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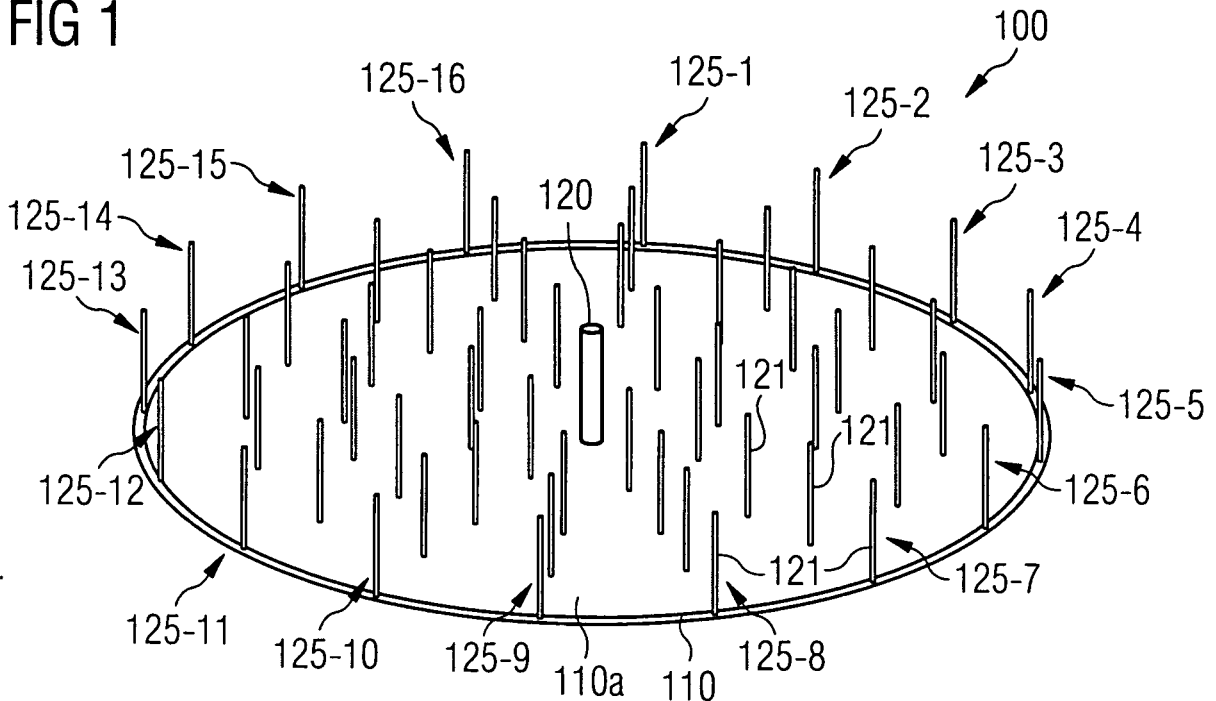
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(54) **Multi row antenna arrangement having a two dimensional omnidirectional transmitting and/or receiving profile**

(57) It is described an antenna arrangement, in particular an antenna arrangement based on the principles Yagi antenna technology. The antenna arrangement (100) comprise a base element (110) having an upper surface (110a), an active antenna element (120), which is attached to the base element (110) and which extends substantially perpendicular to the upper surface (110a), and a plurality of passive antenna elements (121), which are attached to the base element (110) and which extend

substantially perpendicular to the upper surface (110a). The active antenna element (120) is located in the center of the whole antenna arrangement (100) and the passive antenna elements (121) are arranged in at least four rows (125), whereby each row (125) extends radially outwards from the center in a different direction. It is further described a method for transmitting and/or for receiving electromagnetic radiation by means of an antenna arrangement as described above.

FIG 1



Description

Field of invention

[0001] The present invention relates to the technical field of wireless or mobile communication technology via electromagnetic radiation. In particular the present invention relates to the technical field of antenna arrangements, which are specifically designed for having an omni-directional transmitting and/or receiving profile within a two dimensional plane such as the horizontal plane. Further, the present invention relates to a method for transmitting and/or for receiving electromagnetic radiation by means of an antenna arrangement as mentioned above.

Art Background

[0002] In recent years mobile telecommunication became more and more important not only for business but also for private applications. Currently, there have been implemented a plurality of different services which may be provided for a subscriber of a telecommunication network. Such services regularly require a stable wireless connection between a mobile User Equipment and a typically stationary base station. A User Equipment may be for instance a cellular telephone, a Personal Digital Assistant or a notebook computer.

[0003] One example for a small radio telecommunication network having a comparatively small cell size is for instance a so called Wireless Local Area Network (WLAN). In order to serve a cell of a WLAN, base stations are used, which are equipped or connected to antennas having a simple whip-style monopole or dipole antenna element. In order to achieve a higher gain with an omni-directional property at least within a two dimensional plane it is known to use a vertical array of rod-style antenna elements, which consist of stacked dipole elements extending with a significantly length respectively height perpendicular to the two dimensional plane.

[0004] For receiving electromagnetic radiation within the frequency range between 10 MHz and 2000 MHz Yagi Antennas are known. A Yagi antenna is a directional antenna system consisting of an active driven dipole antenna element and additional closely coupled parasitic antenna elements, which are usually a reflector and one or more directors. Such an arrangement gives the antenna directionality that a single dipole lacks.

[0005] In particular for WLAN applications there may be a need for providing a simple, a low-cost and preferably an on ceiling mountable antenna arrangement, which comprises an omni-directional gain and sensitivity property in a predefined horizontal plane. Further, some gain in an elevation view would also be advantageous.

Summary of the Invention

[0006] This need may be met by the subject matter

according to the independent claims. Advantageous embodiments of the present invention are described by the dependent claims.

[0007] According to a first aspect of the invention there is provided an antenna arrangement and in particular an antenna arrangement based on the principles of Yagi antenna technology. The provided antenna arrangement comprises (a) a base element having an upper surface, (b) an active antenna element, which is attached to the base element and which extends substantially perpendicular to the upper surface, and (c) a plurality of passive antenna elements, which are attached to the base element and which extend substantially perpendicular to the upper surface. The active antenna element is located in the center of the whole antenna arrangement and the passive antenna elements are arranged in at least four rows, whereby each row extends radially outwards from the center in a different direction.

[0008] The described antenna arrangement is based on the idea that a multi-row arrangement of passive antenna elements surrounding an active antenna element may provide substantially within a two dimensional plane an omni-directional property for antenna gain and/or for antenna sensitivity. This means that when operating the described antenna arrangement only little radiation is transmitted into respectively received from directions being oriented significantly inclined with respect to a two dimensional plane, which plane is oriented parallel to the upper surface.

[0009] The basic idea of the present invention is to use wire and/or strip directors respectively passive antenna elements being located around a simple feeder respectively active antenna element in order to increase the directivity of the antenna arrangement in the two dimensional plane and maintaining the corresponding two dimensional gain as omni-directional as possible. Of course for the maximum gain slight angular deviations from the two dimensional plane in the range up to 25° to 30° are possible.

[0010] According to Yagi antenna technology the active antenna element is a feed antenna, which may be connected in a known manner to a feed line of the antenna arrangement. Further, the passive antenna elements may be denominated as directors, which are stimulated by the radiation field of active antenna element. However, by contrast to many Yagi antennas having a non omni-directional antenna characteristic the described antenna arrangement comprises no reflector elements.

[0011] The active antenna element and the passive antenna elements as a whole represent a system of coupled resonators. Thereby, in the transmitting case the passive antenna elements are driven by the radiation field being emitted by the active antenna element. The spatial distribution of all the (active and passive) antenna elements is designed in such a way that the phase shifts between the electromagnetic radiation being emitted from all the (active and passive) antenna elements is

substantially constructive for radiation being emitted within the two-dimensional plane. This means that the overall radiation field being emitted from the whole antenna arrangements represents a constructive interference between all radiation fields being emitted from each of the antenna elements. Of course, this relies on the matter of fact that the spatial distance between the various antenna elements is specifically adapted to the electromagnetic wavelength the described antenna arrangement is optimized for.

[0012] It has to be mentioned that of course all the physical properties described above in connection with the transmitting case also apply vice versa for the receiving case, wherein electromagnetic radiation is received by the described antenna arrangement.

[0013] The described antenna arrangement may be realized within a vertically low profile. Thus the antenna arrangement can be used in many locations which do not allow a spatially large extension of an antenna. The antenna arrangement, which may allow for a power gain of 3-6 dBi, can be realized by a simple and low-cost mechanical construction. The antenna arrangement may be used as a Wireless Local Areas Network (WLAN) base station in particular for or in small cells. The antenna arrangement may be suitable for WLAN base station access antennas being adapted for a frequency band between 2.4 and 2.5 GHz.

[0014] Preferably the two dimensional plane of the described antenna arrangement is a horizontal plane. Thereby, a reliable radio respectively wireless communication may be achieved for subscribers, which are located predominately within a horizontal plane such as the floor of one or more rooms.

[0015] According to an embodiment of the invention the passive antenna elements represent a symmetrical structure with respect to the active antenna element. This holds at least within a two dimensional plane being parallel to the upper surface of the base element

[0016] In particular, the structure of the passive antenna elements may be point symmetric with respect to the central active antenna element. This means that for each of the passive antenna elements there is also one another of the passive antenna elements which represent a pair of antenna elements, wherein the active antenna elements is located exactly in the middle of a fictive line connecting the two antenna elements of the respective pair of antenna elements.

[0017] It has to be mentioned that the above described point symmetry is not essential for realizing the invention. It may also be possible to construct any odd number (for example 7) of radial rows of directors around the active antenna element.

[0018] The passive antenna elements respectively the directors of the symmetrical structure may be arranged within a circular, radially periodic geometry. Thereby, horizontally omni-directional high-gain antennas may be realized in a comparatively simple and effective manner.

[0019] According to a further embodiment of the inven-

tion the base element is a plate. This may provide the advantage that the whole antenna arrangement can be constructed within a small vertical extension. Thereby it becomes possible that the antenna arrangement can be mounted for example on ceilings without reducing the effective height of the corresponding room significantly.

[0020] According to a further embodiment of the invention the base element comprises an electrically non conductive material.

[0021] The non conductive material may be any dielectric material such as for instance plastic. Thereby, the active antenna element and/or the passive antenna elements may be round and thin metal rods which can be attached to the plastic plate.

[0022] According to a further embodiment of the invention the antenna arrangement further comprises a conducting ground-plane, which is spatially separated from the passive antenna elements and which laterally extends below all passive antenna elements.

[0023] The passive antenna elements respectively the directors can be realized for example by means of strips on vertical substrate pieces. The active antenna element may be for instance a monopole.

[0024] Such an antenna arrangement may provide the advantage that the beam direction can be located very close to the horizon. Further, electronic components may be located behind the conducting ground-plane representing an effective shielding against unwanted electromagnetic radiation.

[0025] According to a further embodiment of the invention the base element comprises an electrically conductive material.

[0026] The conductive material may be any metallic material such as for instance copper, which comprises a high electrical conductivity and therefore contributes in reducing the ohmic loss when operating the described antenna arrangement.

[0027] A metal base element and in particular a metal plate act as an electromagnetic mirror for the electrical charge respectively for the electrical potential. This may provide the advantage that the vertical size of the (active and passive) antenna elements can be further reduced, because the active and passive antenna elements can be operated quasi as an electromagnetic monopole having only half of the length of a corresponding electromagnetic dipole. In this respect the vertical size is the dimension of the antenna elements in a direction perpendicular to the upper surface of the metallic base element.

[0028] The metallic base plate, which causes all the antenna elements to be operable as quasi electromagnetic monopoles may further comprise the advantage that the active antenna element can be supplied by means of a monopole feed. Such a monopole feed may allow for a straight coaxial connection to the antenna arrangement. Further, a monopole feed can eliminate the need for a so called balun transformer. In this respect balun transformers are passive electronic devices that convert between balanced and unbalanced electrical sig-

nals.

[0029] By employing a metal plate it is possible to design the impedance of the described antenna arrangement to have a good match to an usual 50 Ohm impedance being used for a feed cable and/or for a transmitting respectively a receiving device being connected to the antenna arrangement.

[0030] A further advantage of using a metallic base element is an effective shielding of electromagnetic radiation. Specifically, in the transmitting case the metallic base element may effectively prevent electromagnetic radiation from undesirably entering a spatial region being located behind the base element. Thereby, the electromagnetic compatibility of the described antenna arrangement may further be increased.

[0031] The antenna elements, which may be realized as round thin metal rods or strips, can be welded into a ground-plane of the upper surface representing a ground-plane of the base element. Further, the antenna elements, which may be realized as metallic strips, can be constructed on identical substrate plates, which are assembled radially on the ground-plane. Thereby, the described antenna arrangement can be realized by means of a modular assembly.

[0032] According to a further embodiment of the invention the base element extends along the whole antenna arrangement. This means that all the antenna elements are located directly in front of a metallic surface representing an electromagnetic mirror. This kind of antenna arrangement may provide the advantage that it can be realized within a very flat design. However, a comparatively large metallic ground surface is needed.

[0033] It has to be mentioned that when using a finite metal base plate representing a non perfect infinite electromagnetic mirror, the maximum gain of the antenna arrangement cannot be within the two dimensional plane being oriented parallel to the upper surface. The maximum gain may be rather elevated between 15° and 25° above or below this plane. If the antenna arrangement is oriented horizontally for instance on the ceiling of a room, the maximum gain may be realized within a plane being elevated between 15° and 25° under the horizon.

[0034] It has to be mentioned that for the described antenna arrangement comprising a large metallic ground plane it may be difficult but however not impossible to optimize both the impedance and the gain of the antenna arrangement simultaneously.

[0035] According to a further embodiment of the invention the base element extends solely along a portion of the whole antenna arrangement. This means that only some of the antenna elements are located directly in front of the metal plate respectively the metallic surface representing an electromagnetic mirror. Preferably, the metal plate extends solely below the active antenna element.

[0036] It has to be mentioned that this kind of antenna arrangement cannot be realized within such a small vertical extension as the above described antenna arrangement having a large ground plate. The height of the de-

scribed antenna arrangement having a small or a reduced ground plate will rather be of the order of one height of a dipole, which of course also depends on the wavelength being transmitted and/or received by the antenna arrangement. However, the described small ground plate antenna arrangement may provide the advantage that it's input impedance, which strongly depends on the spatial distribution of the antenna elements, can be easily optimized to be nearly 50 Ohm.

[0037] The described small ground plate antenna arrangement may further provide the advantage that the maximum gain is on the horizon respectively within the two dimensional plane being oriented parallel to the upper surface and the gain and the ripple in gain profile can be controlled by a selection of the number of directors in the radial rows and by the number of radial rows.

[0038] According to a further aspect of the invention there is provided a method for transmitting and/or for receiving electromagnetic radiation by means of an antenna arrangement as described above.

[0039] Also this further aspect of the invention is based on the idea that the above described multi-row arrangement of passive antenna elements surrounding the active antenna element may provide substantially within a two dimensional plane an omni-directional property for the gain and the sensitivity of the antenna arrangement. This means that when operating the described antenna arrangement only little radiation intensity is transmitted into respectively received from directions being oriented significantly inclined with respect to the two dimensional plane being parallel to the upper surface.

[0040] It has to be noted that embodiments of the invention have been described with reference to different subject matters. In particular, some embodiments have been described with reference to apparatus type claims whereas other embodiments have been described with reference to method type claims. However, a person skilled in the art will gather from the above and the following description that, unless other notified, in addition to any combination of features belonging to one type of subject matter also any combination between features relating to different subject matters, in particular between features of the apparatus type claims and features of the method type claims is considered as to be disclosed with this application.

[0041] The aspects defined above and further aspects of the present invention are apparent from the examples of embodiment to be described hereinafter and are explained with reference to the examples of embodiment. The invention will be described in more detail hereinafter with reference to examples of embodiment but to which the invention is not limited.

Brief Description of the Drawings

[0042]

Figure 1 shows the basic idea of a Circular Yagi an-

tenna arrangement with one active dipole-type antenna element and 16 radial rows of passive dipole-type directors in accordance with an embodiment of the present invention.

Figure 2 shows a three dimensional directivity function of the antenna arrangement illustrated in Figure 1.

Figure 3 shows the directivity function of the antenna arrangement illustrated in Figure 1 in the horizontal plane.

Figure 4 shows the directivity function of the antenna arrangement illustrated in Figure 1 in an elevation view.

Figure 5 shows a modification of the Circular Yagi antenna arrangement comprising a metal base plate (Large Ground Plane Circular Yagi, LGPCY) resulting in a monopole-type active antenna element feeding passive monopole-type directors.

Figure 6 shows a three dimensional directivity function of the antenna arrangement illustrated Figure 5.

Figure 7 shows the directivity function of the antenna arrangement illustrated in Figure 5 in the horizontal plane in several frequencies.

Figure 8 shows the directivity function of the antenna arrangement illustrated in Figure 5 in an elevation view in several frequencies.

Figure 9 shows a modification of the Circular Yagi antenna arrangement comprising a small metal base plate (Small Ground Plane Circular Yagi, SGPCY) resulting in a monopole-type active antenna element feeding passive dipole-type directors, which are arranged in 12 rows each comprising four directors.

Figure 10 shows a three dimensional directivity function of the antenna arrangement illustrated in Figure 9.

Figure 11 shows the directivity function of the antenna arrangement illustrated in Figure 9 in the horizontal plane in several frequencies.

Figure 12 shows the directivity function of the antenna arrangement illustrated in Figure 9 in an elevation view in several frequencies.

Figure 13 shows a three dimensional directivity function of a SGPCY antenna arrangement having 12 rows each comprising three (12x3) directors.

Figure 14 shows the directivity function of a SGPCY

antenna arrangement with 12x3 directors in the horizontal plane in several frequencies.

Figure 15 shows the directivity function of a SGPCY antenna arrangement with 12x3 directors in an elevation view in several frequencies.

Figure 16 shows a three dimensional directivity function of a SGPCY antenna arrangement with 8x2 directors.

Figure 17 shows the directivity function of a SGPCY antenna arrangement with 8x2 directors in the horizontal plane in several frequencies.

Figure 18 shows the directivity function of a SGPCY antenna arrangement with 8x2 directors in an elevation view in several frequencies.

Figure 19 shows a further modification of the Circular Yagi antenna arrangement comprising a conductive ground plane, which is spatially separated from the passive antenna elements and which laterally extends below all passive antenna elements.

Detailed Description

[0043] The illustration in the drawing is schematical. It is noted that in different figures, similar or identical elements are provided with the same reference signs or with reference signs, which are different from the corresponding reference signs only within the first digit.

[0044] Figure 1 shows the basic idea of a Circular Yagi antenna arrangement 100. The antenna arrangement 100 comprises a base element 110. According to the embodiment described here the base element is a base plate 110 made from an electrically non conductive respectively a dielectric material. On an upper surface 110a of the base plate 110 there is attached a plurality of dipole type antenna elements 120 and 121. The antenna element 121 is an active antenna element, which is fed by a not depicted feed line from the bottom side of the base plate 110. The passive antenna elements 121, which according to Yagi technology represent directors, are also attached to the dielectric base plate 110. The antenna elements 121 are arranged in a symmetrical way surrounding the active antenna element 120, which is located in the center of the whole antenna arrangement 100.

[0045] The antenna elements 121 are grouped in rows, which radially extend from the central active antenna element 120. As can be seen from Figure 1, the antenna arrangement comprises altogether sixteen rows 125-1, 125-2, 125-3, 125-4, 125-5, 125-6, 125-7, 125-8, 125-9, 125-10, 125-11, 125-12, 125-13, 125-14, 125-15 and 125-16. As can be further seen from Figure 1, rows 125-1, 125-3, 125-5, 125-7, 125-9, 125-11, 125-13 and 125-15 have three passive director elements and correspondingly rows 125-2, 125-4, 125-6, 125-8, 125-10, 125-12,

125-14 and 125-16 have four passive director elements.

[0046] It has to be mentioned that antenna arrangements in accordance with the invention can also comprise a different number of rows. Also the number of directors being assigned to a row can also differ from three or four. There are many different combinations possible wherein the number of rows is preferably equal or larger than four and the number of passive antenna elements being assigned to one row is at least one. There is no fundamental limitation restricting the number of rows and/or the number of passive antenna elements being assigned to a single row. However, it has to be mentioned that there may be a technical limit in that sense, that if the number of passive elements is large the gain doesn't necessarily increase with the number of passive elements or the antenna is not omni-directional anymore.

[0047] Figure 2 shows a three dimensional directivity function of the antenna arrangement 100. Thereby, the gain in a certain directions with respect to the point of origin, which directions are defined by the three coordinates x, y and z, is defined by the spatial distance between the corresponding point of the surface of the three dimensional directivity function and the point of origin.

[0048] The illustrated three dimensional directivity function has been calculated for electromagnetic radiation having a frequency of 2.442 GHz. The maximum gain is 4.9 dBi in certain horizontal directions. Thereby the unit dBi refers to decibels referring to a fictitious isotropic antenna, which uniformly distributes the whole available radiation energy into all directions. This means that in the present case the antenna arrangement 100 comprises a maximum gain in certain horizontal directions, which maximum gain is 4.9 dB higher than the gain of an isotropic antenna.

[0049] It has to be mentioned that according to the mathematical definition of "Decibel" the axis Gx(dB), Gy (dB) and Gz(dB) represent a logarithmic scale.

[0050] Figure 3 shows the directivity function of the antenna arrangement 100 in the horizontal plane for seven different frequencies of electromagnetic radiation. The depicted frequencies are 2.379 MHz, 2.4 MHz, 2.421 MHz, 2.442 MHz, 2.463 MHz, 2.484 MHz and 2.505 MHz. Since these directivity functions are very close to each other they can hardly be resolved in Figure 3.

[0051] Figure 4 shows the directivity function of the antenna arrangement 100 in an elevation view. In the transmitting case most of the radiation intensity is emitted into the horizontal plane given by the angular values -90° and 90° . Further, there are also minor intensity peaks of electromagnetic radiation being emitted into directions having an angle of $+45^\circ$ and -45° with respect to the horizontal plane. However, since again the axis have a logarithmic scale these intensity peaks only represent comparatively little radiation intensity.

[0052] Figure 5 shows a further the Circular Yagi antenna arrangement 500 representing a modification of the antenna arrangement 100. The antenna arrangement 500 comprises a metal base plate 510, which has

an upper surface 510a. The base plate 510 has a substantially circular size, which extends below the active antenna element 520 and below all passive antenna elements 521. In the following such an antenna arrangement having a large metal base plate 510 is denominated a Large Ground Plane Circular Yagi (LGPCY) antenna arrangement.

[0053] According to the embodiment depicted here the passive antenna elements 521 are arranged within 8 rows each extending radially outwards from the center of the antenna arrangement respectively from the active antenna element 520. As can be seen from Figure 5 each row comprises three passive antenna elements 521. Such an arrangement comprising eight rows each having three directors 521 will be denominated as an 8x3 director arrangement.

[0054] The metal base plate 510 represents an electromagnetic mirror in particular for the electric potential being generated by the antenna arrangement 500. This mirror behavior has the advantage that compared to the antenna arrangement 100 shown in Figure 1, the height of the antenna elements 520, 521 can be reduced by a factor of two. This is based on the matter of fact that the electromagnetic mirror has the same effect as a further antenna element arrangement, which is directly attached to the arrangement 500 in a mirror-inverted way. Therefore, by using a metal plate 510 as a base element the effective height of the antenna elements and; as a consequence, the effective height of the whole antenna arrangement 500 can be significantly reduced compared to an antenna arrangement being assembled on a dielectric base element.

[0055] In other words the metal base plate 510 results in a monopole-type active antenna element 520, which is feeding passive monopole-type directors 521.

[0056] Figure 6 shows a three dimensional directivity function of the antenna arrangement 500. The illustrated directivity function has been calculated for electromagnetic radiation having a frequency of 2.442 GHz. The maximum gain is 4.2 dBi in certain directions seen in Figures 7 and 8.

[0057] Figure 7 shows the directivity function of the antenna arrangement 500 in the horizontal plane for seven different frequencies of electromagnetic radiation. Again, the depicted frequencies are 2.379 MHz, 2.4 MHz, 2.421 MHz, 2.442 MHz, 2.463 MHz, 2.484 MHz and 2.505 MHz. Since these directivity functions are very close to each other they can hardly be resolved in Figure 7.

[0058] Each of the depicted directivity functions exhibits eight bumps protruding outwardly. In between two neighboring bumps there is a dimple (minimum). Differences between the different frequency directivity functions can only be seen within the regions of one of the eight the dimples. The difference between the maximums and minimums in the antenna gain, ripple in the antenna gain, depends of the number of passive director element rows used in the antenna.

[0059] Figure 8 shows the directivity function of the antenna arrangement 500 in an elevation view. In the transmitting case most of the radiation intensity is emitted into a direction being oriented approximately 20° angularly offset with respect to the horizontal plane given by the angular values -90° and 90°. This is based on the fact that the metallic base plate 510, which has a diameter of approximately 350 mm, has a limited lateral dimension and therefore does not act as a perfect electromagnetic mirror, which would require an infinite lateral dimension.

[0060] Figure 9 shows a further the Circular Yagi antenna arrangement 900 representing a modification of the antenna arrangement 500. The antenna arrangement 900 comprises a small metal base plate 915. The metal base plate 915 has a substantially circular size, which extends solely below the active antenna element 920.

[0061] Below the passive antenna elements 921 and surrounding the metal base plate 915 there is formed a dielectric base plate 910, which supports the passive antenna elements 921. In the following such an antenna arrangement having a small metal base plate 915 is denominated a Small Ground Plane Circular Yagi (SGPCY) antenna arrangement.

[0062] According to the embodiment depicted here the passive antenna elements 921 are arranged within twelve rows 925-1, 925-2, 925-3, 925-4, 925-5, 925-6, 925-7, 925-8, 925-9, 925-10, 925-11 and 925-12 each extending radially outwards from the center of the antenna arrangement respectively from the active antenna element 920. As can be seen from Figure 9 each row comprises four passive antenna elements 521. Such an arrangement comprising twelve rows each having four directors 921 will be denominated a 12x4 director arrangement.

[0063] Since solely for the active antenna element 920 the metal plate 915 represents an electromagnetic mirror, the length of the active antenna element 920 can be reduced by a factor of two compared to an antenna arrangement having no metal plate. Since the passive antenna elements are supported by a non conductive dielectric base element 910 the length of the directors 921 corresponds to the length of the directors 121 of the antenna arrangement 100 illustrated in Figure 1. According to the embodiment described here the maximal diameter of the base element 910 is 469 mm.

[0064] In other words, the SGPCY antenna arrangement 900 results in a monopole-type active antenna element 920, which in operation feeds the surrounding passive dipole-type directors 921.

[0065] Figure 10 shows a three dimensional directivity function of the antenna arrangement 900. The illustrated directivity function has been calculated for electromagnetic radiation having a frequency of 2.442 GHz. The maximum gain is 6.2 dBi in certain horizontal directions.

[0066] Figure 11 shows the directivity function of the antenna arrangement 900 in the horizontal plane for seven different frequencies of electromagnetic radiation.

The depicted frequencies are again 2.379 MHz, 2.4 MHz, 2.421 MHz, 2.442 MHz, 2.463 MHz, 2.484 MHz and 2.505 MHz. Since also these directivity functions are very close they can hardly be resolved from each other in Figure 11. Each of the depicted directivity functions exhibits twelve bumps protruding outwardly. In between two neighboring bumps there is a radially dimple. Differences between the different frequency directivity functions can only be seen within the regions of the above described dimples.

[0067] Figure 12 shows the directivity function of the antenna arrangement 900 in an elevation view. In the transmitting case most of the radiation intensity is emitted into the horizontal plane given by the angular values -90° and 90°. Further, there are also minor intensity peaks of electromagnetic radiation being emitted into directions having an angle of +-45° with respect to the horizontal plane. However, since the axis have a logarithmic scale these intensity peaks only represent comparatively little radiation intensity.

[0068] Figure 13 shows a three dimensional directivity function of a SGPCY antenna arrangement, which is not explicitly depicted in the accompanying drawing. The antenna arrangement comprises a 12x3 director arrangement and a maximum diameter of 352 mm. The illustrated directivity function has been calculated again for electromagnetic radiation having a frequency of 2.442 GHz. The maximum gain is 4.7 dBi in certain horizontal directions.

[0069] Figure 14 shows the directivity function of the above-mentioned SGPCY antenna arrangement having a 12x3 director arrangement in the horizontal plane. The directivity function is again depicted for the frequencies of 2.379 MHz, 2.4 MHz, 2.421 MHz, 2.442 MHz, 2.463 MHz, 2.484 MHz and 2.505 MHz. Each of the depicted directivity functions exhibits twelve bumps respectively protruding outwardly.

[0070] Figure 15 shows the directivity function of the above-mentioned SGPCY antenna arrangement having a 12x3 director arrangement in an elevation view. Again most of the radiation intensity is emitted into the horizontal plane given by the angular values -90° and 90°. Further, there are again minor intensity peaks of electromagnetic radiation being emitted into directions having an angle of +45° or -45° with respect to the horizontal plane.

[0071] Figure 16 shows a three dimensional directivity function of a further SGPCY antenna arrangement, which is also not explicitly depicted in the accompanying drawing. This antenna arrangement comprises an 8x2 director arrangement and a maximum diameter of 235 mm. The illustrated directivity function has been calculated again for electromagnetic radiation having a frequency of 2.442 GHz. The maximum gain is 4.4 dBi in certain horizontal directions.

[0072] Figure 17 shows the directivity function of the above-mentioned SGPCY antenna arrangement having the 8x2 director arrangement in the horizontal plane. The directivity function is again depicted for the frequencies of 2.379 MHz, 2.4 MHz, 2.421 MHz, 2.442 MHz, 2.463

MHz, 2.484 MHz and 2.505 MHz.

[0073] Each of the depicted directivity functions exhibits eight bumps protruding outwardly.

[0074] Figure 18 shows the directivity function of the above-mentioned SGPCY antenna arrangement having the 8x2 director arrangement in an elevation view. Again most of the radiation intensity is emitted into the horizontal plane given by the angular values -90° and 90° .

[0075] Figure 19 shows an antenna arrangement 1900 representing a further modification of the Circular Yagi antenna arrangement. The antenna arrangement 1900 comprises a conductive ground plane 1955, which is spatially separated from the passive antenna elements 1921 and which laterally extends below all passive antenna elements 1921. The passive antenna elements respectively the directors 1921, which can be realized for instance by strips on vertical substrate pieces, are mounted to a not depicted dielectric support base element.

[0076] According to the embodiment described here, the active antenna element respectively the feed element 1920 is a monopole-type antenna element. A feed connector 1960 is used to electrically connect the active antenna element 1920.

[0077] The antenna arrangement 1900 has the advantage that it directs the beam nearer to the horizon as compared for instance the antenna arrangement 500 (see Figure 8), but a nearby ceiling does not disturb its performance as it is a case with the antenna arrangements 100 and 900 as presented in Figure 1 and Figure 9, respectively. Although the antenna arrangement 1900 is very similar to the antenna arrangement 900 shown in Figure 9, when employing the antenna arrangement 1900 a nearby ceiling and electronics under the conductive ground-plane 1955 are effectively shielded in a more controlled way.

[0078] It should be noted that the term "comprising" does not exclude other elements or steps and the "a" or "an" does not exclude a plurality. Also elements described in association with different embodiments may be combined. It should also be noted that reference signs in the claims should not be construed as limiting the scope of the claims.

List of reference signs:

[0079]

100	antenna arrangement
110	base element / base plate
110a	upper surface
120	active dipole-type antenna element
121	passive dipole-type antenna elements / directors
125-X	row of passive antenna elements / directors (X = 1, 2, 3, ..., 16)
500	antenna arrangement
510	metal base element / metal base plate
510a	upper surface

520	active monopole-type antenna element
521	passive monopole-type antenna elements / directors
525-X	row of passive antenna elements / directors (X = 1, 2, 3, ..., 18)
900	antenna arrangement
910	dielectric base element / dielectric base plate
910a	upper surface
915	metal plate / metal coating
920	active monopole-type antenna element
921	passive antenna elements / directors
925-X	row of passive antenna elements / directors (X = 1, 2, 3, ..., 16)
1900	antenna arrangement
1920	active monopole-type antenna element
1921	passive antenna elements / directors
1955	conducting ground-plane
1960	Feed connector

Claims

1. An antenna arrangement, in particular an antenna arrangement based on the principles of Yagi antenna technology, the antenna arrangement (100, 500, 900) comprising

- a base element (110, 510, 910) having an upper surface (110a, 510a, 910a),
- an active antenna element (120, 520, 920), which is attached to the base element (110, 510, 910) and which extends substantially perpendicular to the upper surface (110a, 510a, 910a), and
- a plurality of passive antenna elements (121, 521, 921), which are attached to the base element (110, 510, 910) and which extend substantially perpendicular to the upper surface (110a, 510a, 910a),

wherein the active antenna element (120, 520, 920) is located in the center of the whole antenna arrangement (100, 500, 900) and

wherein the passive antenna elements (121, 521, 921) are arranged in at least four rows (125, 525, 925), whereby each row (125, 525, 925) extends radially outwards from the center in a different direction.

2. The antenna arrangement according to claim 1, wherein within a two dimensional plane being parallel to the upper surface (110a, 510a, 910a) of the base element (110, 510, 910) the passive antenna elements (121, 521, 921) represent a symmetrical structure with respect to the active antenna element (120, 520, 920).

3. The antenna arrangement according to any one of

the claims 1 to 2, wherein
the base element is a plate (110, 510, 910).

4. The antenna arrangement according to any one of the claims 1 to 3, wherein the base element (110) comprises an electrically non conductive material. 5
5. The antenna arrangement according to claim 4, further comprising 10
 - a conducting ground-plane (1955), which is spatially separated from the passive antenna elements (1921) and which laterally extends below all passive antenna elements (1921). 15
6. The antenna arrangement according to any one of the claims 1 to 3, wherein the base element (510, 910) comprises an electrically conductive material. 20
7. The antenna arrangement according to claim 6, wherein the base element (510) extends along the whole antenna arrangement (500). 25
8. The antenna arrangement according to claim 6, wherein the base element (910) extends solely along a portion of the whole antenna arrangement (900). 30
9. A method for transmitting and/or for receiving electromagnetic radiation by means of an antenna arrangement (100, 500 900) as set forth in any one of the previous claims. 35

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FIG 1

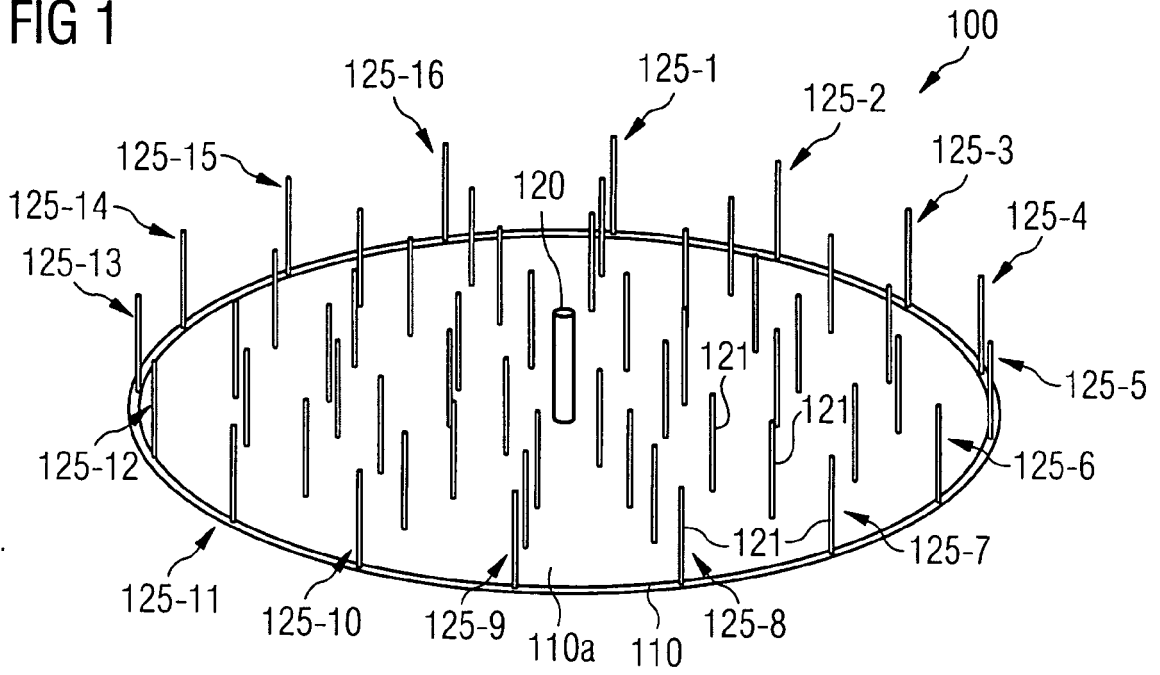


FIG 2

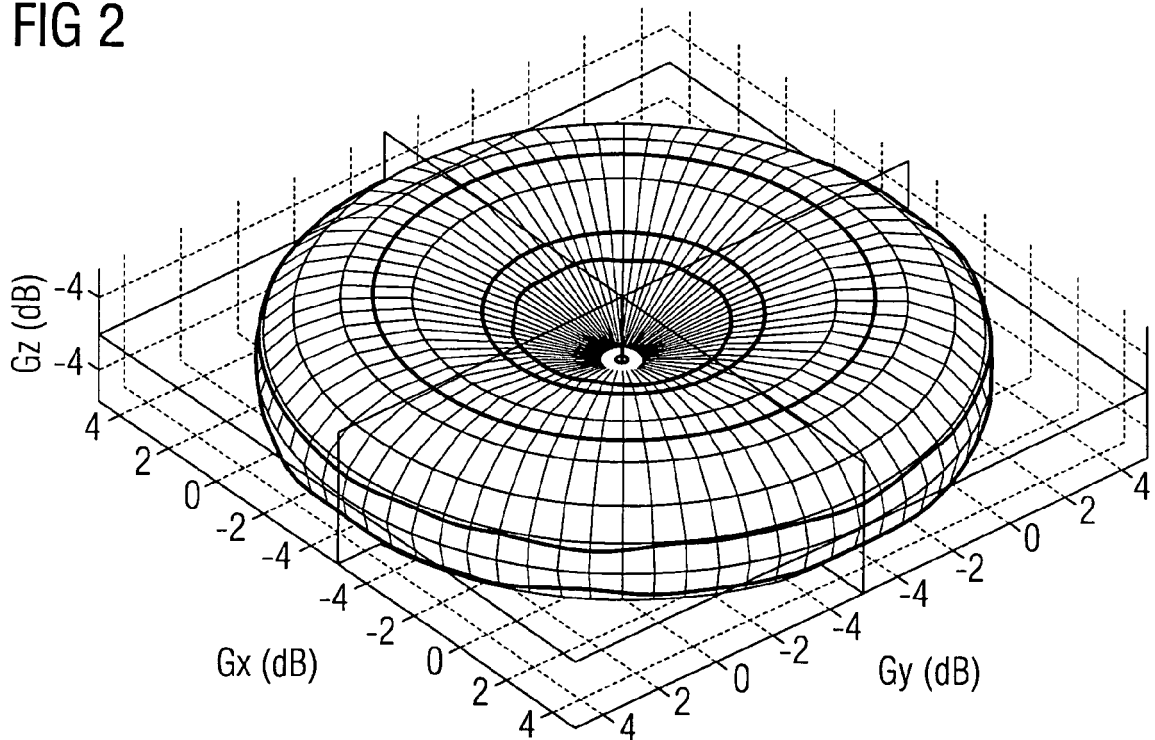


FIG 3

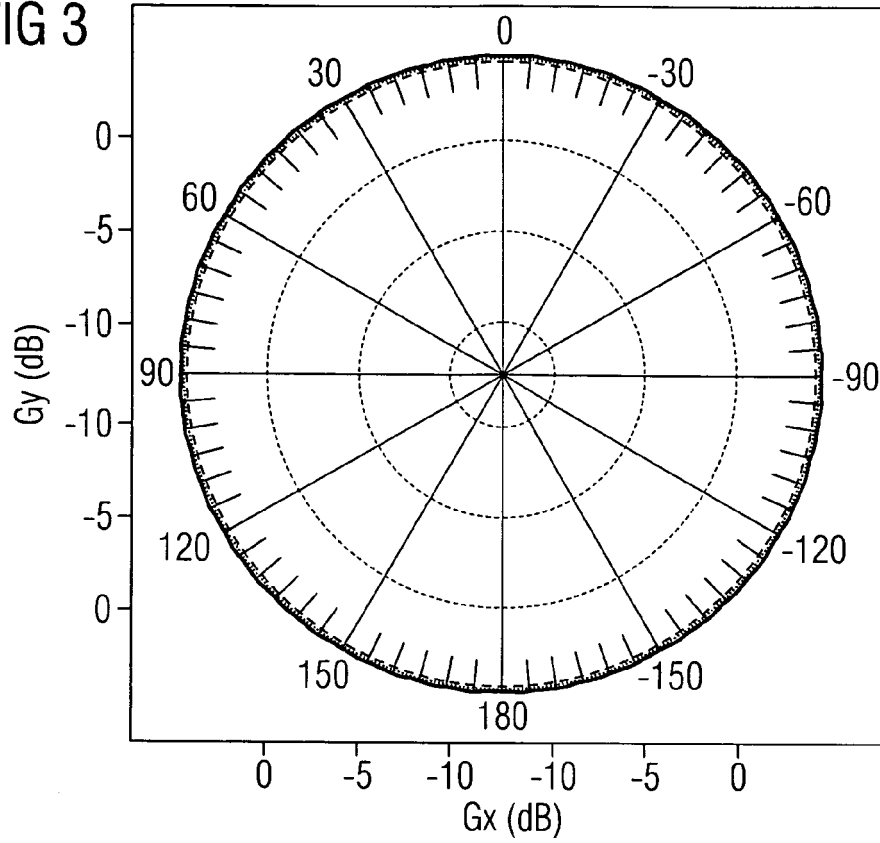


FIG 4

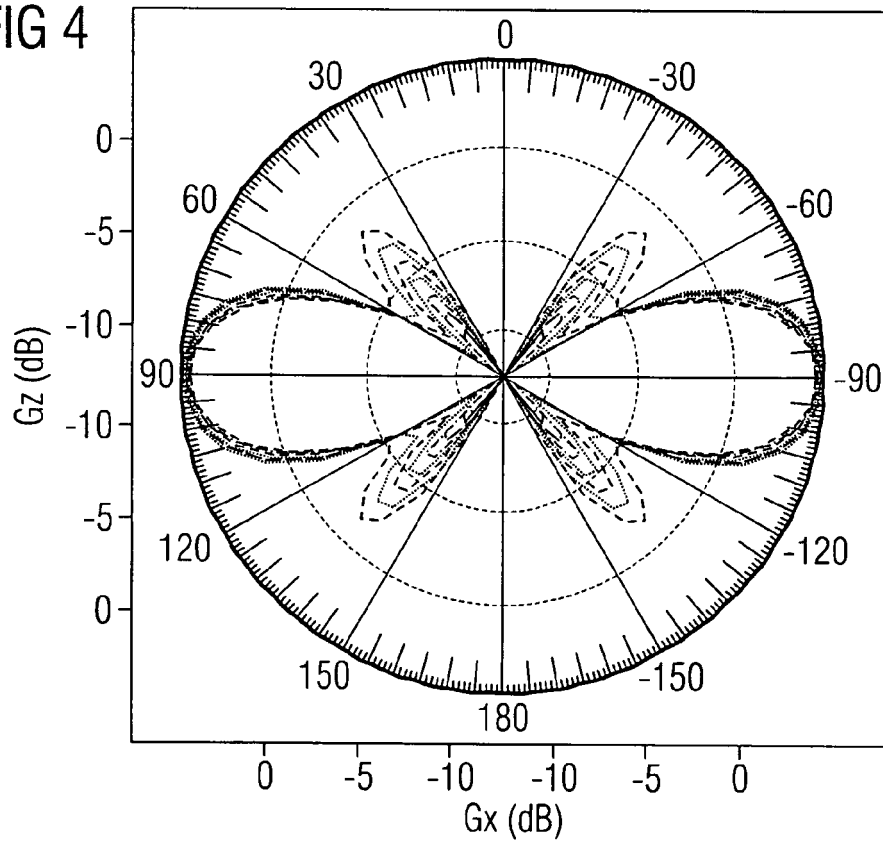


FIG 5

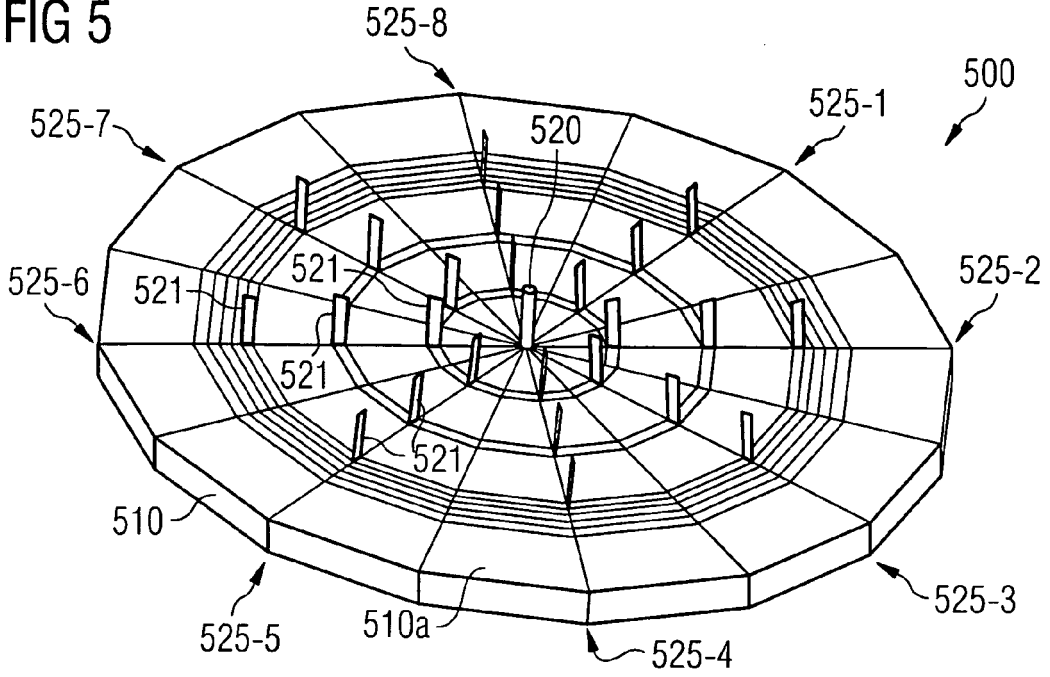


FIG 6

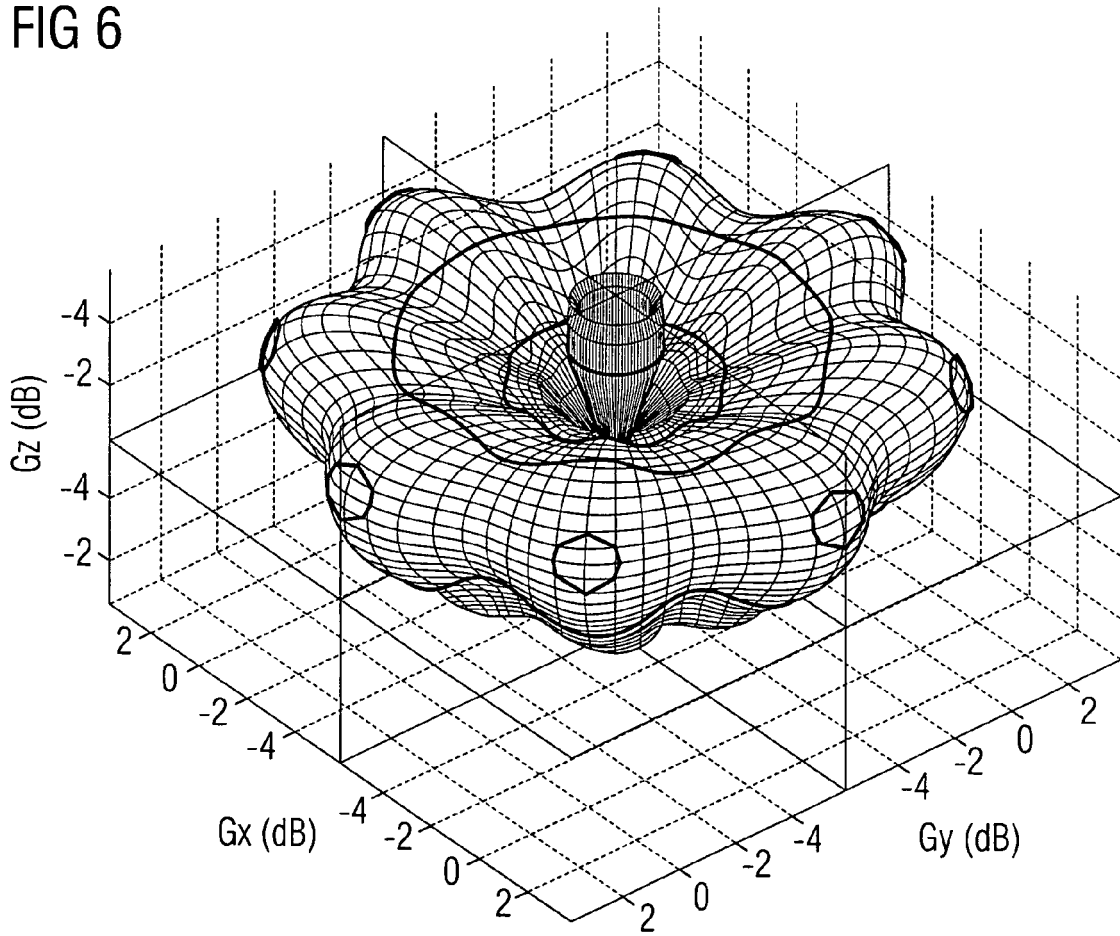


FIG 7

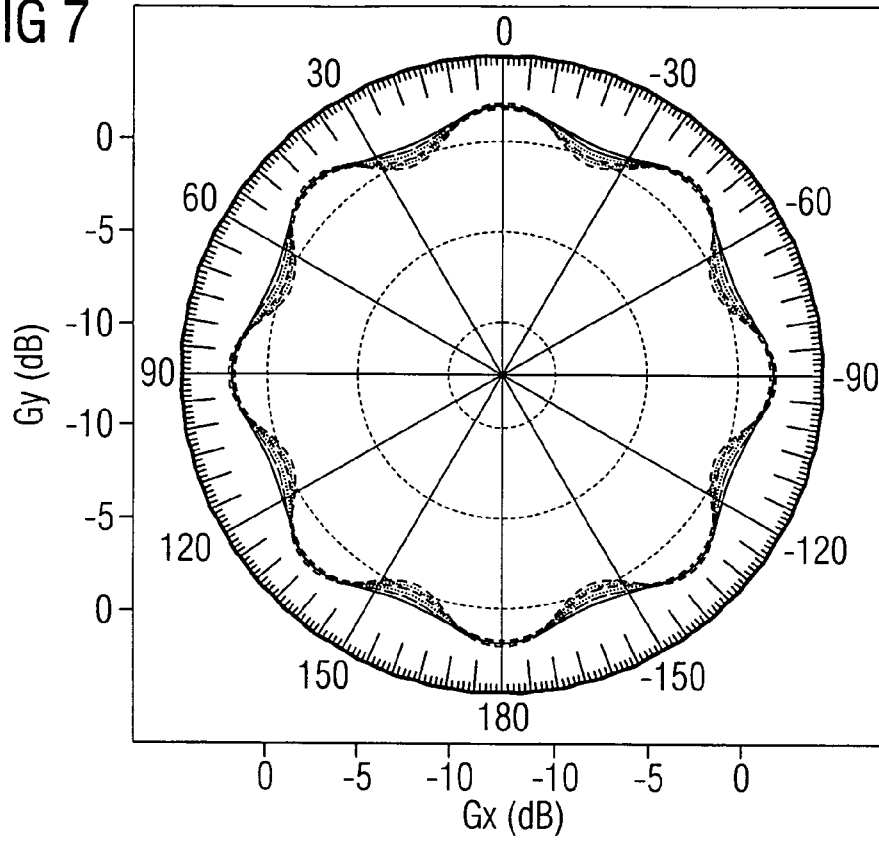


FIG 8

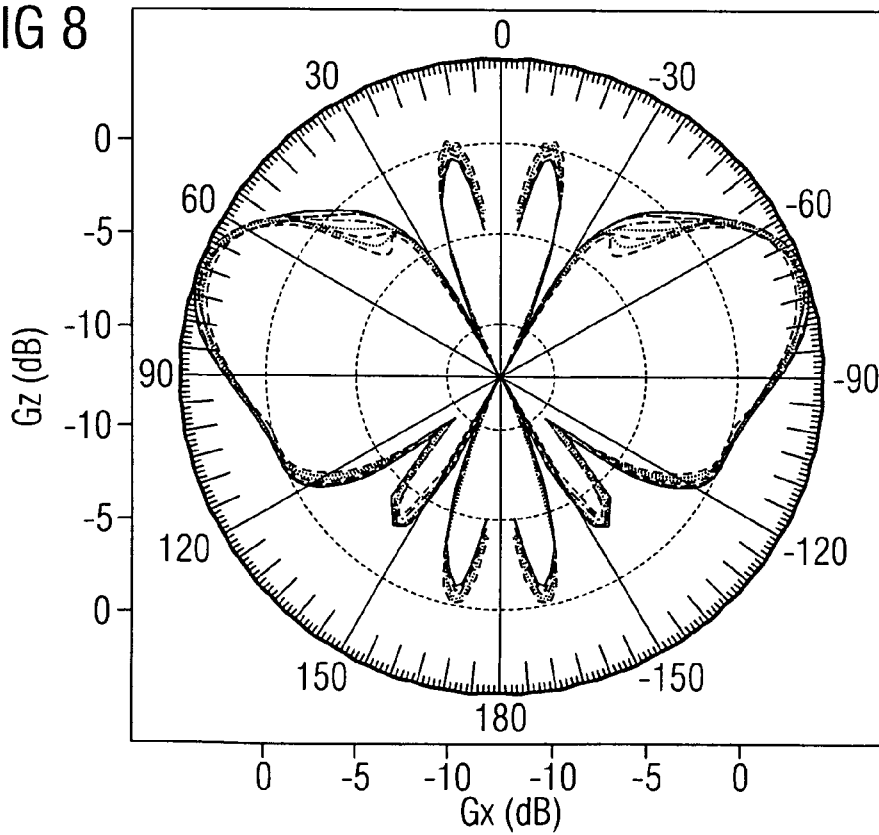


FIG 9

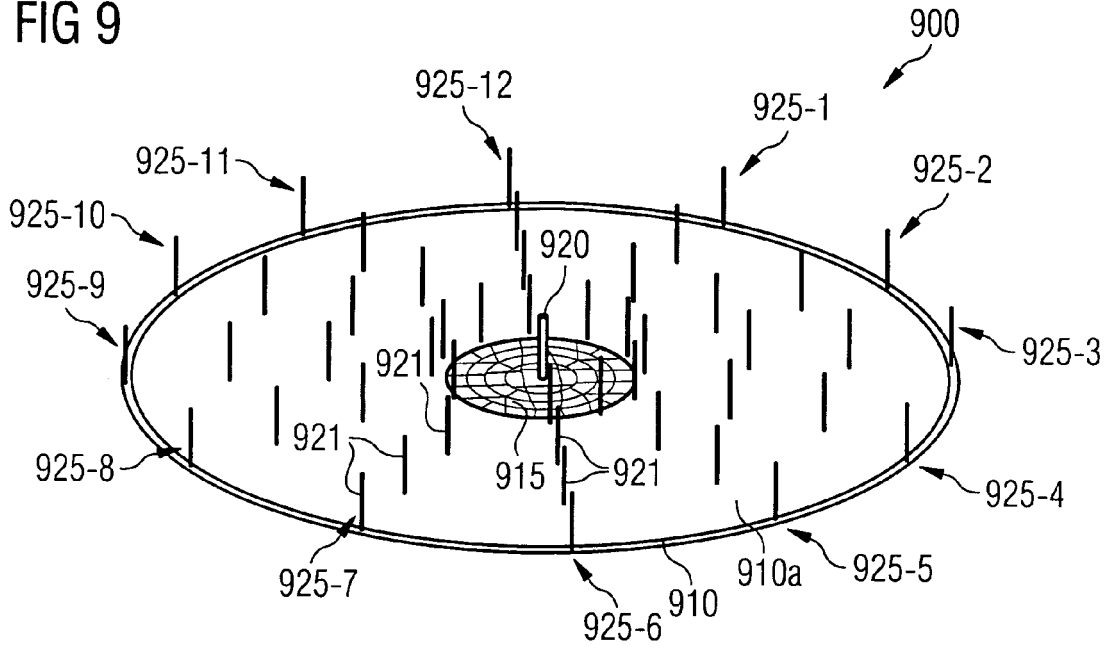


FIG 10

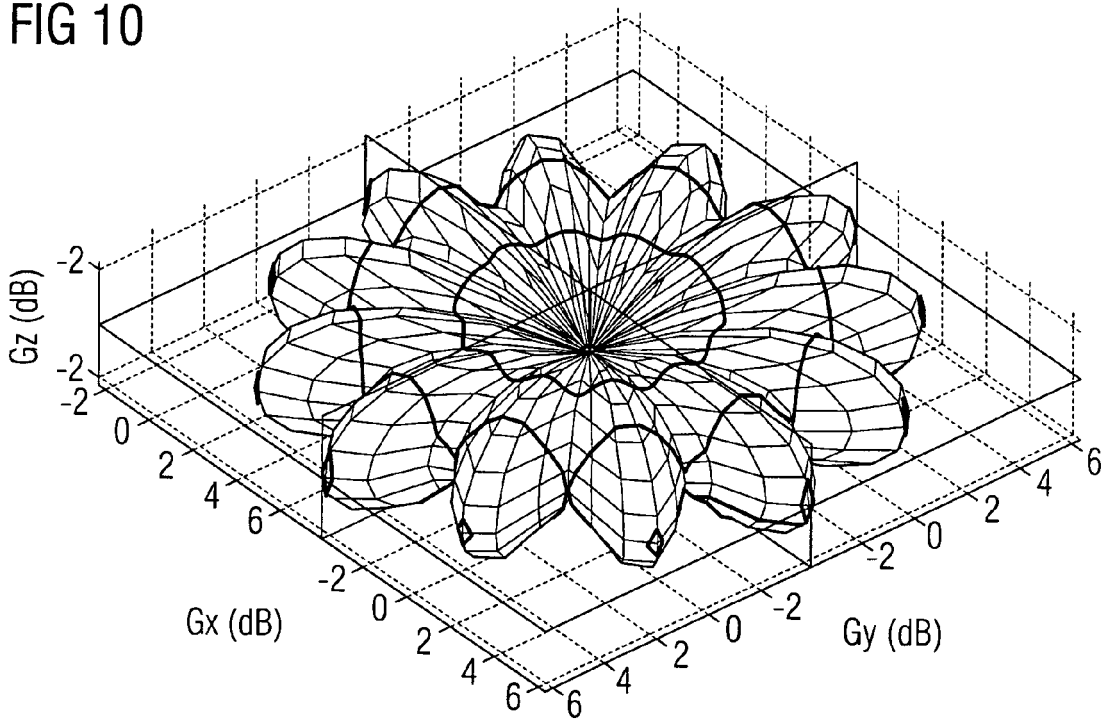


FIG 11

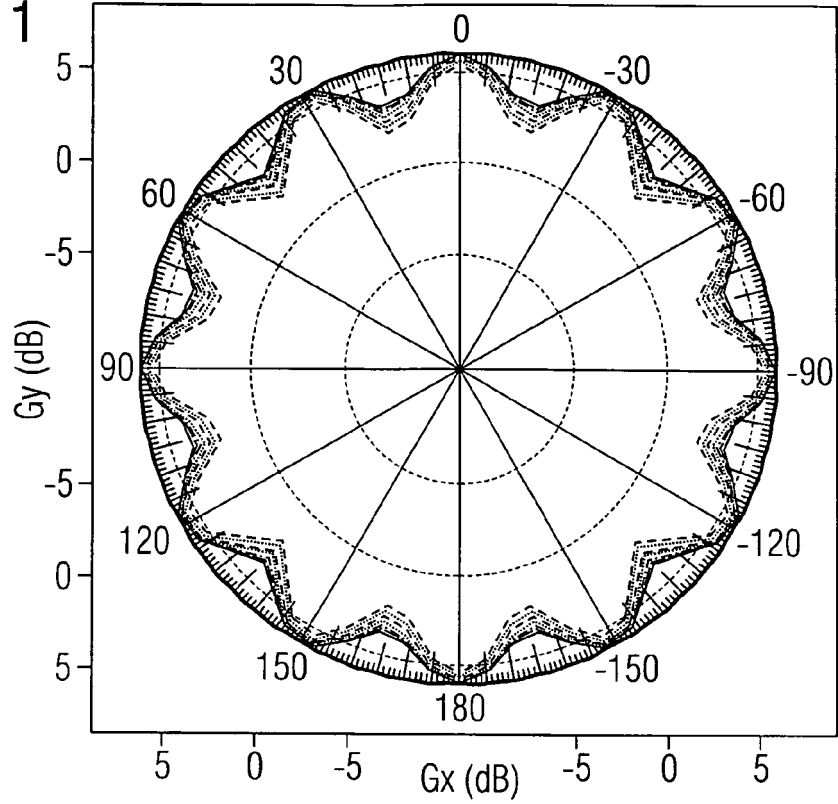


FIG 12

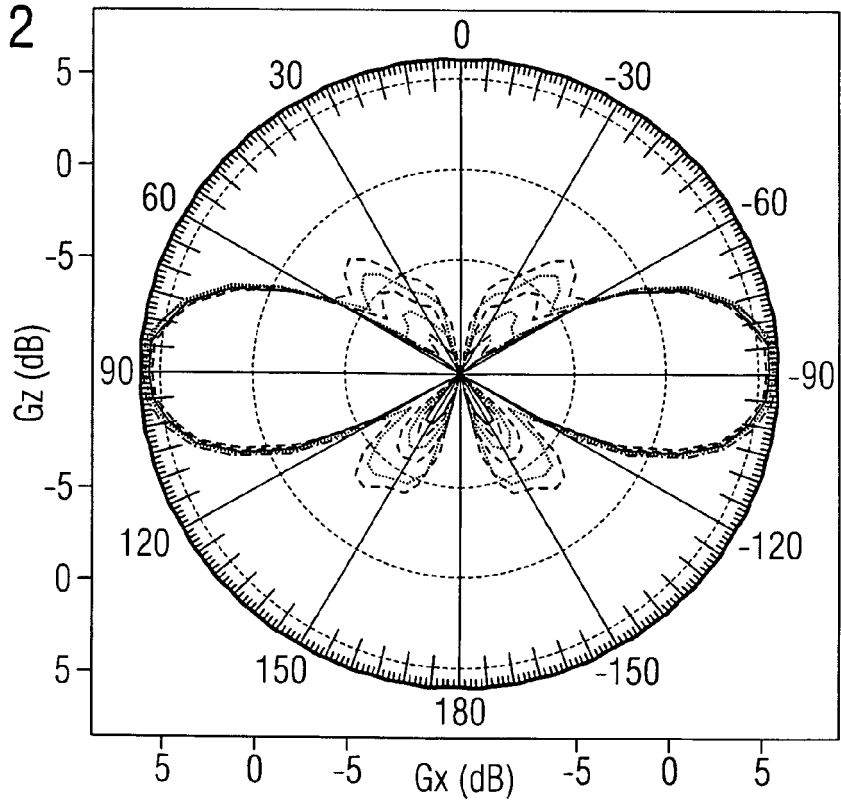


FIG 13

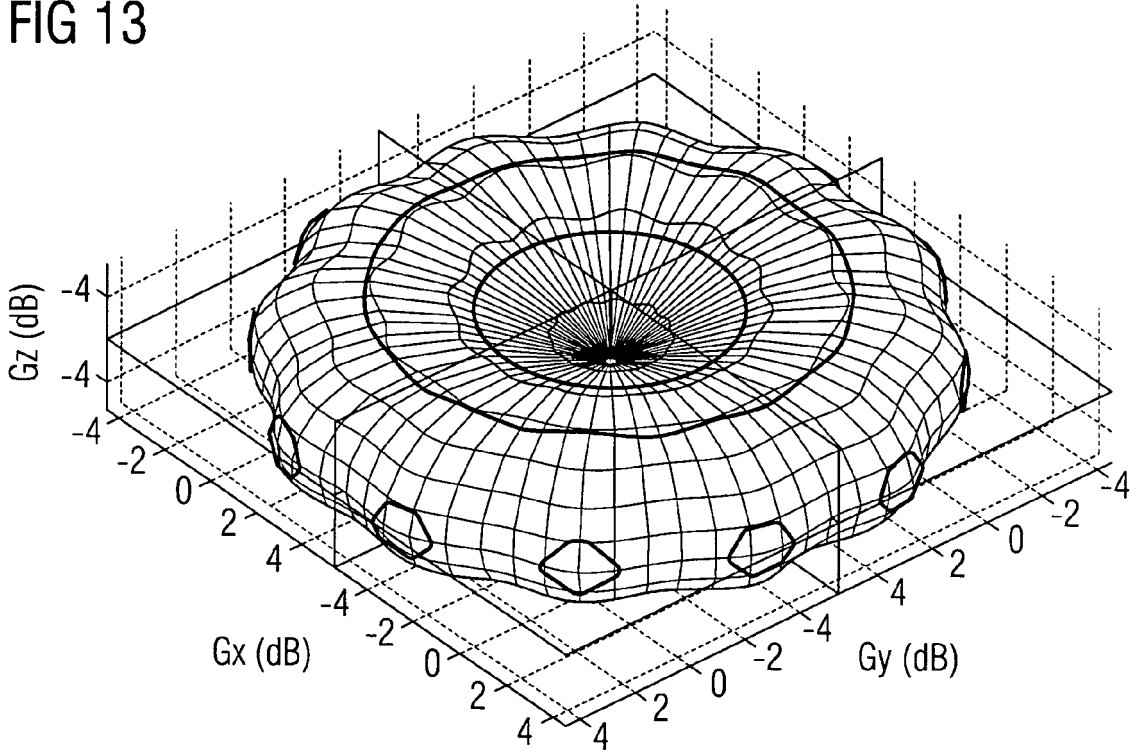


FIG 14

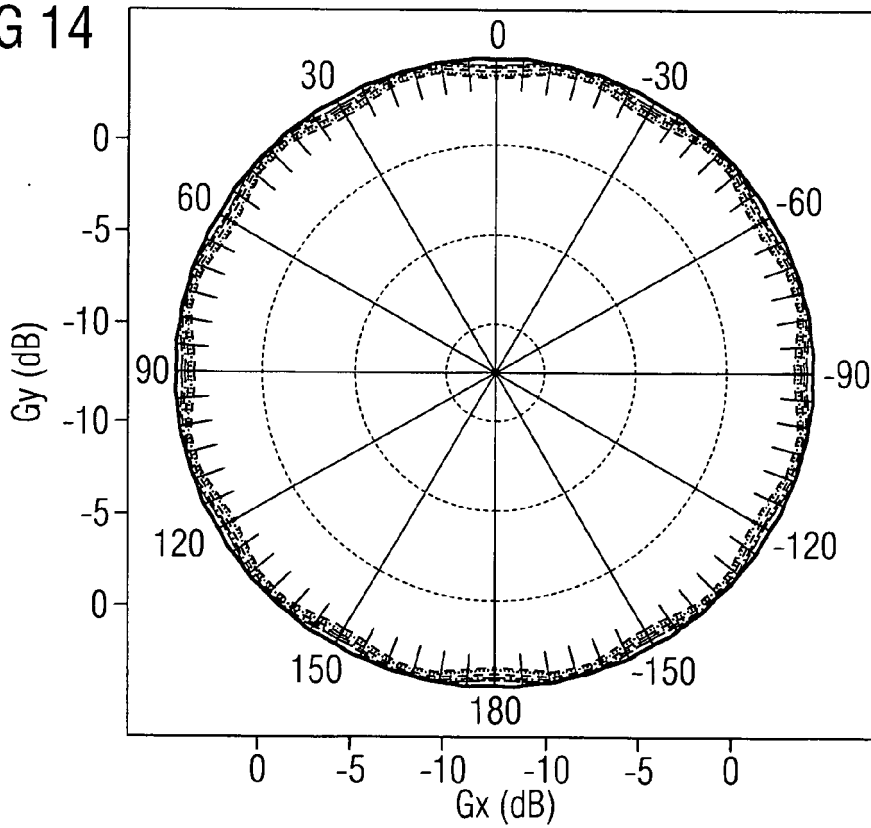


FIG 15

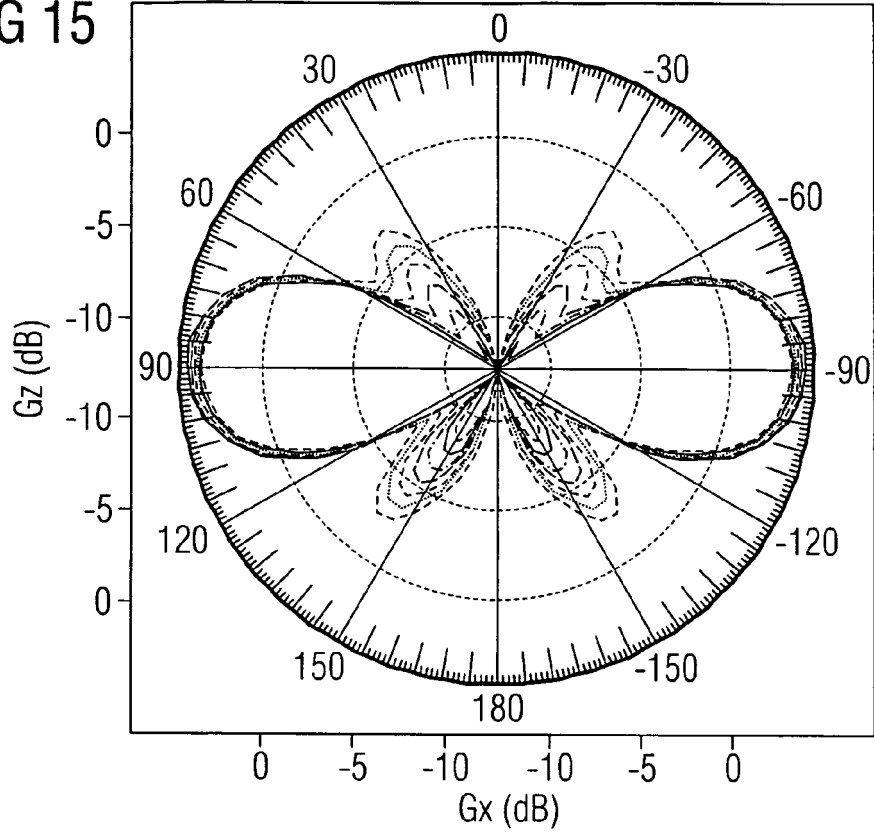


FIG 16

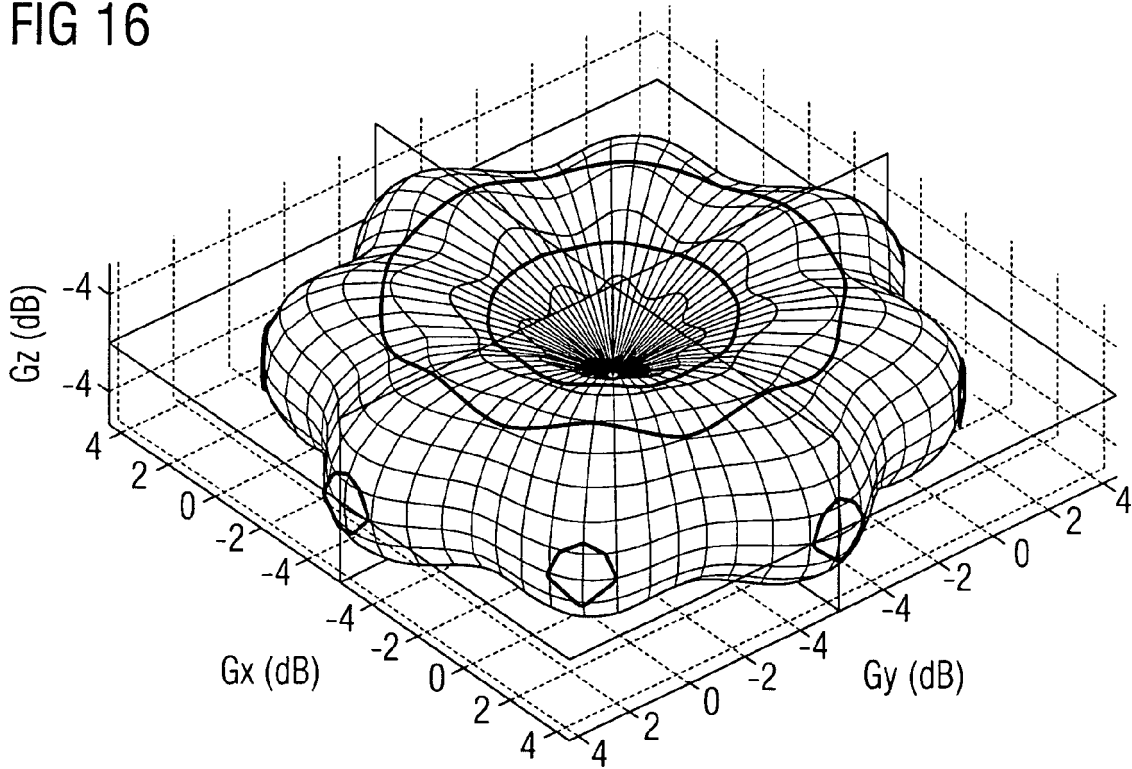


FIG 17

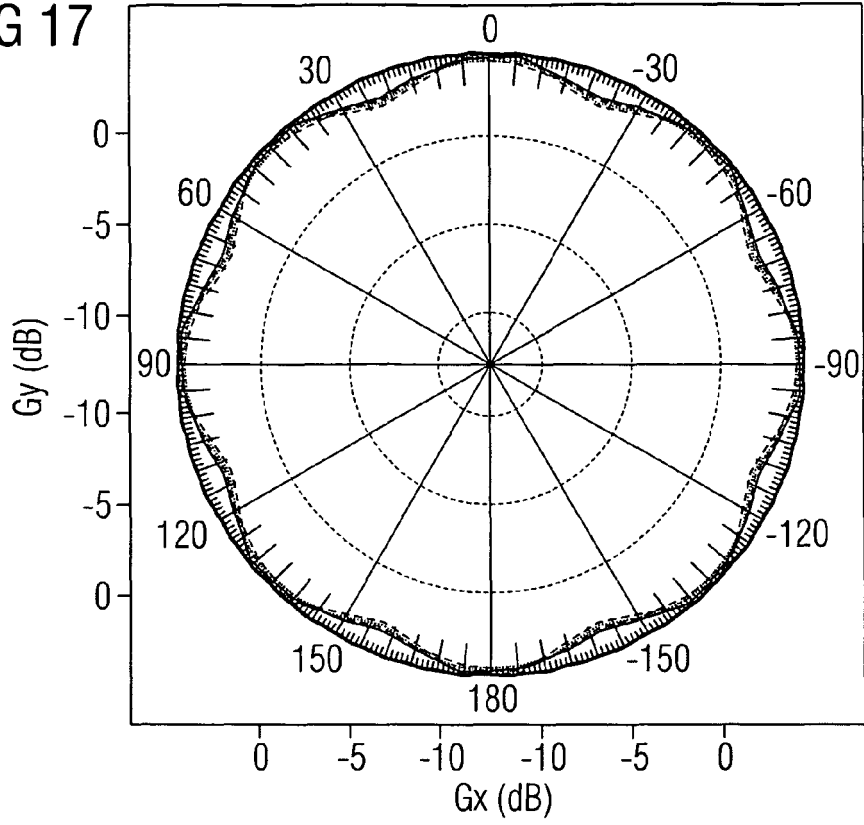


FIG 18

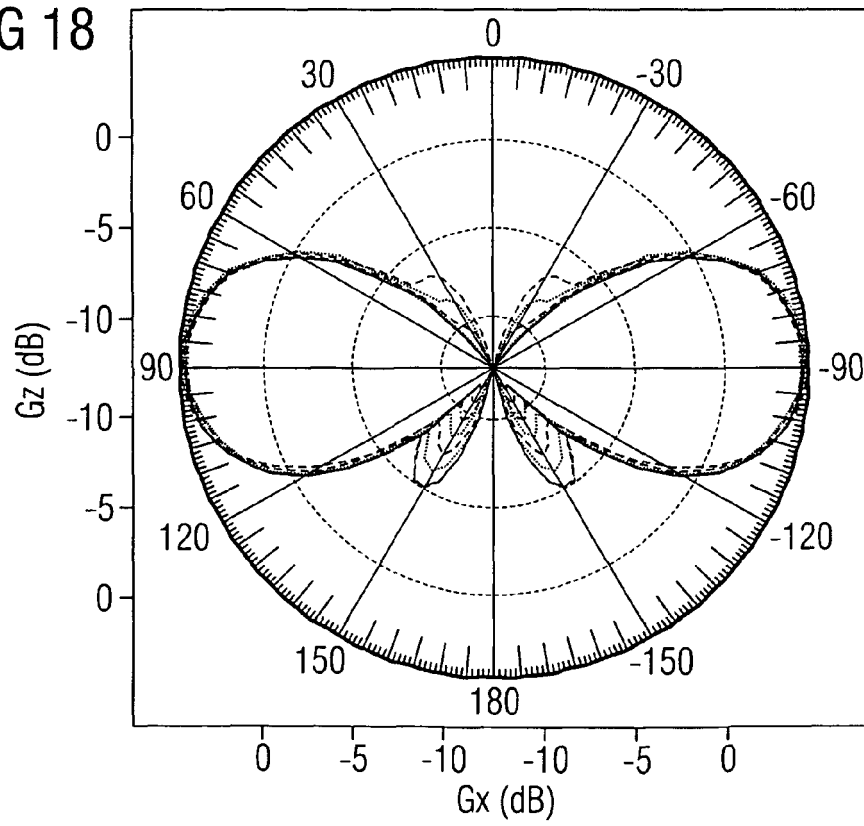
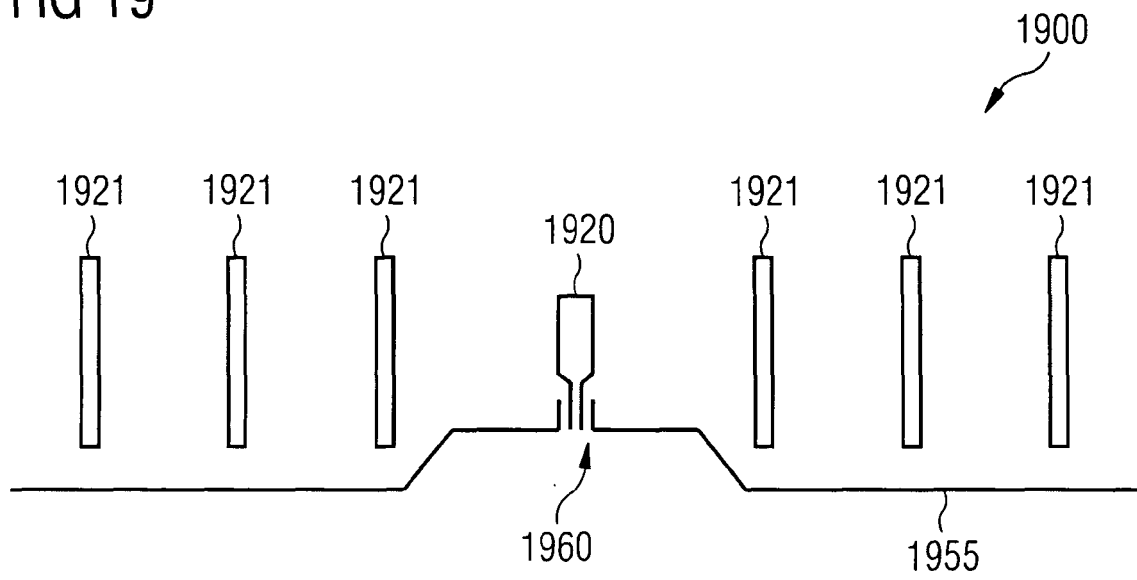


FIG 19





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 0 172 626 A (CANADIAN PATENTS DEV [CA]) 26 February 1986 (1986-02-26) * page 4, line 15 - page 5, line 18; figures 1,4 *	1-9	INV. H01Q19/30 H01Q19/32
X	WO 2004/107497 A (IPR LICENSING INC [US]) 9 December 2004 (2004-12-09) * paragraphs [0060] - [0077]; figure 15 *	1,4,6,8	
X	US 2002/158798 A1 (CHIANG BING [US] ET AL) 31 October 2002 (2002-10-31) * paragraph [0053] *	1,9	
X	US 3 109 175 A (LLOYD ARNOLD T) 29 October 1963 (1963-10-29) * the whole document *	1,9	
X	WO 2005/055365 A (CENTRE NAT RECH SCIENT [FR]; UNIV RENNES [FR]; UNIV PARIS SUD [FR]; DE) 16 June 2005 (2005-06-16) * figure 11 *	1,9	
X	EP 1 804 335 A (TOTO LTD [JP]) 4 July 2007 (2007-07-04) * figures 19,41 *	1,9	TECHNICAL FIELDS SEARCHED (IPC) H01Q
A	EP 0 812 026 A (IBM [US]) 10 December 1997 (1997-12-10) * figures 1,4 *	1,9	
A	MIGLIORE M D ET AL: "A Simple and Robust Adaptive Parasitic Antenna" IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, IEEE SERVICE CENTER, PISCATAWAY, NJ, US, vol. 53, no. 10, October 2005 (2005-10), pages 3262-3272, XP011140098 ISSN: 0018-926X * abstract; figure 1 *	1,9	
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 21 April 2008	Examiner Van Dooren, Gerry
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 08 00 0022

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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21-04-2008

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0172626	A	26-02-1986	CA 1239223 A1	12-07-1988
			DE 3579650 D1	18-10-1990
			JP 1764927 C	11-06-1993
			JP 4053322 B	26-08-1992
			JP 61025304 A	04-02-1986
			US 4700197 A	13-10-1987

WO 2004107497	A	09-12-2004	CA 2526683 A1	09-12-2004
			CN 1792006 A	21-06-2006
			EP 1629570 A2	01-03-2006
			JP 2007501587 T	25-01-2007
			KR 20060016092 A	21-02-2006
			KR 20070072629 A	04-07-2007
			TW 249266 B	11-02-2006

US 2002158798	A1	31-10-2002	US 2004027304 A1	12-02-2004

US 3109175	A	29-10-1963	NONE	

WO 2005055365	A	16-06-2005	CN 1906809 A	31-01-2007
			EP 1702388 A1	20-09-2006
			FR 2863109 A1	03-06-2005
			JP 2007512747 T	17-05-2007
			US 2007080891 A1	12-04-2007

EP 1804335	A	04-07-2007	WO 2006035881 A1	06-04-2006
			KR 20070051928 A	18-05-2007
			TW 273743 B	11-02-2007

EP 0812026	A	10-12-1997	JP 3294155 B2	24-06-2002
			JP 10154911 A	09-06-1998
			JP 3482642 B2	22-12-2003
			JP 2002325012 A	08-11-2002
			US 5767807 A	16-06-1998
