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(74) Representative: **Webster, Jeremy Mark**
Mewburn Ellis LLP
City Tower
40 Basinghall Street
London EC2V 5DE (GB)

(54) **VEHICLE WINDOW GLASS**

tenna element includes a first media element that mainly receives a frequency band of first media, and a second media element that mainly receives a frequency band of second media having a higher frequency band than the first media.

Description

Technical Field

5 **[0001]** The present invention relates to a vehicle window glass.

Background Art

10 **[0002]** An antenna or the like for receiving predetermined radio waves may be provided on the surface of a vehicle window glass (particularly, a rear glass) attached to an automobile. As such an antenna, a DAB (Digital Audio Broadcasting, hereinafter abbreviated as "DAB") antenna element for receiving a DAB broadcasting may be used, for example. Patent Literature 1 proposes a vehicle window glass provided with a DAB antenna element.

Citation List

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Patent Literature

[0003] Patent Literature 1: JP 2014-216805

20 Summary of Invention

Technical Problem

25 **[0004]** For the above-described window glass, it is necessary to mount a DAB antenna and other various types of antennas such as an FM antenna, an AM antenna, a keyless entry antenna. However, an antifogging defogger, in addition to the antennas, is disposed on some window glasses. Therefore, many restrictions are imposed on the design of antenna placement on the window glass, and there has been a need to alleviate such restrictions. The present invention has been made in order to solve the above-described problem, and it is an object of the invention to provide a vehicle window glass that allows an antenna capable of receiving a plurality of media to be mounted in a narrow area.

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Solution to Problem

35 **[0005]** A vehicle window glass according to the present invention includes: a glass plate; a first feeding portion disposed on the glass plate; and a composite antenna element that is disposed on the glass plate and extends from the first feeding portion, wherein the composite antenna element includes a first media element that mainly receives a frequency band of first media, and a second media element that mainly receives a frequency band of second media having a higher frequency band than the first media.

40 **[0006]** In the vehicle window glass, the composite antenna element may further includes, between the first media element and the second media element, a cancel element that blocks or attenuates a received signal in the frequency band of the second media.

[0007] The vehicle window glasses may further include a defogger that is disposed on the glass plate and includes a plurality of horizontal heating lines.

[0008] In the vehicle window glasses, the defogger and the first media element of the composite antenna element may be capacitively coupled or directly coupled.

45 **[0009]** The vehicle window glasses may further include an extension element extending from the defogger, wherein at least a portion of the first media element may be configured to extend parallel to the extension element.

[0010] The vehicle window glasses may further include a second feeding portion disposed on the glass plate; and a first media antenna element that is disposed on the glass plate, extends from the second feeding portion, and receives the frequency band of the first media.

50 **[0011]** The vehicle window glasses may include a second feeding portion disposed on the glass plate; and a first media antenna element that is disposed on the glass plate, extends from the second feeding portion, and receives the frequency band of the first media, wherein the defogger and the first media antenna element are configured to be capacitively coupled or directly coupled.

55 **[0012]** In the vehicle window glass, the defogger and the first media element of the composite antenna element may be configured to be capacitively coupled or directly coupled.

[0013] The vehicle window glasses may further include an extension element extending from the defogger, wherein at least a portion of the first media element may be configured to be in proximity to the extension element.

[0014] In the vehicle window glass, the extension element may be disposed in proximity to the first media element of

the composite antenna element, such that a distance between the first media element of the composite antenna element and the defogger, and a distance between the extension element and the defogger are made different.

[0015] In the vehicle window glasses, at least a portion of the first media element may be configured to extend parallel to the extension element.

[0016] In the vehicle window glass, the portion of the first media element that extends parallel to the extension element may be 200 mm or less.

[0017] In the vehicle window glasses, the first media may be FM broadcasting, and the second media may be DAB broadcasting.

Advantageous Effects of Invention

[0018]

FIG. 1 is a front view of an automobile rear glass serving as one embodiment of a vehicle window glass according to the present invention;

FIG. 2 is an enlarged view of the vicinity of an FM/DAB shared antenna element in FIG. 1;

FIGS. 3A and 3B are diagrams showing the dimensions of an antenna of the window glass according to Example 1;

FIG. 4 is a diagram showing a window glass according to Example 2;

FIG. 5 is a graph showing the receiving sensitivity of an FM antenna element in Examples 1 and 2;

FIG. 6 is a graph showing the receiving sensitivity of an FM element of an FM/DAB shared antenna element in Examples 1 and 2;

FIG. 7 is a window glass according to Examples 3 to 5;

FIG. 8 is a graph showing the relationship between length L and the receiving sensitivity of an FM antenna element according to Examples 3 to 5;

FIG. 9 is a graph showing the relationship between the length L and the receiving sensitivity of an FM element of the FM/DAB shared antenna element according to Examples 3 to 5;

FIG. 10 is a graph showing the relationship between the frequency and the receiving sensitivity of the FM/DAB shared antenna element when the length L is changed in Example 5;

FIG. 11 is a diagram showing a window glass according to Example 7;

FIG. 12 is a graph showing the receiving sensitivity of an FM antenna element in Examples 6 and 7; and

FIG. 13 is a graph showing the receiving sensitivity of an FM/DAB shared antenna element in Examples 6 and 7.

Description of Embodiments

[0019] Hereinafter, an embodiment of a vehicle window glass according to the present invention will be described with reference to the drawings. FIG. 1 is a front view of an automobile rear glass to which a vehicle window glass according to the present embodiment is applied, and FIG. 2 is an enlarged view of the vicinity of an FM/DAB shared antenna element in FIG. 1. In the following, for the sake of simplifying the description, the direction shown in FIG. 1 is used as a reference direction, and the up-down direction of FIG. 1 may be referred to as "up-down direction" or "vertical direction", and the left-right direction of FIG. 1 may be referred to as "left-right direction" or "horizontal direction". However, these directions do not limit the present invention.

<1. Vehicle Window Glass>

[0020] As shown in FIG. 1, a vehicle window glass according to the present embodiment includes a glass plate 1, and a defogger 2, an FM antenna element 3, an AM antenna element 4, and an FM/DAB shared antenna element 5 that are mounted on the glass plate 1. In the following, each of these members will be described in sequence.

<1-1. Glass Plate>

[0021] For the glass plate 1, a known glass plate for use in automobiles can be used. For example, heat absorbing glass, commonly used clear glass or green glass, or UV green glass may be used for the glass plate 1. However, such a glass plate 1 is required to achieve the visible light transmission in accordance with the safety standards of the country in which the automobiles are used. For example, solar absorptivity, visible light transmission, or the like of the glass plate 1 can be adjusted so as to meet the safety standards. The following shows an exemplary composition of clear glass, and an exemplary composition of heat absorbing glass.

(Clear Glass)

[0022]

SiO₂: 70 to 73 mass%
 Al₂O₃: 0.6 to 2.4 mass%
 CaO: 7 to 12 mass%
 MgO: 1.0 to 4.5 mass%
 R²O: 13 to 15 mass% (R is an alkali metal)

[0023] Total iron oxide in terms of Fe₂O₃ (T-Fe₂O₃) : 0.08 to 0.14 mass%

(Heat Absorbing Glass)

[0024] The heat absorbing glass can have a composition obtained by, for example, changing the ratio of the total iron oxide in terms of Fe₂O₃ (T-Fe₂O₃) to 0.4 to 1.3 mass%, and the ratio of CeO₂ to 0 to 2 mass%, and the ratio of TiO₂ to 0 to 0.5 mass%, based on the composition of the clear glass, and reducing the backbone constituents (mainly, SiO₂ and Al₂O₃) of the glass by an amount corresponding to the increased amounts of T-Fe₂O₃, CeO₂ and TiO₂.

[0025] Note that the type of the glass plate 1 is not limited to clear glass or heat absorbing glass, and may be selected as appropriate in accordance with an embodiment. For example, the glass plate 1 may be an acrylic or polycarbonate resin window.

[0026] Such a glass plate 1 may be composed of a single glass plate, or may be a laminated glass plate in which an intermediate film of resin or the like is sandwiched between a plurality of glass plates.

<1-2. Defogger>

[0027] Next, the defogger 2 will be described. As shown in FIG. 1, the defogger 2 is disposed in the vicinity of the center in the vertical direction of the glass plate 1, and formed so as to extend throughout the left-right direction of the glass plate 1. Specifically, the defogger 2 includes a pair of feeding bus bars 21a, 21b extend along opposite side edges of the glass plate 1 in the up-down direction. A plurality of horizontal elements (horizontal heating lines) 22 are disposed in parallel at a predetermined interval between the two bus bars 21a, 21b, so that defogging heat is generated by the power fed from the bus bars 21a, 21b. The defogger 2 is provided with three vertical FM elements 23 extending in the up-down direction so as to divide the horizontal elements 22 into substantially four equal sections in the horizontal direction. The vertical FM elements 23 functions as a part of an antenna element for receiving the FM band, which will be described later. The vertical FM elements extend so as to connect the horizontal element located at the top (hereinafter referred to as "uppermost horizontal element) 221 with the third horizontal element 22 from the bottom.

[0028] An extension element 24 extends from the upper end portion of the right bus bar 21a. The extension element 24 includes a vertical portion 241 extending upward along the right edge of the glass plate 1, and a horizontal portion 242 extending from the upper end of the vertical portion 241 along the upper edge of the glass plate 1 to the left side. A connection portion between the vertical portion 241 and the horizontal portion 242 is curved. The left end of the horizontal portion 242 extends to the vicinity of a right feeding portion 50, which will be described later.

<1-3. FM Antenna Element>

[0029] Next, the FM antenna element (first media antenna element) 3 will be described. The FM antenna element 3 is disposed in a space located above the defogger 2 on the glass plate 1. Specifically, the FM antenna element 3 is formed so as to extend from a left feeding portion (second feeding portion) 30 provided on the left side relative to the center of the upper edge of the glass plate. Specifically, the FM antenna element 3 includes a vertical element 31 extending downward, and four horizontal elements, namely, first to fourth horizontal elements 321 to 324, extending to the left side from the vertical element 31. The first to fourth horizontal elements 321 to 324 are disposed in parallel at a predetermined interval in the up-down direction, and the fourth horizontal element 324 disposed on the lowermost side extends to the left side from the lower end of the vertical element 31. The fourth horizontal element 324 extends parallel to the uppermost horizontal element 221 of the defogger 2 at an interval of a distance D1. Consequently, the defogger 2 and the FM antenna element 3 are capacitively coupled, as a result of which the effective area of the FM antenna element 3 can be extended. The distance D1 is preferably 0 to 60 mm, more preferably 20 to 50 mm, particularly preferably 30 to 45 mm. However, the fourth horizontal element 324 and the uppermost horizontal element 221 of the defogger 2 may be directly coupled, in which case, the distance D1 is 0 mm. Note that the FM antenna element 3 is also used to receive the AM broadcasting.

<1-4. AM Antenna Element>

[0030] As with the FM antenna element, the AM antenna element 4 is formed so as to extend from the left feeding portion 30. Specifically, the AM antenna element 4 includes a first vertical element 411 extending downward from the left feeding portion 30 on the right side of the vertical element 31 of the FM antenna element 3, and a first horizontal element 421 extending to the right side from the vicinity of the upper end of the vertical element 31. The AM antenna element 4 further includes a second vertical element 412 extending downward from the right end of the first horizontal element 421, and three horizontal elements, namely, second to fourth horizontal elements 422 to 424, extending to the left side from the second vertical element 412.

[0031] The first and second vertical elements 411, 412 are substantially parallel to and have the same length as the vertical element 31 of the FM antenna element 3. The second to fourth horizontal elements 422 to 424 are shorter than the first horizontal element 421, resulting in a gap formed between the left end of each of the second to fourth horizontal elements 422 to 424 and the first vertical element 411. Among the horizontal elements, the fourth horizontal element 424 extends parallel to the uppermost horizontal element 221 of the defogger 2 at an interval, as with the fourth horizontal element 324 of the FM antenna element 3. Note that the AM antenna element 4 is not used to receive the FM broadcasting.

[0032] Although not shown, the left feeding portion 30 is connected to FM and AM amplifiers via a lead wire or the like. Note that these amplifiers may be housed in separate casings, or may be housed in the same casing.

<1-5. FM/DAB Shared Antenna Element>

[0033] Next, the FM/DAB shared antenna element (composite antenna element) 5 will be described. DAB is digital radio broadcasting standards adopted in Europe and other countries. In DAB, Band 3, which is a frequency band from 174 MHz to 240 MHz, and L band, which is a frequency band from 1452 MHz to 1492 MHz, are mainly used. The present invention is mainly directed to DAB broadcasting using Band 3 as the frequency band.

[0034] The FM/DAB shared antenna element 5 according to the present embodiment extends from a right feeding portion (first feeding portion) 50 disposed on the right side of the upper edge of the glass plate. Specifically, the FM/DAB shared antenna element 5 includes a DAB element (second media element) 51 extending substantially perpendicularly, downward from the right feeding portion 50, a substantially U-shaped cancel element 52 extending to the right side from the vicinity of the upper end of the DAB element 51, and an FM element (first media element) 53 extending to the right side from the cancel element 52.

[0035] The DAB element 51 receives mainly a DAB frequency band, and includes a main body portion 511 extending downward, and a horizontal portion 512 extending slightly to the right side from the lower end of the main body portion 511. The lower end of the main body portion 511 extends to substantially the same position as the lower end of the second horizontal element of the FM antenna element 3. The horizontal portion 512 extends parallel to the fourth horizontal element 324 of the FM antenna element 3 and the fourth horizontal element 424 of the AM antenna element 4.

[0036] As described above, the cancel element 52 is substantially U-shaped, and includes a first horizontal portion 521 extending horizontally to the right side from the vicinity of the upper end of the DAB element 51, a first vertical portion 522 extending slightly upward from the right end of the first horizontal portion 521, a second horizontal portion 523 extending horizontally to the left side from the upper end of the first vertical portion 522, and a second vertical portion 524 extending slightly upward from the left end of the second horizontal portion 523. The second horizontal portion 523 extends to a position in proximity to the main body portion 511 of the DAB element 51, and the second vertical portion 524 extends to the vicinity of the upper end of the main body portion 511.

[0037] The FM element 53 is an auxiliary element for resonating mainly in the FM frequency band to increase the receiving sensitivity, and includes a horizontal portion 531 extending to the right side from the upper end of the second vertical portion 524 of the cancel element 52, and a vertical portion 532 extending downward from the right end of the horizontal portion 531. A connection portion between the horizontal portion 531 and the vertical portion 532 is formed in an arc shape. The horizontal portion 531 extends slightly below and parallel to the horizontal portion 242 of the extension element 24 described above. Then, the vertical portion 532 extends slightly on the left side of and parallel to the vertical portion 241 of the extension element 24, and extends to a location slightly below the cancel element 52 in the up-down direction. That is, the FM element 53 extends along and parallel to the extension element 24. Here, a distance D2 of the interval between the FM element 53 and the extension element 24 is preferably 0 to 20 mm, more preferably 5 to 15 mm, particularly 8 to 13 mm. However, the FM element 53 and the extension element 24 may be directly coupled, in which case, the distance D2 is 0 mm.

[0038] The length L of the portion of the FM element 53 that extends parallel to the extension element 24 is, for example, preferably 200 mm or less, more preferably 140 mm or less, particularly 100 mm or less. This can increase the receiving sensitivity of the FM/DAB shared antenna element 5 in the FM frequency band. However, as will be described later, the receiving sensitivity can be increased by adjusting (e.g., increasing) the distance between the FM element 53 and the FM antenna element 3 described above even if the above-described length L is further increased.

Note that when the length L is to be 200 mm or less, the FM element 53 and the extension element 24 need to be capacitively coupled.

[0039] Although not shown, the right feeding portion 50 is connected to FM and DAB amplifiers via a lead wire or the like.

<1-6. Material>

[0040] The defogger 2 and the antenna elements 3, 4, 5 described above can be formed by stacking layers of a conductive material having electrical conductivity on the surface of the glass plate 1 so as to have a predetermined pattern. As such a material, any material having electrical conductivity may be selected as appropriate in accordance with an embodiment, and examples thereof include silver, gold, and platinum. The above-described members can be formed, for example, by printing a conductive silver paste containing silver powder, glass frit, and the like on the surface of the glass plate 1, followed by firing.

<1-7. Production Method>

[0041] Next, a production method of the window glass according to the present embodiment will be described. The glass plate 1 of the window glass according to the present embodiment can be formed by a press forming method in which the glass plate 1 is formed by pressing, a gravity sag bending method in which the glass plate 1 is bent with the self weight thereof, or the like.

[0042] Here, when forming the glass plate 1 in each of the methods, the glass plate 1 is heated to the vicinity of the softening point in a heating furnace. Before being loaded into the heating furnace, the glass plate 1 is plate shaped, and the above-described material paste, for example, a silver paste is printed on the surface of the glass plate 1. Then, by loading the glass plate 1 into the heating furnace, the glass plate 1 is formed, and the silver paste printed on the glass plate 1 is fired, thus forming a defogger 2 and antenna elements 3, 4, 5.

<2. Characteristics>

[0043] As described above, according to the present embodiment, the provision of the FM/DAB shared antenna element 5 enables reception of both the FM frequency band and the DAB frequency band even though the antenna elements extend from one feeding portion 50. Further, the FM/DAB shared antenna element 5 includes, between the DAB element 51 and the FM element 53, the cancel element 52 having a folded-back portion 522, and thus can block or attenuate a received signal in the DAB frequency band. As a result, the DAB element 51 will not be influenced by the FM element 53, and therefore, the length of the DAB element 51 can be made suitable for reception of the DAB frequency band. This effect is particularly prominent when the length of one of the first horizontal portion 521 and the second horizontal portion 523 is ± 50 mm (preferably ± 30 mm, more preferably ± 10 mm) $\lambda/4$ of the wavelength band of the DAB broadcasting. The reason is that the impedance is made infinite to maximize the resistance to the radio waves, and thereby a received signal in the DAB frequency band is cancelled. Note that the actual length of the cancel element needs to be tuned in consideration of the influence of the vehicle body.

[0044] On the other hand, the FM element 53 is capacitively coupled to the defogger 2 via the extension element 24, and thus will not be influenced by the DAB element 51, so that the effective area for receiving the FM frequency band can be extended.

<3. Modifications>

[0045] Although an embodiment of the present invention has been described above, the present invention is not limited to the above-described embodiment, and various modifications may be made to the invention without departing from the spirit or essential characteristics thereof. Note that the following modifications may be combined as appropriate.

<3-1>

[0046] The configuration of the defogger 2 of the above-described embodiment is merely an example, and the number of the horizontal elements 22, the number of the vertical FM elements 23, and the number of intersections, and the like are not particularly limited. To increase the receiving sensitivity, an additional element may be provided as needed.

<3-2>

[0047] The configuration of each of the FM antenna element 3, the AM antenna element 4, and the FM/DAB shared antenna element 5 in the above-described embodiment is merely an example, and the number, the length, the direction

and the like of the elements are not particularly limited. The feeding portion 30 may be provided separately for the FM antenna element 3 and the AM antenna element 4. Furthermore, each of the antennas 3, 4, 5 may be formed by a so-called dipole antenna including a ground-connected element.

<3-3>

[0048] In the above-described embodiment, the cancel element 52 of the FM/DAB shared antenna element 5 is provided so as to prevent the DAB element 51 from being influenced by the FM element 53. However, depending on the length of each of the portions of the FM/DAB shared antenna element 5, the cancel element 52 can function as a DAB antenna and/or an FM antenna.

<3-4>

[0049] Although the FM antenna element 3 is capacitively coupled to the defogger 2 in the above-described embodiment, they may be directly coupled. Although the FM element 53 of the FM/DAB shared antenna element 5 is capacitively coupled to the defogger 2 via the extension element 24, the FM element 53 and the defogger 2 may be capacitively coupled by being disposed in proximity to each other, without providing the extension element 24. Alternatively, the FM element 53 and the extension element 24 can be directly coupled (in this case, there is no distinction between the FM element 53 and the extension element 24, which means that the FM element 53 is directly coupled to the defogger 2). Such direct coupling is more advantageous than capacitive coupling in that the phase difference can be adjusted. In this case, the FM element 53 is directly coupled to the defogger 2, and thus can receive the FM broadcasting waves even when it is not connected to the right feeding portion 50 (or the FM element 53 may be distant therefrom, as with the extension element 24). However, the FM element 53 may be capacitively coupled to the defogger 2. Furthermore, although the extension element 24 and the FM element 53 partly extend in parallel due to their capacitive coupling, they may not necessarily extend parallel in a strict sense. For example, when the interval therebetween is 20 mm or less, the same effect as that achieved by the parallel arrangement can be achieved.

<3-5>

[0050] The cancel element 52 of the FM/DAB shared antenna element 5 is not necessarily essential. The length and the shape of the cancel element 52 are not particularly limited, and it is possible to use shapes other than those described above. That is, it is possible to change the length, or reduce or increase the number of the folded-back portions in order to achieve the desired performance.

<3-6>

[0051] Although the FM antenna element 3, the defogger 2, and the AM antenna element 4 are provided in the above-described embodiment, at least the FM/DAB shared antenna element 5 may be simply provided in the vehicle window glass of the present invention. However, various antenna elements, including, for example, a key antenna element may be additionally provided. The key antenna element serves to receive a signal for locking or unlocking the door by using a remote controller for, for example, keyless entry, smart entry or the like.

<3-7>

[0052] In general, when the FM antenna element 3 or the FM/DAB shared antenna element 5 are capacitively coupled to the defogger 2, no RFC circuit needs to be provided between the feeding portions 30, 50 and amplifiers (not shown). In general, when a harness connecting the bus bar on the GND (ground) side of the defogger 2 to the vehicle body is short, the provision of an RFC circuit between the bus bar and the vehicle body increases the receiving sensitivity.

<3-8>

[0053] The adjustment of the receiving sensitivity between the FM antenna element 3 and the FM/DAB shared antenna element 5 can be performed by using a commonly used diversity system, and also can be performed by an FM phase diversity system.

<3-9>

[0054] Although the above-described embodiment uses FM broadcasting as the first media of the present invention

and DAB broadcasting as the second media, the present invention is not limited thereto. That is, any media can be used so long as the frequency band of the second media is higher than that of the first media. For example, it is possible to use FM broadcasting as the first media and DTV (digital television) broadcasting as the second media.

<3-10>

[0055] Although the above-described embodiment shows an example in which the glass antenna according to the present invention is mounted to an automobile rear glass, the glass antenna may be mounted on the glass surface of other glasses.

[Examples]

[0056] In the following, examples of the present invention will be described. However, the present invention is not limited to the following examples.

<1. Influence of Cancel Element on Receiving Performance of FM/DAB Shared Antenna Element>

[0057] As Example 1, a vehicle window glasses shown in FIGS. 1 and 2 was prepared. The dimensions of the various parts are shown in FIGS. 3A and 3B. As Example 2, a vehicle window glass shown in FIG. 4 was prepared. In Example 2, the FM element was directly connected to the DAB element, without providing the cancel element. Using these window glasses, the receiving performance of the FM/DAB shared antenna element in each of the FM frequency band (88 to 108 MHz) and the DAB Band 3 (174 to 240 MHz) was measured as follows.

[0058] That is, each of the window glasses according to the above-described examples was mounted to an automobile. Then, radio waves (V-polarized waves) were emitted to the vehicle, and the sensitivity was measured. The measurement conditions were as follows.

- Attachment angle of the window glass to which the antenna was mounted: Inclined at 23 degrees to the horizontal direction
- Angle resolution: Measured while rotating the automobile 360 degrees for every 3 degrees
- Angle of elevation between the wave transmission location and the antenna: 1.7 degrees (taking the direction horizontal to the ground as 0 degree, and the zenith direction as 90 degrees)

[0059] Note that the same measurement method is also used for Examples 3 to 7 described below. The results were as shown in FIGS. 5 and 6.

[0060] FIG. 5 shows the receiving sensitivity in the FM frequency band (88 to 108 MHz), for which Examples 1 and 2 show substantially the same results. Accordingly, it has been found that there is no influence on the receiving performance in the FM frequency band, irrespective of the presence or absence of the cancel element. On the other hand, FIG. 6 shows the receiving sensitivity in DAB Band 3 (174 to 240 MHz). It has been found that the provision of the cancel element improves the receiving sensitivity.

< 2. Positional Relationship etc. between FM/DAB Shared Antenna Element and FM Antenna Element, and Influence on Receiving Performance>

[0061] Next, investigations were made on how the distance between the FM/DAB shared antenna element and the FM antenna element, and the length L of a parallel portion where the FM element of the FM/DAB shared antenna element and the extension element extend in parallel influence the receiving sensitivity of each of the FM antennas. That is, as shown in FIG. 7, three examples with different distances X between the FM/DAB shared antenna element and the FM antenna element, namely, Examples 3 to 5 were prepared. The distance X in Example 3 was 447 mm, the distance X in Example 4 was 587 mm, and the distance X in Example 5 was 517 mm. In Examples 3 to 5, the cancel element was removed from the FM/DAB shared antenna element, and the FM element was coupled to the DAB element. The distance D2 between the FM element and the extension element was 10 mm. In each of Examples 3 to 5, the receiving sensitivity was calculated while adjusting the length of the FM element to change the length L of the portion extending parallel to the extension element. That is, the receiving sensitivity in the FM frequency band (88 to 108 MHz) was measured under the above-described conditions.

[0062] The results are as shown in FIGS. 8 and 9. These drawings show the lowest values of the receiving sensitivity at a length L of 0 to 450 mm. FIG. 8 shows the receiving sensitivity of the FM antenna element. According to the drawing, there was almost no difference in receiving sensitivity resulting from the difference in the distance X between the FM/DAB shared antenna element and the FM antenna element, and Examples 3 to 5 showed a substantially constant receiving

sensitivity of the FM antenna element, irrespective of the length L. It appears that no FM element is provided when the length L was 0 mm. However, the extension element functions as the FM element in this case, so that the FM/DAB shared antenna element is capable of receiving radio waves of the FM frequency band, due to the influence of the defogger as well.

[0063] On the other hand, FIG. 9 shows the receiving sensitivity of the FM/DAB shared antenna element in the FM frequency band. According to the drawing, it has been found that the receiving sensitivity increases with an increase in the distance X between the FM/DAB shared antenna element and the FM antenna element, irrespective of the length L. That is, when the distance X between the FM/DAB shared antenna element and the FM antenna element is decreased, the receiving sensitivity was reduced with an increase in the length L. When the length L is 0, the lowest value of the receiving sensitivity was -11 dBd in Examples 3 to 5. It has been found that, in general, to maintain this receiving sensitivity, the length L in Example 3 may be set to be 200 mm or less, preferably, 140 mm or less, more preferably 100 mm or less. That is, when the distance X between the FM/DAB shared antenna element and the FM antenna element was decreased, the receiving sensitivity can be increased by decreasing the length of the FM element. On the other hand, when the distance X between the FM/DAB shared antenna element and the FM antenna element was increased as in Example 4, the receiving sensitivity was not reduced even if the length L was changed. Accordingly, when the distance X between the FM/DAB shared antenna element and the FM antenna element needs to be increased due to the limitation on the antenna position on the glass plate, the receiving sensitivity is not substantially reduced, no matter how long the length L is.

[0064] As shown in FIG. 9, the difference in the receiving sensitivity between Examples 3 to 5 is small when the length L is 200 mm or less, preferably 140 mm or less, more preferably 100 mm or less. In other words, it is possible to prevent reduction of the receiving sensitivity of the FM/DAB shared antenna element, irrespective of the distance X between the antennas. On the other hand, when the length L is greater than 200 mm, the receiving sensitivity is reduced depending on the distance X between the antennas.

[0065] FIG. 10 shows the results of investigations on the relationship between the frequency range and the receiving sensitivity when the length L was changed as shown in Table 1 below for Example 5 (X = 517 mm).

[Table 1]

	Ex. 5-1	Ex. 5-2	Ex. 5-3	Ex. 5-4	Ex. 5-5	Ex. 5-6	Ex. 5-7	Ex. 5-8	Ex. 5-9
Length L (mm)	0	100	150	200	250	300	350	400	450

[0066] As shown in FIG. 10, taking the receiving sensitivity when the length L = 0 mm (Example 5-1) as a reference sensitivity, the receiving sensitivity is generally higher than the reference sensitivity when the length L is generally 300 mm or less. Accordingly, the length L is preferably 0 to 250 mm, more preferably 100 to 200 mm.

[0067] In this respect, the following observations can be made. That is, when the defogger is operated as the FM antenna, the defogger has the properties of an inductance because of its large dimension. In this case, if a portion between the extension element and the FM element of the FM/DAB shared antenna element is operated as a capacitance, the inductance of the defogger is combined with the capacitance. As a result, a resonance in the FM band occurs, making it possible to increase the sensitivity of the FM/DAB shared antenna element. At this time, the capacitance for causing a series resonance is influenced by the length L. A shorter length L facilitates the occurrence of the resonance, so that it is possible to increase the receiving sensitivity.

<3. Presence or Absence of Parallel Portion where FM element of FM/DAB Shared Antenna Element and Extension Element Extend in Parallel, Influence on Receiving Performance>

[0068] Next, Examples 6 and 7 were prepared. In Example 6, the cancel element was removed from the FM/DAB shared antenna element, and the FM element was directly coupled to the DAB element, as in FIG. 4. The length L of the parallel portion where the FM element and the extension element extend in parallel was 245 mm. On the other hand, as shown in FIG. 11, in Example 7, the FM element and the cancel element were removed from the FM/DAB shared antenna element shown in FIG. 4. However, in this case, the extension element in FIG. 4 functions as the FM element as shown in FIG. 11. Then, the receiving sensitivity in the FM frequency band (88 to 108 MHz) was measured under the above-described conditions.

[0069] The results are as shown in FIGS. 12 and 13. These drawings show average values of the receiving sensitivity in the FM frequency band (88 to 108 MHz). FIG. 12 shows the receiving sensitivity of the FM antenna element. According to the drawing, it has been found that the receiving sensitivity in the vicinity of 88 to 92 MHz increased in Example 6, which was provided with the parallel portion. FIG. 13 shows the receiving sensitivity of the FM/DAB shared antenna element in the FM frequency band. According to the drawing, it has been found that the receiving sensitivity increased

in all frequency ranges in Example 6, which was provided with the parallel portion.

[0070] The following is considered to be the reason for this. That is, it seems that when the defogger functions as the FM antenna, the energy received by the defogger is distributed between the FM antenna element serving as an FM main antenna, and the FM element of the FM/DAB shared antenna element serving as an FM sub-antenna. Therefore, in Example 7, although the FM/DAB shared antenna serving as the FM sub-antenna is not provided with the FM element connected to the feeding portion as in FIG. 4 and thus is not connected to the feeding portion, the FM element (the extension element in FIG. 4) connected to the defogger is provided. Accordingly, Example 7 does not include a set of the FM element and the extension element as in FIG. 4, and therefore, the defogger does not sufficiently operate as the FM antenna. It seems that for this reason, most of the energy received by the defogger is supplied to the FM main antenna. As a result, as shown in FIG. 12, the receiving sensitivity of the FM main antenna is increased in the bandwidths excluding 88 to 92 MHz.

[0071] On the other hand, Example 6 includes a set of the FM element and the extension element, and the FM element of the FM/DAB shared antenna is capacitively coupled to the extension element from the defogger with an appropriate length. Accordingly, a combination of the defogger, the extension element, and the FM element operates as the FM antenna. As a result, the energy received by the defogger is supplied in a fixed amount to the FM/DAB shared antenna serving as the FM sub-antenna. Accordingly, it is considered that the receiving sensitivity of the FM sub-antenna is increased as shown in FIG. 13, and the receiving sensitivity of the FM main antenna is reduced relatively.

Reference Signs List

[0072]

- 1 Glass plate
- 2 Defogger
- 22 Horizontal element (horizontal heating line)
- 24 Extension element
- 3 FM antenna element (first media antenna element)
- 5 FM/DAB shared antenna element (composite antenna element)
- 51 DAB element (second media element)
- 52 Cancel element
- 53 FM element (first media element)

Claims

1. A vehicle window glass comprising:

a glass plate;
a first feeding portion disposed on the glass plate; and
a composite antenna element that is disposed on the glass plate and extends from the first feeding portion, wherein the composite antenna element includes a first media element that mainly receives a frequency band of first media, and a second media element that mainly receives a frequency band of second media having a higher frequency band than the first media.

2. The vehicle window glass according to claim 1, wherein the composite antenna element further includes, between the first media element and the second media element, a cancel element that blocks or attenuates a received signal in the frequency band of the second media.

3. The vehicle window glass according to claim 1 or 2, further comprising a defogger that is disposed on the glass plate and includes a plurality of horizontal heating lines.

4. The vehicle window glass according to claim 3, wherein the defogger and the first media element of the composite antenna element are capacitively coupled or directly coupled.

5. The vehicle window glass according to claim 4, further comprising an extension element extending from the defogger, wherein at least a portion of the first media element extends parallel to the extension element.

6. The vehicle window glass according to any one of claims 1 to 5, further comprising:

5 a second feeding portion disposed on the glass plate; and
a first media antenna element that is disposed on the glass plate, extends from the second feeding portion, and
receives the frequency band of the first media.

7. The vehicle window glass according to claim 3, further comprising:

10 a second feeding portion disposed on the glass plate; and
a first media antenna element that is disposed on the glass plate, extends from the second feeding portion, and
receives the frequency band of the first media,
wherein the defogger and the first media antenna element are capacitively coupled or directly coupled.

8. The vehicle window glass according to claim 7,

15 wherein the defogger and the first media element of the composite antenna element are capacitively coupled or
directly coupled.

9. The vehicle window glass according to claim 7 or 8,

20 further comprising an extension element extending from the defogger,
wherein at least a portion of the first media element is in proximity to the extension element.

10. The vehicle window glass according to claim 9,

25 wherein the extension element is disposed in proximity to the first media element of the composite antenna element,
such that a distance between the first media element of the composite antenna element and the defogger, and a
distance between the extension element and the defogger are made different.

11. The vehicle window glass according to claim 9 or 10,

wherein at least a portion of the first media element extends parallel to the extension element.

30 12. The vehicle window glass according to claim 11,

wherein the portion of the first media element that extends parallel to the extension element is 200 mm or less.

13. The vehicle window glass according to any one of claims 1 to 12,

35 wherein the first media is FM broadcasting, and the second media is DAB broadcasting.

Fig. 1

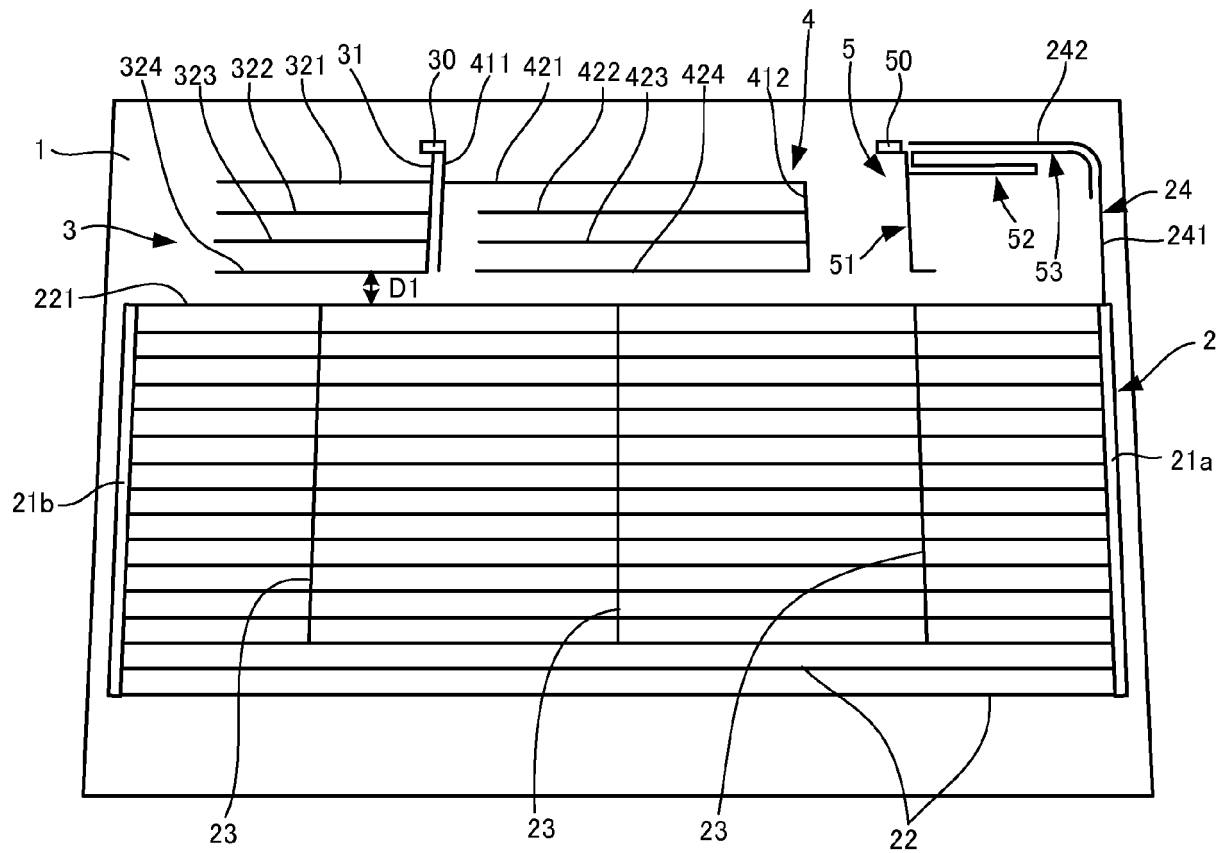


Fig. 2

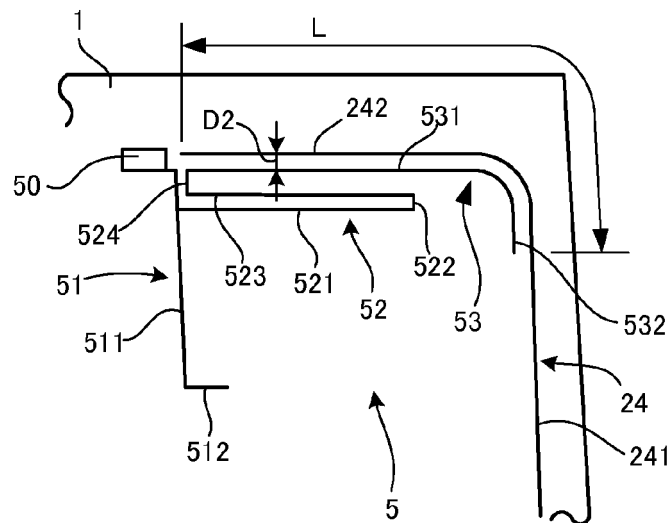
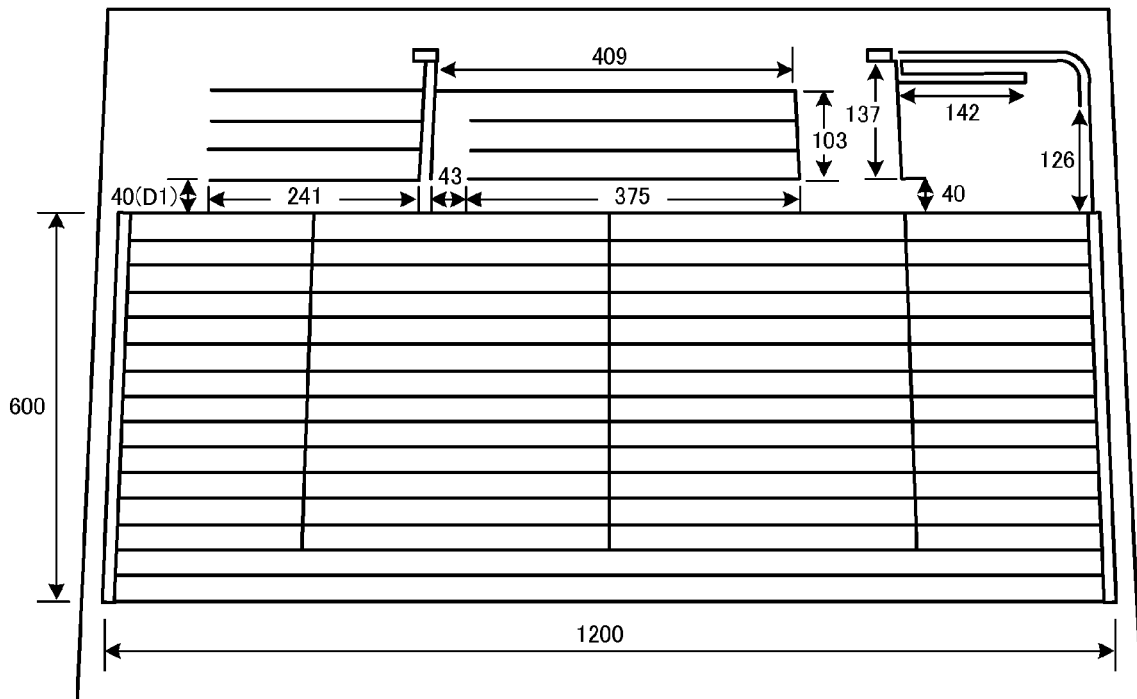


Fig. 3

(a)



(b)

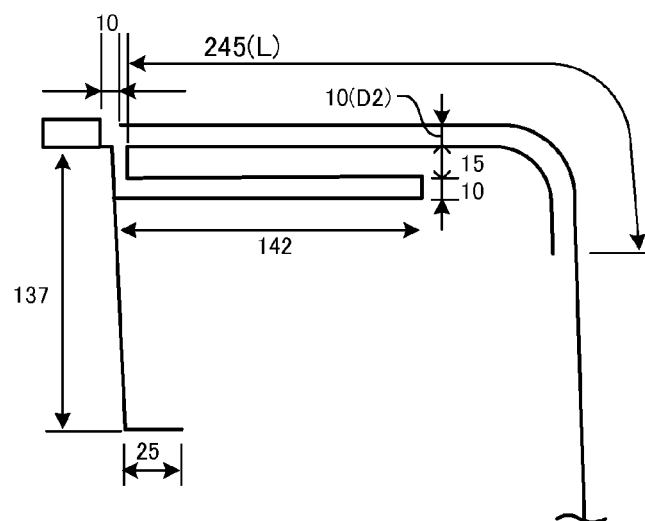


Fig. 4

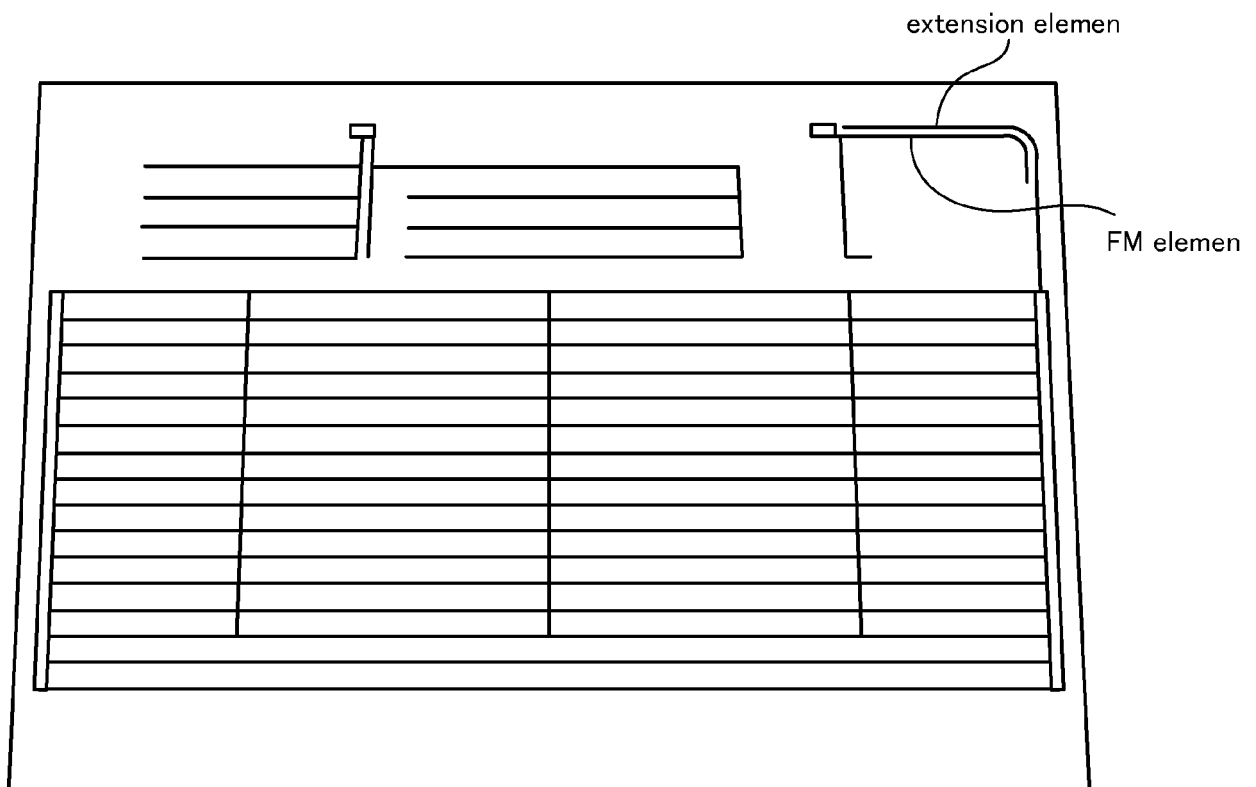


Fig. 5

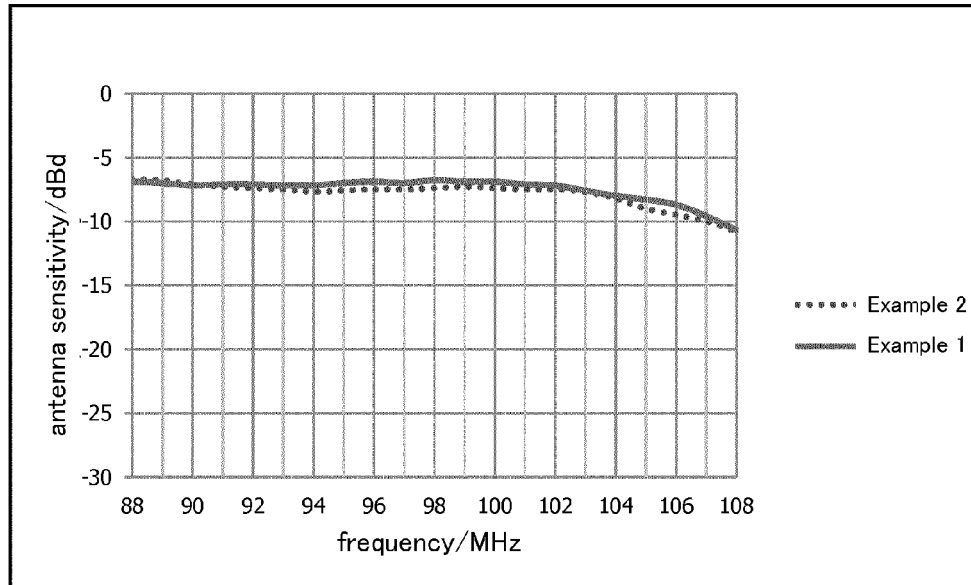


Fig. 6

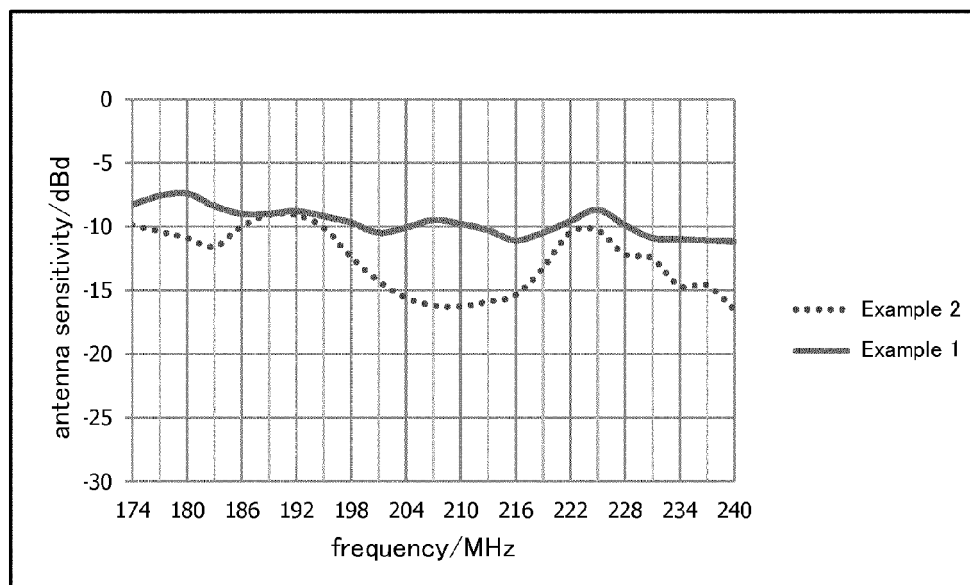


Fig. 7

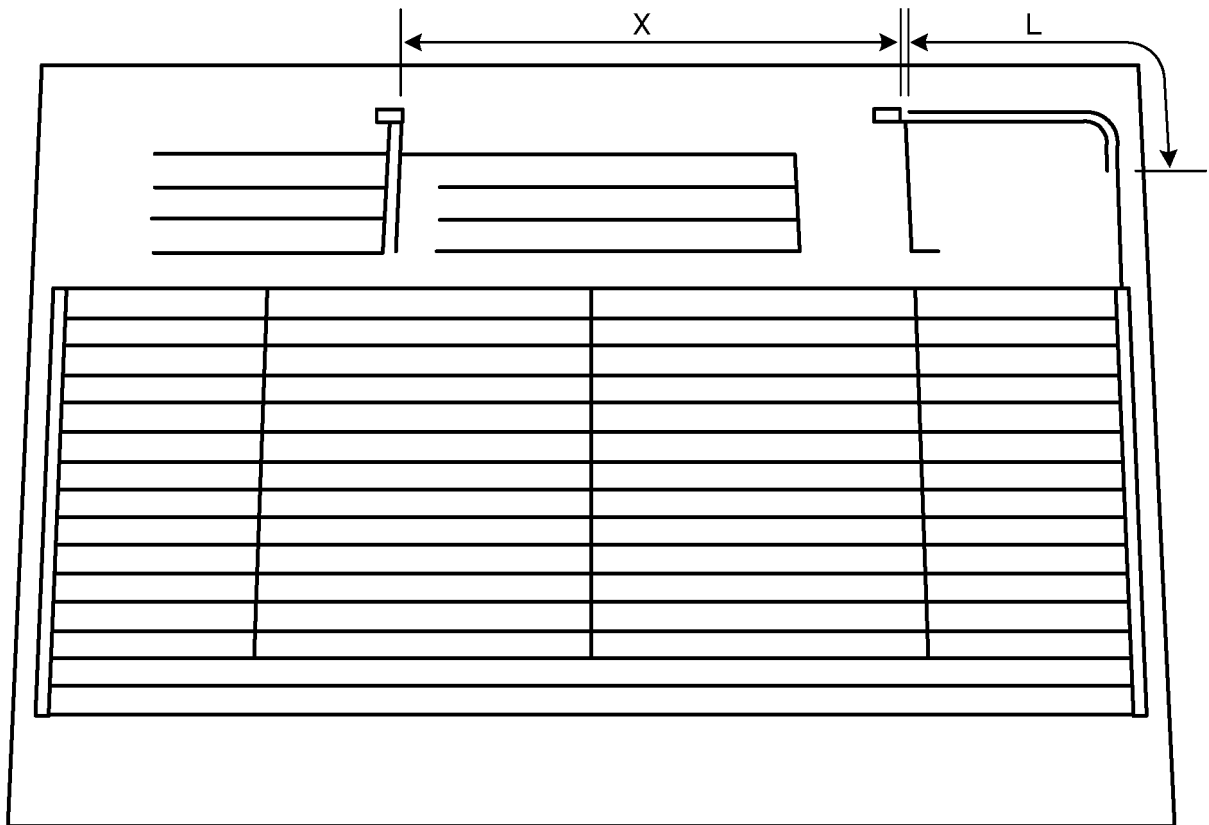


Fig. 8

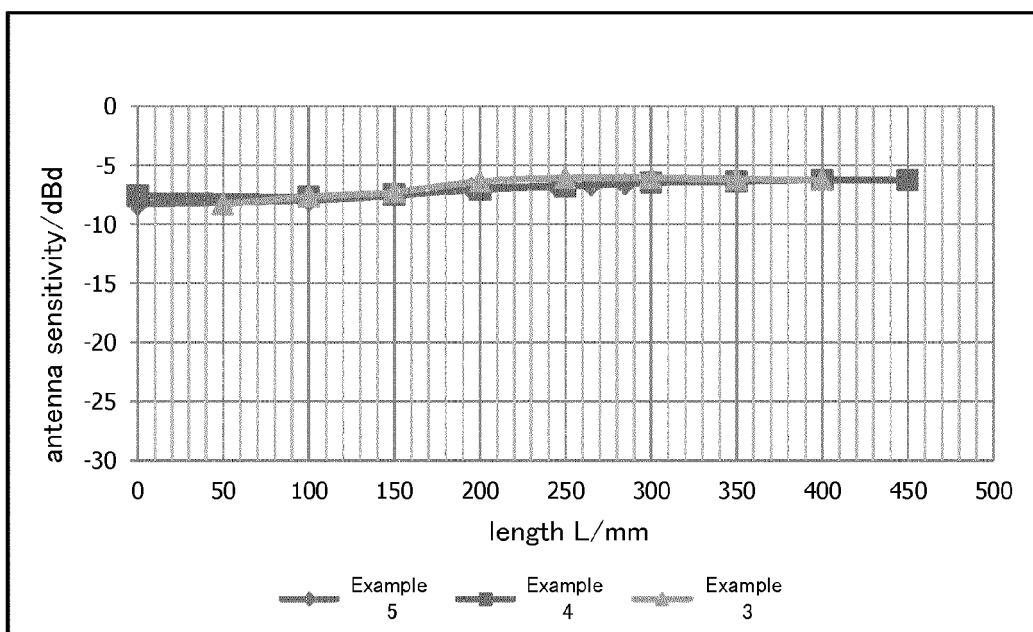


Fig. 9

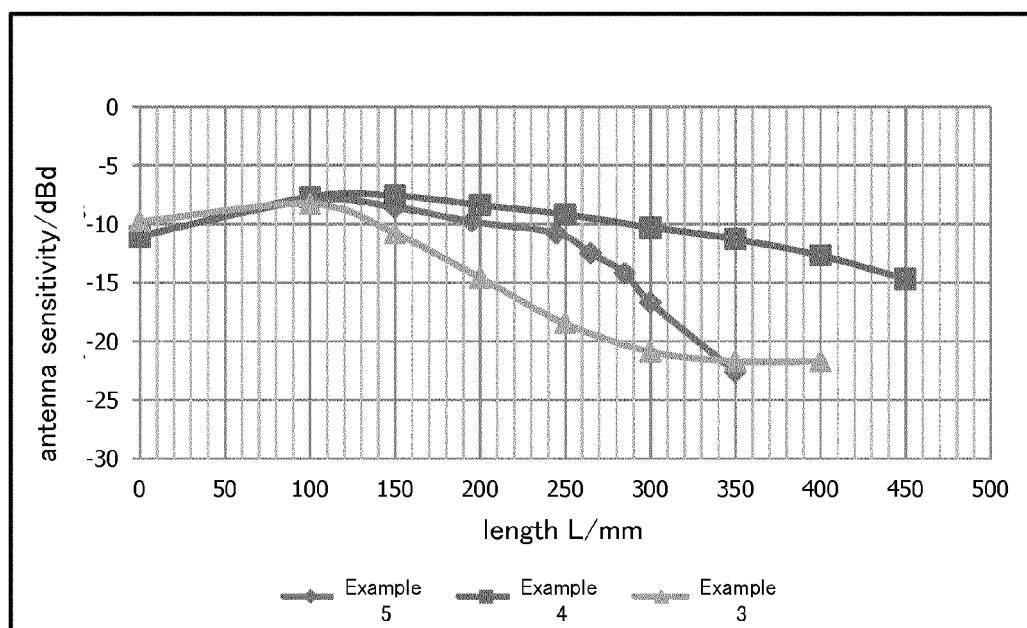


Fig. 10

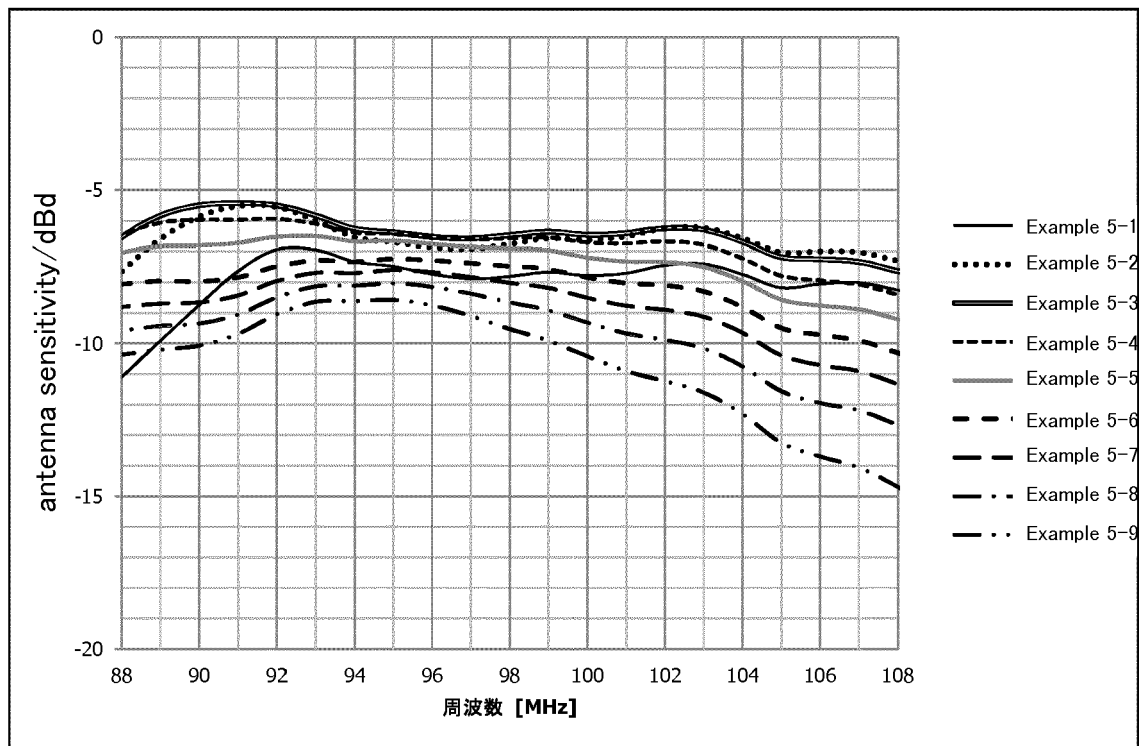


Fig. 11

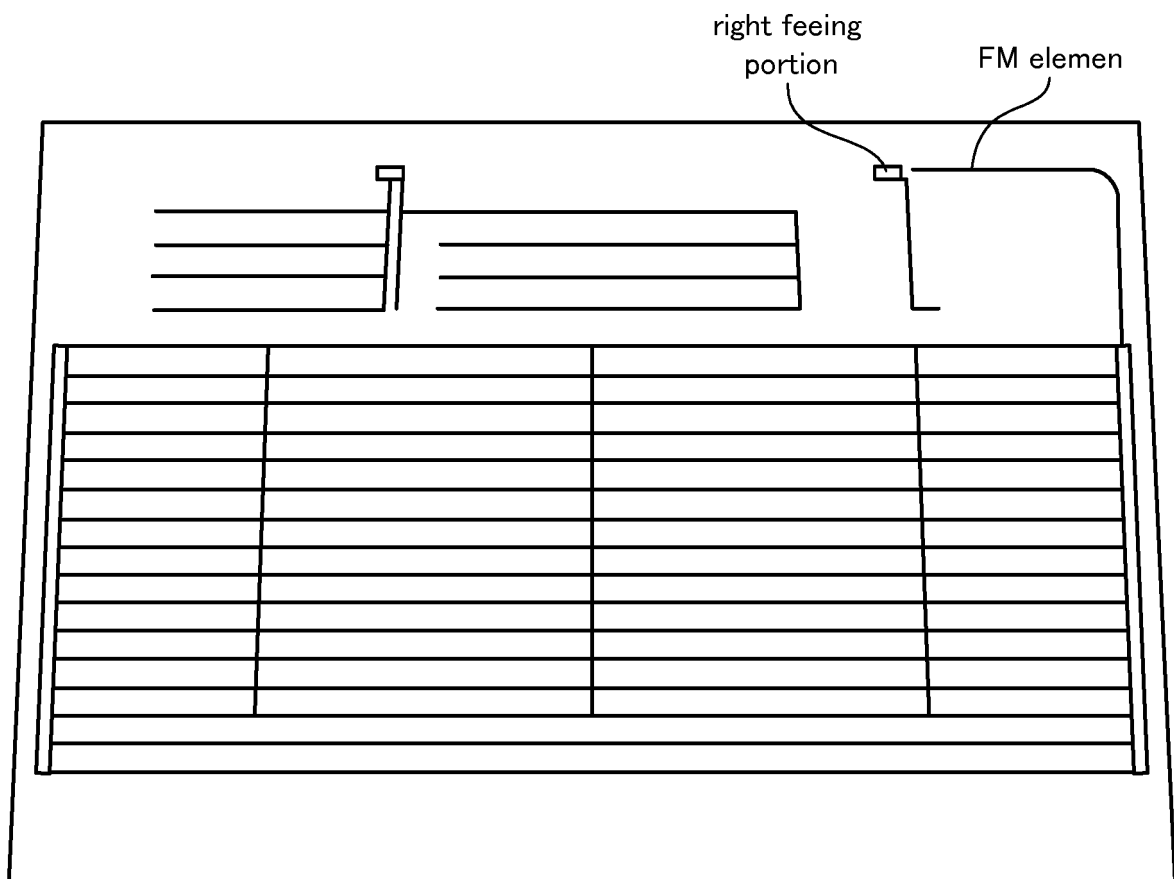


Fig. 12

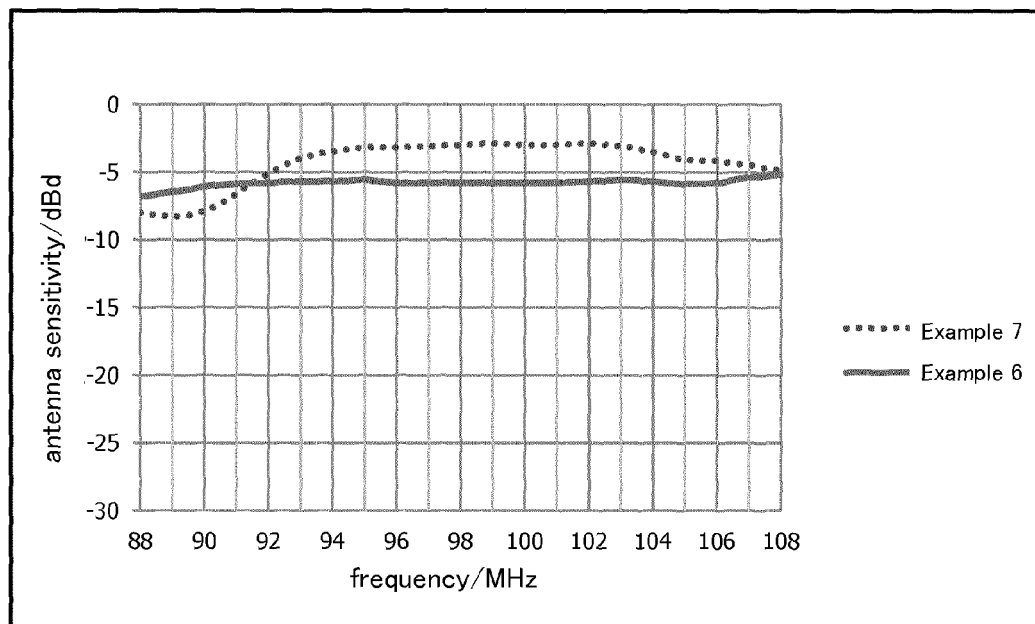
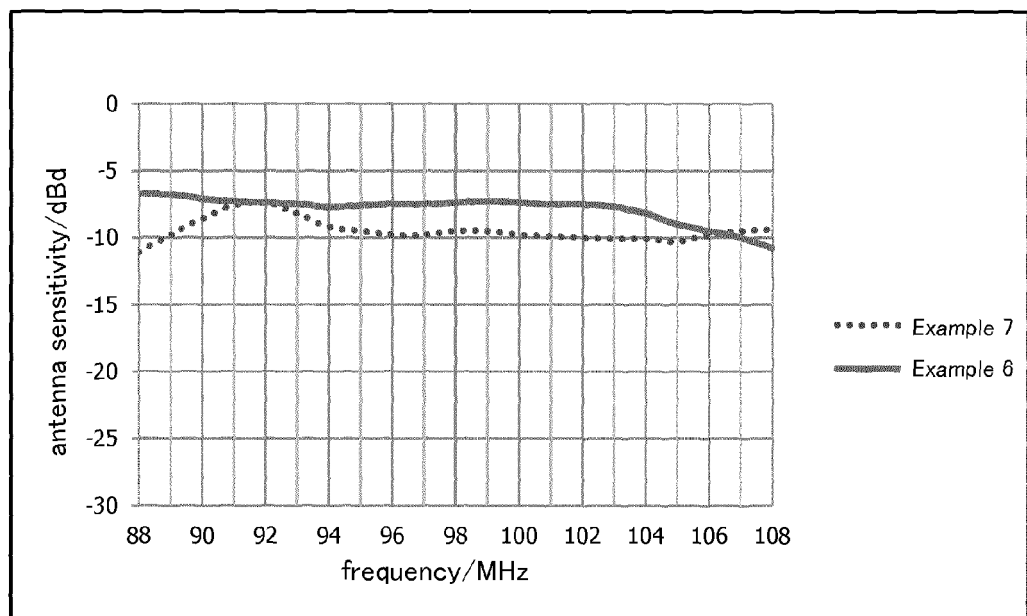


Fig. 13





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			H01Q
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
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CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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