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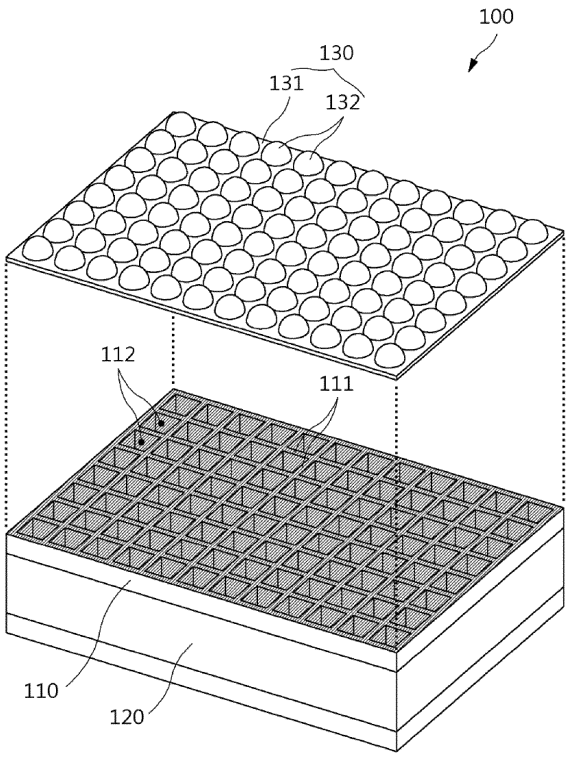
(54) **HORN ARRAY ANTENNA INCLUDING DIELECTRIC COVER**

(57) The purpose of the present invention is to provide a horn array antenna including a dielectric cover, capable of reinforcing a main lobe and effectively diminishing a grating lobe by only the further inclusion of the dielectric cover in the antenna, while not changing an antenna arrangement interval or arrangement structure in the horn array antenna.

FIG. 2




EP 3 518 342 A1

## Description

[Technical Field]

**[0001]** The present invention relates to a horn array antenna, and more particularly, to a horn array antenna including a dielectric cover for reducing a grating lobe.

[Background Art]

**[0002]** An antenna is a device that transmits or receives wireless radio waves in a free space, and is manufactured in various forms and specifications according to the purpose of use thereof. An example of the antenna is a horn array antenna. FIG. 1 shows one example of the form of a general horn array antenna. A horn antenna is a kind of aperture antenna in which a tip of a waveguide (a tubular conductor with an empty center) is formed in a horn shape so that the radio waves may be radiated into space. The horn array antenna refers to an antenna in which a plurality of horn antennas as described above are formed in an array on a plane. That is, the horn array antenna includes a horn array in which a plurality of horns formed by a plurality of partitions are arranged on a plane, and a radio wave module that transmits or receives radio waves through the horn array. A basic structure of such a horn array antenna is disclosed in Korean Patent Laid-Open Publication No. 2012-0014457 ("Horn Array Antenna and Manufacturing Method thereof", 2012. 02. 17).

**[0003]** An energy distribution of the radio waves radiated from the antenna is generally divided into several directions and each radiation group is called a lobe. A lobe in a direction in which radiation energy is maximized is called a main lobe, and the radiation groups in other directions are called side lobes. Meanwhile, a grating lobe is a special type of signal in the side lobe that appears periodically, and is particularly a signal that appears in the array antenna.

**[0004]** Since a size of the side lobe is significantly smaller than that of the main lobe, noise may be easily removed, but since the grating lobe appears to be significantly strong, the grating lobe is similar in size to the main lobe. Therefore, the grating lobe causes various problems such as causing interference in other equipment, accepting adjacent signals to increase noise, and causing detection errors. Therefore, the development of an array antenna structure for attenuating the grating lobe while reinforcing the main lobe is urgently required.

**[0005]** It is known that a location at which the grating lobe appears is determined by an antenna spacing of the array antenna. Therefore, attempts have been made to attenuate the grating lobe by generally changing an arrangement spacing or an arrangement itself of the antennas. However, the horn array antenna has a problem in that a space is required inside the antenna to dispose a combine circuit and a resonance structure, and a space required for the horn array antenna is increased when the arrangement spacing or the arrangement structure is changed in order to attenuate the grating lobe. That is, the antenna may become thick and large, or efficiency thereof may deteriorate.

**[0006]** As such, as a technology for removing a grating lobe peak while properly maintaining the antenna spacing in the array antenna without excessively widening the antenna spacing, there is Korean Patent Laid-Open Publication No. 2014-0142490 ("Apparatus and Method for Removing Grating Lobe Peak in Automotive Radar", 2014. 12. 12). In the related art document, signals in a long region radar (LRR) and a short region radar (SRR) are compared and analyzed to detect a presence of a grating lobe peak, and to remove the grating lobe peak when the grating lobe peak is present. That is, the related art document relates to a technology for attenuating the grating lobe by using a signal processing. However, it is difficult to widely use the technology of the related art document because there is a limit that it is impossible to apply the method of comparing and analyzing the LRR and SRR signals to other types of antennas.

[Related Art Document]

[Patent Document]

**[0007]**

1. Korean Patent Laid-Open Publication No. 2012-0014457 ("Horn Array Antenna and Manufacturing Method thereof", 2012. 02. 17)
2. Korean Patent Laid-Open Publication No. 2014-0142490 ("Apparatus and Method for Removing Grating Lobe Peak in Automotive Radar", 2014. 12. 12)

[Disclosure]

[Technical Problem]

**[0008]** An object of the present invention is to provide a horn array antenna including a dielectric cover for reducing a grating lobe. More specifically, an object of the present invention is to provide a horn array antenna including a dielectric cover, capable of reinforcing a main lobe and effectively attenuating a grating lobe by only further including a dielectric cover in the antenna while not changing an antenna arrangement spacing or an arrangement structure itself in the horn array antenna.

[Technical Solution]

**[0009]** In one general aspect, a horn array antenna 100 including a dielectric cover includes a horn array 110 formed in a form in which a plurality of horns 112 formed by a plurality of partitions 111 are arranged on a plane; an antenna body part 120 provided behind the horn array 110 to transmit or receive radio waves through the horn array 110; and a dielectric cover 130 provided in front of the horn array 110 to refract the radio waves radiated through the horn array 110 to attenuate grating lobes, and formed in a form in which a plurality of embossing cells 132 that protrude forwardly are arranged on the plate 131.

**[0010]** The embossing cells 132 may be formed in at least one outer shape selected from a dome shape, a lens shape, a donut shape, and a pyramid shape.

**[0011]** The embossing cells 132 may be formed so that a cross-sectional thickness of one embossing cell 132 is entirely the same or is different for each region.

**[0012]** The embossing cells 132 may be disposed so that one horn 112 corresponds to one embossing cell 132, or may be disposed so that a plurality of horns 112 correspond to one embossing cell 132.

**[0013]** The embossing cells 132 may be formed so that a size of each of the plurality of embossing cells 132 arranged on the plate 131 is entirely the same or is different for each region.

**[0014]** The embossing cells 132 may be formed so that an outer shape of each of the plurality of embossing cells 132 arranged on the plate 131 is entirely the same or is different for each region.

**[0015]** The dielectric cover may be formed of at least one material selected from Teflon, polyethylene, polycarbonate, and alkyl benzene sulfonate (ABS).

[Advantageous Effects]

**[0016]** According to the present invention, the grating lobe may be significantly attenuated by covering the front surface of the horn array antenna with the dielectric cover formed in a forwardly convex shape. More specifically, according to the present invention, the beam intensity of a specific angle in a single cell of the horn array antenna is adjusted by intentionally distorting the radiated radio waves using the property that the radio waves are refracted according to the permittivity. Therefore, ultimately, according to the present invention, when a plurality of such cells are arranged, the beam intensity at a desired angle may be adjusted, and as a result, the side lobe (and the grating lobe, which is a kind of side lobe) may be effectively suppressed.

**[0017]** In addition, according to the present invention, since there is no need for complicated signal processing or the like, there is also an advantage in that it is not necessary to configure the signal processing unit in a high specification in constituting the apparatus.

[Description of Drawings]

**[0018]**

FIG. 1 is a view showing a general horn array antenna.
FIG. 2 is a view showing a horn array antenna including a dielectric cover according to the present invention.
FIG. 3 is a view illustrating an actual manufacturing of a dielectric cover according to the present invention.
FIG. 4 is a view showing a radio wave refraction principle.
FIG. 5 is a view illustrating a single horn antenna including a dielectric lens.
FIG. 6 is a view showing various examples of a dielectric cover embossing cell form according to the present invention.
FIG. 7 is a view showing various examples of a dielectric cover embossing cell arrangement according to the present invention.
FIG. 8 is a view showing another example of the dielectric cover embossing cell arrangement according to the present invention.

FIG. 9 is a view showing a grating lobe attenuation effect according to a comparison between a conventional horn array antenna and the horn array antenna including the dielectric cover according to the present invention.

[Description of reference numerals]

**[0019]**

100: horn array antenna (according to the present invention)
110: horn array
111: partition 112: horn
120: antenna body part
130: dielectric cover
131: plate 132: embossing cell

[Best Mode]

**[0020]** Hereinafter, a horn array antenna including a dielectric cover according to the present invention having the configuration as described above will be described in detail with reference to the accompanying drawings.

**[0021]** FIG. 2 shows a horn array antenna 100 including a dielectric cover according to the present invention. The horn array antenna 100 according to the present invention basically includes a horn array 110 and an antenna body part 120 similarly to the conventional horn array antenna shown in FIG. 1, and further includes a dielectric cover 130. A description of each part will be provided below.

**[0022]** The horn array 110 is formed in the form in which a plurality of horns 112 formed by a plurality of partitions 111 are arranged on a plane as shown. As briefly described above, a horn antenna is a kind of aperture antenna in which a tip of a waveguide is formed in horn shape so that radio waves may be radiated into space, and the horn array antenna is formed by arranging a plurality of such horn antennas.

**[0023]** The antenna body part 120 is provided behind the horn array 110 to transmit or receive the radio waves through the horn array 110. That is, the antenna body part 120 includes a module capable of transmitting or receiving the radio waves. Depending on the purpose of use of the horn array antenna 100, the antenna body part 120 may be variously modified such as having only a transmitting module, only a receiving module, or both the transmitting and receiving modules.

**[0024]** The conventional horn array antenna basically includes only the horn array 110 and the antenna body part 120. In this case, various attempts have been made to attenuate side lobes, especially, grating lobes, which degrade antenna performance in the conventional horn array antenna. As described above, conventionally, the grating lobes are attenuated by changing an antenna arrangement spacing or an arrangement configuration, and in such a case, there is a problem in that a required space is increased and a volume of the antenna is excessively increased. According to the present invention, in order to solve such a problem, the grating lobe is effectively attenuated by providing the dielectric cover 130 in front of the horn array antenna while not changing the antenna arrangement spacing or the arrangement configuration and leaving them unchanged. Accordingly, the antenna performance may be significantly improved by effectively attenuating the grating lobes while basically solving the problem of unnecessarily increasing the volume of the antenna by changing the antenna arrangement.

**[0025]** The dielectric cover 130 is provided to the front of the horn array 110 as described above to serve to refract the radio waves radiated through the horn array 110 to attenuate the grating lobes. A shape of the dielectric cover 130 will be described in more detail, and as shown in FIG. 2, the dielectric cover 130 is formed in the form in which a plurality of embossing cells 132 that protrude forwardly are arranged on a plate 131. In addition, the dielectric cover 130 may be formed of a plastic material such as Teflon, polyethylene, polycarbonate, alkyl benzene sulfonate (ABS), or the like. FIG. 3 shows a photograph of an actual manufacturing example of a dielectric cover according to the present invention.

**[0026]** Hereinafter, a principle of a grating lobe attenuation effect using the dielectric cover 130 according to the present invention will be described in more detail.

**[0027]** FIG. 4 illustrates a radio wave refraction principle. The radio waves propagating in a space filled with a medium are refracted while a propagation speed thereof changes when permittivity of the medium changes. A phenomenon that light refracts in the air as it propagates to the surface, or refracts when passing through a concave lens or a convex lens is also based on such a principle.

**[0028]** Conventionally, in the field of antennas, a dielectric lens antenna using a phenomenon in which the radio waves are refracted while passing through a dielectric has been used. The dielectric lens antenna is formed in the form in which a dielectric lens is included in a parabolic antenna or a single horn antenna, and FIG. 5 shows an example of a single horn antenna including a dielectric lens. Such a conventional dielectric lens antenna has been used for the purpose of increasing a gain as shown in FIG. 5A.

**[0029]** According to the present invention, the beam intensity of a specific angle in a single cell of the horn array antenna is adjusted by intentionally distorting the radiated radio waves unlike the conventional dielectric lens antenna includes the dielectric lens for the purpose of increasing the gain. As a result, according to the present invention, when a plurality of such cells are arranged, the beam intensity at a desired angle may be ultimately adjusted, and as a result, the side lobe (and the grating lobe, which is a kind of side lobe) may be effectively suppressed. That is, while the conventional dielectric lens has a primary purpose in reinforcing the main lobe, the dielectric cover 130 according to the present invention has a primary purpose in attenuating the side lobe (and the grating lobe).

**[0030]** As such, the dielectric cover 130 according to the present invention ultimately effectively suppresses the grating lobe by adjusting intensity of the side lobe at the specific angle at the same time of providing no or little loss to the main lobe. In this case, a performance of the dielectric cover 130 is associated with various factors such as an array type, the number of elements, a frequency of use, permittivity, refraction angle, impedance matching, and reflected waves of peripheral signals. A shape of the dielectric cover 130 may also be variously modified according to the various factors. Hereinafter, examples of various shapes of the dielectric cover 130 will be described in more detail with the drawings.

**[0031]** FIG. 6 shows various examples of dielectric cover embossing cell form according to the present invention. As shown in FIG. 6, the embossing cell 132 may be formed in a dome shape, a lens shape, a donut shape, a pyramid shape, or the like. FIG. 6A shows the dome shape, FIG. 6B shows the lens shape, FIG. 6C shows the donut shape, and FIG. 6D shows the pyramid shape, respectively.

**[0032]** In addition, the embossing cell 132 may be formed so that a cross-sectional thickness of one embossing cell 132 is entirely the same or is different for each region. For example, the embossing cell 132 may also be formed so that an outer shape of the embossing cell 132 is formed in the dome shape as shown in FIG. 6A and the cross-sectional thickness thereof is entirely the same as shown in the lower left of FIG. 6A, and may also be formed so that the cross-sectional thickness thereof is thick at the central portion and is decreased toward an edge as shown in the lower right of FIG. 6B. As another example, the embossing cell 132 may also be formed so that the outer shape of the embossing cell 132 is formed in the pyramid shape as shown in FIG. 6D and the cross-sectional thickness thereof is entirely the same as shown in the lower left of FIG. 6D, and may also be formed so that the cross-sectional thickness thereof is thin at the central portion and is increased toward the edge as shown in the lower right of FIG. 6D. Of course, various examples of FIG. 6 are to show that although one embossing cell 132 in the present invention has the same shape, the cross-sectional thickness thereof may be variously changed, and the present invention is not limited to such examples.

**[0033]** As such, the shape of the embossing cell 132 may be variously changed, and the arrangement of the embossing cell 132 may also be variously changed. First, the embossing cells 132 may also be disposed so that one horn 112 corresponds to one embossing cell 132 as shown in FIG. 7A, or may also be disposed so that a plurality of horns 112 correspond to one embossing cell 132 as shown in FIG. 7B. FIG. 7B shows an example in which the embossing cells 132 are disposed so that four horns 112 correspond to one embossing cell 132. Meanwhile, although FIG. 7B shows an example in which the four horns 112 corresponding to one embossing cell 132 are arranged in a 2 x 2 array, the embossing cell 132 may elongate to one side and the four horns 112 corresponding to the embossing cell 132 may also be arranged in a 1 x 4 array or a 4 x 1 array, and that is, a correspondence between the embossing cells and the horns may be variously changed depending on the shape and the size of the embossing cells 132.

**[0034]** FIG. 8 shows another example of a dielectric cover embossing cell arrangement according to the present invention. In the example of FIG. 7, the size of each of the plurality of embossing cells 132 arranged on the plate 131 is formed to be entirely the same. On the contrary, in the example of FIG. 8, the size of each of the plurality of embossing cells 132 arranged on the plate 131 is formed to be different for each region. The example of FIG. 8 shows that the embossing cell 132 disposed at the central portion of the plate 131 is formed to be large and the embossing cell 132 disposed at the edge of the plate 131 is formed to be small. Of course, the present invention is not limited thereto, and on the contrary to the example of FIG. 8, the size of the embossing cell may be formed to be reduced toward the central portion, that is, the size of the embossing cell may be variously changed for each plate region.

**[0035]** Meanwhile, in the examples of FIGS. 7 and 8A, the outer shape of each of the plurality of embossing cells 132 arranged on the plate 131 is formed to be entirely the same. On the contrary, in the example of FIG. 8B, the outer shape of each of the plurality of embossing cells 132 arranged on the plate 131 is formed to be different for each region. FIG. 8B shows an example in which the embossing cells are formed in large and small dome shapes or lens shapes at a central region and the embossing cells 132 are formed in the pyramid shape at an edge region. Of course, this is merely an example and the present invention is not limited thereto, and as described above, in the present invention, the outer shape of each of the plurality of embossing cells 132 arranged on the plate 131 is formed to be entirely the same or is formed to be different for each region, i.e., may be variously changed.

**[0036]** FIG. 9 is an experiment result showing a grating lobe attenuation effect according to a comparison between a conventional horn array antenna and the horn array antenna including the dielectric cover according to the present invention. In addition, Tables below are experiment results of a case (Table 1) in which the dielectric cover 130 is not present and a case (Table 2) in which the dielectric cover 130 is present, and are numerical representations of some of the results of FIG. 9.

**[0037]** As shown in Tables 1 and 2 and can be intuitively seen from the graph of FIG. 9, an effect in which the grating lobes (both end portions of the graph) are significantly attenuated exhibits when the dielectric cover is present as compared to when the dielectric cover is not present. In addition, as shown in the graph of FIG. 9, it can be seen that the main lobe (the central portion of the graph, the maximum value portion) appears almost the same both when the dielectric cover is not present and when the dielectric cover is present.

[Table 1] [Table 2]

| No cover data | | Ro=35, Ri=29 | |
|---|---|---|---|
| H-pol (Port 1) | E-plane (Φ=0) | H-pol (Port 1) | E-plane (Φ=0) |
| 7.9 GHz<br>8.15 GHz<br>8.4 GHz | -8.45<br>-7.71<br>-7.21 | 7.9 GHz<br>8.15 GHz<br>8.4 GHz | -11.08<br>-9.74<br>-7.21 |
| V-pol (Port 2) | E-plane (Φ=90) | V-pol (Port 2) | H-plane (Φ=0) |
| 7.9 GHz<br>8.15 GHz<br>8.4 GHz | -8.16<br>-7.4<br>-6.98 | 7.9 GHz<br>8.15 GHz<br>8.4 GHz | -16.36<br>-27.95<br>-13.21 |

**[0038]** As such, it can be seen that the horn array antenna including the dielectric cover according to the present invention may significantly attenuate the grating lobes more effectively than the conventional horn array antenna as shown in FIG. 9, while the main lobe has little or no change in intensity and there is little or no loss in antenna gain, compared to the conventional horn array antenna.

**[0039]** The present invention is not limited to the abovementioned embodiments, but may be variously applied. In addition, the present invention may be variously modified by those skilled in the art to which the present invention pertains without departing from the gist of the present invention claimed in the claims.

[Industrial Applicability]

**[0040]** According to the present invention, the grating lobe may be significantly attenuated by covering the front surface of the horn array antenna with the dielectric cover formed in a forwardly convex shape. In addition, according to the present invention, since there is no need for complicated signal processing or the like, there is also an advantage in that it is not necessary to configure the signal processing unit in a high specification in constituting the apparatus.

## Claims

1. A horn array antenna including a dielectric cover, the horn array antenna comprising
a horn array formed in a form in which a plurality of horns formed by a plurality of partitions are arranged on a plane; an antenna body part provided behind the horn array to transmit or receive radio waves through the horn array; and a dielectric cover provided in front of the horn array to refract the radio waves radiated through the horn array to attenuate grating lobes, and formed in a form in which a plurality of embossing cells that protrude forwardly are arranged on the plate.

2. The horn array antenna of claim 1, wherein the embossing cells are formed in at least one outer shape selected from a dome shape, a lens shape, a donut shape, and a pyramid shape.

3. The horn array antenna of claim 1, wherein the embossing cells are formed so that a cross-sectional thickness of one embossing cell is entirely the same or is different for each region.

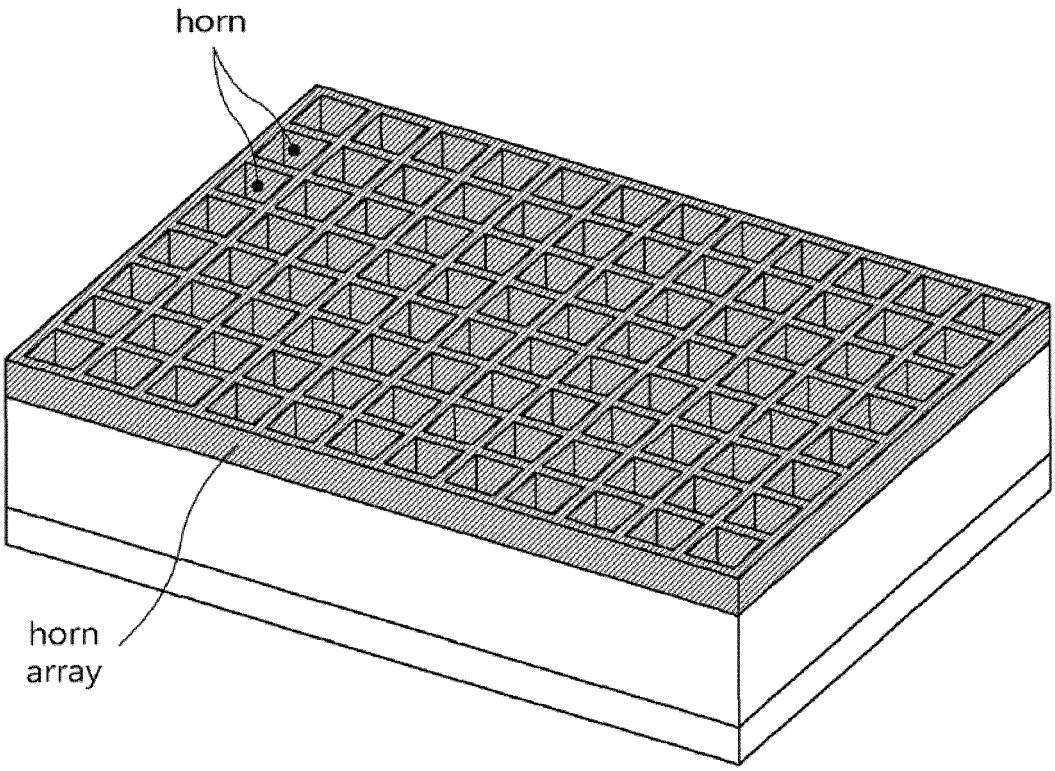
4. The horn array antenna of claim 1, wherein the embossing cells are disposed so that one horn corresponds to one embossing cell, or are disposed so that a plurality of horns correspond to one embossing cell.

5. The horn array antenna of claim 1, wherein the embossing cells are formed so that a size of each of the plurality of embossing cells arranged on the plate is entirely the same or is different for each region.

6. The horn array antenna of claim 1, wherein the embossing cells are formed so that an outer shape of each of the plurality of embossing cells arranged on the plate is entirely the same or is different for each region.

7. The horn array antenna of claim 1, wherein the dielectric cover is formed of at least one material selected from Teflon, polyethylene, polycarbonate, and alkyl benzene sulfonate (ABS).

FIG. 1



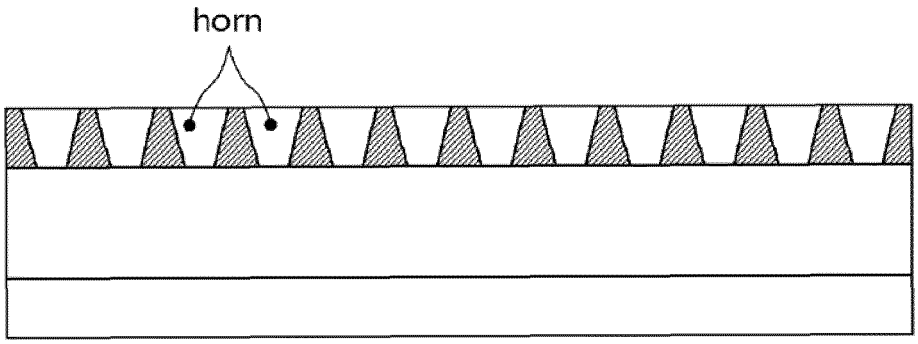



FIG. 2

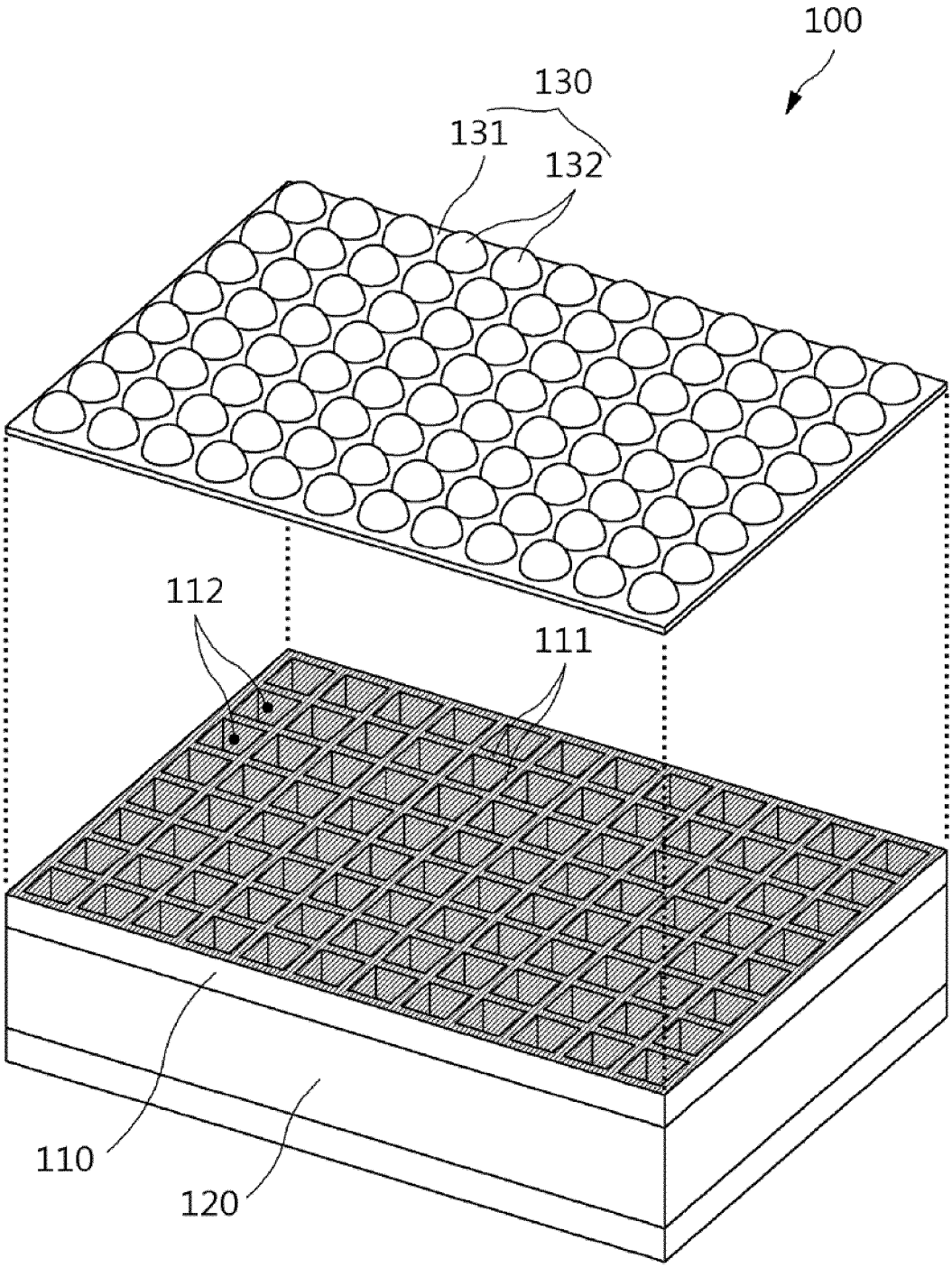


FIG. 3

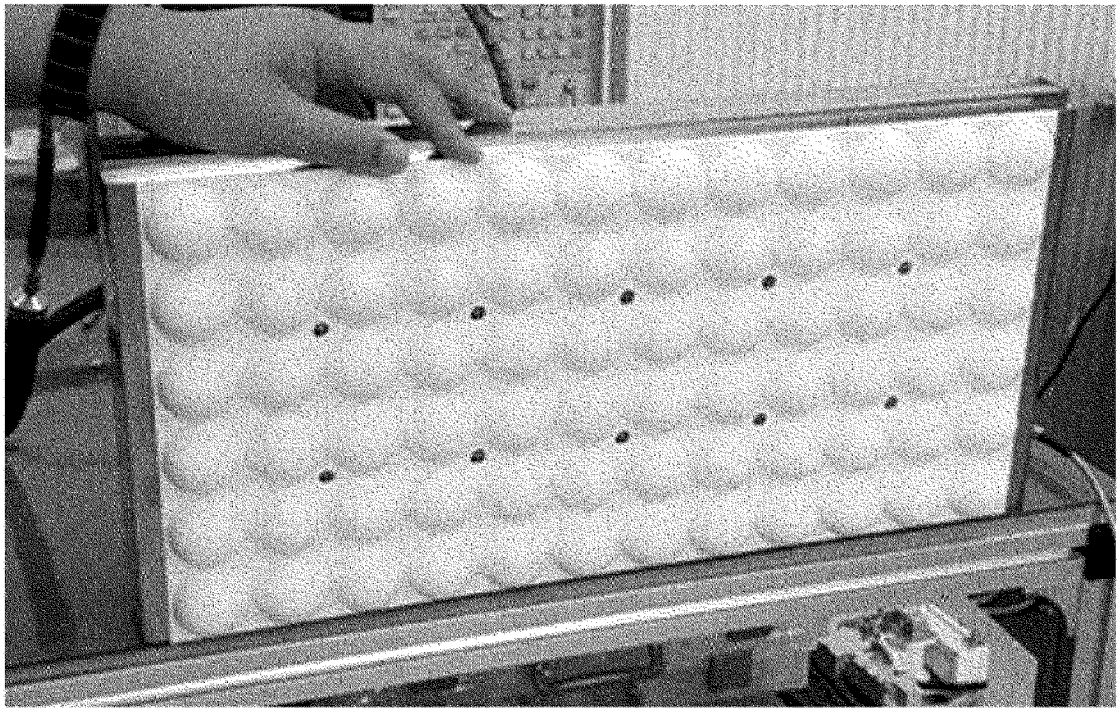


FIG. 4

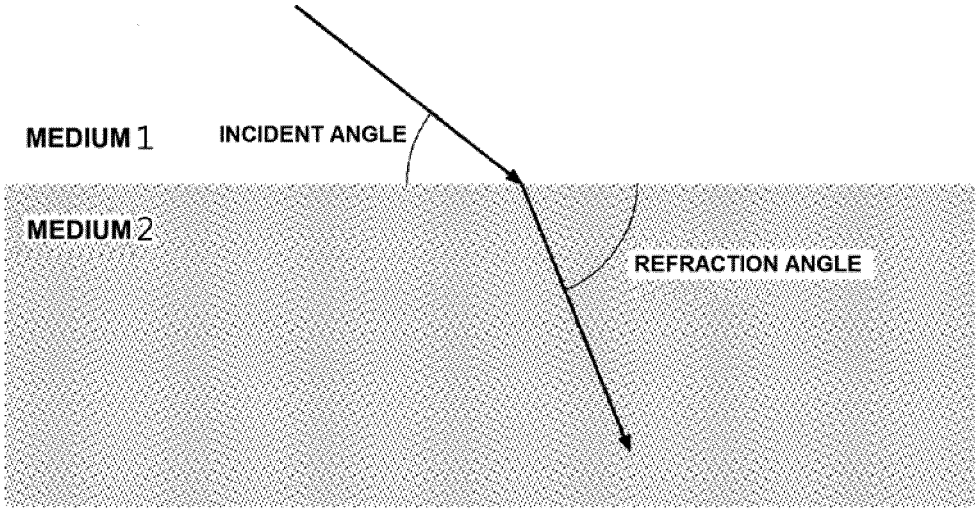
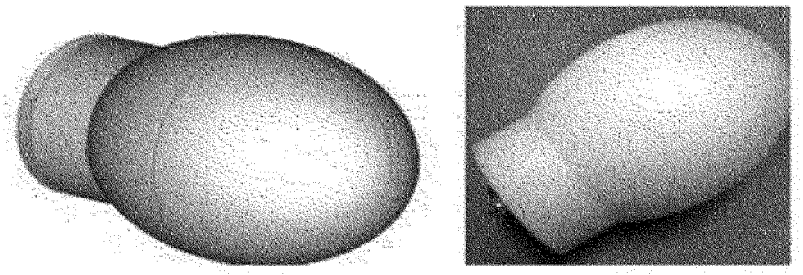
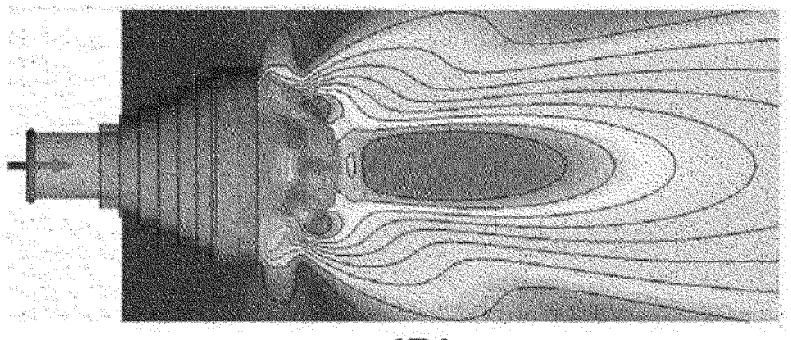


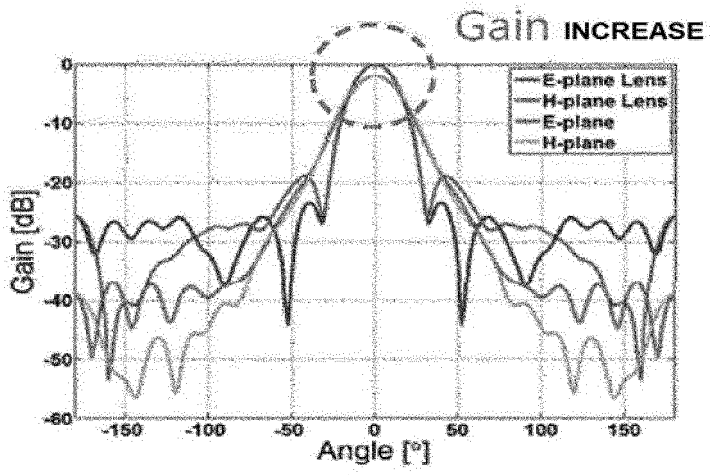
FIG. 5



(A)



(B)


Gain INCREASE
E-plane Lens
H-plane Lens
E-plane
H-plane
Gain [dB]
0
-10
-20
-30
-40
-50
-60
-150
-100
-50
0
50
100
150
Angle [°]

(C)

FIG. 6

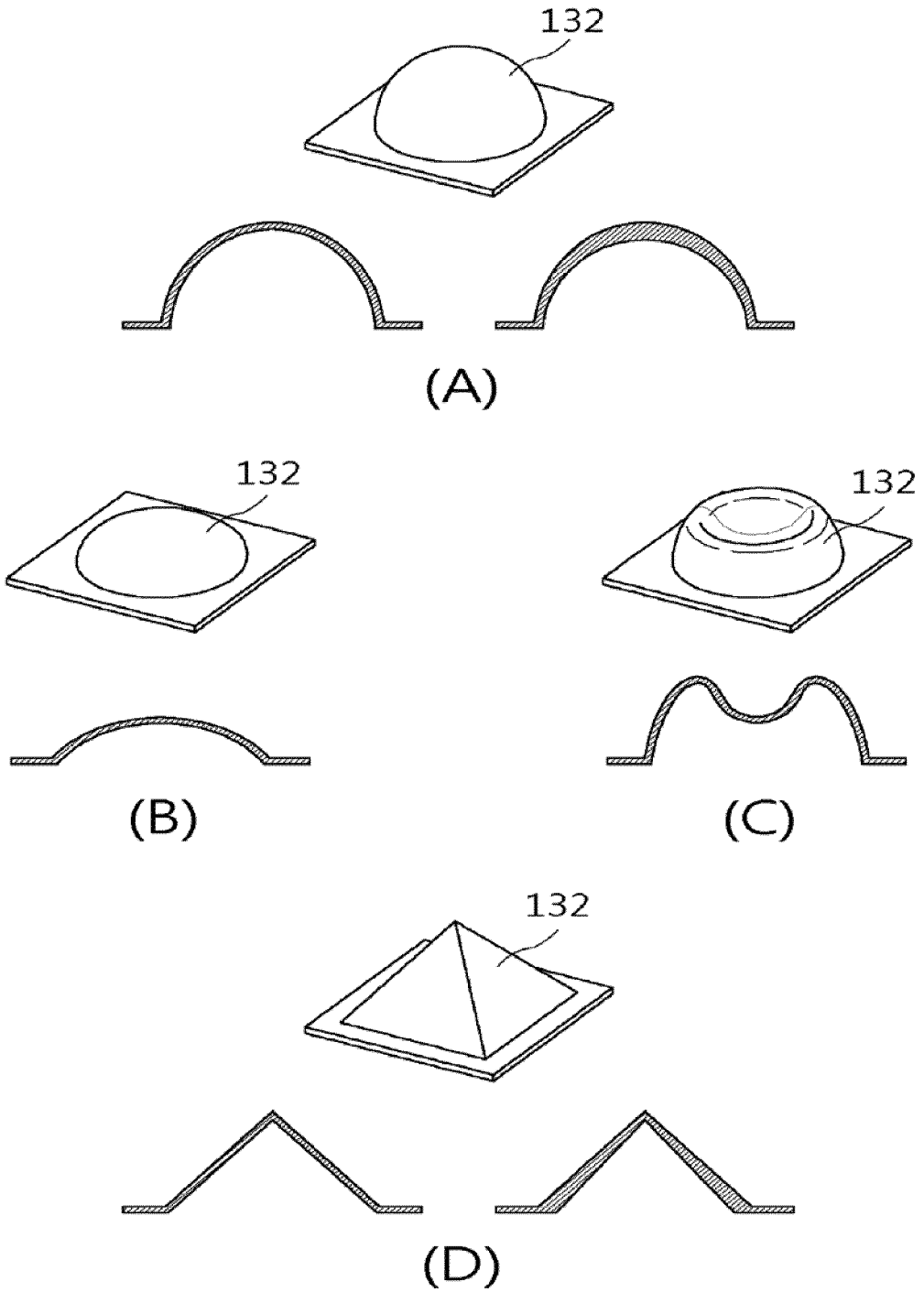
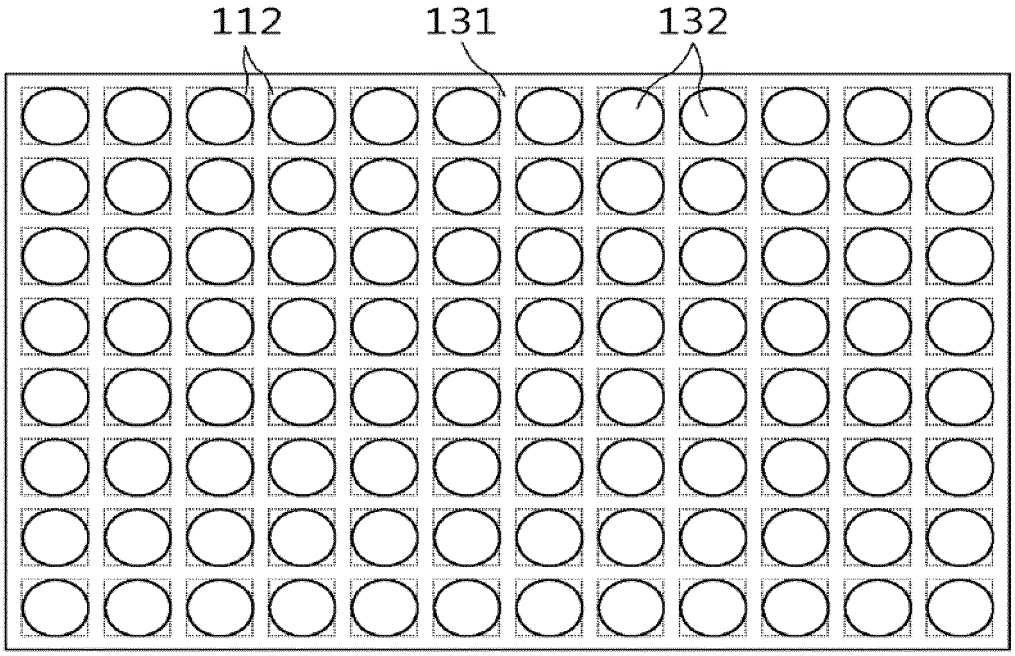
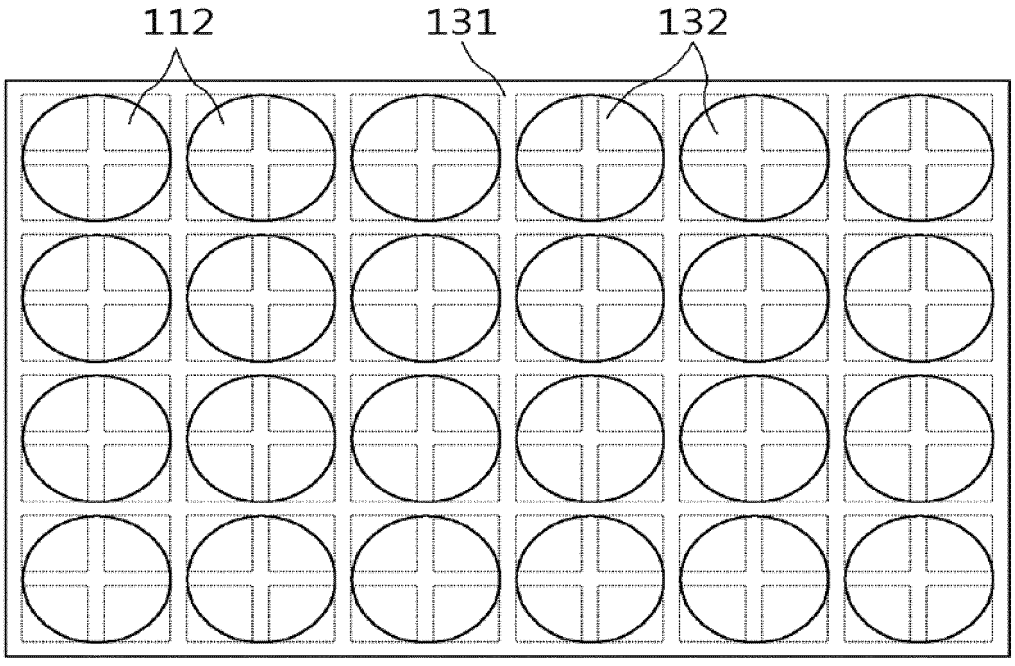


FIG. 7




(A)




(B)

FIG. 8

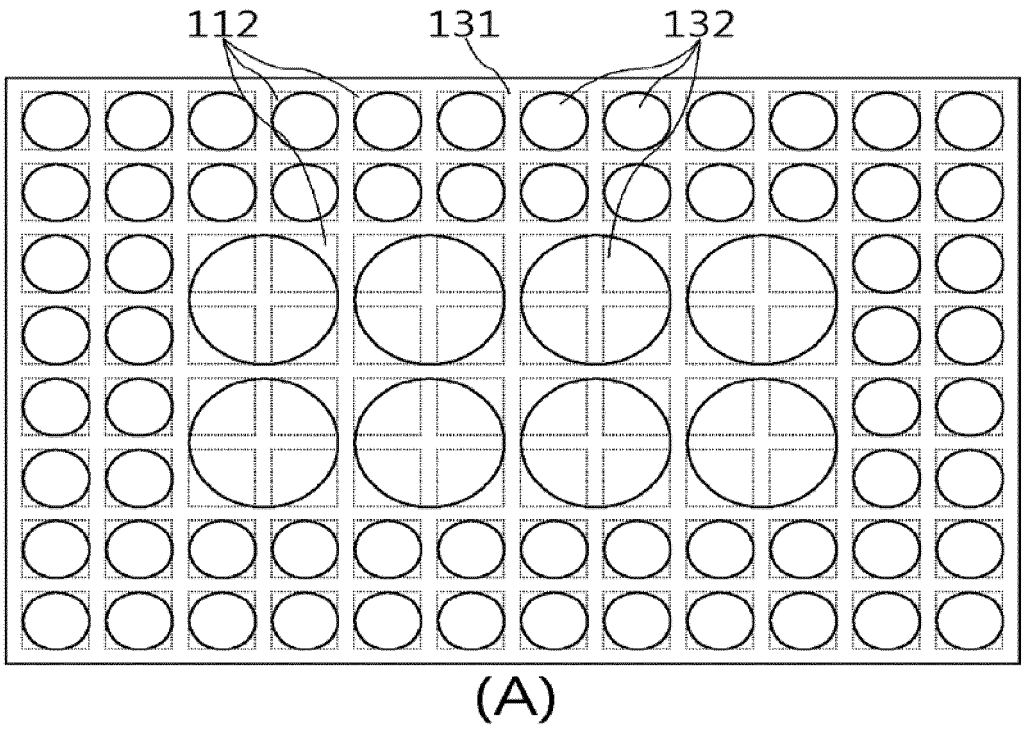
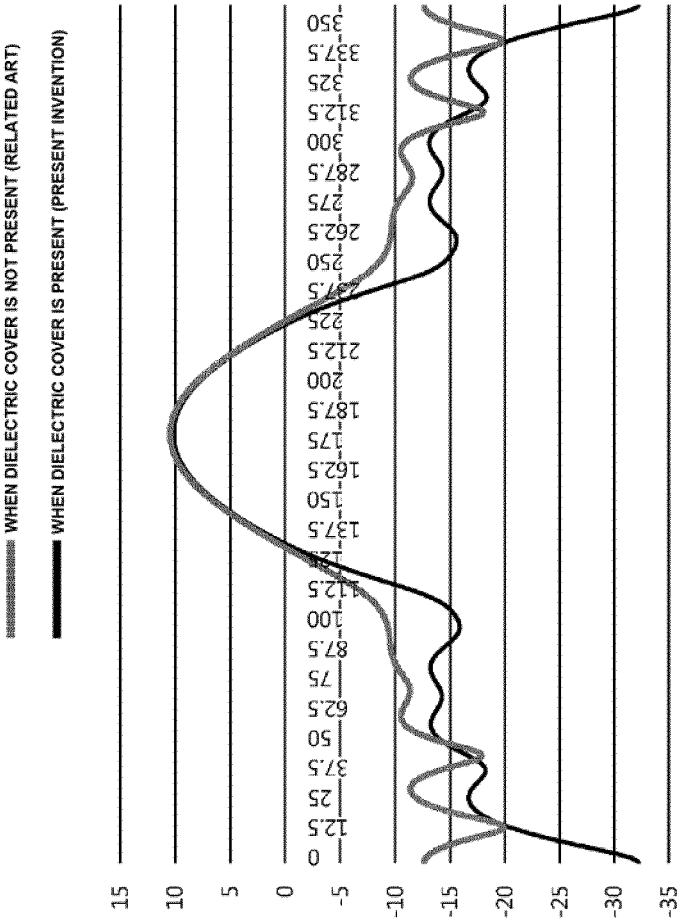


FIG. 9


WHEN DIELECTRIC COVER IS NOT PRESENT (RELATED ART)
WHEN DIELECTRIC COVER IS PRESENT (PRESENT INVENTION)
15
10
5
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-5
-10
-15
-20
-25
-30
-35
0
12.5
25
37.5
50
62.5
75
87.5
100
112.5
137.5
150
162.5
175
187.5
200
212.5
225
262.5
275
287.5
300
312.5
325
337.5
350

## INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2016/011475

A. CLASSIFICATION OF SUBJECT MATTER

*H01Q 15/08(2006.01)i, H01Q 21/06(2006.01)i, H01Q 13/18(2006.01)i*

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)

H01Q 15/08; H01Q 3/08; G01R 31/00; H01Q 13/02; H01Q 21/06; H01Q 13/00; H01P 1/161; H01Q 1/42; H01Q 13/18

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

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

eKOMPASS (KIPO internal) & Keywords: horn, array antenna, dielectric cover

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | JP 2012-175680 A (NEC CORP.) 10 September 2012<br>See paragraphs [0013], [0018], [0042]-[0050] and figures 1-3, 10-11, 14. | 1-7 |
| A | JP 2005-536929 A (AEROSAT CORPORATION) 02 December 2005<br>See claim 1 and figure 4. | 1-7 |
| A | JP 2006-166399 A (MASPRO DENKOH CORP.) 22 June 2006<br>See claim 1 and figures 2-3. | 1-7 |
| A | KR 10-0624049 B1 (PHILL SAT CO., LTD.) 20 September 2006<br>See claim 1 and figure 3. | 1-7 |
| A | JP 07-039109 U (MITSUBISHI ELECTRIC CORP.) 14 July 1995<br>See claim 1 and figures 4-6. | 1-7 |

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"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
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 11 JULY 2017 (11.07.2017) | **11 JULY 2017 (11.07.2017)** |

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**INTERNATIONAL SEARCH REPORT**
Information on patent family members

International application No.
**PCT/KR2016/011475**

| Patent document cited in search report | Publication date | Patent family member | Publication date |
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## REFERENCES CITED IN THE DESCRIPTION

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- KR 20140142490 **[0006] [0007]**