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(71) Applicant: **Nippon Sheet Glass Company Limited**
Tokyo 108-6321 (JP)

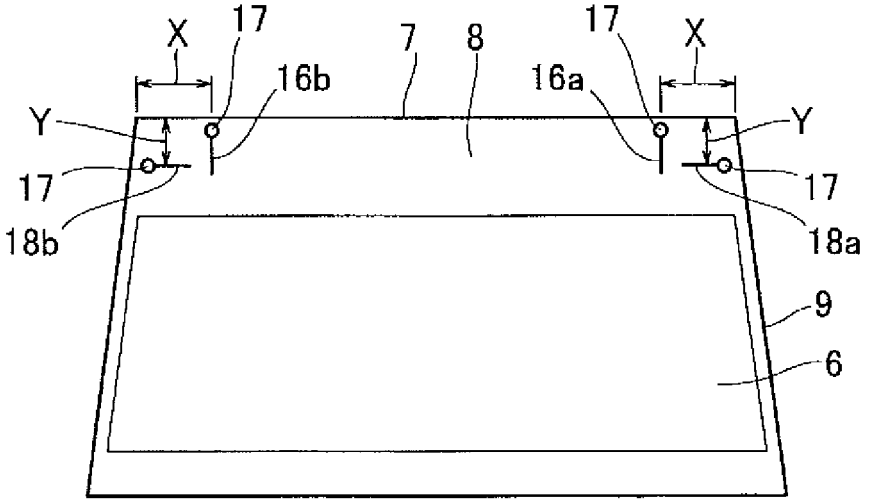
(72) Inventors:
- **Doi, Ryokichi**
  Tokyo (JP)
- **Iijima, Hiroshi**
  Tokyo (JP)
- **Yatabe, Kazumi**
  Tokyo (JP)

(74) Representative: **Intes, Didier Gérard André et al**
Cabinet Beau de Loménie
158, rue de l'Université
75340 Paris Cedex 07 (FR)

(54) Glass antenna for vehicle

(57) A glass antenna for a vehicle includes four antenna elements integrated in one windowpane and has excellent reception sensitivity and directional characteristics. The glass antenna includes two first vertical antenna elements (16a, 16b) and two second horizontal antenna elements (18a, 18b) on a rear window. The first antenna elements extend downwardly from the vicinity of ends of an upper side of the rear window. Second antenna elements extend horizontally from the vicinity of upper portions of sides of the rear window toward the center of the vehicle in the width direction.

FIG.2



EP 2 009 733 A1

Description

[0001] The present invention relates to a glass antenna for a vehicle and, more particularly, to a vehicular glass antenna having at least four antenna elements.

[0002] As a glass antenna for a vehicle used for digital television broadcasting (using frequencies ranging from 470 to 770 MHz), there is an antenna system in which two antenna elements are provided in a windshield or a rear window in a diversity scheme.

[0003] FIG. 1 hereof shows a conventional glass antenna. Two monopole antenna elements 12a, 12b that extend in a horizontal direction are provided in the vicinity of upper portions of right and left sides or edges 2, 2 of a windshield 10. The monopole antenna elements 12a, 12b are provided at positions set apart from an upper side 4 of the windshield 10 by 130 mm. In FIG. 1, reference numerals 14a, 14b denote respective feed points of the monopole antenna elements.

[0004] However, when viewed from the windshield or the rear window, conventional glass antennas provided in the windshield or the rear window are affected by portions of the vehicle body along the transverse direction, rearward direction, or frontward direction, resulting in lower antenna gain in the transverse direction and inwardly with respect to the vehicle.

[0005] Japanese Patent Application Laid-Open Publication No. 2000-252732 (JP 2000-252732 A) discloses a glass antenna for a vehicle provided in a rear window of an automotive vehicle, the antenna including antenna elements that extend respectively from right and left sides of the rear window, an antenna element that extends from an upper side, and an antenna element that extends from a lower side. The antenna has excellent reception sensitivity in all directions as viewed from the automotive vehicle when receiving a television broadcasting band using a plurality of channels in a diversity scheme so as to compensate for the sensitivity of the antenna elements in low-sensitivity directions.

[0006] However, in the antenna disclosed in JP 2000-252732 A, antenna elements extending from the upper side and extending from the lower side must be formed. Therefore, the area of a defogger is reduced, or the areas on the upper or lower side where the antenna elements are formed must be spread out, which leads to interference when other antenna elements are provided.

[0007] Further, a wiper is provided on the rear window in certain automotive vehicles. Therefore, when an antenna element is provided in a lower side of the rear window, insufficient space will be provided for forming the antenna element, or, even when the antenna element can be formed, sufficient performance cannot be assured because of the effect of the wiper.

[0008] Japanese Patent Application Laid-Open Publication No. 2002-135025 (JP 2002-135025 A) discloses a glass antenna provided with two antenna elements in a windshield and two antenna elements in a rear window. In this glass antenna, the antenna elements are disposed in the vicinity of a roof or pillars of the automotive vehicle, whereby the roof or the pillars function as reflectors, and the directional characteristics of the antenna element are controlled. In addition, a radiating element is formed in the vicinity of an antenna element, whereby the directional characteristics of the antenna element are controlled. Further, the directivity of the glass antenna in the horizontal plane is complemented by using a diversity circuit to select one among the antenna elements having directivities in different directions.

[0009] However, the antenna described above cannot provide good reception sensitivity characteristics inwardly with respect to the vehicle for each windowpane; therefore, antenna elements need to be formed in the front and rear windows, resulting in increased cost.

[0010] Moreover, the antenna for an automotive vehicle described above may be tuned by a glass manufacturer. In this case, when the manufacturer of the windshield differs from that of the rear window, tuning-related complications or other problems may occur.

[0011] An object of the invention is to provide a vehicle-mounted glass antenna for receiving television signals, integrated in a single windowpane. The glass antenna is provided at a reduced cost and causes no tuning-related complications.

[0012] According to an aspect of the present invention, there is provided a glass antenna disposed on a surface of a windowpane of a vehicle, which antenna comprises: at least two first antenna elements extending downwardly from a vicinity of opposite ends of an upper side of the windowpane; and at least two second antenna elements extending horizontally from a vicinity of an upper portion of respective right and left sides of the windowpane toward a center of width of the windowpane, so that the first and second antenna elements constitute a diversity scheme.

[0013] In this arrangement, since at least four antenna elements are formed on one windowpane, the cost is reduced and no tuning-related problems occur as a result of antenna elements being formed on a plurality of windowpanes.

[0014] Further, the glass antenna of the invention has no antenna element extending from a lower side of the windowpane, and can therefore be suitably disposed on a windowpane equipped with a rear wiper, and applied to a windshield having limitations in regard to the forming of an antenna element in a lower part thereof.

[0015] Preferably, the first antenna elements are provided at a distance of 0.1 λk to 0.4 λk from the ends of the upper side of the windowpane while the second antenna elements are preferably at a distance of 0.1 λk to 0.4 λk from the upper side of the windowpane.

[0016] In a preferred form, there is provided no conductor parallel to the first antenna elements in the vicinity thereof.

[0017] Desirably, each of the first antennal elements is formed of only a straight conductor extending in a vertical direction.

[0018] Each of the first antennal elements preferably has an inverted-T shape.

[0019] The windowpane may be a windshield or a rear window.

[0020] Certain preferred embodiments of the present invention will be described below, by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 is a schematic view showing a conventional glass antenna;

FIG. 2 is a schematic view showing a glass antenna according to a first embodiment of the invention, which is provided in a rear window of a vehicle;

FIG. 3 is a graph showing vehicle-forward-direction sensitivity of the glass antenna according to the first embodiment shown in FIG. 2;

FIG. 4 is a view showing a result of comparison between directional characteristics of the gain of the inventive glass antenna of FIG. 2 and directional characteristics of the glass antenna of FIG. 1;

FIG. 5 shows a glass antenna according to a second embodiment of the present invention;

FIGS. 6(a) to 6(c) show comparisons of directional characteristics of the gain of the second embodiment glass antenna of FIG. 5 and of the conventional glass antenna of FIG. 1 for frequencies of 470, 590, and 770 MHz, respectively; and

FIGS. 7A and 7B show alterations of the second embodiment glass antenna of FIG. 5.

[0021] Reference is now made to FIG. 2 showing a vehicular glass antenna according to a first embodiment of the present invention.

[0022] As shown in FIG. 2, the glass antenna of the first embodiment is provided in a rear window 8 having a defogger 6 therein. The glass antenna includes two first monopole antenna elements 16a, 16b that extend downward from the vicinity of the ends of an upper side 7 of the rear window, and two second monopole antenna elements 18a, 18b that extend horizontally (toward the center of the vehicle in the width direction) from the vicinity of upper portions of right and left sides or edges 9, 9 of the rear window. The second monopole antenna elements 18a, 18b are provided at positions 0.1 to 0.4 λk below the upper side 7 of the rear window (indicated by Y in the drawing). Having the second antenna elements provided in such positions ensures that areas where no conductor parallel to the second antenna elements is present are provided in the vicinity of the second antenna elements. The influence of other conductors on the second antenna elements can thus be reduced.

[0023] The first monopole antenna elements 16a, 16b are provided at positions that are 0.1 to 0.4 λk from the ends of the upper side of the rear window 8 (indicated by X in the drawing). Having the first antenna elements provided at such positions ensures that areas where no conductor parallel to the first antenna elements is present are provided in the vicinity of the first antenna elements. Therefore, the influence of other conductors on the first antenna elements can be reduced, and at the same time, the reception sensitivity inwardly with respect to the vehicle can be enhanced, as will be described later.

[0024] In FIG. 2, a base of each of the antenna elements 16a, 16b, 18a, 18b is a feed point 17.

[0025] The length of each of the antenna elements is $\lambda k/4$, where λ represents the wavelength, which is, for example, 508 mm, and k represents the wavelength contraction rate deriving from the glass, which is, for example, 0.7.

[0026] FIG. 3 shows results obtained by measuring the sensitivity in the frontward direction (ahead of the vehicle) versus the position (X) of the antenna elements 16a, 16b from the ends of the upper end of the rear window. It is evident that 0.1 to 0.4 λk is a range of good sensitivity.

[0027] FIG. 4 shows results obtained by comparing the measured directivity when the positions (X, Y) of the antenna elements 16a, 16b, 18a, 18b of the first embodiment shown in FIG. 2 are (0.2 λk, 0.2 λk) (in a diversity scheme using four antenna elements) and the measured directivity in a diversity scheme using two antenna elements of related art shown in FIG. 1 (both the directivities are measured at a frequency of 590 MHz).

[0028] The results of the comparison show that the sensitivity in the inward direction with respect to the vehicle (forward direction in FIG. 4) and the transverse direction of the vehicle is improved since part of the antenna elements of the glass antenna of the first embodiment extend in the vertical direction. Specifically, the glass antenna of the first embodiment has excellent directivity despite the four antenna elements being formed in a single windowpane.

[0029] Further, since each of the antenna elements of the first embodiment has a simple shape, the antenna can be relatively readily tuned.

[0030] The directivity of the antenna was measured in the following manner.

[0031] In an anechoic chamber, radio waves in the terrestrial digital broadcasting frequency band were irradiated in a substantially horizontal direction toward a vehicle located far away from a transmission antenna.

[0032] The voltage of the signal received by the glass antenna was measured with the vehicle being rotated on a

turntable by 360° in the horizontal direction, whereby the reception voltage of the signal received for each rotation angle of the vehicle and for each frequency was obtained. A directional characteristics chart for each frequency was obtained by plotting the resultant reception voltage in a radar chart for each frequency.

[0033] In the embodiment, the signal received by the glass antenna was extracted by connecting central conductors of coaxial cables to the feed points and connecting outer conductors of the coaxial cables to the vehicle body above the feed points.

[0034] In the directional characteristics chart, the upper part represents the front of the vehicle, and the lower part represents the rear of the vehicle. The chart shows the directional characteristics when the vehicle is viewed from above.

[0035] FIG. 5 shows a glass antenna for a vehicle of a second embodiment.

[0036] The glass antenna of the second embodiment is provided on the windshield 10. The glass antenna includes two first monopole antenna elements 20a, 20b, each of which has an inverted-T shape and extends vertically downward from the vicinity of the upper side 4 of the windowpane, and two second monopole antenna elements 18a, 18b that extend horizontally toward the center of the vehicle in the width direction from the vicinity of an upper portion of sides 2, 2 of the windowpane.

[0037] The second monopole antenna elements 18a, 18b are provided at positions that are 0.1 to 0.4 λk below the upper side 4 of the windshield.

[0038] The first monopole antenna elements 20a, 20b are located at positions that are 0.1 to 0.4 λk from the ends of the upper side of the windshield, toward the center of the vehicle in the width direction. The inverted-T-shaped first antenna elements have horizontal elements 19a, 19b that are connected to the lower ends of the first antenna elements and extend horizontally.

[0039] In such inverted-T-shaped first antenna elements 20a, 20b, the length of the antenna elements is measured from the feed points 21, 21 to the ends of the horizontal elements 19a, 19b, respectively.

[0040] Table 1 below shows measurement results of the frequency characteristics of the gain of a single antenna element of the glass antenna for horizontally polarized radio waves.

TABLE 1

Performance of single antenna element, Frequency characteristics (H-polarized waves) (dBd)				
Frequencies	Antenna element 18b	Antenna element 18a	Antenna element 20b	Antenna element 20a
470	-8.8	-8.8	-7.1	-8.4
480	-8.9	-8.8	-6.5	-7.4
490	-8.5	-8.1	-5.7	-5.9
500	-8.0	-7.4	-6.5	-5.9
510	-7.0	-6.8	-6.3	-5.1
520	-7.1	-7.1	-7.0	-4.6
530	-7.5	-6.7	-5.8	-4.5
540	-8.1	-7.6	-5.6	-5.1
550	-7.6	-8.1	-6.2	-5.0
560	-7.8	-8.3	-6.5	-6.2
570	-8.4	-8.9	-7.6	-7.2
580	-7.9	-9.0	-7.7	-7.1
590	-8.2	-9.5	-8.3	-7.9
600	-8.8	-9.7	-7.9	-8.0
610	-9.5	-10.0	-8.2	-9.0
620	-10.9	-10.2	-8.7	-9.8
630	-12.1	-11.1	-10.1	-10.8
640	-11.9	-11.0	-9.5	-10.6
650	-12.2	-11.1	-10.6	-10.4

(continued)

Performance of single antenna element, Frequency characteristics (H-polarized waves) (dBd)				
Frequencies	Antenna element 18b	Antenna element 18a	Antenna element 20b	Antenna element 20a
660	-11.6	-11.2	-10.5	-10.1
670	-11.5	-10.7	-10.4	-9.7
680	-12.5	-12.1	-10.3	-10.3
690	-13.0	-11.7	-10.2	-10.4
700	-13.1	-12.0	-9.3	-11.0
710	-11.9	-11.1	-9.0	-10.9
720	-12.2	-11.7	-10.1	-11.3
730	-11.5	-11.6	-10.8	-11.5
740	-11.3	-11.9	-12.0	-12.8
750	-11.1	-11.7	-11.1	-12.2
760	-11.7	-11.9	-10.7	-12.8
770	-10.5	-11.7	-10.2	-12.9
Averages	-10.0	-9.9	-8.6	-8.9

[0041] FIGS. 6(a), 6(b), and 6(c) show results obtained by comparing the measured directivity of the glass antenna of the second embodiment shown in FIG. 5 in a four-channel diversity scheme and the measured directivity of the conventional glass antenna shown in FIG. 1 in a two-channel diversity scheme for frequencies of 470, 590, and 770 MHz, respectively.

[0042] As seen from FIGS. 6(a), 6(b), and 6(c), the glass antenna of the second embodiment shown in FIG. 5, when compared to the glass antenna of the related art, shows improved rippling in the inward direction with respect to the vehicle (in the lower half of FIGS. 6(a), 6(b), and 6(c)) and better reception characteristics.

[0043] As described above, providing an antenna having an antenna element extending in the vertical direction in the windshield improves reception characteristics in the inward direction with respect to the vehicle. Even when such an antenna is formed in a single windowpane, the antenna has exceptional directivity.

[0044] FIGS. 7A and 7B show modifications of the antenna elements of the second embodiment shown in FIG. 5.

[0045] A first modification shown in FIG. 7A is shaped in such a way that horizontal elements 19a-1, 19b-1 of the first monopole antenna elements 20a, 20b extend only toward the center of the vehicle in the width direction.

[0046] A second modification shown in FIG. 7B is shaped in such a way that horizontal elements 19a-2, 19b-2 of the first monopole antenna elements 20a, 20b extend only outward in the vehicle width direction.

[0047] While several embodiments of the invention have been described above, the invention is not limited thereto, and a variety of changes and modifications can be made thereto. For example, in the first embodiment shown in FIG. 2, the number of the first antenna elements extending downward may be two or more, and the number of the second antenna elements extending horizontally may be two or more.

[0048] Further, the glass antenna of the invention may be provided in a side glass as well as in front and rear windows.

Claims

1. A glass antenna disposed on a surface of a windowpane of a vehicle, **characterized in that** it comprises :

at least two first antenna elements (1.6a, 16b; 20a, 20b) extending downwardly from a vicinity of opposite ends of an upper side (7; 4) of the windowpane; and
at least two second antenna elements (18a, 18b) extending horizontally from a vicinity of an upper portion of respective right and left sides (9, 9; 2, 2) of the windowpane toward a center of width of the windowpane, so that the first and second antenna elements constitute a diversity scheme.

2. The glass antenna of claim 1, **characterized in that** the first antenna elements are provided at a distance of 0.1 λk to 0.4 λk from the ends of the upper side of the windowpane, and the second antenna elements being provided at a distance of 0.1 λk to 0.4 λk from the upper side of the windowpane.

3. The glass antenna of claim 1 or 2, including no conductor which is parallel to and in a vicinity of the first antenna elements.

4. The glass antenna of any one of claims 1 to 3, **characterized in that** each of the first antennal elements is comprised of only a conductor extending linearly in a vertical direction.

5. The glass antenna of any one of claims 1 to 3, **characterized in that** each of the first antennal elements has an inverted-T shape.

6. The glass antenna of anyone of claims 1 to 5, **characterized in that** the windowpane comprises one of a windshield and a rear window.

FIG.1
(PRIOR ART)

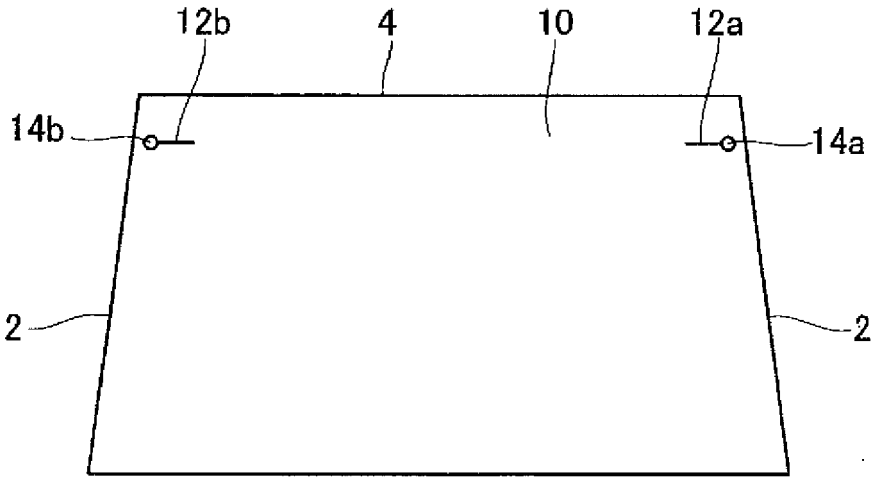


FIG.2

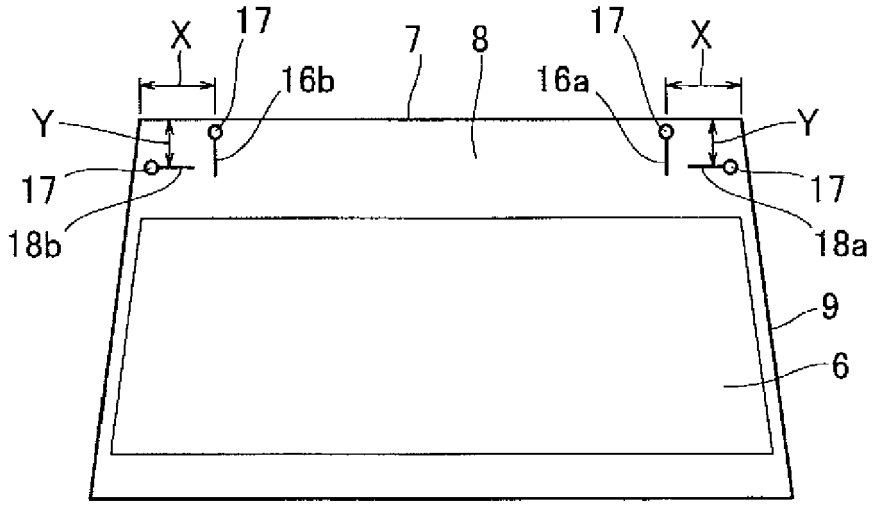


FIG.3

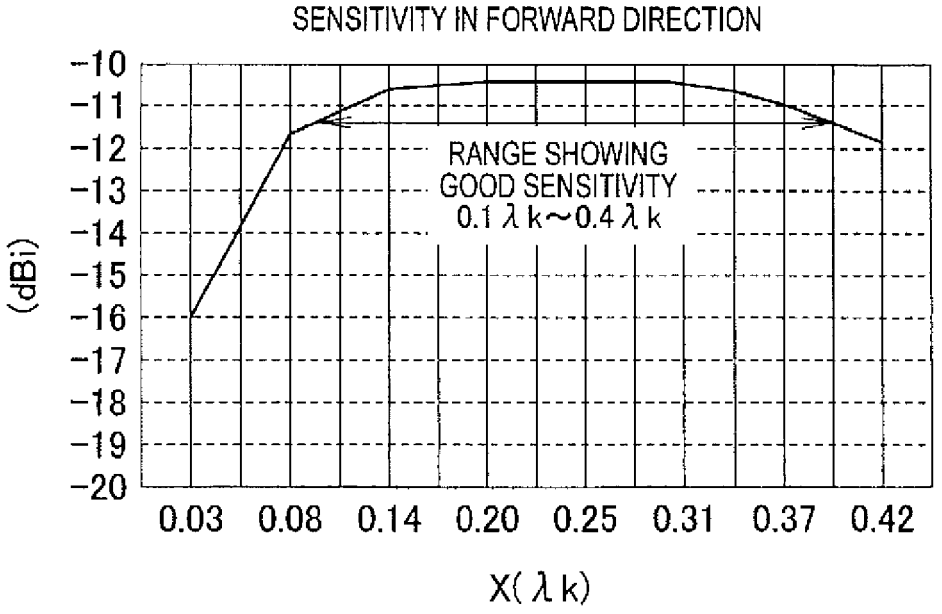

SENSITIVITY IN FORWARD DIRECTION
−10
−11
−12
−13
−14
−15
−16
−17
−18
−19
−20
(dBi)
RANGE SHOWING
GOOD SENSITIVITY
0.1 λ k～0.4 λ k
0.03
0.08
0.14
0.20
0.25
0.31
0.37
0.42
X(λ k)

FIG.4

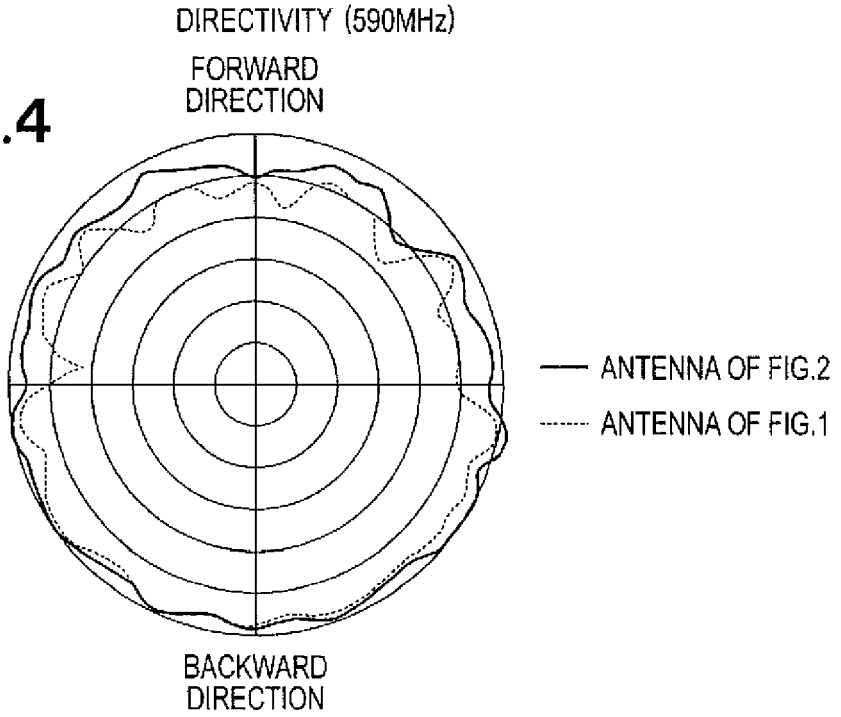

DIRECTIVITY (590MHz)
FORWARD
DIRECTION
BACKWARD
DIRECTION
ANTENNA OF FIG.2
ANTENNA OF FIG.1

FIG.5

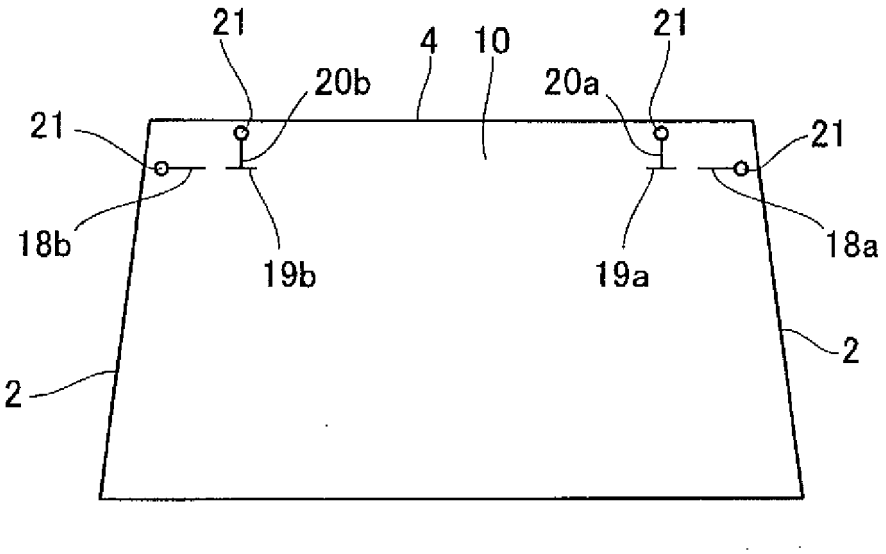


FIG.6A

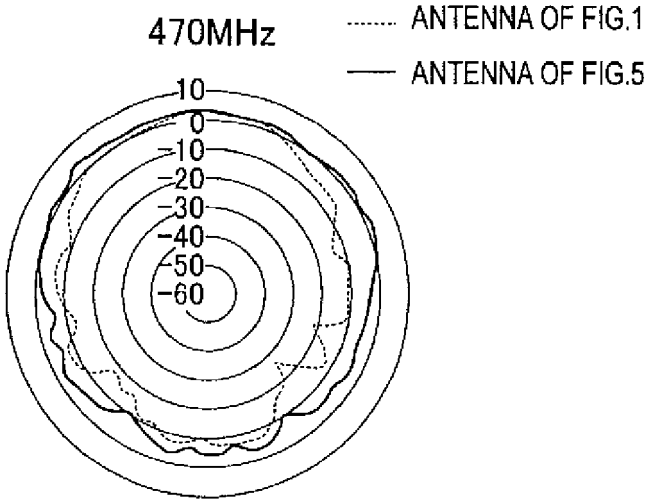


FIG.6B

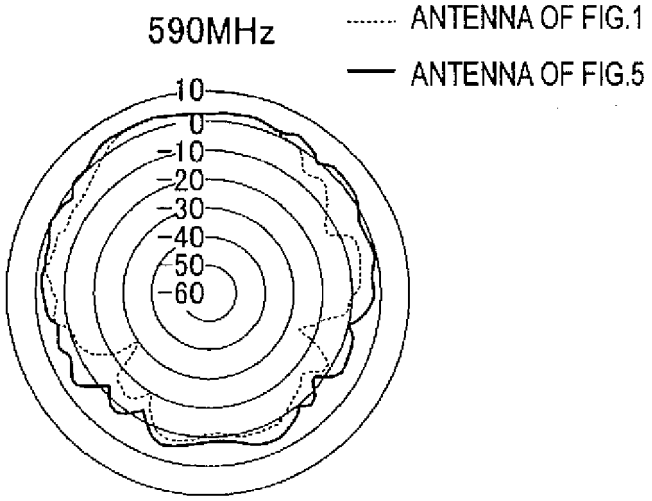


FIG.6C

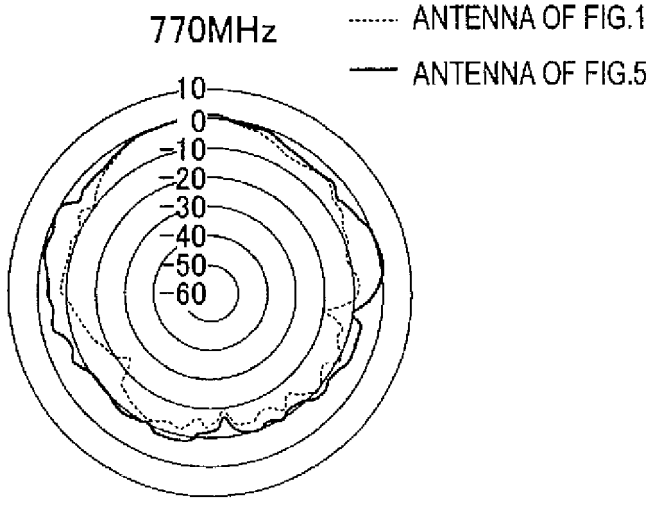


FIG.7A

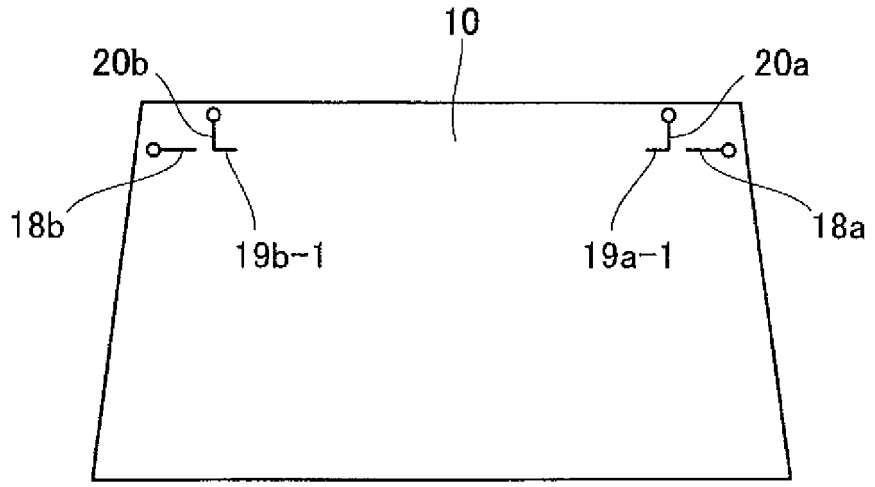
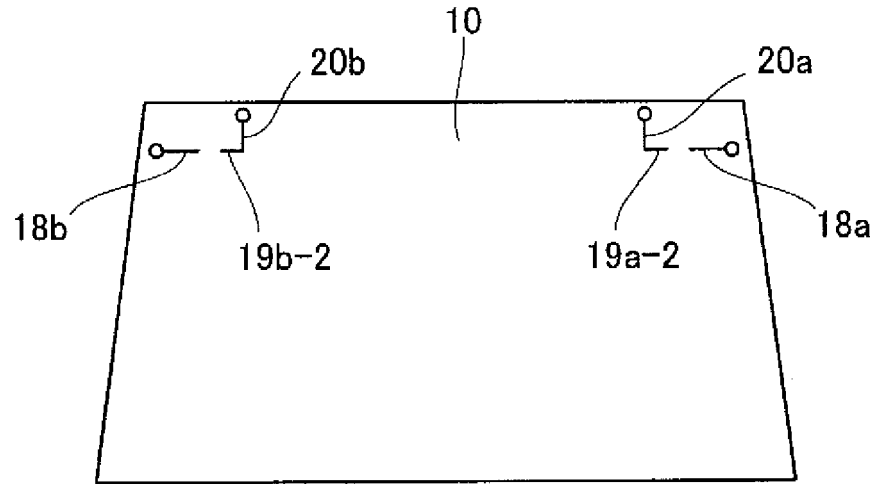


FIG.7B



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EUROPEAN SEARCH REPORT

Application Number
EP 08 15 8694

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	12 August 2008	Kaleve, Abraham

CATEGORY OF CITED DOCUMENTS

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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- JP 2002135025 A **[0008] [0008]**