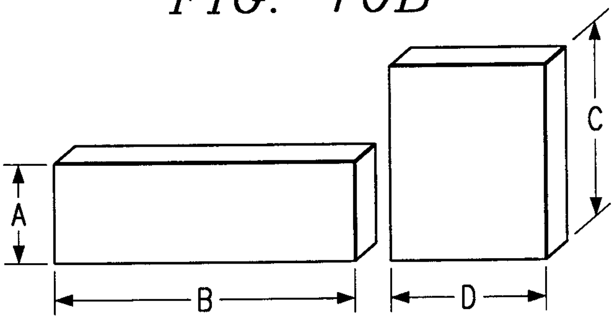


FIG. 9B

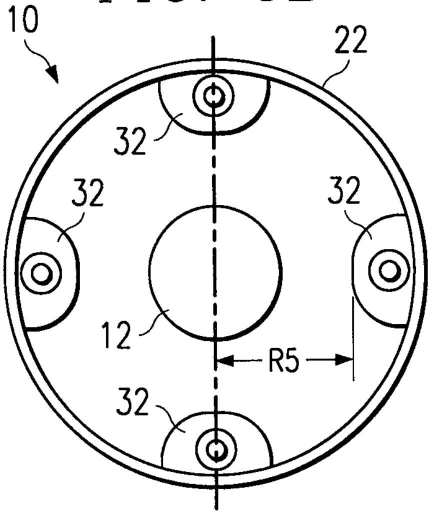


FIG. 12

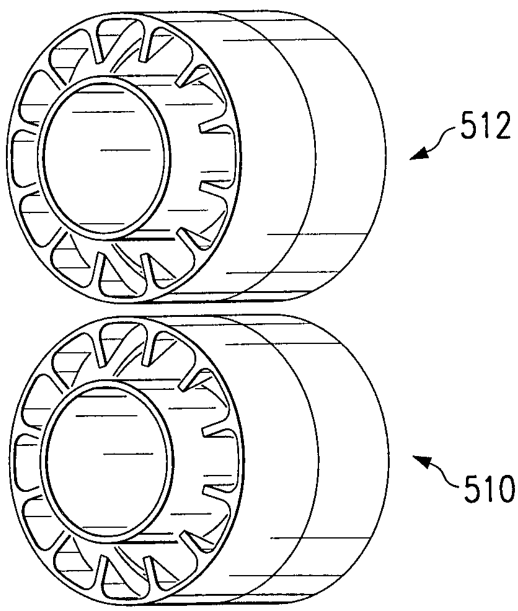


FIG. 11

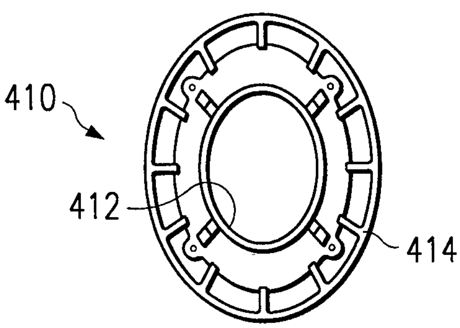


FIG. 14

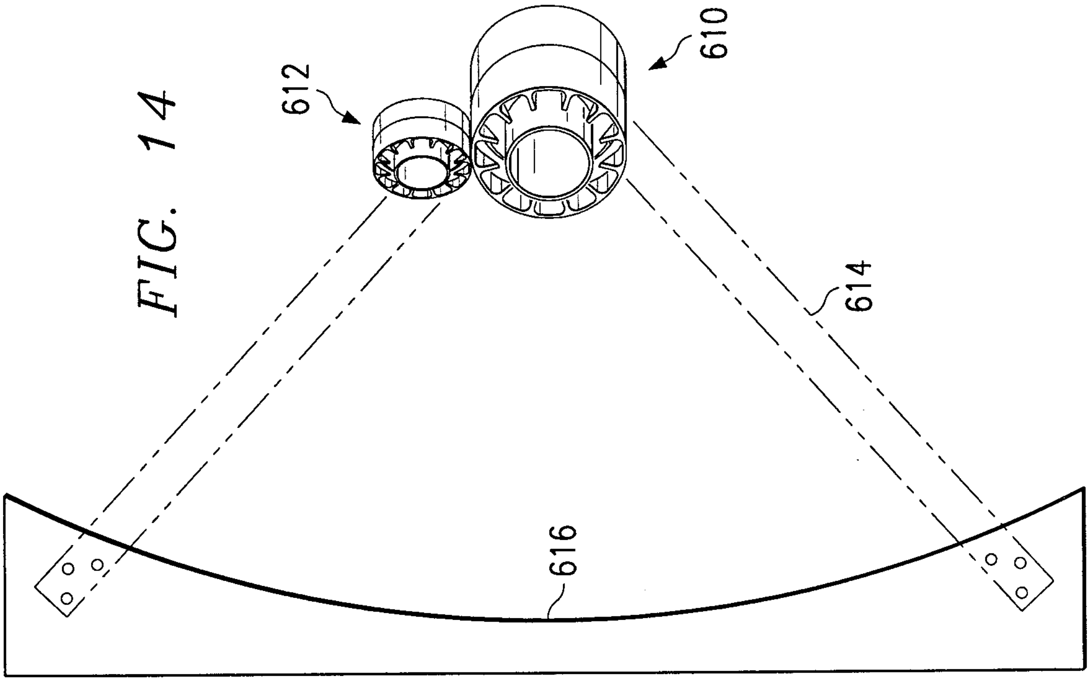
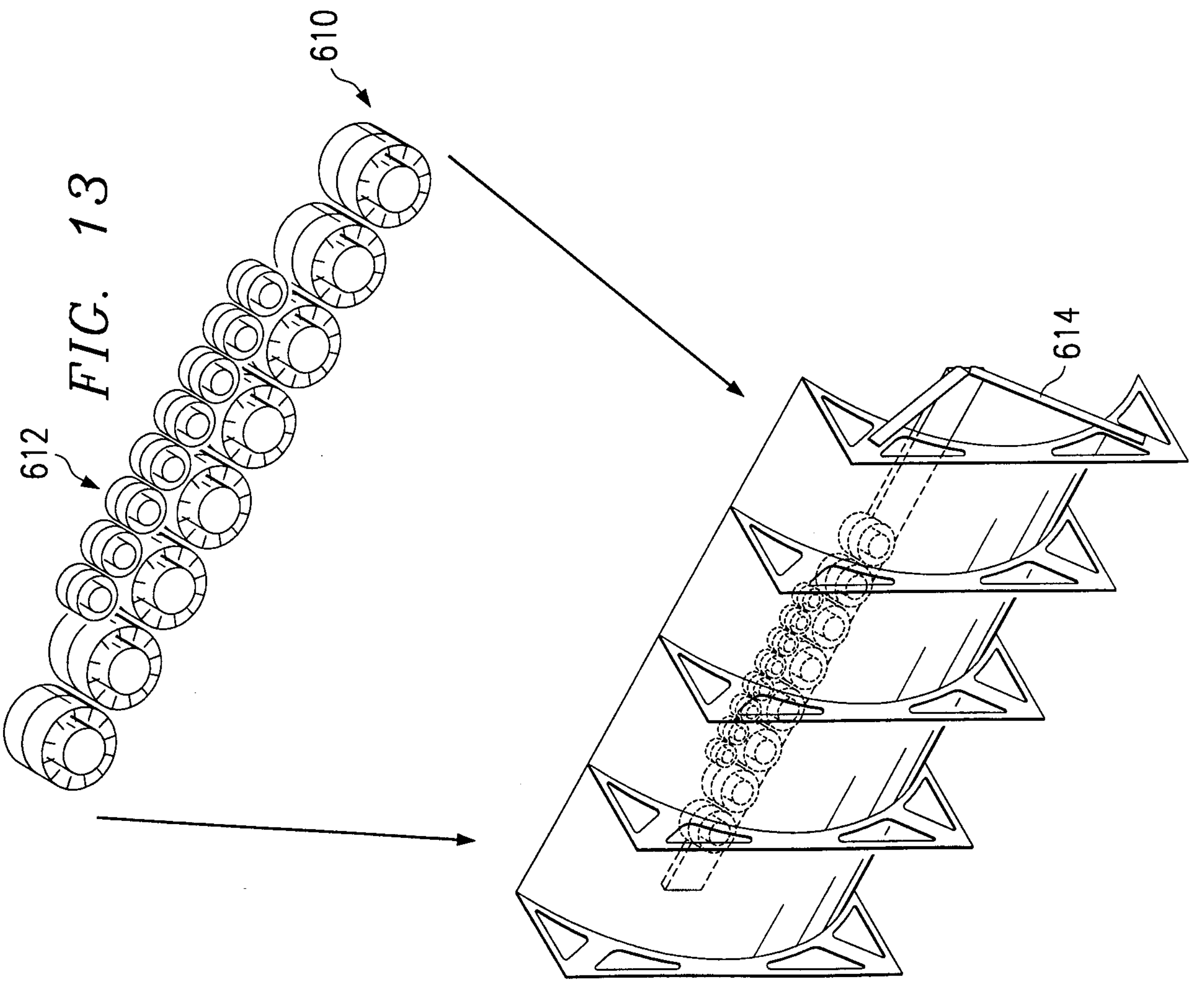


FIG. 13



INTERNATIONAL SEARCH REPORT

Int ional Application No
PCT/US 99/24184

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01Q5/00 H01Q13/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 818 396 A (HARRISON DOUGLAS MELVILLE ET AL) 6 October 1998 (1998-10-06) column 10, line 15 - line 37 ---	16
A	US 3 508 277 A (WARE DAVID GEORGE ET AL) 21 April 1970 (1970-04-21) column 1, line 32 -column 3, line 8 ---	1-35
A	US 4 443 804 A (SMITH TERRY M) 17 April 1984 (1984-04-17) column 1, line 60 -column 3, line 68 ---	1-35
A	EP 0 556 941 A (E SYSTEMS INC) 25 August 1993 (1993-08-25) column 2, line 31 -column 3, line 13 --- -/--	1-35

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
17 February 2000	25/02/2000
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Wattiaux, V

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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1

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Information on patent family members

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