



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
14.10.2009 Bulletin 2009/42

(51) Int Cl.:
H01Q 1/32 (2006.01) H01Q 1/22 (2006.01)

(21) Application number: **08710793.4**

(86) International application number:
PCT/JP2008/051861

(22) Date of filing: **05.02.2008**

(87) International publication number:
WO 2008/096751 (14.08.2008 Gazette 2008/33)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR

(72) Inventor: **TOKUDA, Tatsumi**
Tokyo 108-6321 (JP)

(30) Priority: **06.02.2007 JP 2007026972**

(74) Representative: **Jenkins, Peter David**
Page White & Farrer
Bedford House
John Street
London WC1N 2BF (GB)

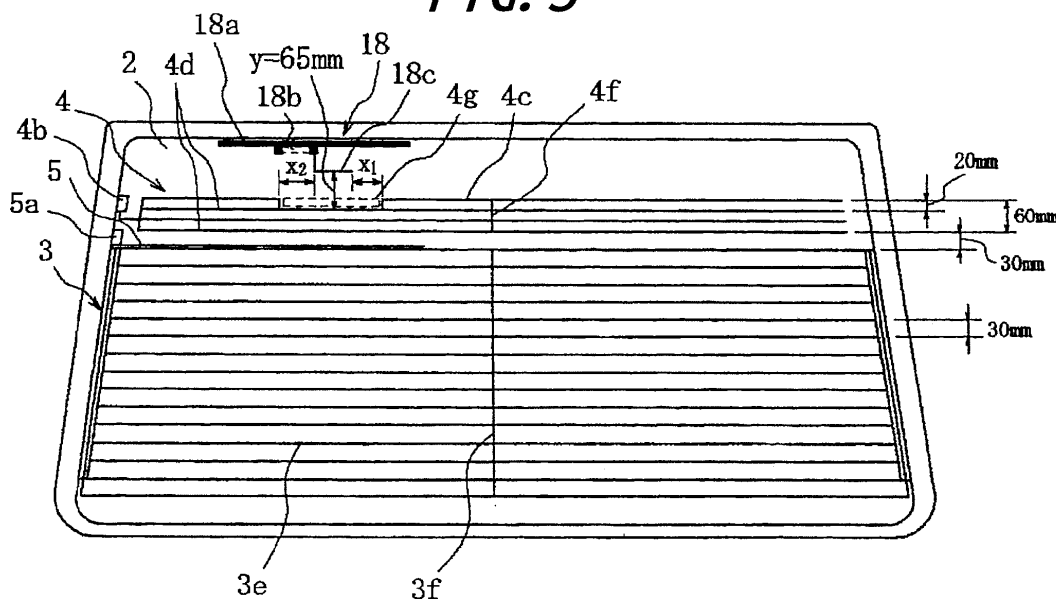
(71) Applicant: **Nippon Sheet Glass Company Limited**
Tokyo 108-6321 (JP)

(54) **VEHICLE GLASS ANTENNA**

(57) There is provided a glass antenna for vehicle which comprises a digital TV antenna appropriate to the reception of TV electromagnetic wave with excellent sensitivity of the horizontal direction, and an AM antenna in the limited area of a rear-window glass. The glass antenna of the invention comprises a digital TV antenna (18) for receiving of TV electromagnetic wave, and an AM antenna (4) for receiving of AM electromagnetic wave,

on a window glass for vehicle with a defogger (3), in which the digital TV antenna (18) includes a horizontal element (18c) formed at the side of the heat wires (3e) and substantially parallel to the plurality of heat wires (3e) of the defogger (3), and the AM antenna (4) is formed between the defogger (3) and the digital TV antenna (18). The AM antenna (4) includes a discontinuous region (4g) closely located at the digital TV antenna (18).

FIG. 3



DescriptionFIELD OF THE INVENTION

5 **[0001]** The invention relates to a glass antenna for vehicle, particularly to an antenna for a motor vehicle which has an digital TV antenna (television).

RELATED ART

10 **[0002]** In the prior art, there is disclosed a glass antenna arrangement for vehicle comprising a defogger having heat wires for defogging, an AM antenna which is formed in the upper area of the defogger, and a FM antenna which is arranged between the defogger and the AM antenna (for example, refer to PCT National-phase Japanese Publication No. 2003-500870).

15 **[0003]** As shown in Fig. 1, the glass antenna arrangement 1, for example, comprises a glass antenna for a motor vehicle, a signal-amplifying means 7, and a receiver 10. The glass antenna for a motor vehicle includes in the surface of a rear-window glass 2 an AM antenna 4 for receiving of the signal of AM band provided in the upper area of the defogger 3 with a plurality of heat wires 3e for defogging, and a FM antenna 5 for receiving of the signal of FM band provided between the heat wires 3e and the AM antenna 4.

20 **[0004]** The signal-amplifying means 7 includes an AM-amplifying means 8 for amplifying through a feeding point 4b the signal of AM-electromagnetic wave received by a plurality of AM-horizontal conductors 4a, and a FM-amplifying means 9 for amplifying through a feeding point 5a the signal of FM-electromagnetic wave received by the FM-horizontal conductors 5 composed of one horizontal pattern.

[0005] The receiver 10 receives, for example through a coaxial cable, the signal of AM or FM band from the signal-amplifying means 7, and then converts the received signal into the visual or audio signal, accordingly.

25 **[0006]** The defogger 3 comprises bus bars 3a and 3b mutually faced, which are arranged over the top-to-bottom direction on the both sides of a window glass of the motor vehicle, feeding points 3c and 3d provided to apply the voltage V_H to the respective bus bars 3a and 3b by means of a power supply 6 for the heat wires, and the plurality of heat wires 3e horizontally arranged between the bus bars 3a and 3b.

30 **[0007]** Moreover, the signal-receiving sensitivity of the AM band tends to be proportional to the area covered by the AM-horizontal conductors of the AM antenna, and therefore the specified length or gross area of the AM-horizontal conductors is requested to be a desired extent.

DISCLOSURE OF INVENTION35 PROBLEMS TO BE SOLVED BY THE INVENTION

[0008] Recently, it is considered to provide in the upper area of the AM antenna of the window glass for vehicle an antenna appropriate to the reception of the electromagnetic wave of Television Broadcasting (TV electromagnetic wave).

40 **[0009]** However, when such an antenna appropriate to the reception of TV electromagnetic wave is provided in the upper area of the AM antenna, the AM antenna may influence the sensitivity characteristic of the antenna appropriate to the reception of TV electromagnetic wave.

[0010] This phenomenon may be considered as follows. When an antenna for digital terrestrial TV broadcasting (hereinafter, it is referred to as the digital TV antenna) is arranged in the upper area of the AM antenna with the horizontal conductors on the rear-window glass, the directivity of the signal-receiving sensitivity of the digital TV antenna changes into a vertical direction with respect to the rear-window glass (i.e., a direction indicated in the dotted line) as shown in Fig. 2, and thus the signal-receiving sensitivity of the digital TV antenna may be decreased.

45 **[0011]** That is, since the sensitivity of the horizontal direction of the digital TV antenna is decreased by the influence of the AM antenna with the horizontal conductors, the directivity of the signal-receiving sensitivity of the digital TV antenna may be changed into a vertical direction to the rear-window glass. As a result, there is caused the problem that the directivity control into the direction of the desired wave in the digital TV antenna becomes difficult, and thus the sensitivity of the digital TV antenna may be decreased.

50 **[0012]** Therefore, the invention is to provide a glass antenna for vehicle which comprises a digital TV antenna appropriate to the reception of TV electromagnetic wave with excellent sensitivity of the horizontal direction, and an AM antenna in the limited area of a rear-window glass.

55 MEANS FOR SOLVING THE PROBLEM

[0013] There is provided a glass antenna for vehicle in an aspect according to the invention, the glass antenna being

formed on the surface of a window glass for vehicle in which a defogger with a plurality of heat wires extended over a horizontal direction is provided, the glass antenna being characterized in that it comprises a first antenna for receiving of TV electromagnetic wave, wherein the first antenna includes a horizontal element formed at the side of the heat wires and substantially parallel to the plurality of heat wires; and a second antenna for receiving of AM electromagnetic wave formed between the defogger and the first antenna, wherein the second antenna includes a discontinuous region closely located at the first antenna.

[0014] Moreover, the glass antenna for vehicle in the aspect according to the invention is characterized in that the second antenna includes in the discontinuous region at least one continuous-horizontal conductor and at least one continuous-horizontal conductor located in parallel to the continuous-horizontal conductor.

[0015] Moreover, the glass antenna for vehicle in the aspect according to the invention is characterized in that the second antenna includes in the discontinuous region at least one gamma-shaped antenna element which is composed of a vertical conductor and a partial, horizontal conductor.

[0016] Moreover, the glass antenna for vehicle in the aspect according to the invention is characterized in that the second antenna includes in the discontinuous region a continuous meander-shaped antenna element composed of vertical conductors and partial, horizontal conductors.

[0017] Moreover, the glass antenna for vehicle in the aspect according to the invention is characterized in that the first antenna includes a L-shaped or loop-shaped antenna element, wherein the horizontal element is a part of the L-shaped or loop-shaped antenna element.

[0018] Moreover, the glass antenna for vehicle in the aspect according to the invention is characterized in that the horizontal element comprises a plurality of conductive elements, each of the conductive elements being mutually capacitive-coupled.

[0019] Moreover, the glass antenna for vehicle in the aspect according to the invention is characterized in that the second antenna includes in the discontinuous region at least one vertical conductor, the vertical conductor being electrically connected to the continuous-horizontal conductor.

[0020] Moreover, the glass antenna for vehicle in the aspect according to the invention is characterized in that the clearance of the horizontal direction between the horizontal element and the discontinuous-horizontal conductor is from 0 to 75 mm, as the distance along the surface of the window glass for vehicle.

[0021] Moreover, the glass antenna for vehicle in the aspect according to the invention is characterized in that the clearance of the vertical direction between the horizontal element and the continuous-horizontal conductor is larger than 10 mm, and is smaller than 135 mm, as the distance along the surface of the window glass for vehicle.

[0022] Preferably, the glass antenna for vehicle in the aspect according to the invention is provided, so that the clearance of the vertical direction between the horizontal element and the continuous-horizontal conductor is larger than 10 mm, and is smaller than 135 mm, as the distance along the surface of the window glass for vehicle. More preferably, the glass antenna for vehicle in the aspect according to the invention is provided, so that the clearance of the vertical direction between the horizontal element and the continuous-horizontal conductor is larger than 45 mm, and is smaller than 135 mm, as the distance along the surface of the window glass for vehicle.

EFFECT OF THE INVENTION

[0023] A glass antenna for vehicle can be provided, the glass antenna comprising a digital TV antenna appropriate to the reception of TV electromagnetic wave with excellent sensitivity of the horizontal direction, and an AM antenna in the limited area of a rear-window glass of a motor vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024]

Fig. 1 is a diagram showing an example of a conventional glass antenna arrangement for vehicle;
 Fig. 2 is a diagram showing the directivity of the signal-receiving sensitivity of a digital TV antenna;
 Fig. 3 is a schematic diagram of a glass antenna for vehicle in a first embodiment according to the invention;
 Fig. 4 is a schematic diagram of a glass antenna for vehicle in a second embodiment according to the invention;
 Fig. 5 is a schematic diagram of a glass antenna for vehicle in a third embodiment according to the invention;
 Fig. 6 is a schematic diagram of a glass antenna for vehicle in a fourth embodiment according to the invention;
 Fig. 7 is a schematic diagram of a glass antenna for vehicle in a first comparative example;
 Fig. 8 is a comparative graph of the measurement result of the sensitivity characteristic of the digital TV antenna with changed values of x_1 and x_2 in the glass antenna for vehicle shown in Fig. 6;
 Fig. 9 is a comparative graph of the measurement result of the sensitivity characteristic of the digital TV antenna in each of the glass antennas for vehicle shown in the first comparative example, the third embodiment and the fourth

embodiment, respectively;

Fig. 10 is a schematic diagram of a glass antenna for vehicle in a fifth embodiment according to the invention;

Fig. 11 is a schematic diagram of a glass antenna for vehicle in a sixth embodiment according to the invention;

Fig. 12 is a schematic diagram of a glass antenna for vehicle in a second comparative example;

Fig. 13 is a comparative graph of the measurement result of the sensitivity characteristic of the digital TV antenna in each of the glass antennas for vehicle shown in the second comparative example, the fifth embodiment and the sixth embodiment, respectively;

Fig. 14 is a schematic diagram of a glass antenna for vehicle in a seventh embodiment according to the invention;

Fig. 15 is a schematic diagram of a glass antenna for vehicle in an eighth embodiment according to the invention;

Fig. 16 is a schematic diagram of a glass antenna for vehicle in a ninth embodiment according to the invention;

Fig. 17 is a schematic diagram of a glass antenna for vehicle in a tenth embodiment according to the invention;

Fig. 18 is a schematic diagram of a glass antenna for vehicle in a third comparative example;

Fig. 19 is a comparative graph of the measurement result of the sensitivity characteristic of the digital TV antenna in each of the glass antennas for vehicle shown in the third comparative example, the seventh to tenth embodiments, respectively;

Fig. 20 is a schematic diagram of a glass antenna for vehicle comprising a digital TV antenna of dipole antenna type in one embodiment according to the invention;

Fig. 21 is a schematic diagram of a glass antenna for vehicle comprising a digital TV antenna of monopole antenna type having parasitic elements in one embodiment according to the invention; and

Fig. 22 is a schematic diagram of a glass antenna for vehicle comprising digital TV antennas which are arranged at both sides of a window glass for vehicle in one embodiment according to the invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0025] Hereinafter, each embodiment of the invention is described in reference to each drawing. The same numerals are fixed to similar components or elements in each drawing.

[0026] According to the embodiment described later, a digital TV antenna has an excellent sensitivity characteristic in the limited area of a rear-window glass 2, hardly deteriorating the necessary performance of an AM antenna.

[0027] Firstly, a glass antenna for vehicle of a first embodiment in accordance with the invention is described.

(FIRST EMBODIMENT)

[0028] Fig. 3 shows a schematic diagram of a glass antenna for vehicle in a first embodiment according to the invention. The glass antenna for vehicle of the first embodiment is formed on the surface of a rear-window glass 2 for vehicle in which a defogger 3 with a plurality of heat wires 3e extended over a horizontal direction of the rear-window glass 2 is provided. The glass antenna comprises a digital TV antenna (a first antenna) 18 for receiving of TV electromagnetic wave, and an AM antenna (a second antenna) 4 for receiving of AM electromagnetic wave, in which the digital TV antenna 18 includes a horizontal element 18c formed essentially parallel to the plurality of heat wires 3e of the defogger, and the AM antenna 4 is formed between the defogger 3 and the digital TV antenna 18. Moreover, a FM antenna 5 is arranged between the defogger 3 and the AM antenna 4.

[0029] As shown in Fig. 3, the defogger 3 with the plural heat wires 3e (at regular intervals of 15-40 mm) for defogging is provided to be enough width for field of view in the rear-window glass 2 of one vehicle (for example, a passenger car), in which the FM antenna 5 and the AM antenna 4 are arranged over the defogger 3. The defogger 3 may include a shorting bar 3f to which each of the plurality of heat wires 3e is mutually connected.

[0030] Moreover, the FM antenna 5 is closely arranged for capacitive-coupling with the heat wire, which is located in top-level of the plurality of heat wires 3e, to improve the signal-receiving sensitivity (at the distance of about 5-10 mm). In addition, the distance between the AM antenna 4 and the defogger 3 is maintained by, for example, 30 mm, and each of horizontal conductors 4a of the AM antenna has the width of 60 mm. Hereinafter, the direction substantially orthogonal to the horizontal direction along the window glass of the vehicle is referred to as a vertical direction.

[0031] The digital TV antenna 18 is composed as a monopole antenna of 1/4 wavelength, and comprises a ground pattern 18a electrically connected to the ground portion of the vehicle (for example, the ground pattern 18a being formed as a L-shape), an antenna element that includes a horizontal element 18c for receiving of the signal carrier of digital terrestrial TV broadcasting, and an amplifier 18b for amplifying of the signal from the digital TV antenna (the amplifier 18b being arranged between the ground pattern 18a and said antenna element). The output from the amplifier 18b is received, for example through a coaxial cable (not shown), by means of the receiver, and is converted into the visual or audio signal, accordingly.

[0032] Preferably, the length of the L-shaped antenna element for the antenna element in the monopole antenna of 1/4 wavelength is within 60-150 mm in case of the shortening rate of 60% caused by the glass material, to resonate by

frequency bands (470-770 MHz) of the signal carrier of digital terrestrial TV broadcasting, and the length may be, for example, 80 mm. In addition, while the horizontal element 18c of the L-shaped antenna element may be formed by the length with extremely near 0 mm, the length of the horizontal element 18c may be preferably the half-length of said length of the L-shaped antenna element to improve the signal-receiving performance of the horizontal polarized electromagnetic radiation, such as, for example, 40 mm.

[0033] The AM antenna 4 comprises a plurality of horizontal conductors, which are electrically connected to a feeding point 4b and being extended in substantially parallel to the horizontal element 18c, and a shorting bar 4f which is extended in substantially orthogonal direction with respect to the plurality of horizontal conductors.

[0034] In addition, the AM antenna 4 in the first embodiment includes a given region where the horizontal conductor is discontinuous (hereinafter, it is referred to as a discontinuous region 4g), closely located at the digital TV antenna 18 (the discontinuous region 4g in the first embodiment is a region where the horizontal conductor has not been provided). In addition, the horizontal conductor with the edge of the discontinuous region 4g is referred to as a continuous-horizontal conductor 4c, and the horizontal conductor other than the continuous-horizontal conductor 4d is referred to as a continuous-horizontal conductor 4c. That is, the plural horizontal conductors are composed of at least one continuous-horizontal conductor 4c and at least one continuous-horizontal conductor 4d. As shown in Fig. 3, the discontinuous region 4g in the first embodiment is located under the digital TV antenna 18, and is arranged over the plurality of continuous-horizontal conductors 4d.

[0035] Moreover, there is defined the physical relationship among the horizontal element 18c of the digital TV antenna 18, the continuous-horizontal conductors 4c and the continuous-horizontal conductors 4d in the AM antenna 4. More specifically, the physical relationship may be specified by defining the clearance of the horizontal direction, x_1 and x_2 , between the horizontal element 18c and the discontinuous-horizontal conductor 4c as the distance along the surface of the window glass for vehicle, and defining the clearance of the vertical direction, y , between the horizontal element 18c and the continuous-horizontal conductor 4d located under the discontinuous region 4g, as the distance of the direction along the surface of the window glass for vehicle.

[0036] Thus, providing of the discontinuous region 4g into the AM antenna 4 enables to improve the sensitivity characteristic of the digital TV antenna 18. Moreover, the physical relationship among the horizontal element 18c, the continuous-horizontal conductors 4c and the continuous-horizontal conductors 4d may be also defined by these x_1 , x_2 , and y , as described later.

[0037] Then, a glass antenna for vehicle of a second embodiment in accordance with the invention is described.

(SECOND EMBODIMENT)

[0038] Fig. 4 shows a schematic diagram of a glass antenna for vehicle in a second embodiment according to the invention. The arrangement of the glass antenna for vehicle of the second embodiment is similar with that of the first embodiment, other than the size of the discontinuous region 4g, and thus its similar description is omitted. As shown in Fig. 4, the discontinuous region 4g in the second embodiment is located under the digital TV antenna 18, and is arranged over one continuous-horizontal conductor 4d.

[0039] Thus, the value of the distance, y , of the glass antenna in the second embodiment is larger than that of the glass antenna in the first embodiment. The larger value of the distance, y , enables to further improve the sensitivity characteristic of the digital TV antenna 18, as described later.

[0040] Then, a glass antenna for vehicle of a third embodiment in accordance with the invention is described.

(THIRD EMBODIMENT)

[0041] Fig. 5 shows a schematic diagram of a glass antenna for vehicle in a third embodiment according to the invention. The arrangement of the glass antenna for vehicle of the third embodiment is similar with that of the first embodiment, other than the configuration of the discontinuous region 4g, and thus its similar description is omitted. As shown in Fig. 5, the discontinuous region 4g in the third embodiment is located under the horizontal element 18c of the digital TV antenna 18, and is arranged over the plurality of continuous-horizontal conductors 4d.

[0042] In addition, the continuous-horizontal conductor at the top-level of the plurality of continuous-horizontal conductors 4d includes in the discontinuous region 4g at least one vertical conductor 4h. The vertical conductors 4h may be formed upon the plurality of continuous-horizontal conductors 4d.

[0043] Thus, providing of the discontinuous region 4g into the AM antenna 4 enables to improve the sensitivity characteristic of the digital TV antenna 18. Moreover, providing of the vertical conductors 4h into the discontinuous region 4g enables to prevent the deterioration of sensitivity characteristic of the AM antenna 4.

[0044] Then, a glass antenna for vehicle of a fourth embodiment in accordance with the invention is described.

(FOURTH EMBODIMENT)

[0045] Fig. 6 shows a schematic diagram of a glass antenna for vehicle in a fourth embodiment according to the invention. The arrangement of the glass antenna for vehicle of the fourth embodiment is similar with that of the second embodiment, other than the configuration of the discontinuous region 4g, and thus its similar description is omitted. As shown in Fig. 6, the discontinuous region 4g in the fourth embodiment is located under the horizontal element 18c of the digital TV antenna 18, and is arranged over one continuous-horizontal conductor 4d.

[0046] In addition, the continuous-horizontal conductor 4d includes in the discontinuous region 4g at least one vertical conductor 4h.

[0047] Thus, providing of the discontinuous region 4g into the AM antenna 4 enables to improve the sensitivity characteristic of the digital TV antenna 18. Moreover, providing of the vertical conductor 4h into the discontinuous region 4g enables to prevent the deterioration of sensitivity characteristic of the AM antenna 4.

[0048] Then, a first comparative example of a glass antenna for vehicle is described hereinafter to make the effect of the first to fourth embodiments clearer. The same numerals are fixed to similar components or elements in this description.

(FIRST COMPARATIVE EXAMPLE)

[0049] Fig. 7 shows a first comparative example in which the digital TV antenna is arranged over a conventional glass antenna for vehicle. The conventional glass antenna for vehicle of the first comparative example comprises the digital TV antenna 18, the AM antenna 4, and the FM antenna 5 on the window glass for vehicle with the defogger 3 as shown in Fig. 7, in similar with the above-described embodiments. In addition, the defogger 3, the digital TV antenna 18 and the FM antenna 5 are similar with the configuration shown in the above-described embodiments, and thus these descriptions are omitted.

[0050] In the first comparative example shown in Fig. 7, the horizontal conductor of the AM antenna 4 is composed of only continuous-horizontal conductors. Moreover, the distance between the horizontal conductor at the top-level of the horizontal conductors in the AM antenna 4 and the digital TV antenna is 45 mm.

[0051] The measurement result of the sensitivity characteristic of the digital TV antenna or the AM antenna is now described as follows, specifying the physical relationship (x_1 , x_2 , y) defined by x_1 , x_2 , and y for the description of the specific effect in relation to each of the above-described embodiments.

[0052] Fig. 8 shows a comparative graph of the measurement result of the sensitivity characteristic of the digital TV antenna with changed values of x_1 and x_2 in each glass antenna for vehicle shown in Fig. 7 (the first comparative example) and in Fig. 6 (the fourth embodiment), respectively. Moreover, the numeric measurement result corresponding to Fig. 8 is shown in Table 1 (the unit is dBi). In addition, the mean value, the minimum value, and the maximum value of the sensitivity characteristic corresponding to Table 1 are shown in Table 2 (the unit is dBi). In addition, each measurement result representing the ratio of the signal-receiving sensitivity based on the measurement result of the average sensitivity received with the dipole antenna is shown in Fig. 8, in Table 1, and in Table 2. Besides, the glass antenna for vehicle as the first comparative example shown in Fig. 7 corresponds to $y=45$ mm. As to the measurement result in Fig. 8, the measurement result of the glass antenna for vehicle shown in Fig. 6 (the fourth embodiment) is the measurement values in case of $y=105$ mm, and with changed values between $x_1 = x_2 = 10$ to 100 mm.

[0053]

[Table 1]

(dBi)						
Frequency [MHz]	Average Sensitivity					
	1st Comparative Example(Fig. 7)	$x_1=x_2=10\text{mm}$	$x_1=x_2=25\text{mm}$	$x_1=x_2=50\text{mm}$	$x_1=x_2=75\text{mm}$	$x_1=x_2=100\text{mm}$
470	-12.4	-9.6	-10.2	-10.8	-11.0	-11.1
480	-12.6	-10.4	-10.0	-10.5	-10.7	-10.8
490	-11.2	-10.0	-9.4	-9.6	-9.7	-9.8
500	-10.7	-8.4	-8.4	-8.9	-9.0	-9.1
510	-10.4	-8.4	-8.0	-8.3	-8.4	-8.4

EP 2 109 181 A1

(continued)

5	Frequency [MHz]	Average Sensitivity					(dBi)
		1st Comparative Example(Fig. 7)	$x_1=x_2=10\text{mm}$	$x_1=x_2=25\text{mm}$	$x_1=x_2=50\text{mm}$	$x_1=x_2=75\text{mm}$	$x_1=x_2=100\text{mm}$
10	520	-8.9	-7.7	-7.0	-6.9	-6.9	-6.8
	530	-8.1	-7.2	-6.5	-6.4	-6.4	-6.3
	540	-7.3	-5.5	-4.8	-4.9	-5.1	-5.0
15	550	-8.3	-6.9	-6.7	-6.4	-6.6	-6.6
	560	-7.9	-6.4	-6.1	-5.9	-6.0	-6.2
	570	-8.6	-6.9	-7.1	-6.8	-6.7	-6.8
20	580	-8.6	-7.0	-6.7	-7.0	-6.8	-6.9
	590	-9.4	-7.0	-7.2	-7.4	-7.2	-7.3
	600	-10.0	-7.2	-7.2	-7.4	-7.4	-7.5
25	610	-10.4	-8.3	-7.7	-7.4	-7.6	-7.6
	620	-10.5	-9.0	-8.4	-7.5	-7.5	-7.5
	630	-11.2	-9.6	-9.0	-8.0	-8.2	-8.1
30	640	-9.9	-8.7	-8.3	-7.4	-7.3	-7.3
	650	-10.5	-8.8	-8.9	-8.2	-7.7	-7.8
	660	-9.4	-7.6	-7.4	-6.9	-6.5	-6.6
35	670	-9.1	-7.6	-6.8	-6.5	-6.0	-6.1
	680	-9.0	-9.2	-7.3	-6.6	-6.4	-6.3
	690	-8.2	-8.8	-7.8	-6.8	-6.7	-6.3
40	700	-7.2	-7.2	-6.8	-6.0	-6.0	-5.8
	710	-7.6	-6.9	-6.4	-5.7	-5.7	-5.7
	720	-8.9	-7.9	-7.4	-6.7	-6.4	-6.5
45	740	-10.7	-8.0	-8.0	-7.6	-7.5	-7.5
	750	-10.9	-8.7	-8.6	-8.4	-8.3	-8.2
	760	-10.4	-9.0	-9.0	-8.9	-8.9	-8.7
	770	-9.7	-8.9	-9.0	-8.8	-8.9	-8.6

[0054]

[Table 2]

50	Average Sensitivity						(dBi)
	1st Comparative Example(Fig. 7)	$x_1=x_2=10\text{mm}$	$x_1=x_2=25\text{mm}$	$x_1=x_2=50\text{mm}$	$x_1=x_2=75\text{mm}$	$x_1=x_2=100\text{mm}$	
55	Mean Value	-9.6	-8.1	-7.7	-7.5	-7.4	-7.4
	Min. Value	-12.6	-10.4	-10.2	-10.8	-11.0	-11.1

(continued)

(dBi)						
Average Sensitivity	1st Comparative Example(Fig. 7)	$x_1=x_2=10\text{mm}$	$x_1=x_2=25\text{mm}$	$x_1=x_2=50\text{mm}$	$x_1=x_2=75\text{mm}$	$x_1=x_2=100\text{mm}$
Max. Value	-7.2	-5.5	-4.8	-4.9	-5.1	-5.0

[0055] It should be understood from Fig. 8, Table 1, and Table 2 that the sensitivity characteristic of the digital TV antenna is improved by providing the AM antenna 4 with the discontinuous region 4g and increasing x_1 and x_2 , compared with the glass antenna for vehicle shown in Fig. 7 (the first comparative example).

[0056] In addition, it should be understood that the minimum value of the average sensitivity becomes larger than -11.0 preferably, when the clearance of x_1 and x_2 for defining the discontinuous region 4g is from 0 to 75 mm.

[0057] Fig. 9 shows a comparative graph of the measurement result of the sensitivity characteristic of the digital TV antenna in each glass antenna for vehicle shown in Fig. 7 (the first comparative example), in Fig. 5 (the third embodiment) and in Fig. 6 (the fourth embodiment), respectively. Moreover, the numeric measurement result corresponding to Fig. 9 is shown in Table 3 (the unit is dBi). In addition, the mean value, the minimum value, and the maximum value of the sensitivity characteristic corresponding to Table 3 are shown in Table 4 (the unit is dBi). In addition, each measurement result representing the ratio of the signal-receiving sensitivity based on the measurement result of the mean value (the average of signal-receiving sensitivity) received with the dipole antenna is shown in Fig. 9, in Table 3, and in Table 4 respectively, where the mean value is value averaged by 180 degrees over the horizontal direction of the digital TV antenna in the outside direction of the vehicle (i.e., the signal-receiving sensitivity measured from the sideward of the vehicle to the backward thereof). As described above, the glass antenna for vehicle as the first comparative example shown in Fig. 7 corresponds to $y=45$ mm. As to the measurement result in Fig. 9, each measurement result of the glass antenna for vehicle shown in Fig. 5 (the third embodiment) and in Fig. 6 (the fourth embodiment) corresponds to the measurement value in case of $x_1=x_2=50$ mm, $y=65$ mm (Fig. 5), and $y=105$ mm (Fig. 6) respectively.

[0058]

[Table 3]

(dBi)			
Frequency [MHz]	Average Sensitivity		
	1st Comparative Example(Fig.7)	3rd Embodiment (Fig. 5)	4th Embodiment (Fig. 6)
470	-12.4	-11.6	-10.8
480	-12.6	-12.1	-10.5
490	-11.2	-10.5	-9.6
500	-10.7	-10.0	-8.9
510	-10.4	-9.3	-8.3
520	-8.9	-7.9	-6.9
530	-8.1	-7.4	-6.4
540	-7.3	-5.8	-4.9
550	-8.3	-7.3	-6.4
560	-7.9	-7.0	-5.9
570	-8.6	-7.4	-6.8
580	-8.6	-7.1	-7.0
590	-9.4	-7.6	-7.4
600	-10.0	-8.5	-7.4
610	-10.4	-9.1	-7.4

(continued)

(dBi)			
Frequency [MHz]	Average Sensitivity		
	1st Comparative Example(Fig.7)	3rd Embodiment (Fig. 5)	4th Embodiment (Fig. 6)
620	-10.5	-8.7	-7.5
630	-11.2	-9.0	-8.0
640	-9.9	-7.9	-7.4
650	-10.5	-9.0	-8.2
660	-9.4	-8.2	-6.9
670	-9.1	-7.7	-6.5
680	-9.0	-7.8	-6.6
690	-8.2	-7.4	-6.8
700	-7.2	-6.6	-6.0
710	-7.6	-6.3	-5.7
720	-8.9	-7.1	-6.7
730	-10.1	-7.4	-7.1
740	-10.7	-8.1	-7.6
750	-10.9	-9.1	-8.4
760	-10.4	-9.9	-8.9
770	-9.7	-9.6	-8.8

[0059]

[Table 4]

(dBi)			
Average Sensitivity	1st Comparative Example(Fig.7)	3rd Embodiment (Fig. 5)	4th Embodiment (Fig. 6)
Mean Value	-9.6	-8.3	-7.5
Min. Value	-12.6	-12.1	-10.8
Max. Value	-7.2	-5.8	-4.9

[0060] It should be understood from Fig. 9 and Table 3 that the sensitivity characteristic of the digital TV antenna is improved by providing the AM antenna 4 with the discontinuous region 4g and increasing the value y.

[0061] It should be understood from Table 4 that the sensitivity characteristic of the digital TV antenna of the glass antenna shown in Fig. 5 (the third embodiment) is improved by 1.3 dB as the average sensitivity of the digital TV antenna, compared with the glass antenna for vehicle shown in Fig. 7 (the first comparative example). Moreover, it should be understood from Table 4 that the sensitivity characteristic of the digital TV antenna of the glass antenna shown in Fig. 6 (the fourth embodiment) is improved by 2.1 dB as the average sensitivity of the digital TV antenna, compared with the glass antenna for vehicle shown in Fig. 7 (the first comparative example).

[0062] Moreover, taking into account the limited area of the antenna arrangement of the glass antenna for vehicle, it should be understood from Table 4 that the clearance of y defining the discontinuous region is larger than 45 mm, and is smaller than 135 mm, preferably.

[0063] Then, the sensitivity characteristic of the AM antenna by providing the AM antenna with the discontinuous region 4g is described.

[0064] Table 5 shows comparative values of the measurement result of the sensitivity characteristic of the digital TV antenna in each glass antenna for vehicle shown in Fig. 7 (the first comparative example), in Fig. 4 (the second embodiment), and in Fig. 6 (the fourth embodiment), respectively (the unit is dB μ V). As described above, the glass antenna

for vehicle as the first comparative example shown in Fig. 7 corresponds to $y=45$ mm. Each measurement result of the glass antenna for vehicle shown in Fig. 4 (the second embodiment) and in Fig. 6 (the fourth embodiment) corresponds to the measurement value in case of $x_1 = x_2 = 50$ mm, and $y=105$ mm (Fig. 4 and Fig. 6).

[0065]

[Table 5]

	(dB μ V)					
	594KHz	954KHz	1242KHz	1458KHz	Mean Value	Min. Value
1st Comparative Example (Fig. 7)	31.2	30.5	31.3	33.6	31.7	30.5
2nd Embodiment (Fig. 4)	30.3	29.6	30.5	32.8	30.8	29.6
4th Embodiment (Fig. 6)	31.1	30.4	31.3	33.5	31.6	30.4

[0066] It should be understood from Table 5 that the providing of the discontinuous region 4g into the AM antenna have little to do with the influence of the AM signal-receiving sensitivity. Moreover, as described in the fourth embodiment (Fig. 6), it should be understood that the signal-receiving sensitivity of the AM antenna significantly equal to the first comparative example (Fig. 7) is obtained by providing the vertical conductor 4h into the discontinuous region 4g of the AM antenna 4.

[0067] Moreover, according to the glass antenna for vehicle in the first to fourth embodiments, providing of the discontinuous region 4g into the AM antenna enables to change the directivity of the digital TV antenna 18 into the direction vertical to the surface of the rear-window glass, and to control said directivity into the direction of the desired wave of the digital TV antenna.

[0068] The connection between the vertical conductors 4h and the continuous-horizontal conductors 4d may be electrical connection by the capacitive-coupling, while it is described to maintain the connection by the physical connection in the above described third and fourth embodiments. Moreover, parasitic elements may be closely located at the vertical conductors 4h so as to assist the vertical conductors 4h.

[0069] Then, a glass antenna for vehicle of a fifth embodiment in accordance with the invention is described.

(FIFTH EMBODIMENT)

[0070] Fig. 10 shows a schematic diagram of a glass antenna for vehicle in a fifth embodiment according to the invention. The arrangement of the glass antenna for vehicle of the fifth embodiment is similar with that of the third embodiment, other than the configuration of the digital TV antenna, and thus its similar description is omitted. As shown in Fig. 10, the digital TV antenna 58 of the fifth embodiment comprises a loop-conductive element 58c with horizontal elements; a vertical-conductive element to which the loop-conductive element 58c and a feeding point are connected; an auxiliary-conductive element 58d extended from the vertical-conductive element; and a parasitic element 58e to which the auxiliary-conductive element 58d and the loop-conductive element 58c are capacitive-coupled.

[0071] As shown in Fig. 10 of the glass antenna of the fifth embodiment, the clearance of the vertical direction, y , between the horizontal element of the loop-conductive element 58c and the continuous-horizontal conductor 4d is maintained by 30 mm. Moreover, the clearance of the horizontal direction, x , between the horizontal element of the loop-conductive element 58c and the discontinuous-horizontal conductor 4c is provided from 0 to 75 mm, as the distance along the surface of the window glass for vehicle.

[0072] Then, a glass antenna for vehicle of a sixth embodiment in accordance with the invention is described.

(SIXTH EMBODIMENT)

[0073] Fig. 11 shows a schematic diagram of a glass antenna for vehicle in a sixth embodiment according to the invention. The arrangement of the glass antenna for vehicle of the sixth embodiment is similar with that of the fourth embodiment, other than the configuration of the digital TV antenna, and thus its similar description is omitted. Moreover, the glass antenna of the sixth embodiment comprises the digital TV antenna 58 similar with that of the fifth embodiment.

[0074] As shown in Fig. 11 of the glass antenna of the sixth embodiment, the clearance of the vertical direction, y , between the horizontal element of the loop-conductive element 58c and the continuous-horizontal conductor 4d is maintained by 70 mm. Moreover, the clearance of the horizontal direction, x , between the horizontal element of the loop-conductive element 58c and the discontinuous-horizontal conductor 4c is provided from 0 to 75 mm, as the distance along the surface of the window glass for vehicle.

[0075] Then, a second comparative example of a glass antenna for vehicle is described hereinafter to make the effect

of the fifth and sixth embodiments clearer. The same numerals are fixed to similar components or elements in this description.

(SECOND COMPARATIVE EXAMPLE)

[0076] Fig. 12 shows a schematic diagram of a glass antenna for vehicle in a second comparative example. The arrangement of the glass antenna for vehicle of the second comparative example shown in Fig. 12 is similar with the above-described arrangement shown in Fig. 7, other than the configuration of the digital TV antenna, and thus its similar description is omitted. Moreover, the glass antenna of the second comparative example shown in Fig. 12 comprises the digital TV antenna 58 similar with that of the fifth or sixth embodiment.

[0077] As shown in Fig. 12 of the second comparative example, the clearance of the vertical direction between the horizontal element of the loop-conductive element 58c and the continuous-horizontal conductor 4d is maintained by 10 mm.

[0078] Fig. 13 shows the measurement result of the average sensitivity in the glass antenna for vehicle of the second comparative example shown in Fig. 12, and of the respective embodiments shown in Fig. 10 and Fig. 11. Moreover, the numeric measurement result corresponding to Fig. 13 is shown in Table 6 (the unit is dBi). In addition, each measurement result representing the ratio of the signal-receiving sensitivity based on the measurement result of the mean value (the average of signal-receiving sensitivity) received with the dipole antenna is shown in Table 6, where the mean value is value averaged by 180 degrees over the horizontal direction of the digital TV antenna in the outside direction of the vehicle (i.e., the signal-receiving sensitivity measured from the sideward of the vehicle to the backward thereof).

[0079]

[Table 6]

	(dBi)		
Average Sensitivity	2nd Comparative Example (Fig. 12)	5th Embodiment (Fig. 10)	6th Embodiment (Fig. 11)
Mean Value	-8.3	-7.1	-6.2
Min. Value	-11.2	-10.4	-9.6
Max. Value	-6.8	-5.5	-4.5

[0080] It should be understood from Fig. 13 and Table 6 that the sensitivity characteristic of the digital TV antenna of each glass antenna in the fifth embodiment (Fig. 10) and the sixth embodiment (Fig. 11) is improved, compared with the second comparative example (Fig. 12).

[0081] Moreover, it should be noted that each arrangement of the fifth embodiment and the sixth embodiment enables to prevent the deterioration of the sensitivity characteristic of the AM antenna, in similar with the above third and fourth embodiments.

[0082] Therefore, according to the glass antenna for vehicle in the fifth and sixth embodiments, providing of the discontinuous region into the AM antenna 4 also enables to change the directivity of the digital TV antenna 18 into the direction vertical to the surface of the rear-window glass, and to control said directivity into the direction of the desired wave of the digital TV antenna.

[0083] Then, a glass antenna for vehicle of a seventh embodiment in accordance with the invention is described.

(SEVENTH EMBODIMENT)

[0084] Fig. 14 is a schematic diagram of a glass antenna for vehicle in a seventh embodiment according to the invention. The glass antenna for vehicle of the seventh embodiment comprises a digital TV antenna 28 for twin loop antenna, and is similar with that of the above described fourth embodiment, other than the configuration of the digital TV antenna, and thus its similar description is omitted. In this embodiment, it is noted that the digital TV antenna is not limited to the type of twin loop antenna, and may be applied to the type of single loop antenna. The horizontal elements in the digital TV antenna 28 of the seventh embodiment are composed of conductor elements 28c and 28d.

[0085] As shown in Fig. 14, the digital TV antenna 28 for twin loop antenna includes the horizontal elements being composed of the conductor elements 28c and 28d. The clearance of the vertical direction, y, between theses horizontal elements and the continuous-horizontal conductor 4d is maintained by 90 mm. Moreover, the clearance of the horizontal direction, x, between each horizontal element (the conductor element 28c or 28d) of the twin loop-conductive element 28 and the discontinuous-horizontal conductor 4c is provided by 40 mm, as the distance along the surface of the window glass for vehicle.

[0086] Then, a glass antenna for vehicle of an eighth embodiment in accordance with the invention is described.

(EIGHTH EMBODIMENT)

[0087] Fig. 15 is a schematic diagram of a glass antenna for vehicle in an eighth embodiment according to the invention. The arrangement of the glass antenna for vehicle of the eighth embodiment is similar with that of the seventh embodiment, other than the configuration of the AM antenna 4, and thus its similar description is omitted. As shown in Fig. 15, the AM antenna 4 of the eighth embodiment includes in the discontinuous region at least one gamma (Γ)-shaped AM antenna element which is composed of a vertical conductor 4h and a partial, horizontal conductor 4j (in this figure, four gamma-shaped AM antenna elements). Thus, the signal-receiving sensitivity of the AM antenna 4 can be improved with little influence for the signal-receiving sensitivity of the digital TV antenna 28 if the AM antenna 4 is arranged by providing the discontinuous region 4g with the gamma-shaped AM antenna elements, while this will be clear from the later description. This means that the clearance of the vertical direction, y, between each horizontal element (the conductor element 28c or 28d) of the twin loop-conductive element 28 and the continuous-horizontal conductor 4d may be defined.

[0088] Besides, in the eighth embodiment shown in Fig. 15, the clearance of the vertical direction, y, between each horizontal element (the conductor element 28c or 28d) of the twin loop-conductive element 28 and the continuous-horizontal conductor 4d is maintained by 90 mm. Moreover, the clearance of the horizontal direction, x, between each horizontal element (the conductor element 28c or 28d) of the twin loop-conductive element 28 and the discontinuous-horizontal conductor 4c is provided by 25 mm, as the distance along the surface of the window glass for vehicle.

[0089] Then, a glass antenna for vehicle of a ninth embodiment in accordance with the invention is described.

(NINTH EMBODIMENT)

[0090] Fig. 16 is a schematic diagram of a glass antenna for vehicle in a ninth embodiment according to the invention. The arrangement of the glass antenna for vehicle of the ninth embodiment is similar with that of the eighth embodiment, other than the configuration of the AM antenna 4, and thus its similar description is omitted. As shown in Fig. 16, the AM antenna 4 of the ninth embodiment includes in the discontinuous region 4g an AM antenna element of continuous meander-shape (hereinafter, it is referred to as a meander-shaped AM antenna element) which is composed of a vertical conductor 4h and a partial, horizontal conductor 4k. Thus, the signal-receiving sensitivity of the AM antenna 4 can be improved with little influence for the signal-receiving sensitivity of the digital TV antenna 28 if the AM antenna 4 is arranged by providing the discontinuous region 4g with the meander-shaped AM antenna elements, while this will be clear from the later description. This means that the clearance of the vertical direction, y, between each horizontal element (the conductor element 28c or 28d) of the twin loop-conductive element 28 and the FM antenna 5 or the defogger 3 may be defined.

[0091] Besides, in the ninth embodiment shown in Fig. 16, the clearance of the vertical direction, y, between each horizontal element (the conductor element 28c or 28d) of the twin loop-conductive element 28 and the FM antenna 5 is maintained by 120 mm. Moreover, there is provided the clearance of the horizontal direction, x, between each horizontal element (the conductor element 28c or 28d) of the twin loop-conductive element 28 and the discontinuous-horizontal conductor 4c is provided by 25 mm, as the distance along the surface of the window glass for vehicle.

[0092] Then, a glass antenna for vehicle of a tenth embodiment in accordance with the invention is described.

(TENTH EMBODIMENT)

[0093] Fig. 17 is a schematic diagram of a glass antenna for vehicle in a tenth embodiment according to the invention. The arrangement of the glass antenna for vehicle of the tenth embodiment is another aspect of the ninth embodiment in which a meander-shaped AM antenna element, which is composed of a vertical conductor 4h and a partial, horizontal conductor 4k, is provided in the discontinuous region 4g. In the tenth embodiment shown in Fig. 17, the clearance of the vertical direction, y, between each horizontal element (the conductor element 28c or 28d) of the twin loop-conductive element 28 and the continuous-horizontal conductor 4d is maintained by 120 mm. Moreover, the clearance of the horizontal direction, x, between each horizontal element (the conductor element 28c or 28d) of the twin loop-conductive element 28 and the discontinuous-horizontal conductor 4c is provided by 55 mm, as the distance along the surface of the window glass for vehicle.

[0094] Then, a third comparative example of a glass antenna for vehicle is described hereinafter to make the effect of the seventh to tenth embodiments clearer. The same numerals are fixed to similar components or elements in this description.

(THIRD COMPARATIVE EXAMPLE)

[0095] Fig. 18 shows a schematic diagram of a glass antenna for vehicle in a third comparative example. The composition of the glass antenna for vehicle of the third comparative example shown in Fig. 18 is different from these glass antennas for vehicle of the seventh to tenth embodiments, since the AM antenna 4 does not have the discontinuous region 4g.

[0096] As shown in Fig. 18 of the glass antenna for vehicle in the third comparative example, the clearance of the vertical direction, y, between the twin loop-conductive element 28 and the continuous-horizontal conductor 4d is maintained by 30 mm.

[0097] Fig. 19 shows a comparative graph of the measurement result of the sensitivity characteristic of the digital TV antenna in the glass antenna for vehicle of the third comparative example shown in Fig. 18 and of the respective seventh to the tenth embodiments shown in Figs. 14-17. Moreover, the numeric measurement result corresponding to Fig. 19 is shown in Table 7 (the unit is dBi). In addition, the mean value, the minimum value, and the maximum value of the sensitivity characteristic corresponding to Table 7 are shown in Table 8 (the unit is dBi). In addition, each measurement result representing the ratio of the signal-receiving sensitivity based on the measurement result of the mean value (the average of signal-receiving sensitivity) received with the dipole antenna is shown in Fig. 19, in Table 7, and in Table 8, where the mean value is value averaged by 180 degrees over the horizontal direction of the digital TV antenna in the outside direction of the vehicle (i.e., the signal-receiving sensitivity measured from the sideward of the vehicle to the backward thereof).

[0098]

[Table 7]

Frequency [MHz]	Average Sensitivity					(dBi)
	3rd Comparative Example (Fig. 18)	7th Embodiment (Fig. 14)	8th Embodiment (Fig. 15)	9th Embodiment (Fig. 16)	10th Embodiment (Fig. 17)	
470	-12.6	-10.2	-10.1	-10.1	-10.0	
480	-11.8	-9.5	-9.7	-9.8	-9.7	
490	-11.0	-9.2	-9.1	-9.3	-9.2	
500	-10.5	-9.3	-8.9	-8.9	-8.8	
510	-9.2	-8.7	-8.5	-8.2	-8.1	
520	-8.4	-9.2	-8.5	-8.3	-8.0	
530	-8.3	-10.1	-9.8	-9.1	-8.5	
540	-8.8	-8.5	-9.5	-9.7	-9.3	
550	-9.0	-8.3	-9.0	-8.8	-8.8	
560	-8.5	-8.1	-8.2	-7.7	-7.8	
570	-8.4	-9.1	-8.3	-7.4	-7.4	
580	-8.4	-8.3	-7.6	-7.0	-7.0	
590	-8.4	-7.5	-6.9	-6.6	-6.5	
600	-8.4	-6.8	-6.2	-6.2	-6.1	
610	-9.1	-6.4	-6.4	-6.4	-6.0	
620	-9.7	-6.0	-6.6	-6.6	-6.3	
630	-10.3	-6.8	-7.0	-7.0	-6.9	
640	-9.3	-6.9	-7.0	-6.8	-7.0	
650	-9.9	-7.4	-7.5	-7.5	-7.3	

(continued)

(dBi)					
Frequency [MHz]	Average Sensitivity				
	3rd Comparative Example (Fig. 18)	7th Embodiment (Fig. 14)	8th Embodiment (Fig. 15)	9th Embodiment (Fig. 16)	10th Embodiment (Fig. 17)
660	-9.9	-7.0	-6.9	-6.8	-6.7
670	-9.0	-6.8	-7.0	-7.0	-6.9
680	-9.5	-6.8	-7.4	-7.3	-7.2
690	-10.5	-6.5	-7.2	-7.3	-7.2
700	-10.4	-6.5	-7.0	-7.2	-7.1
710	-9.7	-6.1	-6.3	-6.4	-6.3
720	-10.0	-6.4	-6.5	-6.6	-6.5
730	-9.8	-6.9	-6.9	-7.1	-6.8
740	-8.5	-7.1	-6.8	-6.8	-6.7
750	-7.6	-6.4	-6.3	-6.2	-6.1
760	-6.9	-5.5	-5.3	-5.3	-5.2
770	-6.0	-4.8	-4.7	-4.8	-4.6

[0099]

[Table 8]

(dBi)					
Average Sensitivity	3rd Embodiment (Fig. 18)	7th Embodiment (Fig. 14)	8th Embodiment (Fig. 15)	9th Embodiment (Fig. 16)	10th Embodiment (Fig. 17)
Mean Value	-9.3	-7.5	-7.5	-7.4	-7.3
Min. Value	-12.6	-10.2	-10.1	-10.1	-10.0
Max. Value	-6.0	-4.8	-4.7	-4.8	-4.6

[0100] It should be understood from Fig. 19, and Table 8 that the sensitivity characteristic of the digital TV antenna is improved by providing the AM antenna 4 with the discontinuous region 4g.

[0101] In particular, it should be understood from Table 8 that the average sensitivity of the digital TV antenna of each glass antenna of the seventh to tenth embodiments shown in Figs. 14-17 is improved by 1.8 dB, 1.8 dB, 1.9 dB, and 2.0 dB respectively, compared with the glass antenna for vehicle shown in Fig. 18 (the third comparative example).

[0102] Then, the sensitivity characteristic of the AM antenna by providing the AM antenna with the discontinuous region 4g is described.

[0103] Table 9 shows comparative values of the measurement result of the sensitivity characteristic of the digital TV antenna in each glass antenna for vehicle of the third comparative example shown in Fig. 18 and of the seventh to tenth embodiments shown in Figs. 14-17, respectively (the unit is dB μ V).

[0104]

[Table 9]

	(dB μ V)					
	594KHz	954KHz	1242KHz	1458KHz	Mean Value	Min. Value
3rd Embodiment (Fig. 18)	31. 2	30. 5	31. 3	33. 6	31. 7	30. 5
7th Embodiment (Fig. 14)	31. 0	30. 2	31. 1	33. 3	31. 4	30. 2
8th Embodiment (Fig. 15)	30. 9	30. 1	31. 0	33. 2	31. 3	30. 1
9th Embodiment (Fig. 16)	30. 8	30. 0	31. 0	33. 2	31. 3	30. 0
10th Embodiment (Fig. 17)	30. 7	30. 0	31. 0	33. 2	31. 2	30. 0

[0105] As described in each glass antenna for vehicle of the seventh to tenth embodiments shown in Figs. 14-17, it should be understood from Table 9 that the signal-receiving sensitivity of the AM antenna significantly equal to the third comparative example (Fig. 18) is obtained by providing the gamma-shaped AM antenna element or the meander-shaped AM antenna element into the discontinuous region 4g of the AM antenna 4.

[0106] Therefore, it should be understood that the antenna characteristic for digital TV broadcasting is improved in each glass antenna for vehicle of the seventh to tenth embodiments shown in Figs. 14-17, without decreasing the signal-receiving sensitivity of the AM antenna 4.

[0107] Therefore, in each glass antenna for vehicle of the seventh to tenth embodiments, providing of the discontinuous region into the AM antenna 4 also enables to change the directivity of the digital TV antenna into the direction vertical to the surface of the rear-window glass, and to control said directivity into the direction of the desired wave of the digital TV antenna.

[0108] The invention is not limited to these embodiments shown in drawings, while the examples of the meander-shaped AM antenna elements provided into the discontinuous region 4g are shown in Figs. 16 and 17 of the glass antenna for vehicle of the above the ninth and tenth embodiments. For example, the meander-shaped AM antenna elements shown in Figs. 16 and 17 may be not only the rectangular-shaped bending wire but also the round corner-shaped bending wire or the meander-shaped wire with respect to entirely sinusoidal-shape of the meander-shaped AM antenna.

[0109] Moreover, since the clearance of the vertical direction, y, is defined by the part of the antenna element extended in parallel with the digital TV antenna 28 as visibly described, the AM antenna elements each of which is composed of a vertical conductor 4h and a partial, horizontal conductor 4j or 4k in the discontinuous region 4g may be provided individually (Figs. 14-17). Moreover, the shape and the size of the AM antenna element, and the distance between said AM antenna elements may be formed by any manner.

[0110] Then, glass antennas for vehicle of other embodiments in accordance with the invention are described.

(OTHER EMBODIMENTS)

[0111] As shown in Fig. 20, this glass antenna for vehicle may comprise a digital TV antenna 38 of the dipole antenna type. The horizontal element of the digital TV antenna 38 in this embodiment is composed of conductor elements 38c and 38d.

[0112] As shown in Fig. 21, this glass antenna for vehicle may comprise a digital TV antenna 48 of the monopole antenna type with parasitic elements 41a and 41b to improve the sensitivity characteristic thereof. Besides, the digital TV antenna 48 may be either of parasitic elements 41a and 41b. The horizontal element of the digital TV antenna 48 in this embodiment is composed of conductor elements 41a, 41b and 41c which are capacitive-coupled mutually.

[0113] As shown in Fig. 22, this glass antenna for vehicle may comprise digital TV antennas 18L and 18R arranged at both ends of the window glass for vehicle. Besides, the plurality of the digital TV antennas may be arranged at not only the rear-window glass but also the front-window glass or the side of the window glass of the vehicle for diversity combining of the received signal from the respective digital TV antennas.

[0114] Moreover, The shape of the AM antenna may be transformed in arbitrary antenna pattern, and the connection between the discontinuous-horizontal conductor 4c and the continuous-horizontal conductor 4d in the AM antenna may be arbitrarily formed. For example, the opposed edge to the feeding point of the AM antenna 4 shown in Figs. 3-6 may be electrically connected with conductive elements, while each AM antenna 4 shown in Figs. 3-6 has the opposed edge of open-end as antenna pattern. Alternatively, while the edge of this discontinuous-horizontal conductor 4c is connected to the continuous-horizontal conductor 4d, the edge of the discontinuous-horizontal conductor 4c may be the edge of open-end as antenna pattern.

[0115] Moreover, the AM antenna may include a shorting-wire 4f for connecting between the plural horizontal con-

ductors respectively, and the location of the shorting-wire may be arbitrarily fixed.

[0116] Besides, the distance between the heat wires 3e for defogging or the main body of the vehicle and the AM antenna is preferably 30 mm or more, to prevent the decrease of the signal-receiving sensitivity of the AM antenna because of capacitive-coupling into the heat wires 3e or the main body.

[0117] It is noted for those skilled in the art to be able to achieve the invention by variously combining the above embodiments other than the configuration of the embodiments described in the above.

[0118] For example, the area of the AM antenna may be the same by extending or adding the horizontal conductor of the AM antenna to an extent that the horizontal conductor of the AM antenna located under the digital TV antenna is deleted.

[0119] In addition, the distance of x_1 and x_2 need not be limited to 0 mm or more, while the distance of x_1 and x_2 in case of 0 mm or more is described in the above embodiments. That is, the clearance of the horizontal direction of the discontinuous region 4g may be shorter than the length of the horizontal element 18c of the digital TV antenna 18. Providing of the discontinuous region 4g into the AM antenna 4 improves the sensitivity characteristic of the digital TV antenna with respect to the first comparative example (Fig. 7). This should be understood on the basis of the result in the above described Table 4.

[0120] It should be understood that a lot of variations and modifications is able to be implemented by those skilled in the art in the spirit or scope of the present invention, while the specific examples are described in the above-described embodiments. For example, the digital TV antenna may be arranged under the defogger or the AM antenna, while there is described the arrangement of the digital TV antenna provided over the defogger or the AM antenna. Accordingly, the invention is not to be considered as limited by the foregoing description but is only limited by the scope of the appended claims.

INDUSTRIAL APPLICABILITY

[0121] According to the invention, a glass antenna for vehicle, which comprises an antenna for digital terrestrial TV broadcasting and an AM antenna, may be provided with extremely high sensitivity, and thus it is useful to a motor vehicle comprising such a glass antenna.

Claims

1. A glass antenna for vehicle, the glass antenna being formed on the surface of a window glass for vehicle in which a defogger with a plurality of heat wires extended over a horizontal direction is provided, the glass antenna being **characterized in that** it comprises:

a first antenna for receiving of TV electromagnetic wave, wherein the first antenna includes a horizontal element formed at the side of the heat wires and substantially parallel to the plurality of heat wires; and
a second antenna for receiving of AM electromagnetic wave formed between the defogger and the first antenna, wherein the second antenna includes a discontinuous region closely located at the first antenna.

2. The glass antenna according to claim 1, in which the second antenna includes in the discontinuous region at least one continuous-horizontal conductor and at least one continuous-horizontal conductor located in parallel to the continuous-horizontal conductor.

3. The glass antenna according to claim 1, in which the second antenna includes in the discontinuous region at least one gamma-shaped antenna element which is composed of a vertical conductor and a partial, horizontal conductor.

4. The glass antenna according to claim 1, in which the second antenna includes in the discontinuous region a continuous meander-shaped antenna element composed of vertical conductors and partial, horizontal conductors.

5. The glass antenna according to claim 1, in which the first antenna includes a L-shaped or loop-shaped antenna element, wherein the horizontal element is a part of the L-shaped or loop-shaped antenna element.

6. The glass antenna according to claim 1, in which the horizontal element comprises a plurality of conductive elements, each of the conductive elements being mutually capacitive-coupled.

7. The glass antenna according to claim 2, in which the second antenna includes in the discontinuous region at least one vertical conductor, the vertical conductor being electrically connected to the continuous-horizontal conductor.

EP 2 109 181 A1

8. The glass antenna according to claim 2, in which the clearance of the horizontal direction between the horizontal element and the discontinuous-horizontal conductor is from 0 to 75 mm, as the distance along the surface of the window glass for vehicle.

5 9. The glass antenna according to claim 2, in which the clearance of the vertical direction between the horizontal element and the continuous-horizontal conductor is larger than 10 mm, and is smaller than 135 mm, as the distance along the surface of the window glass for vehicle.

10

15

20

25

30

35

40

45

50

55

FIG. 1

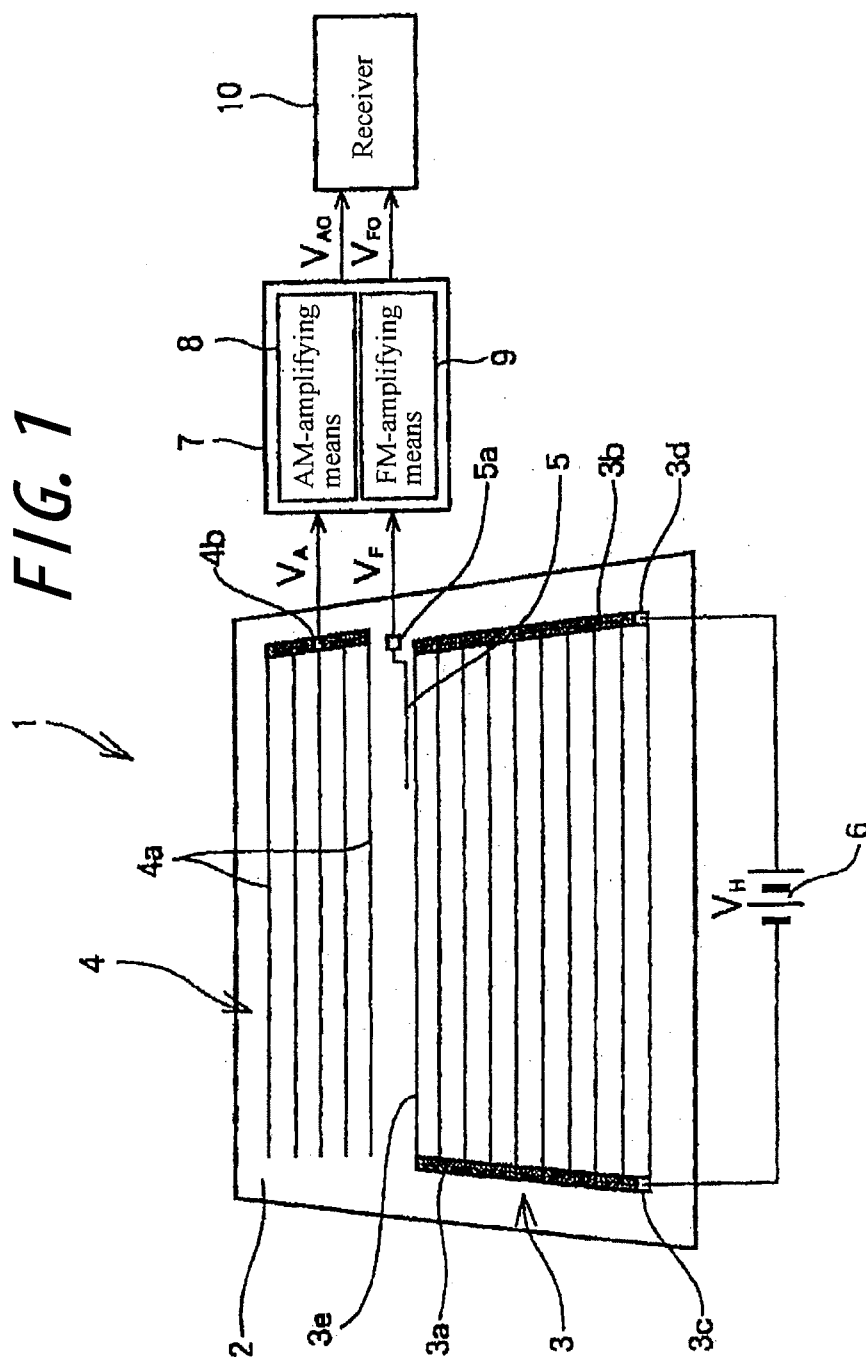


FIG. 2

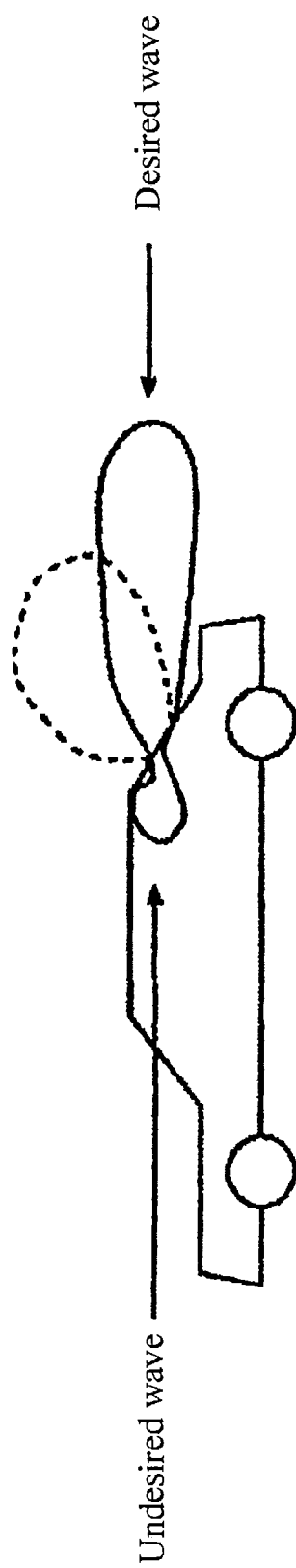


FIG. 3

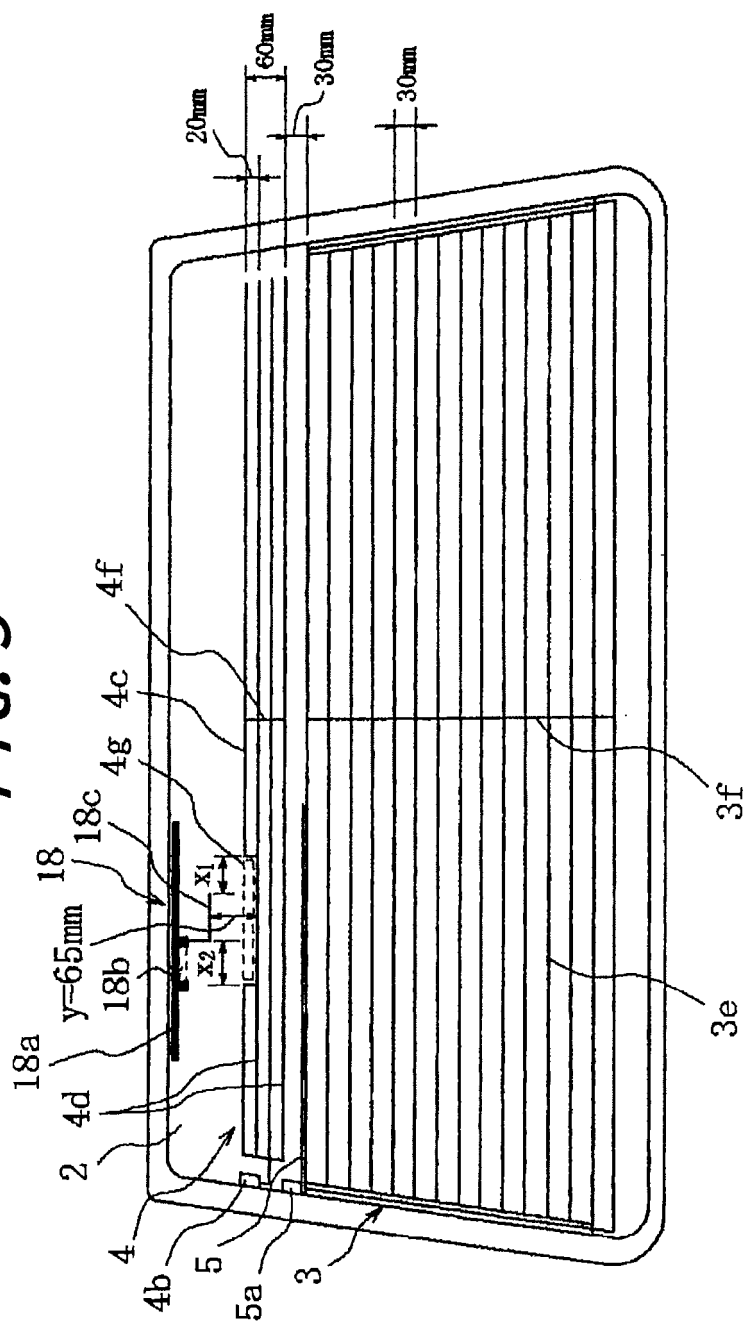


FIG. 4

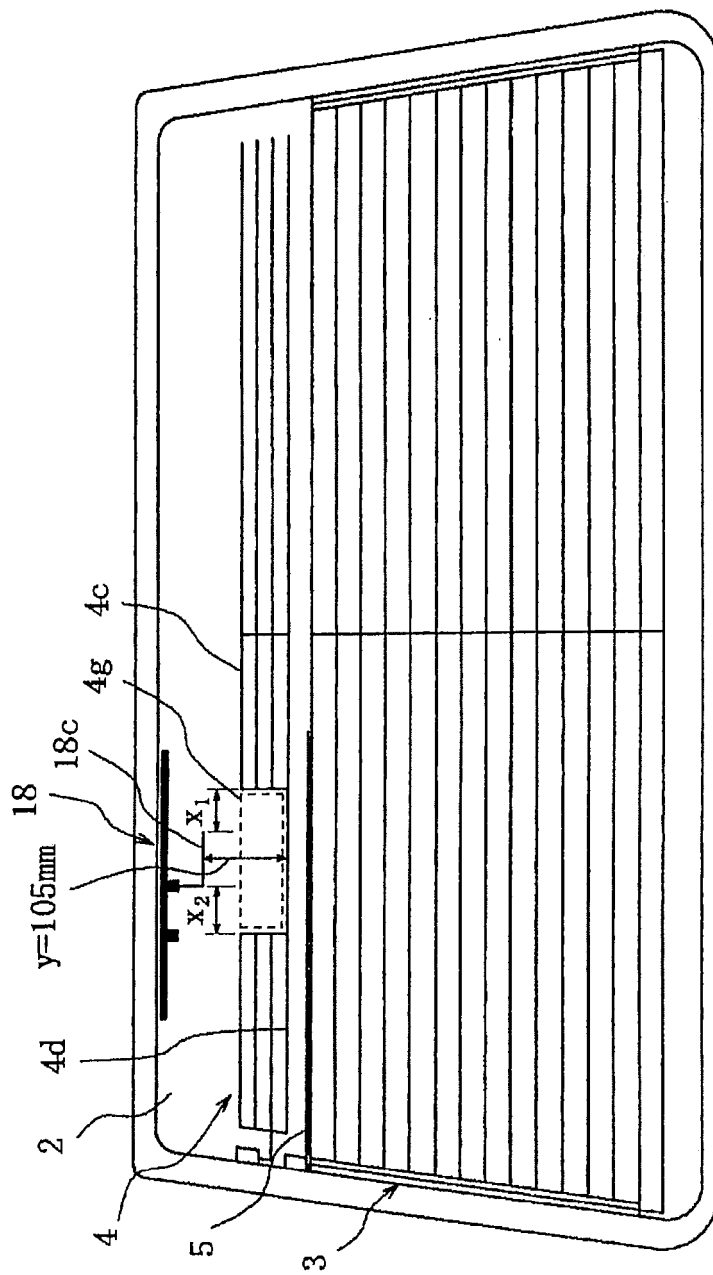


FIG. 5

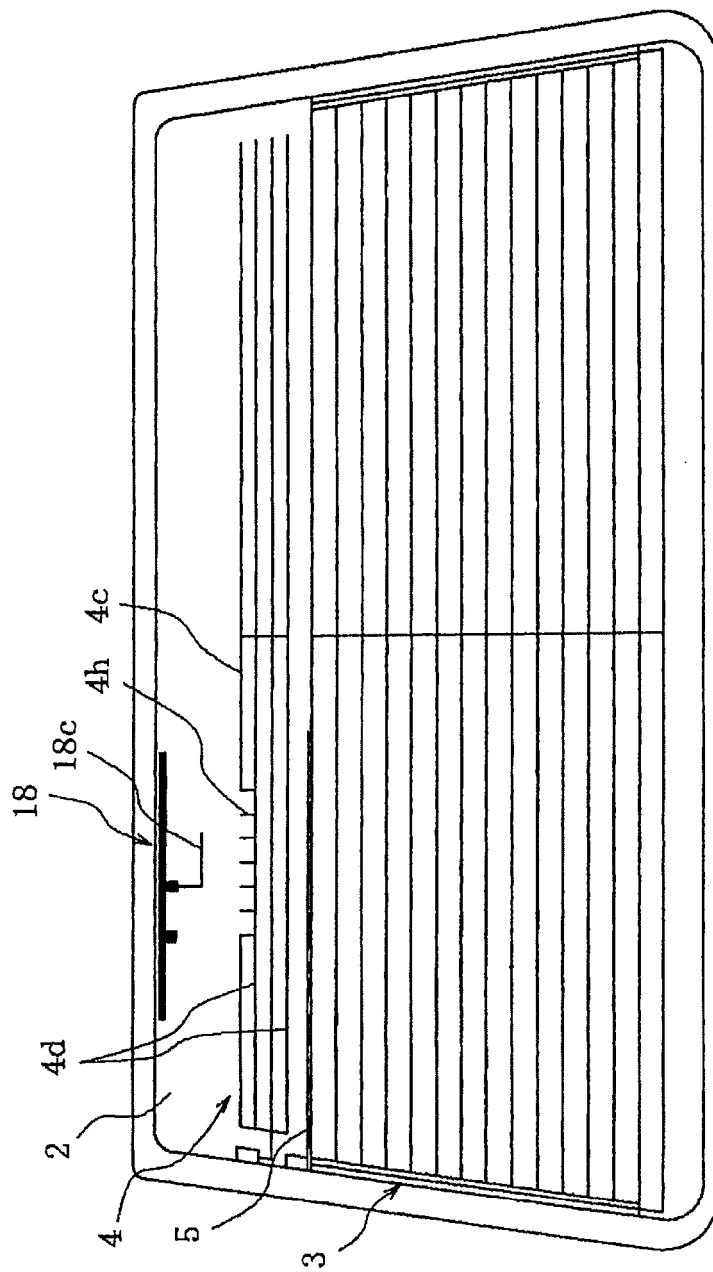


FIG. 6

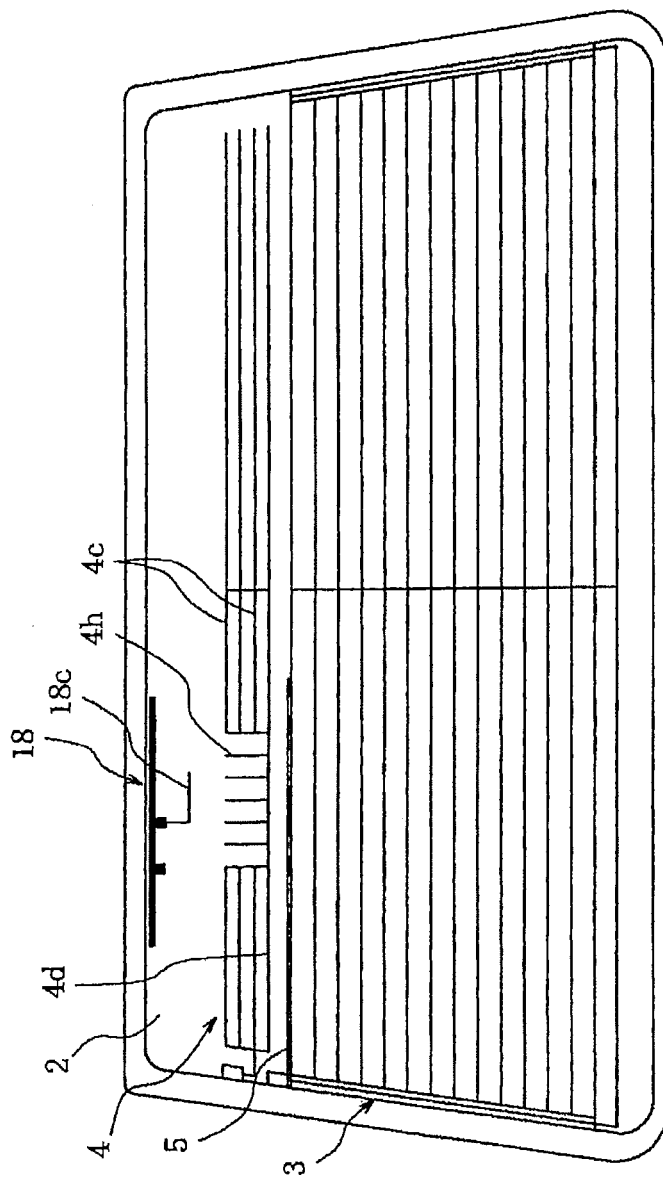


FIG. 7

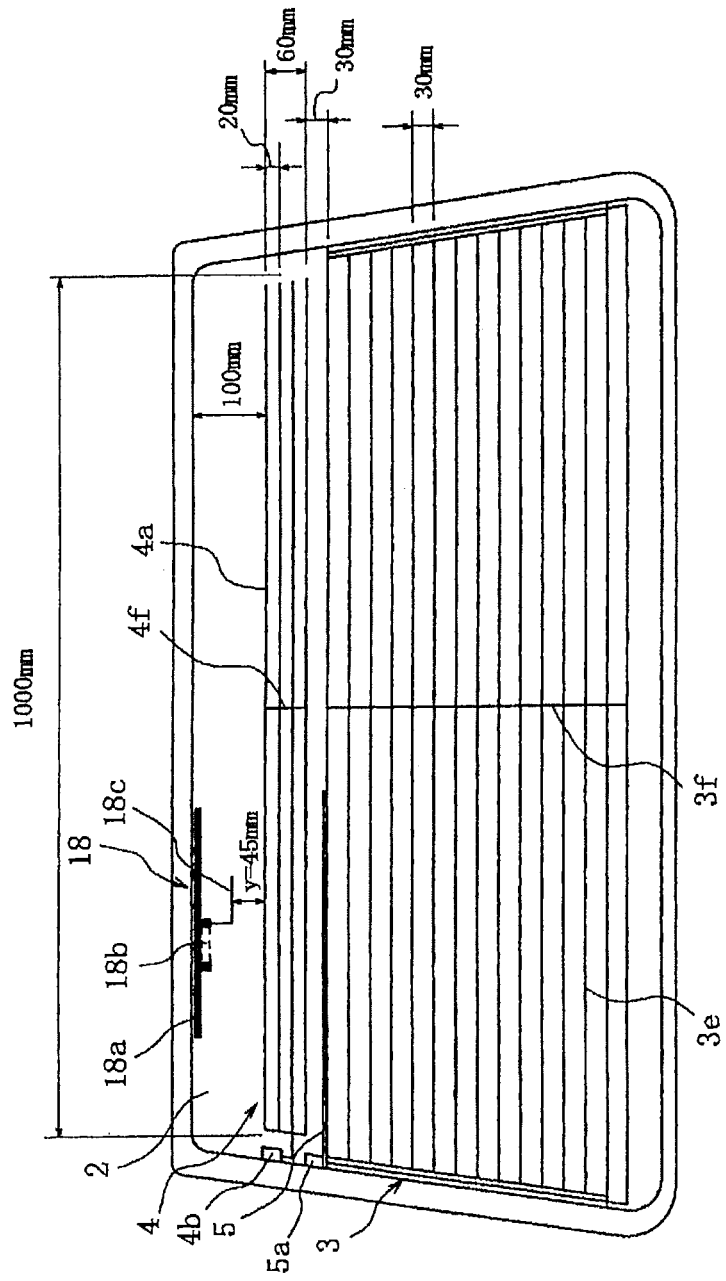


FIG. 8

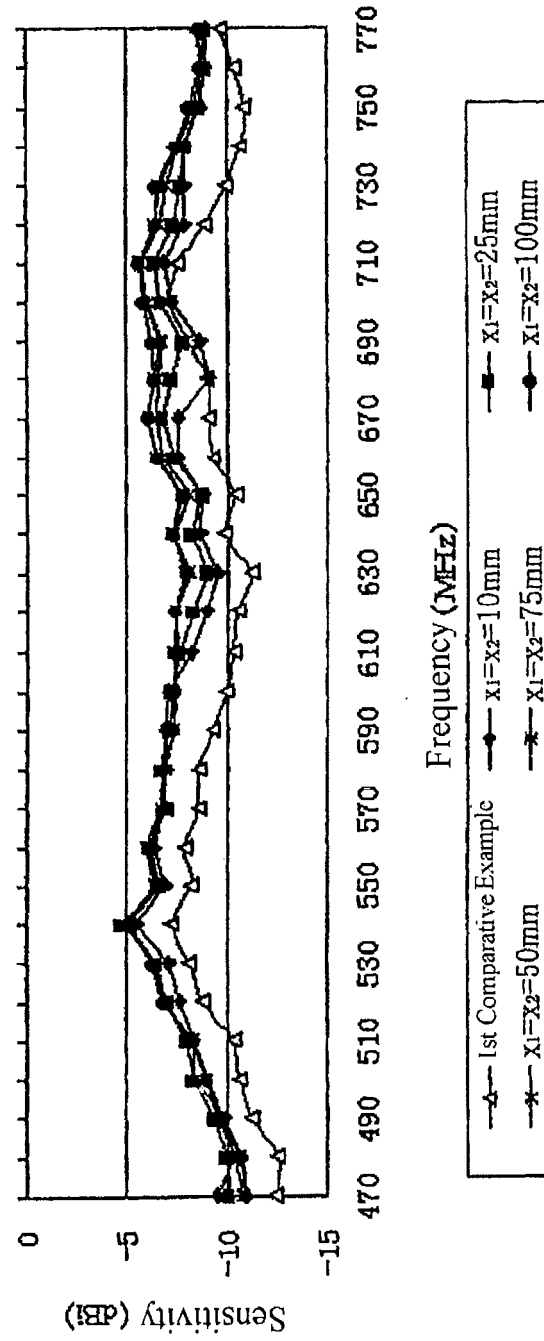


FIG. 9

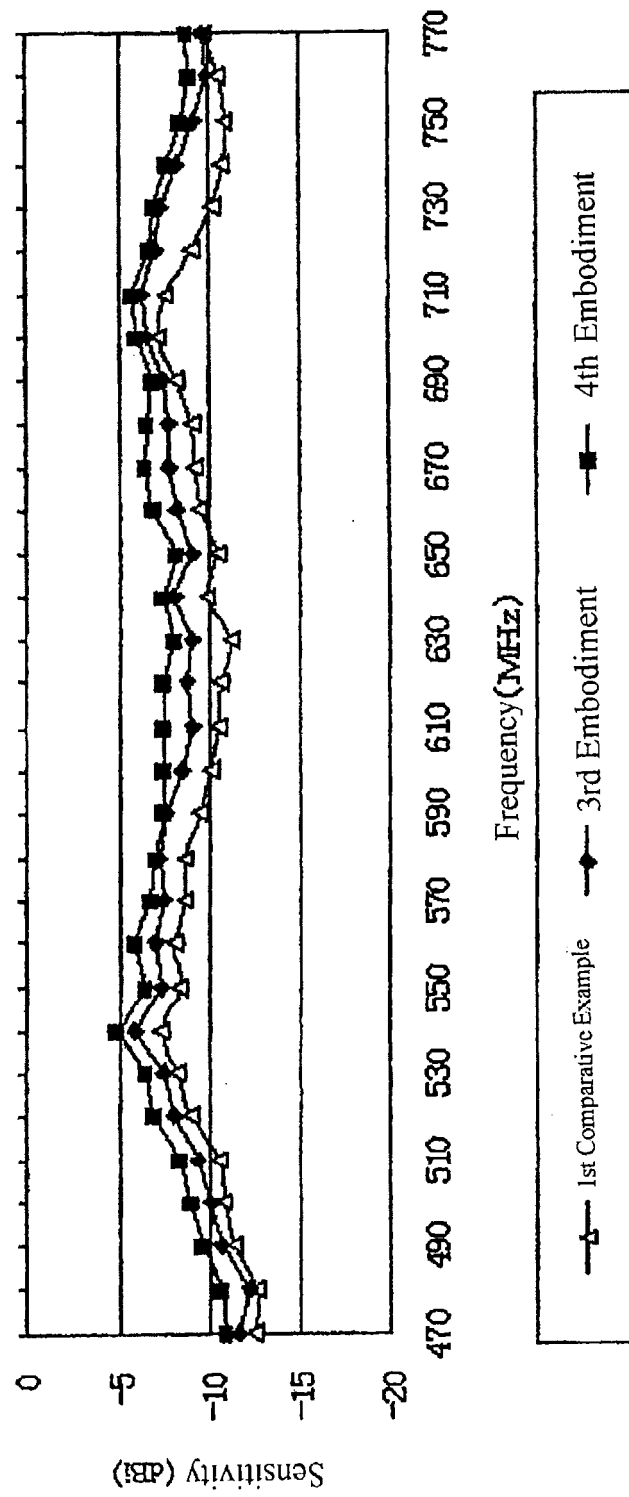


FIG. 10

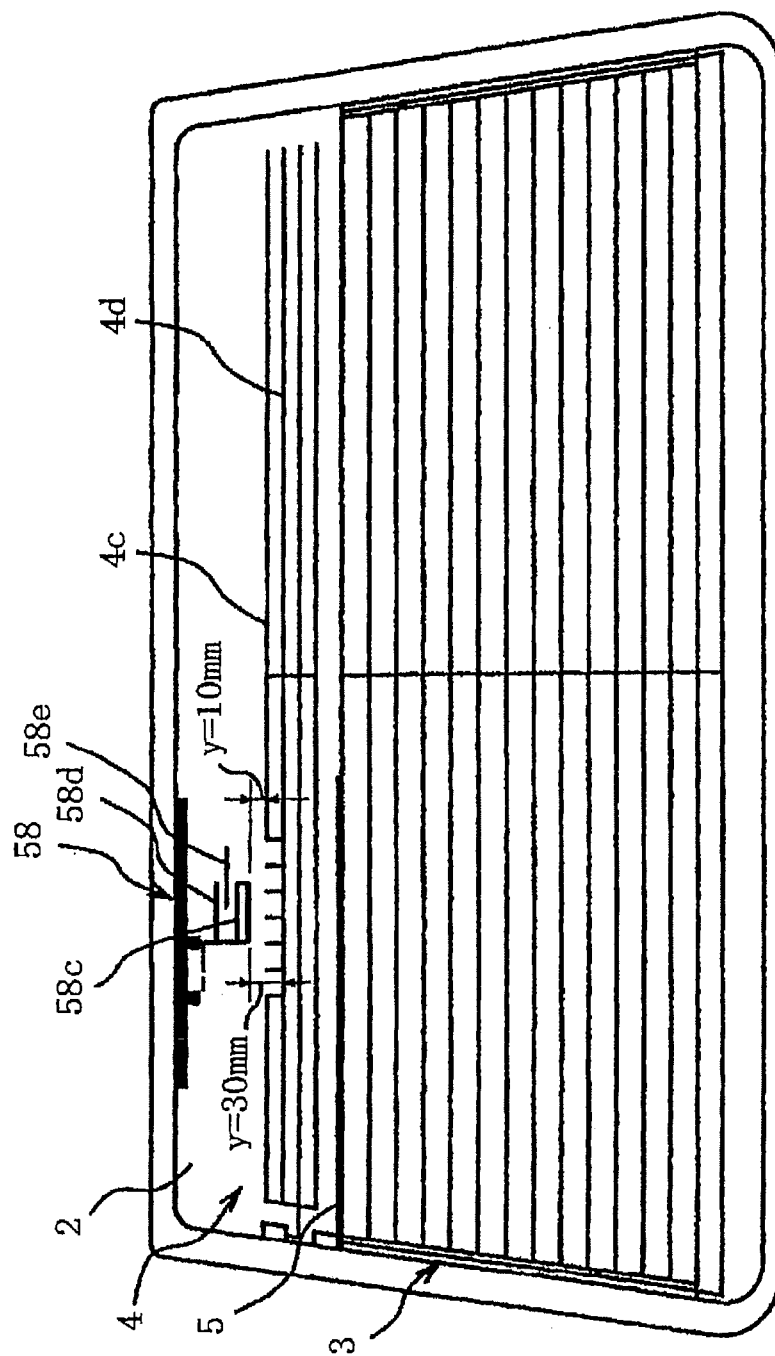


FIG. 11

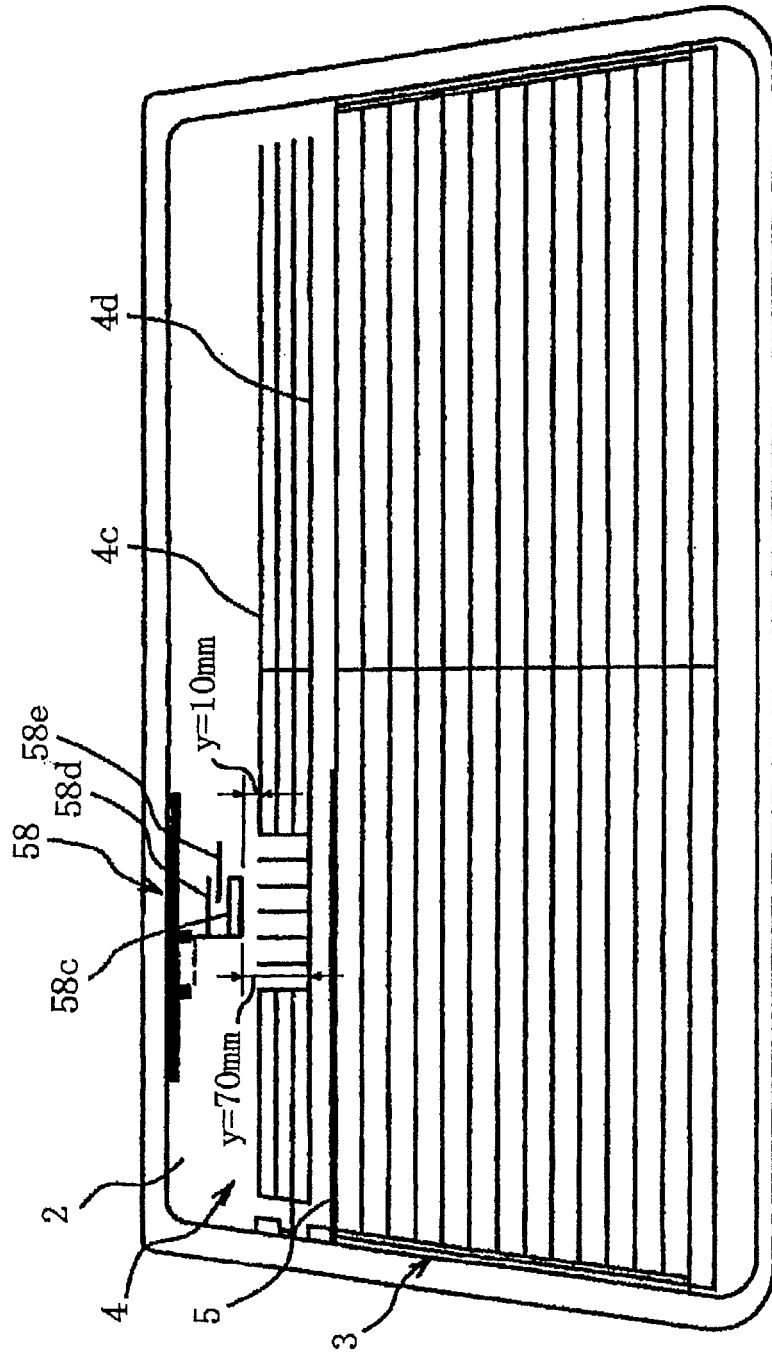


FIG. 12

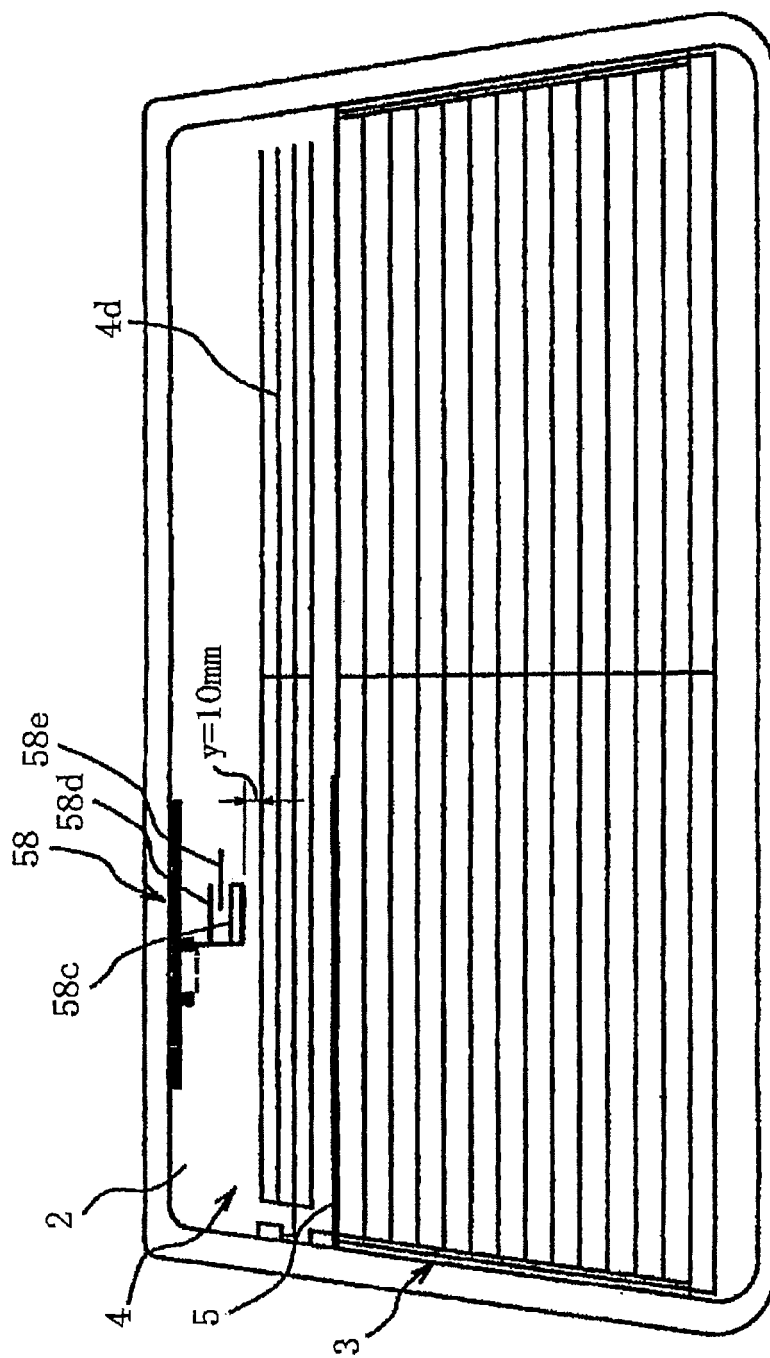


FIG. 13

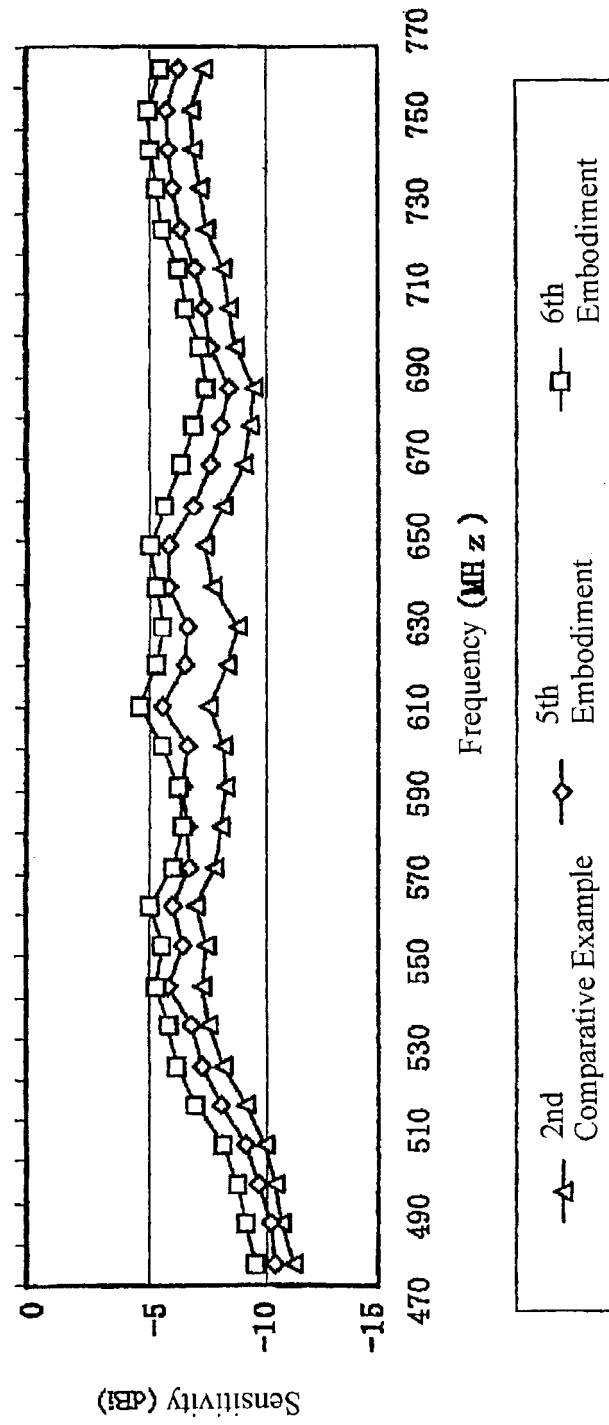


FIG. 14

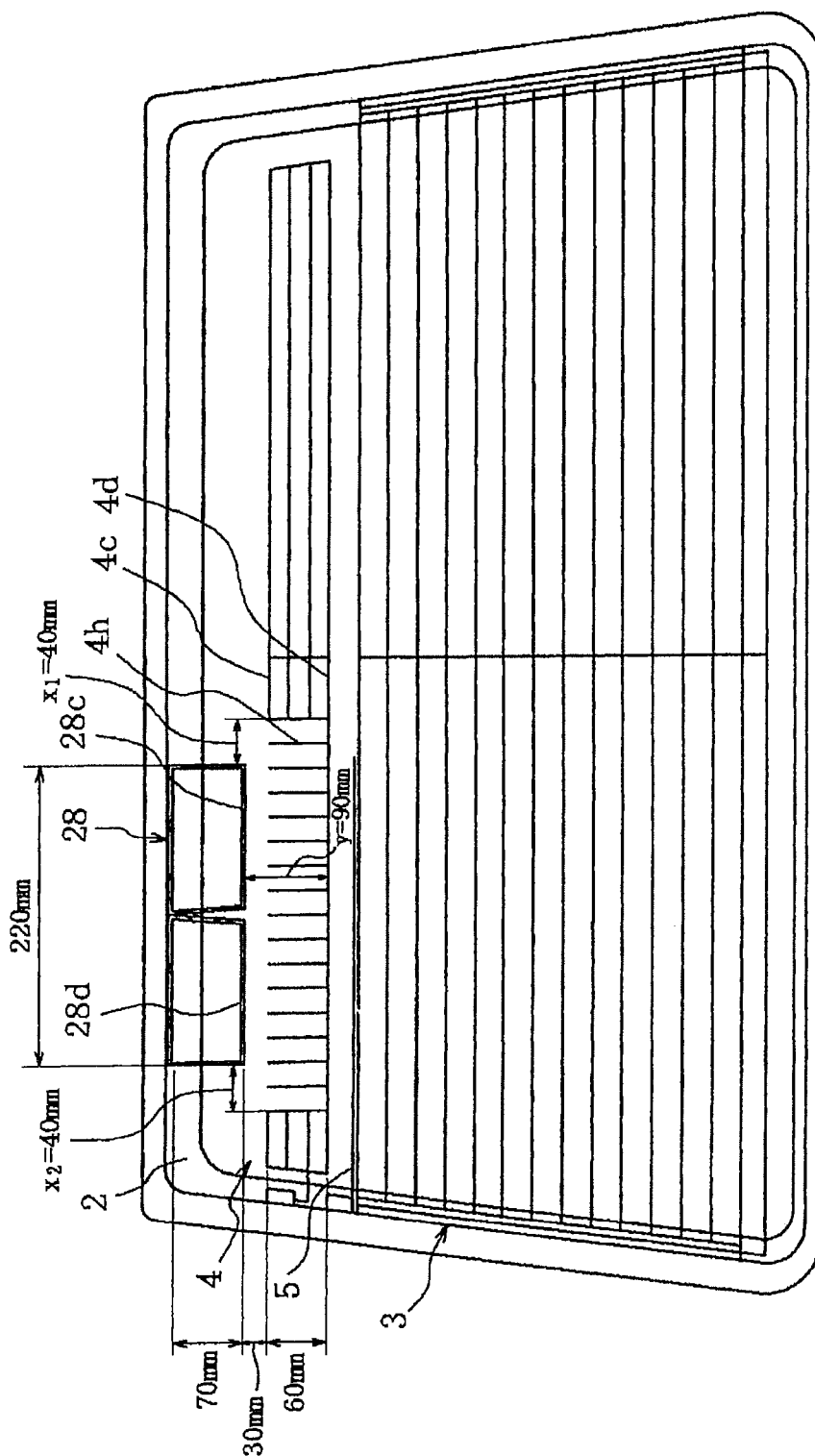


FIG. 15

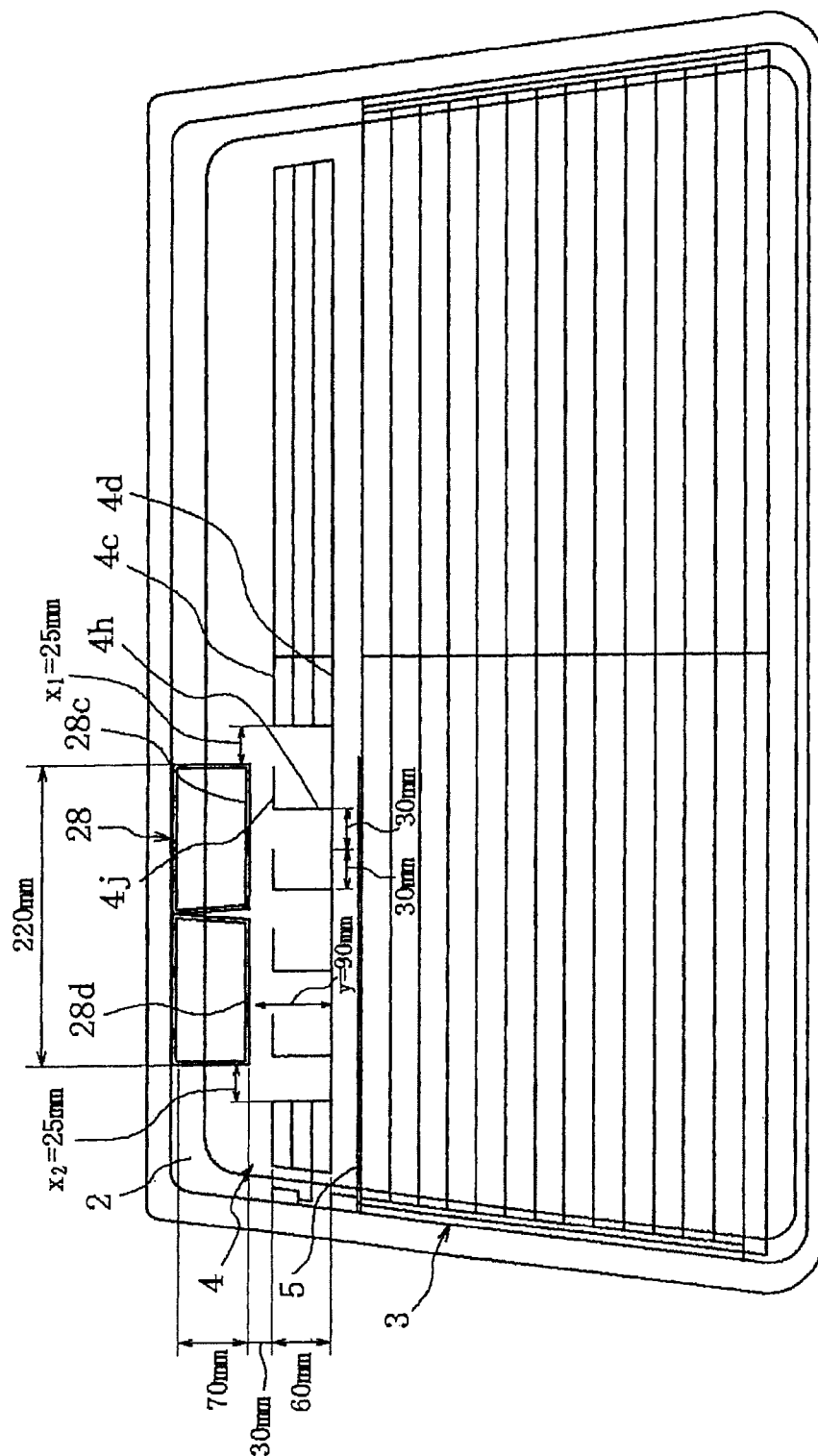


FIG. 16

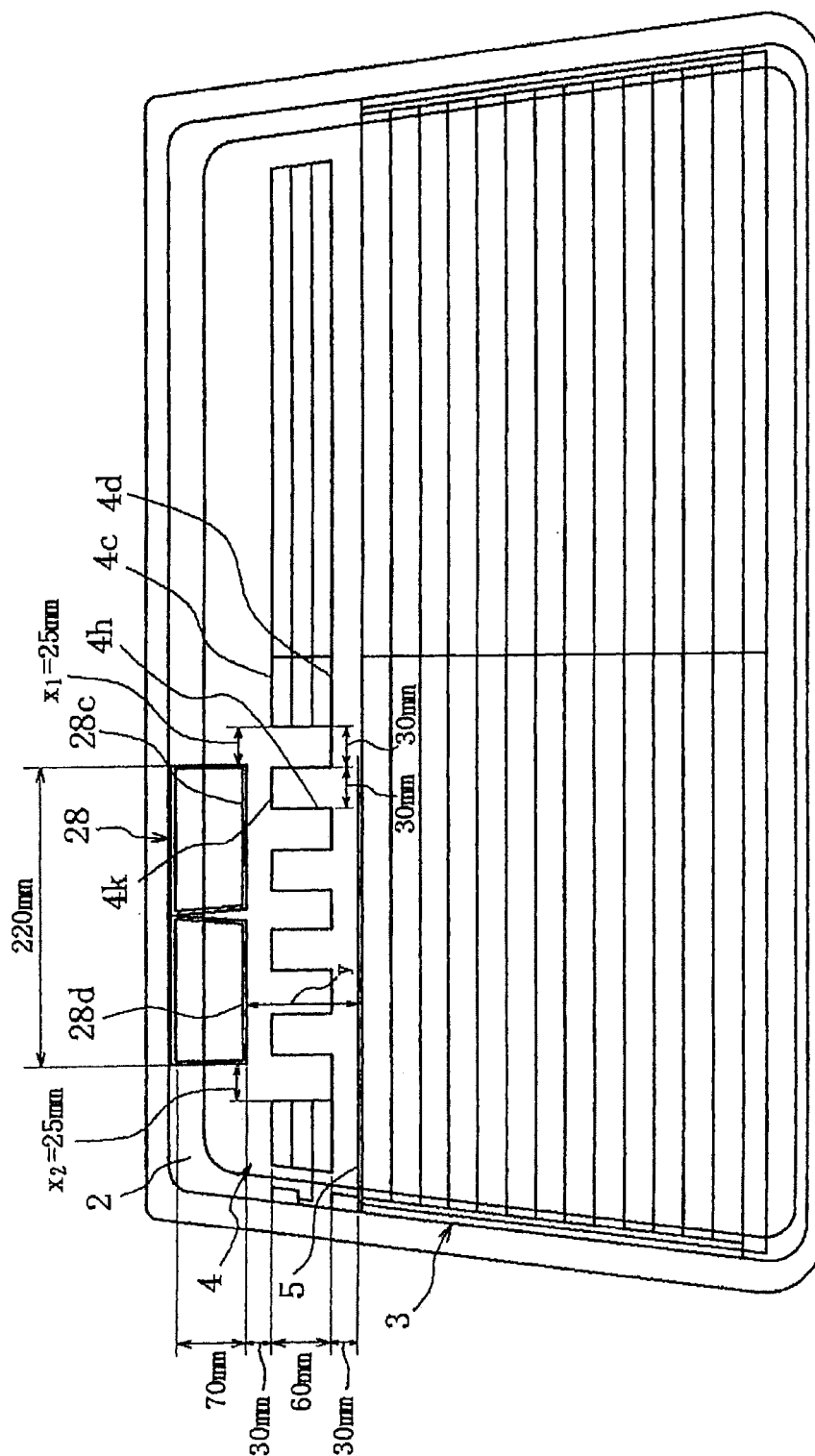


FIG. 17

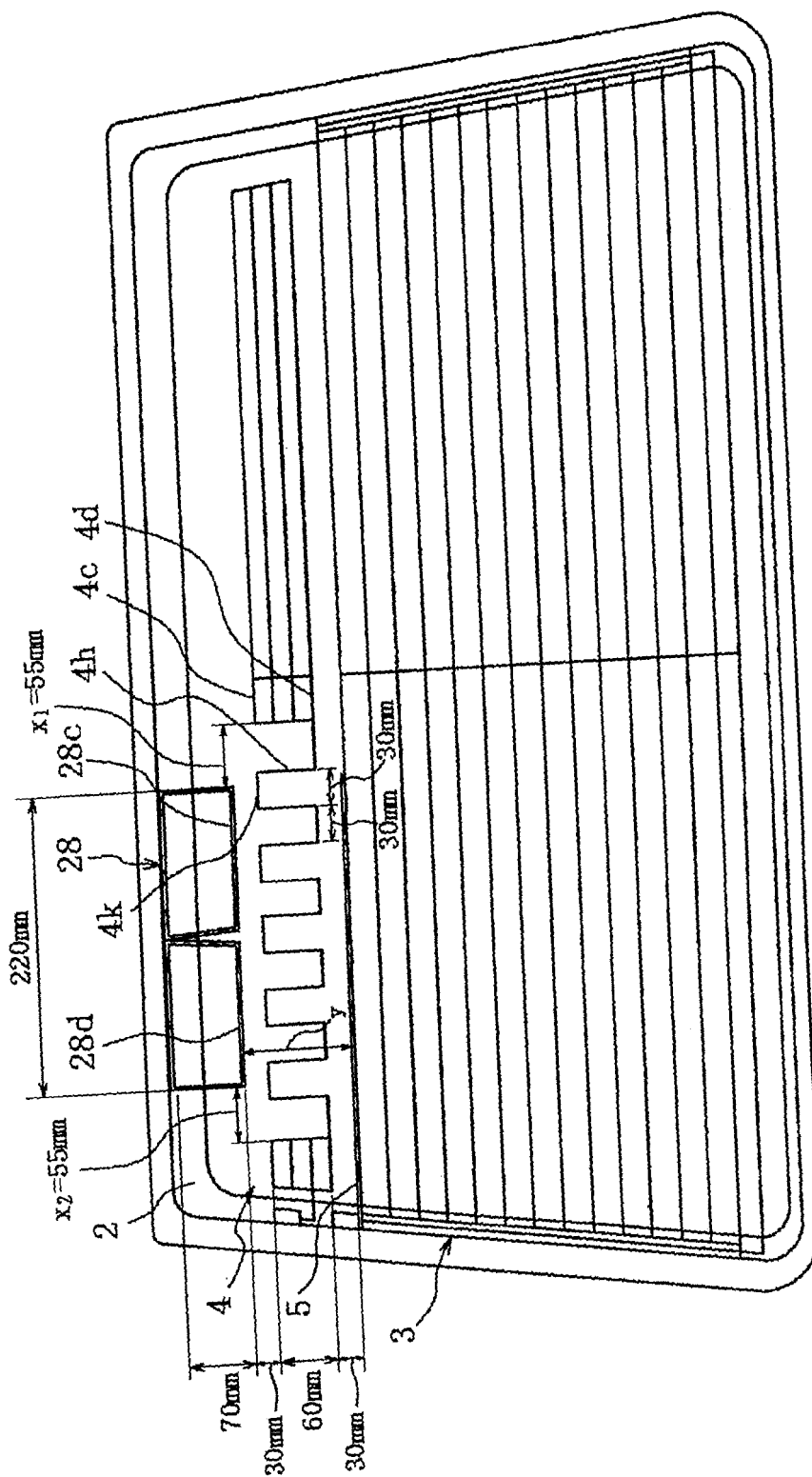


FIG. 18

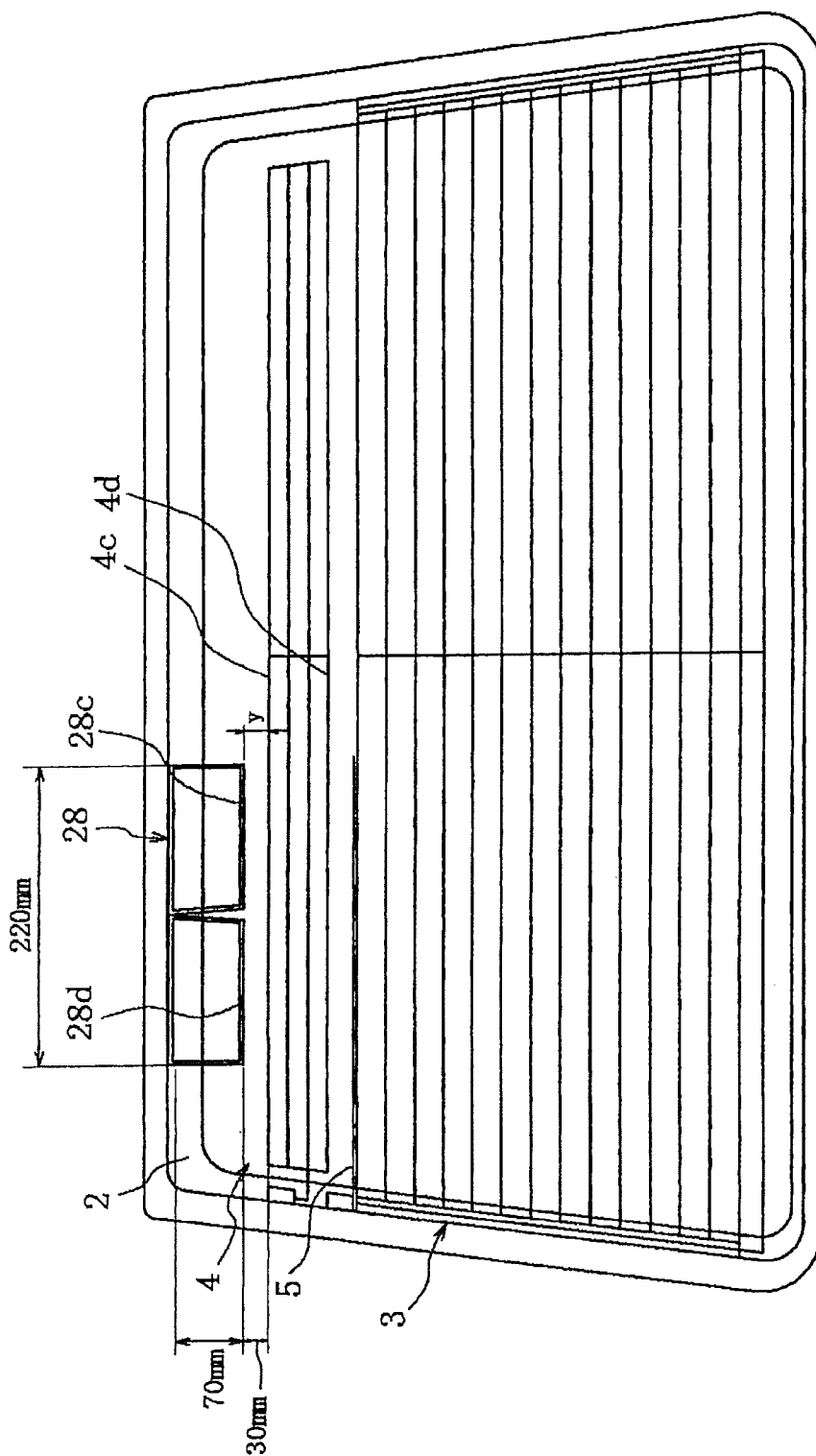


FIG. 19

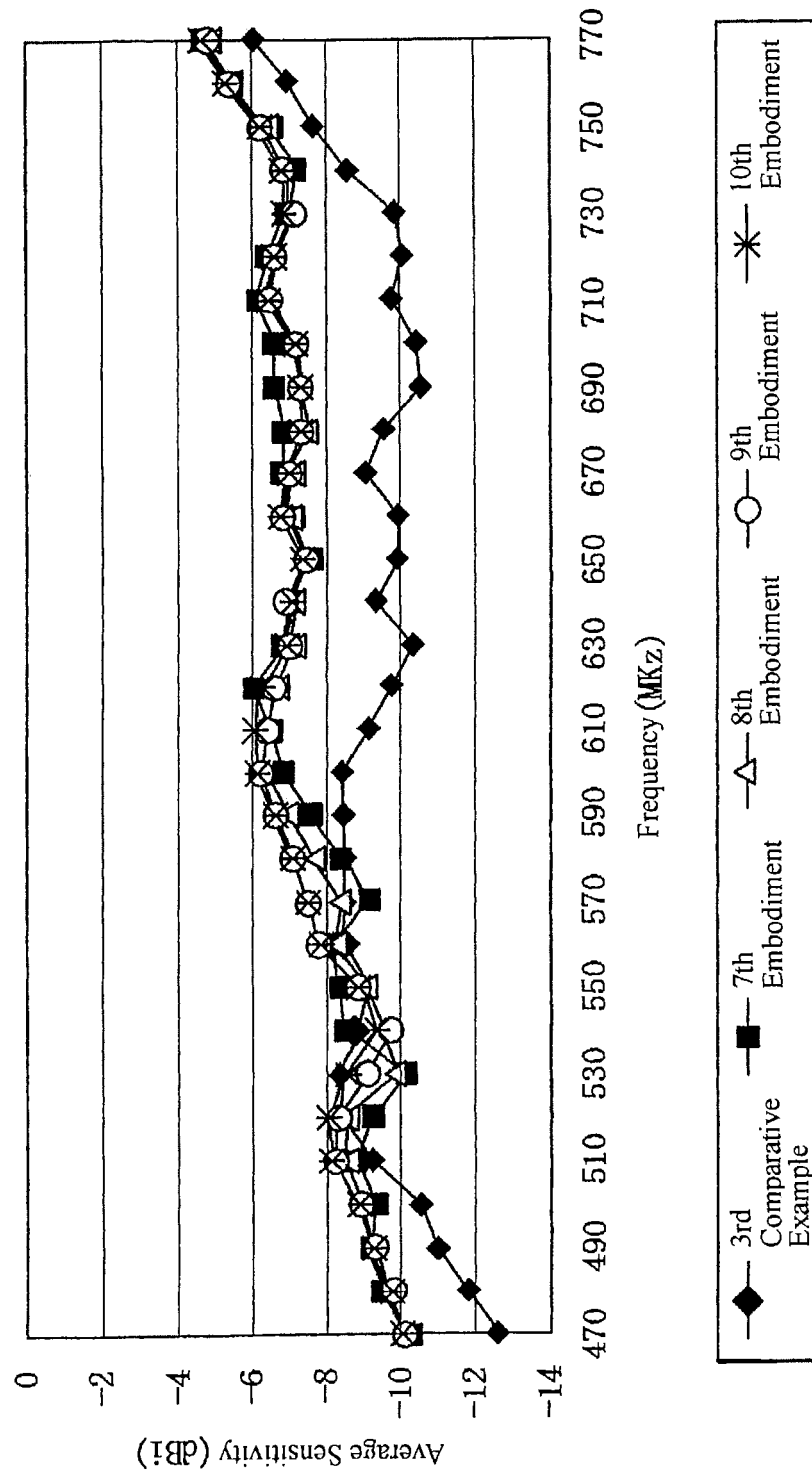


FIG. 20

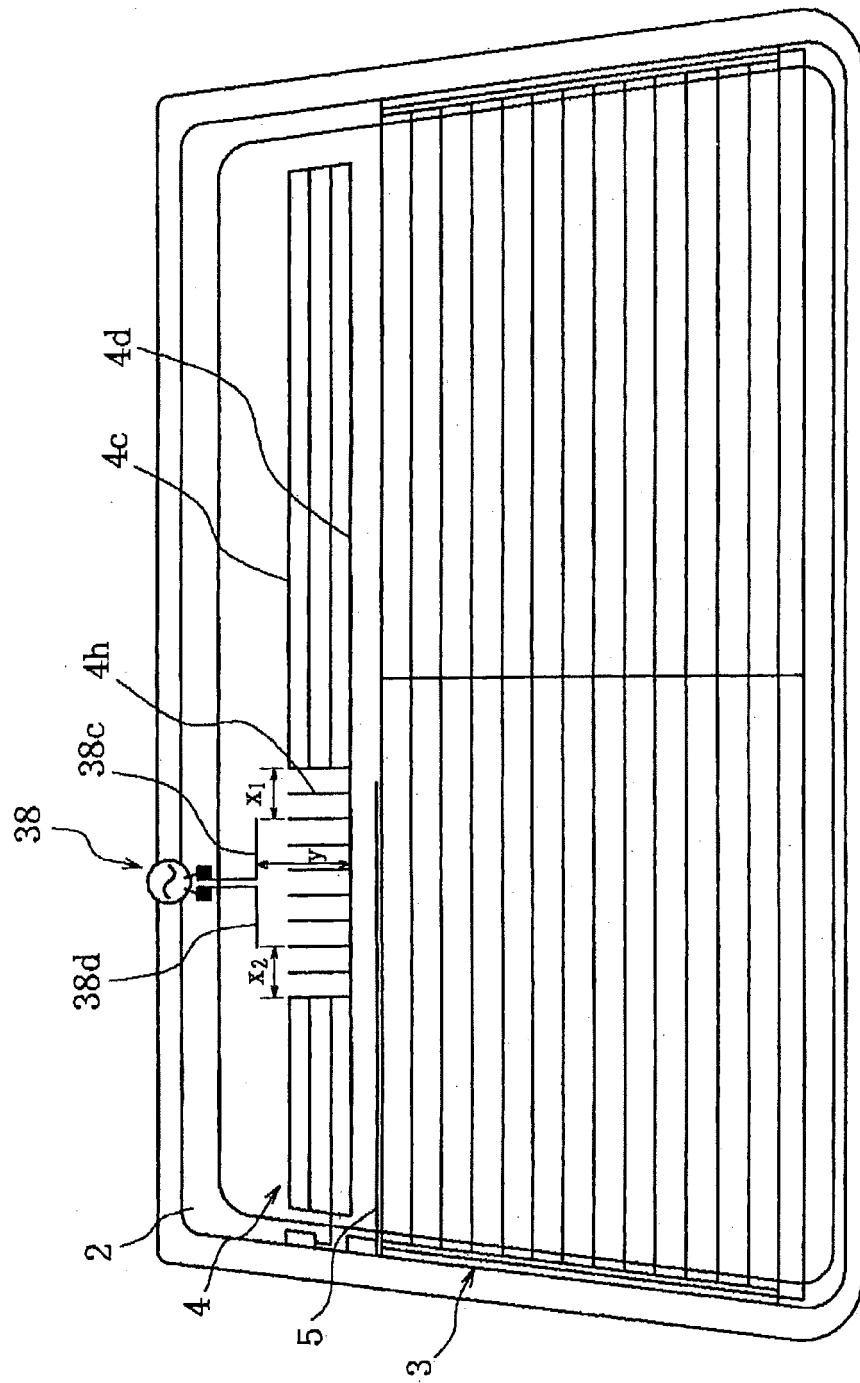


FIG. 21

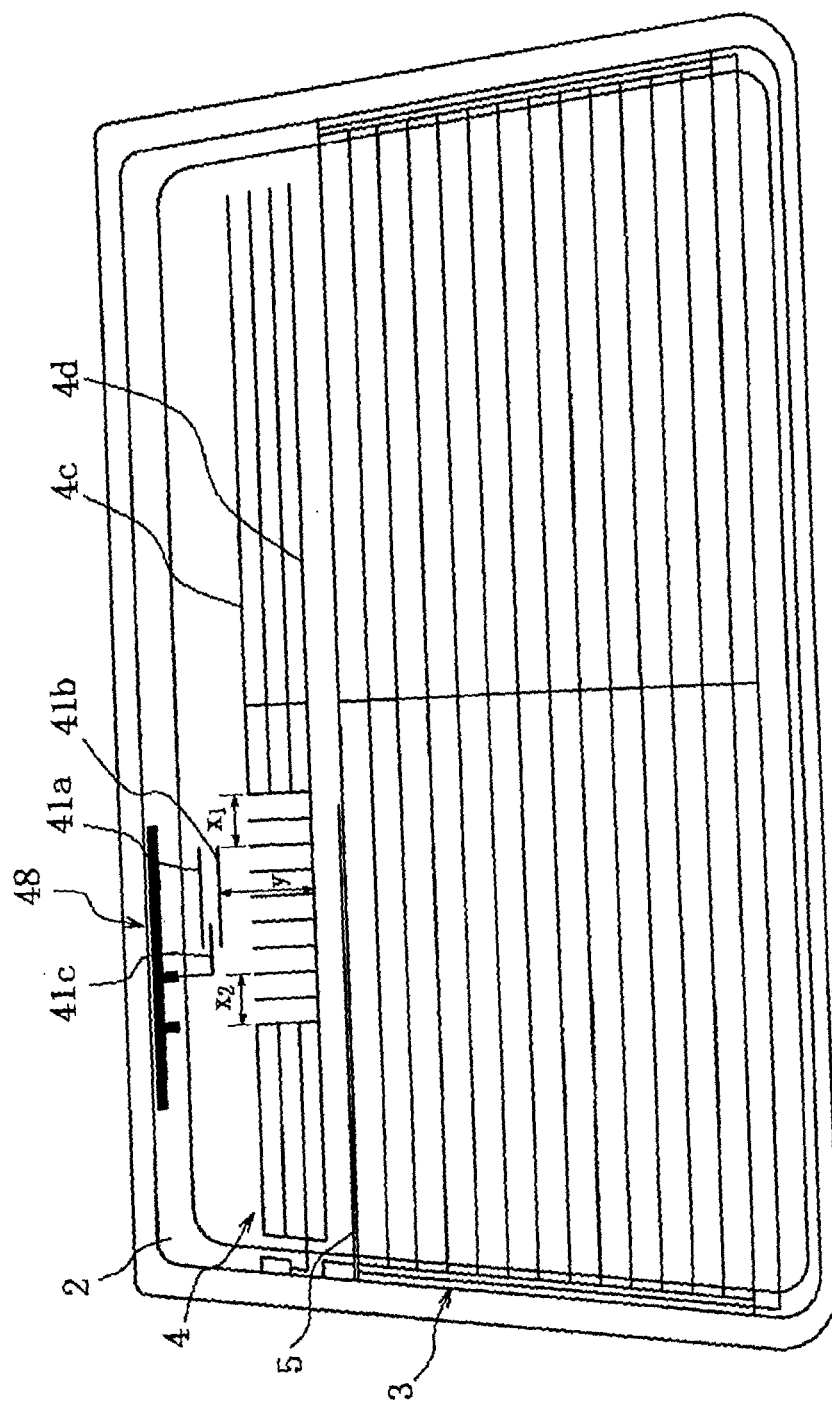
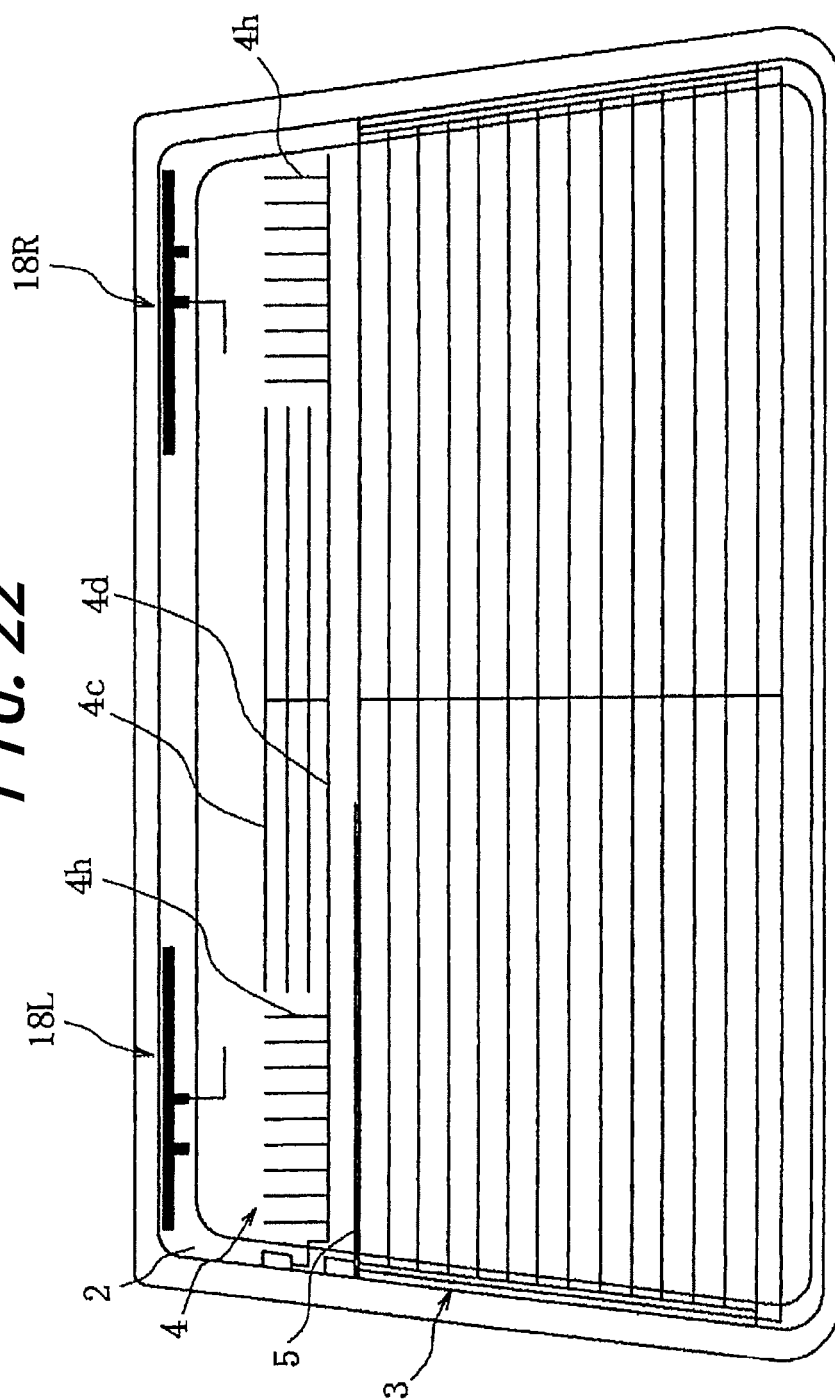


FIG. 22



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/051861

A. CLASSIFICATION OF SUBJECT MATTER

H01Q1/32 (2006.01) i, H01Q1/22 (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)

H01Q1/32, H01Q1/22

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2008
Kokai Jitsuyo Shinan Koho	1971-2008	Toroku Jitsuyo Shinan Koho	1994-2008

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2003-304166 A (Toyota Motor Corp.), 24 October, 2003 (24.10.03), Full text; all drawings (Family: none)	1-9
A	JP 2005-101809 A (Central Glass Co., Ltd., Nissan Motor Co., Ltd.), 14 April, 2005 (14.04.05), Full text; all drawings (Family: none)	1-9
A	JP 2006-117026 A (Nippon Sheet Glass Co., Ltd.), 11 May, 2006 (11.05.06), Full text; all drawings & US 2006/0086714 A1	1-9

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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
08 May, 2008 (08.05.08)Date of mailing of the international search report
20 May, 2008 (20.05.08)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/051861

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 116603/1990 (Laid-open No. 72712/1992) (Nippon Sheet Glass Co., Ltd.), 26 June, 1992 (26.06.92), Full text; all drawings & EP 504525 A1 & DE 69124502 T	1-9

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2003500870 A [0002]