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(54) **GLASS ANTENNA**

(57) It is provided a glass antenna arranged on a window glass for a vehicle, comprising a first antenna. The first antenna includes a first power feeding point connected to a receiver, a first element connected to the first power feeding point, and a second element connected to the first power feeding point. The second element in-

cludes a main body portion extending from the first power feeding point, and a folded portion connected to the main body portion. The folded portion is folded back from the main body portion and is arranged along the main body portion.

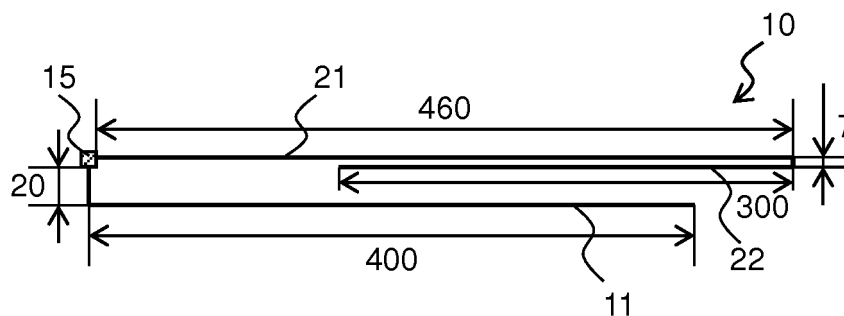


Fig. 2

Description

BACKGROUND OF THE INVENTION

[0001] This invention relates to a glass antenna arranged on a surface of a glass sheet, and more particularly, to an antenna configured to receive broadcast waves having a plurality of frequencies.

[0002] In countries all over the world, radio and television broadcasting frequencies and a frequency used for a remote keyless entry system differ among countries and regions, and hence it is necessary to develop an antenna having elements that differ in length for each delivery destination. However, in order to develop various kinds of antennas, a large number of work man-hours are required, and hence an antenna configured to support a plurality of bands is desired. For example, the frequency of an FM radio broadcast is from 76 MHz to 90 MHz in Japan, and is from 88 MHz to 108 MHz in most countries other than Japan. Therefore, when a satisfactory sensitivity cannot be obtained in a plurality of bands, it is necessary to adjust the lengths of the elements for each delivery destination.

[0003] Further, with digital audio broadcasting (DAB) becoming common in Europe, there are cases where only FM and AM radio broadcast bands are covered and where the FM and AM radio broadcast bands and a DAB band are covered depending on the delivery destination. Therefore, with one antenna supporting a plurality of bands, it is possible to reduce the number of kinds of antennas to be developed and the number of development man-hours.

[0004] As an antenna for obtaining a satisfactory sensitivity with such a plurality of frequencies, in JP 2010-81567 A, there is disclosed an antenna capable of satisfactorily receiving two kinds of DAB bands (Band III: from 174 MHz to 245 MHz and L-Band: from 1,452 MHz to 1,492 MHz).

[0005] Further, in JP H06-291530 A, there is disclosed an antenna of a typical two-frequency switching type. In order to receive two radio waves in an 800 MHz band and a 1,500 MHz band, the antenna disclosed in JP H06-291530 A includes two elements having lengths suitable for the respective frequencies, and has the two elements connected to each other in a bifurcated shape or a V shape.

[0006] However, the antenna disclosed in JP 2010-81567 A cannot satisfactorily receive the FM radio broadcast and a DAB broadcast band. Further, with the antenna disclosed in JP H06-291530 A, it is difficult to obtain a satisfactory sensitivity in two wide bands such as an FM radio broadcast band and DAB Band III.

SUMMARY OF THE INVENTION

[0007] This invention has an object to provide an antenna capable of satisfactorily receiving both frequencies of an FM radio broadcast band and a DAB band.

[0008] That is, according to one embodiment of this invention, there is provided a glass antenna arranged on a window glass for a vehicle, comprising a first antenna including: a first power feeding point connected to a receiver; a first element connected to the first power feeding point; and a second element connected to the first power feeding point, in which: the second element includes: a main body portion extending from the first power feeding point; and a folded portion connected to the main body portion; and the folded portion is folded back from an end portion of the main body portion, and is arranged along the main body portion.

[0009] Further, in the glass antenna according to the one embodiment of this invention, the folded portion is folded back from the end portion of the main body portion, and is arranged along and in proximity to the main body portion.

[0010] Further, in the glass antenna according to the one embodiment of this invention, the glass antenna is configured to receive a first frequency band having a wavelength of a center frequency set as λ_1 and a second frequency band having a wavelength of a center frequency set as λ_2 . The folded portion has a length of approximately $\alpha\lambda_2/4$. The main body portion has a length of approximately $\alpha\lambda_1/5$. The first element has a length of approximately $\alpha\lambda_1/6$. The parameter α represents a wavelength shortening rate of the window glass.

[0011] Further, in the glass antenna according to the one embodiment of this invention, the first element and the main body portion of the second element extend in the same direction.

[0012] Further, in the glass antenna according to the one embodiment of this invention, the first antenna further includes a third element extending from the first power feeding point in a direction different from an extending direction of the first element and an extending direction of the main body portion of the second element.

[0013] Further, in the glass antenna according to the one embodiment of this invention, the first antenna further includes at least one of an auxiliary element extending from the first power feeding point and an auxiliary element extending from the first element.

[0014] Further, in the glass antenna according to the one embodiment of this invention, the at least one of the auxiliary elements is arranged in proximity to a heating wire on an outermost side of a defogger arranged on the window glass, and is capacitively coupled to the heating wire.

[0015] Further, in the glass antenna according to the one embodiment of this invention, the first antenna is arranged in proximity to a linear conductor arranged on the window glass, and is capacitively coupled to the linear conductor.

[0016] Further, in the glass antenna according to the one embodiment of this invention, further comprises a second antenna including the linear conductor.

[0017] Further, in the glass antenna according to the one embodiment of this invention, the second antenna

includes: a plurality of horizontal wires; at least one vertical wire connecting the plurality of horizontal wires to one another; and a second power feeding point. The second antenna is configured to receive a signal of a third frequency band.

[0018] Further, in the glass antenna according to the one embodiment of this invention, the at least one vertical wire includes a plurality of vertical wires.

[0019] Further, in the glass antenna according to the one embodiment of this invention, at least one of the plurality of horizontal wires is arranged in proximity to the second element, and is capacitively coupled to the second element.

[0020] Further, in the glass antenna according to the one embodiment of this invention, at least one of the plurality of horizontal wires is arranged between the first element and the second element.

[0021] Further, in the glass antenna according to the one embodiment of this invention, at least one of the plurality of horizontal wires includes a folded portion having an end portion folded back toward one of an upper side and a lower side.

[0022] Further, in the glass antenna according to the one embodiment of this invention, the second power feeding point is provided to an end portion of any one of the plurality of horizontal wires. The second antenna further includes: a wire for capacitive coupling that extends from an uppermost wire of the plurality of horizontal wires, and is arranged in a position capacitively coupled to a body flange; and an auxiliary wire extending in a direction opposite to a direction in which the any one of the plurality of horizontal wires extends from the second power feeding point.

[0023] Further, in the glass antenna according to the one embodiment of this invention, the glass antenna further comprises a third antenna, and the first antenna and the third antenna form a diversity antenna.

[0024] Further, in the glass antenna according to the one embodiment of this invention: the third antenna is composed by using a wire of a defogger arranged on the window glass as an antenna; and the third antenna includes a third power feeding point provided to the defogger, the third power feeding point being connected to the receiver.

[0025] Further, in the glass antenna according to the one embodiment of this invention, the defogger includes a pair of bus bars provided on left and right of the window glass, and a plurality of heating wires connecting the pair of bus bars to each other. The third antenna includes a plurality of horizontal wires for use in combination with the plurality of heating wires, and at least two parallel auxiliary wires that extend from one of: one of the pair of bus bars; and one of the plurality of horizontal wires on an outermost side, and are arranged so that end portions of the at least two parallel auxiliary wires are spaced apart from each other, and the at least two parallel auxiliary wires are arranged along and in proximity to each other.

[0026] Further, in the glass antenna according to the

one embodiment of this invention, the third antenna further includes at least one auxiliary wire.

[0027] Further, in the glass antenna according to the one embodiment of this invention, the third antenna further includes at least one vertical wire connecting plurality of horizontal wires of the third antenna to one another.

[0028] Further, in the glass antenna according to the one embodiment of this invention, the glass antenna further includes a horizontal auxiliary wire extending from an end portion of the at least one vertical wire along one of the plurality of horizontal wires.

[0029] According to the representative embodiments of this invention, it is possible to obtain a satisfactory sensitivity in both frequencies of an FM radio broadcast band and a DAB band.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030]

FIG. 1 is a front view for illustrating an antenna pattern according to an example 1 of this invention.

FIG. 2 is a front view for illustrating an antenna pattern according to an example 2 of this invention.

FIG. 3 is a front view for illustrating an antenna pattern according to an example 3 of this invention.

FIG. 4 is a front view for illustrating an antenna pattern according to an example 4 of this invention.

FIG. 5 is a front view for illustrating an antenna pattern according to an example 5 of this invention.

FIG. 6 is a front view for illustrating an antenna pattern according to an example 6 of this invention.

FIG. 7 is a front view for illustrating an antenna pattern according to an example 7 of this invention.

FIG. 8 is a front view for illustrating an antenna pattern according to an example 8 of this invention.

FIG. 9 is a front view for illustrating an antenna pattern according to an example 9 of this invention.

FIG. 10 is a front view for illustrating an antenna pattern according to an example 10 of this invention.

FIG. 11 is a front view for illustrating an antenna pattern according to an example 11 of this invention.

FIG. 12 is a front view for illustrating an antenna pattern according to an example 12 of this invention.

FIG. 13 is a front view for illustrating an antenna pattern according to an example 13 of this invention.

FIG. 14 is a front view for illustrating an antenna pattern according to an example 14 of this invention.

FIG. 15 is a front view for illustrating an antenna pattern according to an example 15 of this invention.

FIG. 16 is a front view for illustrating an antenna pattern according to an example 16 of this invention.

FIG. 17 is a front view for illustrating an antenna pattern according to an example 17 of this invention.

FIG. 18 is a front view for illustrating an antenna pattern according to an example 18 of this invention.

FIG. 19 is a front view for illustrating an antenna pattern according to an example 19 of this invention.

FIG. 20 is a front view for illustrating an antenna pattern according to an example 20 of this invention.
 FIG. 21 is a front view for illustrating an antenna pattern according to an example 21 of this invention.
 FIGs. 22 to 24 are drawings for illustrating frequency characteristics of the antenna according to the example 21.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0031] FIG. 1 to FIG. 20 are diagrams of a glass antenna according to each embodiment of this invention when viewed from the inside of a vehicle.

[0032] As illustrated in FIG. 1, the glass antenna according to the embodiment of this invention is provided to a rear glass of an automobile, and includes a first power feeding point 15, a first element 11 connected to the first power feeding point 15 and extending in a substantially horizontal direction, and a second element connected to the first power feeding point 15 and extending in a direction opposite to the extending direction of the first element 11. The second element is formed of a main body portion 21 extending from the first power feeding point 15 and a folded portion 22 that is folded back at an end portion of the main body portion 21 and extends along the main body portion 21 in a direction approaching the first power feeding point 15. The folded portion 22 is arranged in proximity to and in substantially parallel with the main body portion 21.

[0033] The first power feeding point 15 is connected to a reception amplifier 6 through a connecting line (for example, low voltage cable for automobile) 5, and the reception amplifier 6 is connected to a receiver (not shown) by a high-frequency cable (for example, coaxial cable). Further, the reception amplifier 6 is connected to the ground (vehicle body).

[0034] It should be noted that in the example of FIG. 1, the folded portion 22 extends from the end portion of the main body portion 21, but may extend from a position (midpoint) of the main body portion 21 other than the end portion.

[0035] Further, as illustrated in FIG. 2, the first element 11 and the second element may extend in the same direction.

[0036] Further, as illustrated in FIG. 3, a third element 31 extending from the first power feeding point 15 may be provided. The third element 31 may extend in a direction different from the extending direction of the first element 11 or the extending direction of the second element.

[0037] Further, as illustrated in FIG. 4 and FIG. 5, auxiliary elements 12 and 13 extending from the first element 11 along (for example, in parallel with) the first element 11 may be provided. The number of auxiliary elements may be one as illustrated in FIG. 4, may be two as illustrated in FIG. 5, or may be a plurality larger than two. Further, the auxiliary element may be provided above or

below the first element 11. For example, one auxiliary element may be provided above the first element 11. The auxiliary elements 12 and 13 may extend from the first power feeding point 15, or may extend from the first element 11, or another auxiliary element may extend from a given auxiliary element.

[0038] A first antenna 10 is formed in the above-mentioned manner. Elements of the first antenna 10 are adjusted to have lengths suitable to receive an FM radio broadcast band (from 76 MHz to 108 MHz) and Band III (from 174 MHz to 245 MHz) of digital audio broadcasting (DAB).

[0039] Further, as illustrated in FIG. 5 and FIG. 6, the auxiliary element 12 may be arranged in proximity to a defogger 90, and may be capacitively coupled to a heating wire 91 on an outermost side of the defogger 90. It should be noted that an illustration of the right half of the defogger 90 is omitted in FIG. 5 and FIG. 6.

[0040] It should be noted that elements of a first antenna may be arranged in proximity to a conductor (for example, another antenna) that is not connected to the ground instead of the defogger 90, and may be capacitively coupled to the conductor. In other words, the conductor in proximity to the elements of the first antenna may be the heating wire 91 of the defogger 90 as illustrated in FIG. 5 and FIG. 6, may be a non-feed element 40 as illustrated in FIG. 6, or may be a second antenna 50 as illustrated in FIG. 7 and FIG. 8. The second antenna 50 has respective wires arranged so as to secure a reception effective area for enabling an AM radio frequency band (from 526.5 kHz to 1,606.5 kHz) to be received in a preferred manner. In addition, the elements of the first antenna in proximity to the conductor that is not connected to the ground may be any one of the first element 11, the auxiliary elements 12 and 13, and the second element (21 and 22).

[0041] Further, as illustrated in FIG. 9 and FIG. 10, a folded portion 56 may be included at an end portion of a horizontal wire 52D. Further, the folded portion 56 may be folded back in a downward direction as illustrated in FIG. 9, or may be folded back in an upward direction as illustrated in FIG. 10.

[0042] Further, as illustrated in FIG. 11, the folded portion 56 may extend from an end portion of an uppermost horizontal wire 52F, may be folded back in the upward direction, and may extend along (for example, in parallel with) the horizontal wire 52F. The folded portion 56 is arranged in proximity to a body flange 2 of the vehicle body on which a rear glass 1 is mounted, and is capacitively coupled to the body flange 2.

[0043] Further, as illustrated in FIG. 12, two folded portions 56 and 57 may be capacitively coupled to the body flange 2.

[0044] Further, as illustrated in FIG. 13, an auxiliary wire 58 extending from a second power feeding point 54 outward (in a direction opposite to the extending direction of a horizontal wire 52) may be provided. The auxiliary wire 58 may be bent downward and may extend down-

ward (along the third element 31) as illustrated in FIG. 13, or may extend outward linearly.

[0045] Further, as illustrated in FIG. 14, a third antenna 60 may be provided on the rear glass 1 in a position spaced apart from the first antenna 10 (for example, below the defogger 90). The third antenna 60 is formed of two horizontal elements 61 and 62 and a third power feeding point 63, which are adjusted to have lengths suitable to receive the FM radio broadcast band (from 76 MHz to 108 MHz) and a TV broadcast band (from 470 MHz to 770 MHz). In this case, the first antenna 10 and the third antenna 60 may form a diversity antenna to diversity-receive an FM radio broadcast.

[0046] The defogger 90 includes a pair of bus bars 93 provided on the left and right of the rear glass 1 and a plurality of heating wires 91 connecting the two bus bars 93 to each other. Further, the defogger 90 may include a vertical wire 92 connecting the plurality of heating wires 91 to one another. The number of vertical wires 92 may be one or a plurality.

[0047] Further, as illustrated in FIG. 15, the defogger 90 may be used as the third antenna 60. The heating wire 91 and the vertical wire 92 that form the defogger 90 function as a horizontal wire and a vertical wire, respectively, in the third antenna 60.

[0048] In this case, one of the bus bars 93 of the defogger 90 is connected to a power supply via a defogger coil 94, and the other bus bar 93 is connected to the ground via the defogger coil 94, to thereby suppress noise in a received frequency band flowing into the third antenna 60 from the power supply and the ground. Further, a third power feeding point 95 is provided to one bus bar 93. Further, also in this case, the first antenna 10 and the third antenna 60 form a diversity antenna.

[0049] Further, as illustrated in FIG. 16, the third antenna 60 includes a plurality of parallel auxiliary wires 96, 97, and 98 that extend downward from a lowermost horizontal wire 91 and are arranged along the horizontal wire 91. End portions the parallel auxiliary wires 96, 97, and 98 are in positions spaced apart from one another. Further, a part of the parallel auxiliary wire 96 and a part of the parallel auxiliary wire 97 are arranged along, in proximity to, and in substantially parallel with each other. In addition, a part of the parallel auxiliary wire 97 and a part of the parallel auxiliary wire 98 are arranged along, in proximity to, and in substantially parallel with each other. It should be noted that not parts of but almost all of parallel auxiliary wires may be arranged along and in proximity to each other.

[0050] Further, the number of auxiliary wires extending along the horizontal wire 91 may be three as illustrated in FIG. 16, may be two as illustrated in FIG. 17, or may be equal to or larger than four. In addition, the auxiliary wires extending along the horizontal wire 91 may extend downward from the horizontal wire 91 as illustrated in FIG. 16, or may extend downward from the bus bar 93 as illustrated in FIG. 17. Further, also in the case illustrated in FIG. 17, a part of the parallel auxiliary wire 96

and at least a part of the parallel auxiliary wire 98 are arranged along, in proximity to, and in substantially parallel with each other.

[0051] Further, as illustrated in FIG. 18, an auxiliary wire 89 extending upward from the bus bar 93 (or horizontal wire 91 on the outermost side) may be provided. In addition, a fourth antenna 70 may be provided in proximity to the auxiliary wire 89. The fourth antenna 70 is formed of a fourth power feeding point 71 and a horizontal element 72, which are adjusted to have lengths suitable to receive the TV broadcast band (from 470 MHz to 770 MHz). In this case, the third antenna 60 and the fourth antenna 70 may form a diversity antenna to diversity-receive a TV broadcast.

[0052] Further, as illustrated in FIG. 19, the heating wires 91 of the defogger 90 may be connected to one another by a plurality of vertical wires 92. It should be noted that the number of vertical wires 92 may be three as illustrated in FIG. 19, or may be one, two, or equal to or larger than four.

[0053] Further, as illustrated in FIG. 20, there may be provided a horizontal auxiliary wire 99 extending downward from the lowermost horizontal wire 91 and extending both leftward and rightward from the center of a defogger along the horizontal wire 91.

[0054] The antenna according to the embodiment of this invention is formed by printing a pattern of the antenna with conductive ceramic paste in a predetermined position on an indoor surface side of a window glass sheet with each wire having a width of approximately 0.7 millimeter, drying the pattern, and then baking the pattern in a heating furnace. Further, the antenna may be formed of a conductive pattern formed on a resin film that transmits light, and may be bonded to a glass sheet.

[0055] The embodiment of this invention is described above by taking a mode of providing the antenna on the rear glass 1 of the automobile, but the antenna according to the embodiment of this invention may be provided on another part (for example, windshield or side glass).

[0056] Next, an action of the glass antenna according to the embodiment of this invention is described.

[0057] The antenna according to this embodiment includes the first element 11, the main body portion 21 of the second element, and the folded portion 22 of the second element, and therefore can obtain a satisfactory sensitivity in a plurality of frequency bands. In particular, the length of the folded portion 22 is set to approximately $\alpha\lambda_2/4$, the length of the main body portion 21 is set to approximately $\alpha\lambda_1/5$, the length of the first element 11 is set to approximately $\alpha\lambda_1/6$, and hence a satisfactory sensitivity can be obtained in both the FM radio broadcast band having a low frequency ((wavelength of center frequency)= λ_1) and a DAB broadcast band ((wavelength of center frequency)= λ_2). A satisfactory sensitivity can also be obtained in DAB L-Band (from 1,452 MHz to 1,492 MHz).

[0058] The folded portion 22 is folded back from the end portion of the main body portion 21, and arranged

along and in proximity to the main body portion 21, and hence the folded portion 22 and the main body portion 21 are connected to each other electrically strongly. Therefore, it is possible to obtain a satisfactory sensitivity in both the FM radio broadcast band having a low frequency and the DAB broadcast band.

[0059] Further, two elements (first element 11 and main body portion 21 of second element) having different lengths for FM radio broadcast reception are provided, and hence it is possible to improve the sensitivity in the FM radio broadcast band over a wide bandwidth. In addition, the folded portion 22 is formed by folding back the second element, to thereby be able to improve the sensitivity also in DAB Band III having a high frequency.

[0060] Further, the first element 11 and the main body portion 21 of the second element extend in the same direction, to thereby arrange the first element 11 and the second element (21 and 22) on one side of the first power feeding point 15 and allow downsizing of the antenna. Therefore, the first power feeding point 15 can be arranged in a position close to a side of a glass sheet 1.

[0061] Further, the third element 31 extending from the first power feeding point 15 is provided in the direction opposite to the extending direction of the first element 11 and the extending direction of the main body portion 21 of the second element, and the length and a relative positional relationship of the third element 31 are adjusted, to thereby be able to improve the sensitivity on a high band side of the FM radio broadcast band. It is also possible to improve the sensitivity in DAB Band III as a whole.

[0062] Further, the auxiliary element 12 extending from the first power feeding point 15 is provided as illustrated in FIG. 4, and the auxiliary elements 12 and 13 extending from the first element 11 are provided as illustrated in FIG. 5. Therefore, it is possible to improve the sensitivity in DAB Band III having a high frequency.

[0063] Further, the auxiliary element 12 is arranged in proximate to the heating wire 91 of the defogger 90, and the first antenna 10 is capacitively coupled to the defogger 90. Therefore, a broadcast wave received by the heating wire 91 of the defogger 90 can be guided to the first antenna 10, and it is possible to improve the sensitivity of the first antenna 10. In particular, it is possible to improve the sensitivity in DAB Band III having a high frequency.

[0064] Further, the first antenna 10 (auxiliary element 12 and second element) is arranged in proximate to linear conductors 91, 42, and 52, and the first antenna 10 is capacitively coupled to the conductors 91, 42, and 52. Therefore, the broadcast wave received by the conductors 91, 42, and 52 can be guided to the first antenna 10, and it is possible to improve the sensitivity of the antenna. Further, the lengths and the relative positional relationship of the elements on sides of the conductors 91, 42, and 52 are adjusted, to thereby be able to improve the sensitivity in the FM radio broadcast band having a low frequency.

[0065] Further, the second element (21 and 22) is ar-

ranged in proximate to the horizontal wire 52, and the first antenna 10 is capacitively coupled to the second antenna 50. Therefore, the broadcast wave received by the second antenna 50 can be guided to the first antenna 10, and it is possible to improve the sensitivity of the first antenna 10. Further, the lengths and the relative positional relationship of elements 52 and 53 of the second antenna 50 are adjusted, to thereby be able to improve the sensitivity in the FM radio broadcast band.

[0066] Further, the second antenna 50 is formed of a plurality of horizontal wires 52, a vertical wire 53 connecting the horizontal wires 52 to one another, and the second power feeding point 54, and hence it is possible to form an antenna for another frequency (for example, for AM radio broadcast reception) with a simple structure.

[0067] Further, a plurality of vertical wires 53 are provided, and intervals between the vertical wires 53 are adjusted, to thereby be able to easily improve the sensitivity in the FM radio broadcast band.

[0068] Further, the second element (21 and 22) is arranged in proximity to the horizontal wire 52, to thereby be able to capacitively couple the first antenna 10 and the second antenna 50 to each other.

[0069] Further, the horizontal wires 52 are arranged between the first element 11 and the second element (21 and 22), and hence the first antenna 10 and the second antenna 50 are connected to each other strongly, and are likely to be affected by each other. Therefore, the first antenna 10 is susceptible to a change in characteristics of the second antenna 50 due to the adjustment of the lengths of elements thereof and the relative positional relationship of the elements, and it is possible to easily improve the characteristics of the first antenna 10.

[0070] Further, the folded portions 56 and 57 folded back upward or downward are provided, and hence it is possible to adjust the sensitivity of the first antenna 10 without greatly changing the characteristics of the second antenna 50. Further, the folded portions 56 and 57 are formed to be folded back upward from the horizontal wire 52, to thereby be able to improve the sensitivity of the first antenna 10 in the FM radio broadcast band (in particular, middle band).

[0071] Further, the folded portions 56 and 57 are capacitively coupled to the body flange 2 as illustrated in FIG. 11 to FIG. 15. Therefore, it is possible to improve the sensitivity of the first antenna 10 in the FM radio broadcast band (in particular, middle band) by adjusting the lengths of the folded portions 56 and 57 and a spacing from a body flange.

[0072] Further, the auxiliary wire 58 extending from the second power feeding point 54 in the direction opposite to the extending direction of the horizontal wire 52 is provided, and hence by adjusting the length and the extending direction of the auxiliary wire 58, it is possible change the characteristics of the second antenna 50 and to improve the sensitivity of the first antenna 10 in the FM radio broadcast band (in particular, middle band).

[0073] Further, the third antenna 60 is arranged in the

position spaced apart from the first antenna 10, and diversity reception is effected by the first antenna 10 and the third antenna 60. Therefore, it becomes easy to receive an arrival wave, and it is possible to improve reception performance.

[0074] Further, the third antenna 60 is formed of the wires 91 and 92 of the defogger 90. Therefore, an antenna element does not need to be provided separately, and it is possible to suppress deterioration in an outer appearance. Further, the third power feeding point 95 is provided to the bus bar 93, and hence a power feeding point for the radio-frequency signal and a power feeding point for the heating wire can be shared. Further, the bus bar 93 is connected to the power supply and the ground via the defogger coil 94, and hence the bus bar 93 can be connected to the power supply and the ground in terms of a direct current, and can be floated from the power supply and the ground in terms of a high frequency.

[0075] Further, the horizontal wires (heating wires) 91 and the parallel auxiliary wires 96, 97, and 98 extending from the bus bar 93 or the horizontal wire 91 on the outermost side are provided, end portions of the parallel auxiliary wires 96, 97, and 98 are isolated from one another, and two of the parallel auxiliary wires 96, 97, and 98 are arranged along and in proximity to each other. Therefore, by adjusting a width and a length of an overlap between the parallel auxiliary wires, it is possible to improve the sensitivity of the third antenna 60 and to improve the sensitivity of another antenna with which a diversity is formed.

[0076] Further, the parallel auxiliary wires 96, 97, and 98 extend from the bus bar 93. Therefore, by increasing the lengths of the parallel auxiliary wires and increasing the length of the overlap between the parallel auxiliary wires, it is possible to widen an adjustment range.

[0077] Further, the auxiliary wire 89 is provided to the third antenna 60, and hence it is possible to improve the sensitivity of the third antenna 60, and to improve the sensitivity of the antenna provided around the third antenna 60.

[0078] Further, the vertical wire 92 connecting the horizontal wires 91 to one another is provided, and hence it is possible to improve the sensitivity of the third antenna 60.

[0079] Further, the horizontal auxiliary wire 99 extending from an end portion of the vertical wire 92 along the horizontal wire 91 is provided, and an end portion of the horizontal auxiliary wire 99 is not connected to the defogger 90. Therefore, it is possible to increase a degree of freedom for adjusting antenna characteristics.

Examples

[0080] Various examples of this invention are described below.

<Example 1>

[0081] FIG. 1 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 1 of this invention.

[0082] A glass antenna according to the example 1 is formed of the first antenna 10. The first antenna 10 includes the first power feeding point 15, the first element 11 connected to the first power feeding point 15 and extending in a substantially horizontal direction (leftward direction in FIG. 1), and the second element connected to the first power feeding point 15 and extending in a direction (rightward direction in FIG. 1) opposite to the extending direction of the first element 11.

[0083] The second element is formed of the main body portion 21 extending from the first power feeding point 15 and the folded portion 22 that is folded back at the end portion of the main body portion 21 in the downward direction (or, upward direction) and extends along and in substantially parallel with the main body portion 21 in the direction approaching the first power feeding point 15. It should be noted that the folded portion 22 may extend from the midpoint of the main body portion 21.

[0084] By making the length of each of elements according to the example 1 the same as the length of each of elements according to an example 2 described later, it is possible to realize the antenna suitable to receive the FM radio broadcast band and DAB Band III.

[0085] A third element (not shown) extending from the first power feeding point 15 may be provided to the antenna according to the example 1. The third element may extend in the direction (for example, downward direction) different from the extending direction of the first element 11 or the extending direction of the second element.

<Example 2>

[0086] FIG. 2 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 2 of this invention.

[0087] A glass antenna according to the example 2 is different from the glass antenna according to the example 1 in the extending direction of the first element 11.

[0088] The glass antenna according to the example 2 is formed of the first antenna 10. The first antenna 10 includes the first power feeding point 15, the first element 11 connected to the first power feeding point 15 and extending in a substantially horizontal direction (rightward direction in FIG. 2), and the second element connected to the first power feeding point 15 and extending along and in substantially parallel with the first element 11 in the same direction (rightward direction in FIG. 2) as the extending direction of the first element 11.

[0089] The second element is formed of the main body portion 21 extending from the first power feeding point 15 and the folded portion 22 that is folded back at the

end portion of the main body portion 21 in the downward direction (or, upward direction) and extends along and in substantially parallel with the main body portion 21 in the direction approaching the first power feeding point 15. It should be noted that the folded portion 22 may extend from the midpoint of the main body portion 21.

[0090] Each of the elements of the first antenna 10 according to the example 2 has a length adjusted to have the length suitable to receive the FM radio broadcast band and DAB Band III such that a vertical portion of the first element 11 extending from the first power feeding point 15 has a length of 20 millimeters, a horizontal portion extending from an end portion of the vertical portion of the first element 11 has a length of 400 millimeters, the main body portion 21 of the second element has a length of 460 millimeters, the folded portion 22 of the second element has a length of 300 millimeters, and a spacing between the main body portion 21 and the folded portion 22 is 7 millimeters.

[0091] In other words, when a wavelength shortening rate α of the rear glass 1 is 0.7 and the center frequency (wavelength= λ_1) of the FM radio broadcast band is 92 MHz, the length of the first element 11 is approximately $\alpha\lambda_1/6$, and the length of the main body portion 21 is approximately $\alpha\lambda_1/5$. Further, when the center frequency (wavelength= λ_2) of DAB Band III is 210 MHz, the length of the folded portion 22 is approximately $\alpha\lambda_2/4$.

[0092] At this time, the length of the first element 11 may be only the length of the horizontal portion, or may include the length of the vertical portion in addition to the length of the horizontal portion.

[0093] In the examples 1 and 2, two elements having different lengths, that is, the first element 11 and the main body portion 21 of the second element, are provided in order to receive the FM radio broadcast band having a low frequency, and hence it is possible to improve the sensitivity in a wide bandwidth of the FM radio broadcast band having a low frequency. In addition, the folded portion 22 is formed by folding back the second element, and is arranged in proximity to the main body portion 21 (in parallel with the main body portion 21 with a spacing of 7 millimeters), to thereby be able to improve the sensitivity in DAB Band III having a high frequency without impairing the sensitivity in the FM radio broadcast band having a low frequency.

[0094] Further, in the example 2, the first element 11 and the main body portion 21 of the second element extend in the same direction, to thereby arrange the first element 11 and the second element (21 and 22) on one side of the first power feeding point 15 and allow the downsizing of the antenna. Therefore, the first power feeding point 15 can be arranged in the position close to the side of the glass sheet 1.

< Example 3 >

[0095] FIG. 3 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illus-

trating an antenna pattern according to an example 3 of this invention.

[0096] A glass antenna according to the example 3 is different from the glass antenna according to the example 2 in that the third element 31 is provided.

[0097] The glass antenna according to the example 3 is formed of the first antenna 10. The first antenna 10 includes the first power feeding point 15, the first element 11, the second element, and the third element 31. The second element is formed of the main body portion 21 and the folded portion 22.

[0098] The third element 31 extends from the first power feeding point 15 in the direction different from the extending direction of the first element 11 or the extending direction of the second element. Specifically, the third element 31 includes: a horizontal portion extending from the first power feeding point 15 in a direction (leftward direction in FIG. 3) opposite to the extending direction of the main body portion 21 of the second element; and a vertical portion extending from an end portion of the horizontal portion in the downward direction (direction different from the rightward direction in which the first element 11 and the second element extend). The horizontal portion of the third element 31 has a length of 5 millimeters, and the vertical portion has a length of 150 millimeters. In FIG. 3, the number of third elements 31 is one, but a plurality of third elements 31 may be provided.

[0099] Components of the example 3 other than the above-mentioned components are the same as those of the example 2, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0100] In the example 3, the third element 31 extending from the first power feeding point 15 is provided. Therefore, by adjusting the lengths and the relative positional relationship of the third element 31, it is possible to improve the sensitivity on the high band side of the FM radio broadcast band. It is also possible to improve the sensitivity in DAB Band III as a whole.

< Example 4 >

[0101] FIG. 4 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 4 of this invention.

[0102] A glass antenna according to the example 4 is different from the glass antenna according to the example 3 in that the auxiliary element 12 is provided.

[0103] The glass antenna according to the example 4 is formed of the first antenna 10. The first antenna 10 includes the first power feeding point 15, the first element 11, the second element, the third element 31, and the auxiliary element 12. The second element is formed of the main body portion 21 and the folded portion 22.

[0104] The auxiliary element 12 is arranged so as to extend downward from the first power feeding point 15 and then extend along and in substantially parallel with the first element 11. The auxiliary element 12 may have

a length shorter than the length of the first element 11, or may have almost the same length as the length of the first element 11. Specifically, a vertical portion of the auxiliary element 12 has a length of 33 millimeters, and a horizontal portion of the auxiliary element 12 has a length of 125 millimeters. The auxiliary element 12 may extend from the first power feeding point 15, or may extend from the first element 11.

[0105] Components of the example 4 other than the above-mentioned components are the same as those of the example 3, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0106] In the example 4, the auxiliary element 12 extending from the first power feeding point 15 is provided, and hence it is possible to improve the sensitivity in DAB Band III having a high frequency.

< Example 5>

[0107] FIG. 5 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 5 of this invention.

[0108] A glass antenna according to the example 5 is different from the glass antenna according to the example 3 in that the auxiliary elements 12 and 13 are provided.

[0109] The glass antenna according to the example 5 is formed of the first antenna 10. The first antenna 10 includes the first power feeding point 15, the first element 11, the second element, the third element 31, and the auxiliary elements 12 and 13. The second element is formed of the main body portion 21 and the folded portion 22.

[0110] The auxiliary element 12 is arranged so as to extend downward from an intersection point of the vertical portion and the horizontal portion of the first element and then extend along and in substantially parallel with the first element 11. The auxiliary element 12 may have a length shorter than the length of the first element 11, or may have almost the same length as the length of the first element 11. Specifically, the vertical portion of the auxiliary element 12 has a length of 33 millimeters, and the horizontal portion of the auxiliary element 12 has a length of 125 millimeters.

[0111] The auxiliary element 13 is arranged so as to extend rightward from the vertical portion of the first element and then extend along and in substantially parallel with the first element 11. The auxiliary element 13 may have a length shorter than the length of the first element 11, or may have almost the same length as the length of the first element 11. Specifically, the auxiliary element 13 has a length of 175 millimeters.

[0112] The auxiliary elements 12 and 13 may extend from the first element 11, or may extend from the first power feeding point 15.

[0113] Components of the example 5 other than the above-mentioned components are the same as those of the example 3, and are therefore denoted by like refer-

ence symbols, and descriptions thereof are omitted.

[0114] In the example 4, the auxiliary element 12 is provided on the lower side of the first element 11. Further, in the example 5, the auxiliary element 12 is provided on the lower side of the first element 11, and the auxiliary element 13 is provided on the upper side of the first element 11. That is, the number of auxiliary elements is not limited to the numbers exemplified. Further, the auxiliary elements may be each provided on any one of the upper side and the lower side of the first element 11. For example, in the example 5, only the auxiliary element 13 may be provided on the upper side of the first element 11.

[0115] Further, when a plurality of auxiliary elements are provided, one auxiliary element may extend from another auxiliary element.

[0116] Further, in the example 5, the auxiliary element 12 is arranged along and in proximity to the defogger 90 (for example, in parallel with the defogger 90 with a spacing of 5 millimeters) so as to be capacitively coupled to the uppermost heating wire 91 of the defogger 90.

[0117] The defogger 90 includes the pair of bus bars 93 provided on the left and right of the rear glass 1 and the plurality of heating wires 91 connecting the two bus bars 93 to each other. It should be noted that in FIG. 5, only the left half of the defogger 90 is illustrated.

[0118] In the example 5, the auxiliary elements 12 and 13 extending from the first element 11 are provided, and hence it is possible to improve the sensitivity in DAB Band III having a high frequency. In addition, the first antenna 10 (auxiliary element 12) and the defogger 90 (heating wire 91) are arranged in proximity to each other, and the first antenna 10 is capacitively coupled to the defogger 90. Therefore, the broadcast wave received by the heating wire 91 of the defogger can be guided to the first antenna 10, and it is possible to improve the sensitivity of the first antenna 10. In particular, it is possible to improve the sensitivity in DAB Band III having a high frequency.

< Example 6>

[0119] FIG. 6 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 6 of this invention.

[0120] A glass antenna according to the example 6 includes the first antenna 10 and the non-feed element 40, and is different from the glass antenna according to the example 5 in that the second element (21 and 22) and the non-feed element 40 are capacitively coupled to each other.

[0121] The glass antenna according to the example 6 is formed of the first antenna 10 and the non-feed element 40. The first antenna 10 includes the first power feeding point 15, the first element 11, the second element, the third element 31, and the auxiliary elements 12 and 13. The second element is formed of the main body portion 21 and the folded portion 22.

[0122] The non-feed element 40 is formed of a plurality of horizontal wires 42 and at least one vertical wire 43 connecting the horizontal wires 42 to one another, and the power feeding point is not provided thereto. In other words, the non-feed element 40 is a conductor that is not connected to the ground. It suffices that the number of horizontal wires 42 is at least one, and a plurality of vertical wires 43 may be provided as long as at least one vertical wire 43 is provided.

[0123] The auxiliary element 12 is arranged along, in proximity to, and in substantially parallel with the defogger 90 so as to be capacitively coupled to the uppermost heating wire 91 of the defogger 90.

[0124] The defogger 90 includes the pair of bus bars 93 provided on the left and right of the rear glass 1, the plurality of heating wires 91 connecting the two bus bars 93 to each other, and the vertical wire 92 connecting the plurality of heating wires 91 to one another. It should be noted that in FIG. 6, only the left half of the defogger 90 is illustrated.

[0125] The main body portion 21 of the second element is arranged along and in proximity to the non-feed element 40 (for example, in parallel with the non-feed element 40 with a spacing of 10 millimeters) so as to be capacitively coupled to a lowermost horizontal wire 42A of the non-feed element 40.

[0126] Components of the example 6 other than the above-mentioned components are the same as those of the example 5, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0127] In the example 6, the main body portion 21 of the second element and the horizontal wire 42 of the non-feed element 40 are arranged in proximity to each other, and the first antenna 10 and the non-feed element 40 are capacitively coupled to each other. Therefore, the broadcast wave received by the non-feed element 40 can be guided to the first antenna 10, and it is possible to improve the sensitivity of the antenna. Further, the length and a relative positional relationship of the non-feed element 40 are adjusted, to thereby be able to improve the sensitivity in the FM radio broadcast band having a low frequency.

< Example 7 >

[0128] FIG. 7 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 7 of this invention.

[0129] A glass antenna according to the example 7 includes the first antenna 10 and the second antenna 50, and is different from the glass antenna according to the example 5 in that the second element (21 and 22) and the second antenna 50 are capacitively coupled to each other.

[0130] The glass antenna according to the example 7 is formed of the first antenna 10 and the second antenna 50. The first antenna 10 includes the first power feeding

point 15, the first element 11, the second element, the third element 31, and the auxiliary elements 12 and 13. The second element is formed of the main body portion 21 and the folded portion 22.

[0131] The second antenna 50 includes a plurality of horizontal wires 52, a plurality of vertical wires 53 connecting the horizontal wires 52 to one another, and the second power feeding point 54. Further, the intervals between the vertical wires 53 may be regular intervals, or may be different intervals. The intervals between the vertical wires 53 are adjusted, to thereby be able to improve the sensitivity in the FM radio broadcast band. It suffices that the number of horizontal wires 52 is at least one, and the number of vertical wires 53 is at least one. The second antenna 50 has the respective wires arranged so as to secure a reception effective area for enabling an AM radio broadcast band (from 526.5 kHz to 1,606.5 kHz) to be received in a preferred manner.

[0132] The second power feeding point 54 may be provided at an end portion of the horizontal wire 52, may be provided in a central portion (for example, intersection point of a horizontal wire 52B and the vertical wire 53) of the horizontal wire 52, or may be provided to another part. The second power feeding point 54 is connected to a reception amplifier through the connecting line (for example, low voltage cable for automobile), and the reception amplifier is connected to the receiver by the high-frequency cable (for example, coaxial cable). Further, the reception amplifier is connected to the ground (vehicle body).

[0133] The second element (21 and 22) is arranged in proximity to a horizontal wire 52A of the second antenna 50, and the first antenna 10 and the second antenna 50 are capacitively coupled to each other.

[0134] It should be noted that the defogger is not illustrated in FIG. 7, but the defogger 90 may be provided so as to be capacitively coupled to the auxiliary element 12 or may not be provided.

[0135] The main body portion 21 of the second element is arranged along and in proximity to the second antenna 50 (for example, in parallel with the second antenna 50 with a spacing of 10 millimeters) so as to be capacitively coupled to the horizontal wire 52A provided at a lower portion of the second antenna 50.

[0136] Components of the example 7 other than the above-mentioned components are the same as those of the example 5, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0137] In the example 7, the main body portion 21 of the second element and the horizontal wire 52 of the second antenna 50 are arranged in proximity to each other, and the first antenna 10 and the second antenna 50 are capacitively coupled to each other. Therefore, the broadcast wave received by the second antenna 50 can be guided to the first antenna 10, and it is possible to improve the sensitivity of the first antenna 10. Further, the length and the relative positional relationship of the horizontal wire 52 and the vertical wire 53 of the second

antenna 50 are adjusted, to thereby be able to improve the sensitivity in the FM radio broadcast band having a low frequency.

[0138] Further, it is possible to form the second antenna 50 for another frequency (for example, for AM radio broadcast reception) with a simple structure.

< Example 8>

[0139] FIG. 8 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 8 of this invention.

[0140] A glass antenna according to the example 8 is different from the glass antenna according to the example 7 in that the horizontal wire 52B of the second antenna 50 is arranged between the auxiliary element 13 and the folded portion 22 of the first antenna 10.

[0141] The glass antenna according to the example 8 is formed of the first antenna 10 and the second antenna 50. The first antenna 10 includes the first power feeding point 15, the first element 11, the second element, the third element 31, and the auxiliary elements 12 and 13. The second element is formed of the main body portion 21 and the folded portion 22. The second antenna 50 includes the plurality of horizontal wires 52, a plurality of vertical wires 53, and the second power feeding point 54.

[0142] In the example 8, the left part of the lowermost horizontal wire 52B extends into a region in which the first antenna 10 is provided. In other words, the left part of the horizontal wire 52B is arranged between the auxiliary element 13 and the folded portion 22 of the first antenna 10 along, in proximity to, and in substantially parallel with the auxiliary element 13 and along, in proximity to, and in substantially parallel with the folded portion 22. In short, the left part of the horizontal wire 52B is arranged between the first element 11 and the second element (21 and 22) of the first antenna 10. The plurality of horizontal wires 52 (for example, two horizontal wires 52) may be arranged between the first element 11 and the second element (21 and 22).

[0143] Further, the second power feeding point 54 is connected to the second antenna 50 via a connecting wire 55 extending from a horizontal wire 52C.

[0144] It should be noted that the defogger is not illustrated in FIG. 8, but the defogger 90 may be provided so as to be capacitively coupled to the auxiliary element 12 or may not be provided.

[0145] Components of the example 8 other than the above-mentioned components are the same as those of the example 7, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0146] In the example 8, the horizontal wires 52 are arranged between the first element 11 and the second element (21 and 22), and hence the first antenna 10 and the second antenna 50 are connected to each other strongly, and are likely to be affected by each other. Therefore, the first antenna 10 is susceptible to a change

in characteristics of the second antenna 50 due to the adjustment of the lengths and the relative positional relationship of the elements, and it is possible to easily adjust the characteristics of the first antenna 10.

< Example 9>

[0147] FIG. 9 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 9 of this invention.

[0148] A glass antenna according to the example 9 is different from the glass antenna according to the example 8 in that the horizontal wire 52D of the second antenna 50 includes the folded portion 56 and that the second power feeding point 54 is arranged at the end portion of a horizontal wire 52E provided therebelow.

[0149] The glass antenna according to the example 9 is formed of the first antenna 10 and the second antenna 50. The first antenna 10 includes the first power feeding point 15, the first element 11, the second element, the third element 31, and the auxiliary elements 12 and 13. The second element is formed of the main body portion 21 and the folded portion 22. The second antenna 50 includes the plurality of horizontal wires 52, the plurality of vertical wires 53, the second power feeding point 54, and the folded portion 56.

[0150] In the second antenna 50 according to the example 9, the second power feeding point 54 is arranged at a left end portion of the horizontal wire 52E provided in the lower part. Therefore, the first power feeding point 15 of the first antenna 10 and the second power feeding point 54 of the second antenna 50 are arranged so as to be adjacent to each other, which facilitates the work of connecting a connecting line to the power feeding point of each antenna.

[0151] Further, the folded portion 56 is provided at a right end of the horizontal wire 52D of the second antenna 50. The folded portion 56 extends in the downward direction from the right end of the horizontal wire 52D, is folded back in the leftward direction, and extends in the leftward direction along and in proximity to the horizontal wire 52D (for example, in parallel with the horizontal wire 52D with a spacing of 5 millimeters).

[0152] It should be noted that the defogger is not illustrated in FIG. 9, but the defogger 90 may be provided so as to be capacitively coupled to the auxiliary element 12 or may not be provided.

[0153] Components of the example 9 other than the above-mentioned components are the same as those of the example 7, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0154] In the example 9, the folded portion 56 is provided, and hence it is possible to improve the sensitivity of the first antenna 10 without greatly changing the characteristics of the second antenna 50.

< Example 10>

[0155] FIG. 10 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 10 of this invention.

[0156] A glass antenna according to the example 10 is different from the glass antenna according to the example 9 in the direction in which the folded portion 56 is folded back from the horizontal wire 52D.

[0157] The glass antenna according to the example 10 is formed of the first antenna 10 and the second antenna 50. The first antenna 10 includes the first power feeding point 15, the first element 11, the second element, the third element 31, and the auxiliary elements 12 and 13. The second element is formed of the main body portion 21 and the folded portion 22. The second antenna 50 includes the plurality of horizontal wires 52, the plurality of vertical wires 53, the second power feeding point 54, and the folded portion 56.

[0158] The folded portion 56 is provided at the right end of the horizontal wire 52D of the second antenna 50. The folded portion 56 extends in the upward direction from the right end of the horizontal wire 52D, is folded back in the leftward direction, and extends in the leftward direction along and in proximity to the horizontal wire 52D (for example, in parallel with the horizontal wire 52D with a spacing of 5 millimeters).

[0159] It should be noted that the defogger is not illustrated in FIG. 10, but the defogger 90 may be provided so as to be capacitively coupled to the auxiliary element 12 or may not be provided.

[0160] Components of the example 10 other than the above-mentioned components are the same as those of the example 9, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0161] In the example 10, the folded portion 56 is formed by upwardly folding back the horizontal wire 52. Therefore, it is possible to improve the sensitivity of the first antenna 10 in the FM radio broadcast band (in particular, middle band).

< Example 11 >

[0162] FIG. 11 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 11 of this invention.

[0163] A glass antenna according to the example 11 is different from the glass antenna according to the example 10 in that the folded portion 56 is capacitively coupled to the body flange 2.

[0164] The glass antenna according to the example 11 is formed of the first antenna 10 and the second antenna 50. The first antenna 10 includes the first power feeding point 15, the first element 11, the second element, the third element 31, and the auxiliary elements 12 and 13. The second element is formed of the main body portion

21 and the folded portion 22. The second antenna 50 includes the plurality of horizontal wires 52, the plurality of vertical wires 53, the second power feeding point 54, and the folded portion 56.

[0165] The folded portion 56 is provided at a right end of the uppermost horizontal wire 52F of the second antenna 50. The folded portion 56 extends in the upward direction from the right end of the horizontal wire 52F, is folded back in the leftward direction, and extends in the leftward direction along and in proximity to the horizontal wire 52F (for example, in parallel with the horizontal wire 52F with a spacing of 5 millimeters). The folded portion 56 is arranged in proximity to the body flange 2 of the vehicle body (for example, in parallel with the body flange 2 with a spacing of 5 millimeters), and is capacitively coupled to the body flange (that is, ground).

[0166] It should be noted that the defogger is not illustrated in FIG. 11, but the defogger 90 may be provided so as to be capacitively coupled to the auxiliary element 12 or may not be provided.

[0167] Components of the example 11 other than the above-mentioned components are the same as those of the example 9, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0168] In the example 11, the folded portion 56 is capacitively coupled to the body flange 2. Therefore, it is possible to improve the sensitivity of the first antenna 10 in the FM radio broadcast band (in particular, middle band) by adjusting the length of the folded portion 56 and a spacing from the body flange 2.

< Example 12>

[0169] FIG. 12 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 12 of this invention.

[0170] A glass antenna according to the example 12 is different from the glass antenna according to the example 11 in that the glass antenna according to the example 12 includes the two folded portions 56 and 57.

[0171] The glass antenna according to the example 12 is formed of the first antenna 10 and the second antenna 50. The first antenna 10 includes the first power feeding point 15, the first element 11, the second element, the third element 31, and the auxiliary elements 12 and 13. The second element is formed of the main body portion 21 and the folded portion 22. The second antenna 50 includes the plurality of horizontal wires 52, the plurality of vertical wires 53, the second power feeding point 54, and the folded portions 56 and 57.

[0172] The folded portion 56 is provided at the right end of the uppermost horizontal wire 52F of the second antenna 50. The folded portion 56 extends in the upward direction from the right end of the horizontal wire 52F, is folded back in the leftward direction, and extends in the leftward direction along and in proximity to the horizontal wire 52F (for example, in parallel with the horizontal wire

52F with a spacing of 5 millimeters). Further, the folded portion 57 is provided at a midpoint of the horizontal wire 52F. The folded portion 57 extends in the upward direction from the horizontal wire 52F, is folded back in the leftward direction, and extends along and in proximity to the horizontal wire 52F (for example, in parallel with the horizontal wire 52F with a spacing of 5 millimeters). The folded portions 56 and 57 are arranged in proximity to the body flange 2 of the vehicle body (for example, in parallel with the body flange 2 with a spacing of 5 millimeters), and are capacitively coupled to the body flange 2 (that is, ground).

[0173] It should be noted that the number of folded portions may be one as illustrated in FIG. 11, may be two as illustrated in FIG. 12, or may be equal to or larger than three.

[0174] It should be noted that the defogger is not illustrated in FIG. 12, but the defogger 90 may be provided so as to be capacitively coupled to the auxiliary element 12 or may not be provided.

[0175] Components of the example 12 other than the above-mentioned components are the same as those of the example 9, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0176] In the example 12, the two folded portions 56 and 57 are capacitively coupled to the body flange 2, and hence it is possible to widen an adjustment range of the antenna characteristics.

< Example 13 >

[0177] FIG. 13 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 13 of this invention.

[0178] A glass antenna according to the example 13 is different from the glass antenna according to the example 12 in that the glass antenna according to the example 13 includes the auxiliary wire 58.

[0179] The glass antenna according to the example 13 is formed of the first antenna 10 and the second antenna 50. The first antenna 10 includes the first power feeding point 15, the first element 11, the second element, the third element 31, and the auxiliary elements 12 and 13. The second element is formed of the main body portion 21 and the folded portion 22. The second antenna 50 includes the plurality of horizontal wires 52, the plurality of vertical wires 53, the second power feeding point 54, the folded portions 56 and 57, and the auxiliary wire 58.

[0180] The auxiliary wire 58 extends from the second power feeding point 54 outward (in the direction opposite to the extending direction of the horizontal wire 52), is bent downward, and extends along the third element 31. The auxiliary wire 58 may extend outward (in the direction opposite to the extending direction of the horizontal wire 52) linearly.

[0181] Further, the folded portion 57 according to the example 13 extends in the upward direction from an in-

tersection point of the horizontal wire 52F and the vertical wire 53, is folded back in the leftward direction, and extends along and in proximity to the horizontal wire 52F (for example, in parallel with the horizontal wire 52F with a spacing of 5 millimeters).

[0182] It should be noted that a position of the horizontal wire 52F from which the folded portion extends may be the intersection point of the horizontal wire 52F and the vertical wire 53 as illustrated in FIG. 13, or may be another position as illustrated in FIG. 12, as long as the position falls on the horizontal wire 52F.

[0183] It should be noted that the defogger is not illustrated in FIG. 13, but the defogger 90 may be provided so as to be capacitively coupled to the auxiliary element 12 or may not be provided.

[0184] Components of the example 13 other than the above-mentioned components are the same as those of the example 9, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0185] In the example 13, the auxiliary wire 58 extending from the second power feeding point 54 in the direction opposite to the extending direction of the horizontal wire 52 is provided. Therefore, by adjusting the length and the extending direction of the auxiliary wire 58, it is possible to change the characteristics of the second antenna 50, and to improve the sensitivity of the first antenna 10 in the FM radio broadcast band (in particular, middle band).

< Example 14 >

[0186] FIG. 14 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 14 of this invention.

[0187] A glass antenna according to the example 14 is different from the glass antenna according to the example 13 in that the glass antenna according to the example 14 includes the third antenna 60.

[0188] The glass antenna according to the example 14 is formed of the first antenna 10, the second antenna 50, and the third antenna 60. The first antenna 10 includes the first power feeding point 15, the first element 11, the second element, the third element 31, and the auxiliary elements 12 and 13. The second element is formed of the main body portion 21 and the folded portion 22. The second antenna 50 includes the plurality of horizontal wires 52, the plurality of vertical wires 53, the second power feeding point 54, the folded portions 56 and 57, and the auxiliary wire 58. The third antenna 60 includes the two horizontal elements 61 and 62 arranged along each other and the third power feeding point 63, and is adjusted to have a length suitable to receive at least one broadcast wave of the FM radio broadcast band, the TV broadcast band, and DAB Band III.

[0189] The third antenna 60 is arranged in a position spaced apart from the first antenna 10, and forms the diversity antenna with the first antenna 10 to diversity-

receive the FM radio broadcast.

[0190] It should be noted that the defogger 90 is illustrated in FIG. 14, but the defogger 90 may not be provided. The defogger 90 includes the pair of bus bars 93 provided on the left and right of the rear glass 1, the plurality of heating wires 91 connecting the two bus bars 93 to each other, and the vertical wire 92 connecting the plurality of heating wires 91 to one another. The number of vertical wires 92 may be one or a plurality.

[0191] The auxiliary element 12 is arranged along and in proximity to the defogger 90 so as to be capacitively coupled to the uppermost heating wire 91 of the defogger 90. Therefore, the broadcast wave received by the heating wire 91 can be guided to the first antenna 10, and it is possible to improve the sensitivity of the antenna.

[0192] Components of the example 14 other than the above-mentioned components are the same as those of the example 13, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0193] In the example 14, the diversity reception is effected by the first antenna 10 and the third antenna 60. Therefore, it becomes easy to receive the arrival wave, and it is possible to improve the reception performance.

< Example 15 >

[0194] FIG. 15 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 15 of this invention.

[0195] A glass antenna according to the example 15 is different from the glass antenna according to the example 14 in that the defogger 90 functions as a third antenna.

[0196] The glass antenna according to the example 15 is formed of the first antenna 10, the second antenna 50, and the third antenna 60. The defogger 90 functions as the third antenna 60 as described later.

[0197] The first antenna 10 includes the first power feeding point 15, the first element 11, the second element, the third element 31, and the auxiliary elements 12 and 13. The second element is formed of the main body portion 21 and the folded portion 22. The second antenna 50 includes the plurality of horizontal wires 52, the plurality of vertical wires 53, the second power feeding point 54, the folded portions 56 and 57, and the auxiliary wire 58.

[0198] The defogger 90 functioning as the third antenna 60 includes the pair of bus bars 93 provided on the left and right of the rear glass 1, the plurality of heating wires 91 connecting the two bus bars 93 to each other, and the vertical wire 92 connecting the plurality of heating wires 91 to one another. The number of vertical wires 92 may be one or a plurality. The defogger 90 according to the example 15 functions as the third antenna, and hence the heating wire 91 and the vertical wire 92 that form the defogger 90 function as the horizontal wire and the vertical wire, respectively, in the third antenna 60.

[0199] The defogger coils 94 and the third power feeding point 95 are provided to the bus bars 93. In other words, one bus bar 93 is connected to the power supply via the defogger coil 94, and the other bus bar 93 is connected to the ground via the defogger coil 94. By the defogger coils 94, noise in a received frequency band flowing into the third antenna 60 from the power supply and the ground is suppressed. Further, the third power feeding point 95 is provided to one of the bus bars 93 (for example, on a power supply side). The third power feeding point 95 is connected to the reception amplifier through the connecting line (for example, low voltage cable for automobile), and the reception amplifier is connected to the receiver by the high-frequency cable (for example, coaxial cable). Further, the reception amplifier is connected to the ground (vehicle body).

[0200] The defogger coil 94 and the third power feeding point 95 are arranged in a central portion of the bus bar 93 so that the defogger coil 94 is positioned on the upper side and the third power feeding point 95 is positioned on the lower side, but the defogger coil 94 and the third power feeding point 95 may be arranged in any positions on the bus bar 93. In addition, an arrangement order (vertical positional relationship) of the defogger coil 94 and the third power feeding point 95 is not limited to the order illustrated in FIG. 15.

[0201] When the third antenna 60 (defogger 90) receives the broadcast wave of DAB Band III, a power feeding point may be provided separately from the power feeding point for extracting a received FM radio broadcast wave. In this case, the power feeding point for an FM radio broadcast wave and the power feeding point for a DAB broadcast wave may be provided to the bus bars 93 different from (opposed to) each other.

[0202] The third antenna 60 forms a diversity antenna with the first antenna 10 to diversity-receive at least one broadcast wave of the FM radio broadcast and DAB Band III broadcast.

[0203] The auxiliary element 12 is arranged along and in proximity to the defogger 90 so as to be capacitively coupled to the uppermost heating wire 91 of the defogger 90.

[0204] Components of the example 15 other than the above-mentioned components are the same as those of the example 14, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0205] In the example 15, the third antenna 60 is formed of the wires 91 and 92 of the defogger 90. Therefore, an antenna element does not need to be provided separately, and it is possible to suppress deterioration in an appearance. Further, the third power feeding point 95 is provided to the bus bar 93, and hence the power feeding point for the radio-frequency signal and the power feeding point for the heating wire can be shared. Further, the bus bar 93 is connected to the power supply and the ground via the defogger coil 94, and hence the bus bar 93 can be connected to the power supply and the ground in terms of a direct current, and can be floated from the

power supply and the ground in terms of a high frequency.

< Example 16 >

[0206] FIG. 16 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 16 of this invention.

[0207] A glass antenna according to the example 16 is different from the glass antenna according to the example 15 in that the auxiliary wires 96, 97, and 98 extending from the lowermost horizontal wire 91 of the third antenna 60 are provided. Further, the glass antenna according to the example 16 is different from the glass antenna according to the example 15 in that the configuration of the example 2 is employed for the first antenna 10.

[0208] The glass antenna according to the example 16 is formed of the first antenna 10 and the third antenna 60. It should be noted that in FIG. 16, only the first antenna 10 and the third antenna 60 (defogger 90) are illustrated, but the second antenna 50 according to another example described above may be provided, and the second antenna 50 and the body flange 2 may be capacitively coupled to each other.

[0209] The first antenna 10 includes the first power feeding point 15, the first element 11, and the second element. The second element is formed of the main body portion 21 and the folded portion 22. It should be noted that the configuration of the first antenna is not limited to the configuration illustrated in FIG. 16, and the configuration of any one of the examples described above may be employed. For example, the first antenna 10 may include the auxiliary element 12 that is capacitively coupled to the uppermost horizontal wire 91 of the third antenna 60.

[0210] The defogger 90 functioning as the third antenna 60 includes the pair of bus bars 93 provided on the left and right of the rear glass 1, the plurality of heating wires 91 connecting the two bus bars 93 to each other, and the parallel auxiliary wires 96, 97, and 98 extending from the lowermost heating wire 91. The defogger 90 may include at least one vertical wire 92 connecting the plurality of heating wires 91 to one another. The defogger 90 according to the example 16 functions as the third antenna, and hence the heating wire 91 that forms the defogger 90 functions as the horizontal wire of the third antenna 60. The defogger coils 94 and the third power feeding point 95 are provided to the bus bars 93.

[0211] The parallel auxiliary wire 96 is arranged so as to extend downward from the lowermost horizontal wire 91, and extend along the horizontal wire 91 in the leftward direction. The parallel auxiliary wire 97 is arranged so as to extend from the midpoint of the parallel auxiliary wire 96 substantially horizontally in the leftward direction, be then bent downward, and further extend along the horizontal wire 91 in the leftward direction. The parallel auxiliary wire 98 is arranged so as to extend downward from the lowermost horizontal wire 91, and extend along the

horizontal wire 91 in the rightward direction.

[0212] The end portions of the respective parallel auxiliary wires 96, 97, and 98 are in positions spaced apart from one another. Further, a part of the parallel auxiliary wire 96 and a part of the parallel auxiliary wire 97 are arranged along, in proximity to, and in substantially parallel with each other. In addition, a part of the parallel auxiliary wire 97 and a part of the parallel auxiliary wire 98 are arranged along, in proximity to, and in substantially parallel with each other. In this manner, two of the respective parallel auxiliary wires 96, 97, and 98 are arranged with an overlap (part indicated by the broken line), and the respective parallel auxiliary wires are thus capacitively coupled to each other at the end portions. It should be noted that not parts of but almost all of the parallel auxiliary wires may be arranged along and in proximity to each other.

[0213] It should be noted that the number of auxiliary wires extending along the horizontal wire 91 may be two as illustrated in FIG. 17, may be three as illustrated in FIG. 16 and FIG. 18, or may be equal to or larger than four. The position of the defogger 90 from which each of the parallel auxiliary wires 96, 97, and 98 extends may be a position in the bus bar 93 as illustrated in FIG. 17, or may be a position in the horizontal wire 91 as illustrated in FIG. 16 and FIG. 18.

[0214] Components of the example 16 other than the above-mentioned components are the same as those of the example 15, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0215] In the example 16, the parallel auxiliary wires 96, 97, and 98 two of which are arranged along and in proximity to each other are provided. Therefore, by adjusting the width and the length of the overlap between the parallel auxiliary wires, it is possible to improve the sensitivity of the third antenna 60 and to improve the sensitivity of another antenna with which a diversity is formed.

< Example 17 >

[0216] FIG. 17 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 17 of this invention.

[0217] A glass antenna according to the example 17 is different from the glass antenna according to the example 15 in that the auxiliary wires 96 and 98 extending from bus bars are provided.

[0218] The glass antenna according to the example 17 is formed of the first antenna 10 and the third antenna 60. It should be noted that in FIG. 17, only the first antenna 10 and the third antenna 60 (defogger 90) are illustrated, but the second antenna 50 according to another example described above may be provided, and the second antenna 50 and the body flange 2 may be capacitively coupled to each other.

[0219] The first antenna 10 includes the first power

feeding point 15, the first element 11, and the second element. The second element is formed of the main body portion 21 and the folded portion 22. It should be noted that the configuration of the first antenna is not limited to the configuration illustrated in FIG. 17, and the configuration of any one of the examples described above may be employed.

[0220] The defogger 90 functioning as the third antenna 60 includes the pair of bus bars 93 provided on the left and right of the rear glass 1, the plurality of heating wires 91 connecting the two bus bars 93 to each other, and the parallel auxiliary wires 96 and 98 extending from the bus bars 93. The defogger coils 94 and the third power feeding point 95 are provided to the bus bars 93.

[0221] The parallel auxiliary wire 96 is arranged so as to extend downward from the bus bar 93 on the right side, and extend along the horizontal wire 91 in the leftward direction. The parallel auxiliary wire 98 is arranged so as to extend downward from the bus bar 93 on the left side, and extend along the horizontal wire 91 in the rightward direction. The end portions of the respective parallel auxiliary wires 96 and 98 are in positions spaced apart from each other. Further, a part of the parallel auxiliary wire 96 and a part of the parallel auxiliary wire 98 are arranged along, in proximity to, and in substantially parallel with each other. In this manner, two of the respective parallel auxiliary wires 96 and 98 are arranged with an overlap (part indicated by the broken line), and the respective parallel auxiliary wires are thus capacitively coupled to each other at the end portions. It should be noted that not parts of but almost all of the parallel auxiliary wires may be arranged along and in proximity to each other.

[0222] Components of the example 17 other than the above-mentioned components are the same as those of the example 16, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0223] In the example 17, the parallel auxiliary wires 96 and 98 extend from the bus bars 93. Therefore, by increasing the lengths of the parallel auxiliary wires and increasing the length of the overlap between the parallel auxiliary wires, it is possible to widen the adjustment range.

< Example 18 >

[0224] FIG. 18 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 18 of this invention.

[0225] A glass antenna according to the example 18 is different from the glass antenna according to the example 15 in that the auxiliary wires 96, 97, 98 and 89 extending from a bus bar are provided, and that the fourth antenna 70 is provided.

[0226] The glass antenna according to the example 18 is formed of the first antenna 10, the third antenna 60, and the fourth antenna 70. It should be noted that in FIG. 18, only the first antenna 10, the third antenna 60 (de-

fogger 90), and the fourth antenna 70 are illustrated, but the second antenna 50 according to another example described above may be provided, and the second antenna 50 and the body flange 2 may be capacitively coupled to each other.

[0227] The first antenna 10 includes the first power feeding point 15, the first element 11, and the second element. The second element is formed of the main body portion 21 and the folded portion 22. It should be noted that the configuration of the first antenna is not limited to the configuration illustrated in FIG. 18, and the configuration of any one of the examples described above may be employed. For example, the first antenna 10 may include the auxiliary element 12 that is capacitively coupled to the uppermost horizontal wire 91 of the third antenna 60.

[0228] The defogger 90 functioning as the third antenna 60 includes the pair of bus bars 93 provided on the left and right of the rear glass 1, the plurality of heating wires 91 connecting the two bus bars 93 to each other, and the parallel auxiliary wires 96, 97, and 98 and the auxiliary wire 89 extending from the bus bars 93. The defogger coils 94 and the third power feeding point 95 are provided to the bus bars 93.

[0229] The parallel auxiliary wire 96 is arranged so as to extend downward from the bus bars 93, and extend along the horizontal wire 91 in the leftward direction. The parallel auxiliary wire 97 is arranged so as to extend from the midpoint of the parallel auxiliary wire 96 substantially horizontally in the leftward direction, be then bent downward, and further extend along the horizontal wire 91 in the leftward direction. The parallel auxiliary wire 98 is arranged so as to extend downward from the bus bars 93, and extend along the horizontal wire 91 in the rightward direction.

[0230] The end portions of the respective parallel auxiliary wires 96, 97, and 98 are in positions spaced apart from one another. Further, a part of the parallel auxiliary wire 96 and a part of the parallel auxiliary wire 97 are arranged along, in proximity to, and in substantially parallel with each other. In addition, a part of the parallel auxiliary wire 97 and a part of the parallel auxiliary wire 98 are arranged along, in proximity to, and in substantially parallel with each other. In this manner, two of the respective parallel auxiliary wires 96, 97, and 98 are arranged with an overlap (part indicated by the broken line), and the respective parallel auxiliary wires are thus capacitively coupled to each other at the end portions. It should be noted that not parts of but almost all of the parallel auxiliary wires may be arranged along and in proximity to each other.

[0231] The auxiliary wire 89 extends upward from the bus bar 93 on the right side (to which the third power feeding point 95 is provided), and is bent in the leftward direction to further extend. The auxiliary wire 89 may extend from the horizontal wire 91 on the outermost side. The auxiliary wire 89 may be bent in the rightward direction instead of being bent in the leftward direction, or may

merely extend in the upward direction without being bent.

[0232] In addition, the auxiliary wire 89 may extend in the downward direction from the defogger 90 (bus bar 93 and lowermost horizontal wire 91), and may extend along the horizontal wire 91. In this case, the auxiliary wire 89 functions as the parallel auxiliary wire.

[0233] The auxiliary wire 89 may extend downward from the bus bar 93 on the right side, or may extend upward or downward from the bus bar 93 on the left side. In particular, when the auxiliary wire 89 is connected to a lower edge of the bus bar 93 to which the third power feeding point 95 is provided, it is possible to improve the sensitivity in DAB Band III having a high frequency. When the auxiliary wire 89 is connected to an upper edge of the bus bar 93, on the other hand, it is possible to improve the sensitivity of the antenna for television broadcast reception provided separately (in particular, VHF-High-band of from 170 MHz to 230 MHz).

[0234] The fourth antenna 70 is formed of the fourth power feeding point 71 and the horizontal element 72, and is adjusted to have a length suitable to receive the TV broadcast band (from 470 MHz to 770 MHz). In this case, the third antenna 60 and the fourth antenna 70 may form a diversity antenna to diversity-receive the TV broadcast. The fourth power feeding point 71 is connected to the reception amplifier through the connecting line (for example, low voltage cable for automobile), and the reception amplifier is connected to the receiver by the high-frequency cable (for example, coaxial cable). Further, the reception amplifier is connected to the ground (vehicle body).

[0235] When the auxiliary wire 89 is bent in the leftward direction or the rightward direction, the end portion of the auxiliary wire 89 may be arranged in proximity to the fourth antenna 70.

[0236] Components of the example 18 other than the above-mentioned components are the same as those of the example 16, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0237] In the example 18, the auxiliary wire 89 is provided to the third antenna 60, and hence it is possible to improve the sensitivity of the third antenna 60. Further, the auxiliary wire 89 is arranged in proximity to the fourth antenna 70, and hence it is possible to improve the sensitivity of the antenna (for example, fourth antenna 70) provided around the third antenna 60.

< Example 19 >

[0238] FIG. 19 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 19 of this invention.

[0239] A glass antenna according to the example 19 is different from the glass antenna according to the example 18 in that the third antenna 60 (defogger 90) includes the vertical wire 92.

[0240] The glass antenna according to the example 19

is formed of the first antenna 10, the third antenna 60, and the fourth antenna 70. It should be noted that in FIG. 19, only the first antenna 10, the third antenna 60 (defogger 90), and the fourth antenna 70 are illustrated, but the second antenna 50 according to another example described above may be provided, and the second antenna 50 and the body flange 2 may be capacitively coupled to each other.

[0241] The first antenna 10 includes the first power feeding point 15, the first element 11, and the second element. The second element is formed of the main body portion 21 and the folded portion 22. It should be noted that the configuration of the first antenna is not limited to the configuration illustrated in FIG. 19, and the configuration of any one of the examples described above may be employed. For example, the first antenna 10 may include the auxiliary element 12 that is capacitively coupled to the uppermost horizontal wire 91 of the third antenna 60.

[0242] The defogger 90 functioning as the third antenna 60 includes the bus bars 93, the heating wires 91, the vertical wires 92, the parallel auxiliary wires 96, 97, and 98, and the auxiliary wire 89. The defogger 90 according to the example 19 functions as the third antenna, and hence the heating wire 91 and the vertical wire 92 that form the defogger 90 function as the horizontal wire and the vertical wire of the third antenna 60, respectively. The number of vertical wires 92 is not limited to three as illustrated in FIG. 19, and may be one, two, or equal to or larger than four. The defogger coils 94 and the third power feeding point 95 are provided to the bus bars 93.

[0243] The fourth antenna 70 is formed of the fourth power feeding point 71 and the horizontal element 72, and is adjusted to have a length suitable to receive the TV broadcast band (from 470 MHz to 770 MHz).

[0244] Components of the example 19 other than the above-mentioned components are the same as those of the example 18, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0245] In the example 19, the vertical wire 92 connecting the horizontal wires 91 to each other is provided, and hence it is possible to improve the sensitivity of the third antenna 60.

< Example 20 >

[0246] FIG. 20 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 20 of this invention.

[0247] A glass antenna according to the example 20 is different from the glass antenna according to the example 19 in that the third antenna 60 (defogger 90) includes the horizontal auxiliary wire 99.

[0248] The glass antenna according to the example 20 is formed of the first antenna 10, the third antenna 60, and the fourth antenna 70. It should be noted that in FIG. 20, only the first antenna 10, the third antenna 60 (de-

fogger 90), and the fourth antenna 70 are illustrated, but the second antenna 50 according to another example described above may be provided, and the second antenna 50 and the body flange 2 may be capacitively coupled to each other.

[0249] The first antenna 10 includes the first power feeding point 15, the first element 11, and the second element. The second element is formed of the main body portion 21 and the folded portion 22. It should be noted that the configuration of the first antenna is not limited to the configuration illustrated in FIG. 20, and the configuration of any one of the examples described above may be employed. For example, the first antenna 10 may include the auxiliary element 12 that is capacitively coupled to the uppermost horizontal wire 91 of the third antenna 60.

[0250] The defogger 90 functioning as the third antenna 60 includes the bus bars 93, the heating wires 91, the vertical wires 92, the parallel auxiliary wires 96, 97, and 98, the auxiliary wire 89, and the horizontal auxiliary wire 99. The defogger coils 94 and the third power feeding point 95 are provided to the bus bars 93.

[0251] The horizontal auxiliary wire 99 is formed of a horizontal portion extending downward from the lowermost horizontal wire 91, and extending both leftward and rightward from the center of the defogger along the horizontal wire 91.

[0252] The fourth antenna 70 is formed of the fourth power feeding point 71 and the horizontal element 72, and is adjusted to have a length suitable to receive the TV broadcast band (from 470 MHz to 770 MHz).

[0253] Components of the example 20 other than the above-mentioned components are the same as those of the example 19, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0254] In the example 20, the horizontal auxiliary wire 99 extending from the end portion of the vertical wire 92 along the horizontal wire 91 is provided, and hence the end portion of the horizontal auxiliary wire 99 is not connected to the defogger 90. Therefore, it is possible to increase the degree of freedom for adjusting the antenna characteristics.

< Example 21 >

[0255] FIG. 21 is a front view of the glass antenna to be provided to the rear glass 1 of the automobile, for illustrating an antenna pattern according to an example 21 of this invention.

[0256] The glass antenna according to the example 21 is formed of the first antenna 10, the second antenna 50, the third antenna 60, the fourth antenna 70, and the fifth antenna 100.

[0257] The first antenna 10 includes the first power feeding point 15, the first element 11, the second element, the third element 31, and the auxiliary elements 12 and 13. The second element is formed of the main body portion 21 and the folded portion 22. The first an-

tenna 10 according to the example 21 has the same configuration as the configuration of the first antenna 10 according to the example 5 illustrated in FIG. 5, and hence a detailed description thereof is omitted.

[0258] The second antenna 50 includes the plurality of horizontal wires 52, the plurality of vertical wires 53, the second power feeding point 54, and the folded portions 56 and 57. The second antenna 50 according to the example 21 has the same configuration as the configuration of the second antenna 50 according to the example 12 illustrated in FIG. 12, and hence a detailed description thereof is omitted.

[0259] The left part of the horizontal wire 52B is arranged between the auxiliary element 13 of the first antenna 10 and the folded portion 22 along, in proximity to, and in substantially parallel with the auxiliary element 13 and along, in proximity to, and in substantially parallel with the folded portion 22. Therefore, the first antenna 10 and the second antenna 50 are capacitively coupled to each other. Further, the folded portions 56 and 57 are arranged in proximity to the body flange 2 of the vehicle body (for example, in parallel with the body flange 2 with a spacing of 5 millimeters), and the second antenna 50 and the body flange 2 (that is, ground) are capacitively coupled to each other.

[0260] The defogger 90 functioning as the third antenna 60 includes the bus bars 93, the heating wires 91, the vertical wires 92, the parallel auxiliary wires 96, 97, and 98, the auxiliary wire 89, and the horizontal auxiliary wire 99. The defogger coils 94 and the third power feeding point 95 are provided to the bus bars 93. The third antenna 60 according to the example 21 has the same configuration as the configuration of the third antenna 60 according to the example 20 illustrated in FIG. 20, and hence a detailed description thereof is omitted.

[0261] The fourth antenna 70 is formed of the fourth power feeding point 71, a plurality of horizontal elements 72, and a plurality of vertical elements 73, and is adjusted to have a length suitable to receive the TV broadcast band (from 470 MHz to 770 MHz).

[0262] The horizontal element 72 is arranged in proximity to the horizontal wires 52 of the second antenna 50, and the fourth antenna 70 and the second antenna 50 are capacitively coupled to each other. Further, the horizontal element 72 is arranged in proximity to the auxiliary wire 89 of the third antenna 60, and the fourth antenna 70 and the third antenna 60 are capacitively coupled to each other.

[0263] The fifth antenna 100 includes a fifth power feeding point, a plurality of vertical wires, and one horizontal wire. The fifth power feeding point is connected to the reception amplifier through the connecting line (for example, low voltage cable for automobile), and the reception amplifier is connected to the receiver by the high-frequency cable (for example, coaxial cable). Further, the reception amplifier 6 is connected to the ground (vehicle body).

[0264] The descriptions made below with reference to

FIG. 22 to FIG. 24 each relate to a sensitivity of an antenna exhibited when the arrangement or the length of an element described below is changed without changing the configuration of other elements. Further, the sensitivity of the antenna has a value obtained by measuring omnidirectional (360-degree) sensitivities of the antenna within a horizontal plane and calculating an average thereof.

[0265] FIG. 22 is an illustration of a gain (sensitivity) of the antenna in DAB Band III exhibited when the length of the folded portion 22 is changed in the antenna according to the example 21. The length of the main body portion 21 is fixed at 460 millimeters, and the spacing between the main body portion 21 and the folded portion 22 is fixed at 7 millimeters. In FIG. 22, a characteristic exhibited when the length of the folded portion 22 is set to 300 millimeters is indicated by the solid line, a characteristic exhibited when the length is set to 400 millimeters is indicated by the broken line, and a characteristic exhibited when the length is set to 200 millimeters is indicated by the one-dot chain line. According to FIG. 22, when the length of the folded portion 22 is set to 300 millimeters, the gain drops by a small amount on the high band side, and the antenna exhibits the highest average gain within the band. Therefore, it may be preferred that the length of the folded portion 22 be approximately $\alpha\lambda_2/4$. Here, λ_2 represents a wavelength (1.5 meters) of the center frequency of DAB Band III being 210 MHz.

[0266] FIG. 23 is an illustration of a gain (sensitivity) of the antenna in the FM radio broadcast band exhibited when the length of the main body portion 21 is changed in the antenna according to the example 21. The length of the folded portion 22 is fixed at 300 millimeters, and the spacing between the main body portion 21 and the folded portion 22 is fixed at 7 millimeters. In FIG. 23, a characteristic exhibited when the length of the main body portion 21 is set to 460 millimeters is indicated by the solid line, a characteristic exhibited when the length is set to 410 millimeters is indicated by the broken line, and a characteristic exhibited when the length is set to 510 millimeters is indicated by the one-dot chain line. According to FIG. 23, when the length of the main body portion 21 is set to 460 millimeters, the antenna has a flat characteristic within the band, and exhibits the highest average gain within the band. Therefore, it may be preferred that the length of the main body portion 21 be approximately $\alpha\lambda_1/5$. Here, λ_1 represents a wavelength (3.3 meters) of the center frequency of the FM radio broadcast band being 92 MHz.

[0267] FIG. 24 is an illustration of a gain (sensitivity) of the antenna in the FM radio broadcast band exhibited when the length of the first element 11 is changed in the antenna according to the example 21. The length of the vertical portion of the first element 11 is fixed at 20 millimeters. In FIG. 24, a characteristic exhibited when the length of the horizontal portion of the first element 11 is set to 400 millimeters is indicated by the solid line, a characteristic exhibited when the length is set to 350 millim-

eters is indicated by the broken line, and a characteristic exhibited when the length is set to 450 millimeters is indicated by the one-dot chain line. According to FIG. 24, when the length of the main body portion 21 is set to 400 millimeters, the antenna has a flat characteristic within the band. Therefore, it may be preferred that the length of the first element 11 be approximately $\alpha\lambda_1/6$.

[0268] While the present invention has been described in detail and pictorially in the accompanying drawings, the present invention is not limited to such detail but covers various obvious modifications and equivalent arrangements, which fall within the purview of the appended claims.

[0269] The present application claims priority from Japanese patent application JP 2014-12484 filed on January 27, 2014, the content of which is hereby incorporated by reference into this application.

Claims

1. A glass antenna arranged on a window glass for a vehicle, comprising a first antenna, wherein the first antenna includes:

- a first power feeding point connected to a receiver;
- a first element connected to the first power feeding point; and
- a second element connected to the first power feeding point,

the second element includes:

- a main body portion extending from the first power feeding point; and
- a folded portion connected to the main body portion, and

the folded portion is folded back from the main body portion and is arranged along the main body portion.

2. The glass antenna according to claim 1, wherein the folded portion is folded back from an end portion of the main body portion, and is arranged along and in proximity to the main body portion.

3. The glass antenna according to claim 1, wherein:

- the glass antenna is configured to receive signals on a first frequency band having a wavelength of a center frequency set as λ_1 and a second frequency band having a wavelength of a center frequency set as λ_2 ; and
- the folded portion has a length of approximately $\alpha\lambda_2/4$, the main body portion has a length of approximately $\alpha\lambda_1/5$, and the first element has a length of approximately $\alpha\lambda_1/6$, where α rep-

- resents a wavelength shortening rate of the window glass.
4. The glass antenna according to claim 1, wherein the first element and the main body portion of the second element extend in the same direction.
 5. The glass antenna according to claim 4, wherein the first antenna further includes a third element extending from the first power feeding point in a direction different from an extending direction of the first element and an extending direction of the main body portion of the second element.
 6. The glass antenna according to claim 1, wherein the first antenna further includes at least one of an auxiliary element extending from the first power feeding point and an auxiliary element extending from the first element.
 7. The glass antenna according to claim 6, wherein the at least one of the auxiliary elements is arranged in proximity to a heating wire on an outermost side of a defogger arranged on the window glass, and is capacitively coupled to the heating wire.
 8. The glass antenna according to claim 1, wherein the first antenna is arranged in proximity to a linear conductor arranged on the window glass, and is capacitively coupled to the linear conductor.
 9. The glass antenna according to claim 8, further comprising a second antenna, wherein the second antenna includes the linear conductor.
 10. The glass antenna according to claim 9, wherein:

the second antenna includes:

a plurality of horizontal wires;
at least one vertical wire connecting the plurality of horizontal wires to one another; and
a second power feeding point; and
the second antenna is configured to receive a signal on a third frequency band.
 11. The glass antenna according to claim 10, wherein the at least one vertical wire includes a plurality of vertical wires.
 12. The glass antenna according to claim 10, wherein at least one of the plurality of horizontal wires is arranged in proximity to the second element, and is capacitively coupled to the second element.
 13. The glass antenna according to claim 10, wherein at least one of the plurality of horizontal wires is arranged between the first element and the second element.
 14. The glass antenna according to claim 10, wherein at least one of the plurality of horizontal wires includes a folded portion having an end portion folded back toward one of an upper side and a lower side.
 15. The glass antenna according to claim 10, wherein:

the second power feeding point is provided to an end portion of any one of the plurality of horizontal wires; and
the second antenna further includes:

a wire for capacitive coupling that extends from an uppermost wire of the plurality of horizontal wires, and is arranged in a position capacitively coupled to a body flange; and
an auxiliary wire extending in a direction opposite to a direction in which the one of the plurality of horizontal wires extends from the second power feeding point.
 16. The glass antenna according to claim 1, further comprising a third antenna, wherein the first antenna and the third antenna compose a diversity antenna.
 17. The glass antenna according to claim 16, wherein:

the third antenna is composed by using a wire of a defogger arranged on the window glass as an antenna; and
the third antenna includes a third power feeding point provided to the defogger, the third power feeding point being connected to the receiver.
 18. The glass antenna according to claim 17, wherein:

the defogger includes:

a pair of bus bars provided on left and right of the window glass; and
a plurality of heating wires connecting the pair of bus bars to each other;
the third antenna includes:

a plurality of horizontal wires used for the plurality of heating wires; and
at least two parallel auxiliary wires that extend from one of: one of the bus bars; and one of the plurality of horizontal wires on an outermost side, and are arranged so that end portions of the at least two parallel auxiliary wires are spaced apart from each other; and
the at least two parallel auxiliary wires

are arranged along and in proximity to each other.

19. The glass antenna according to claim 18, wherein the third antenna further includes at least one auxiliary wire. 5
20. The glass antenna according to claim 18, wherein the third antenna further includes at least one vertical wire connecting the plurality of horizontal wires of the third antenna to one another. 10
21. The glass antenna according to claim 20, further comprising a horizontal auxiliary wire extending from an end portion of the at least one vertical wire along one of the plurality of horizontal wires. 15

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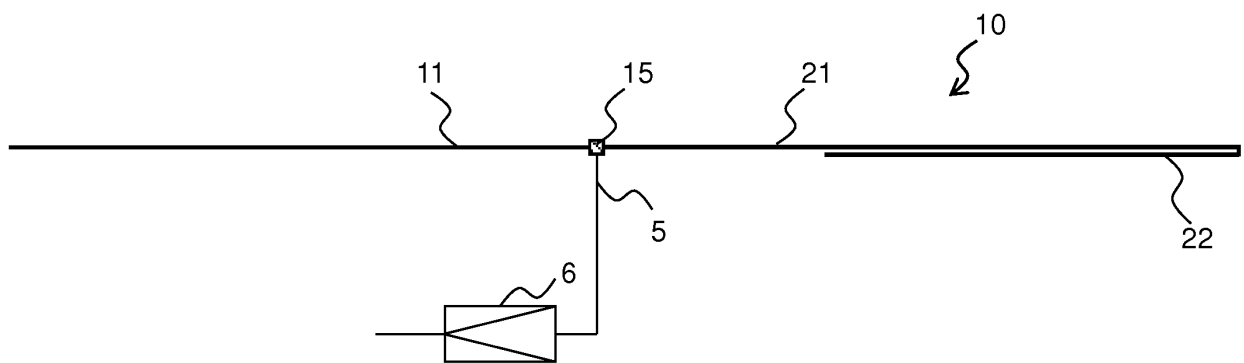


Fig. 1

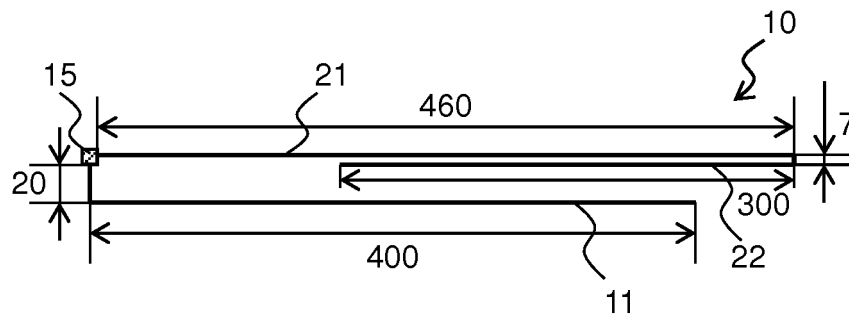


Fig. 2

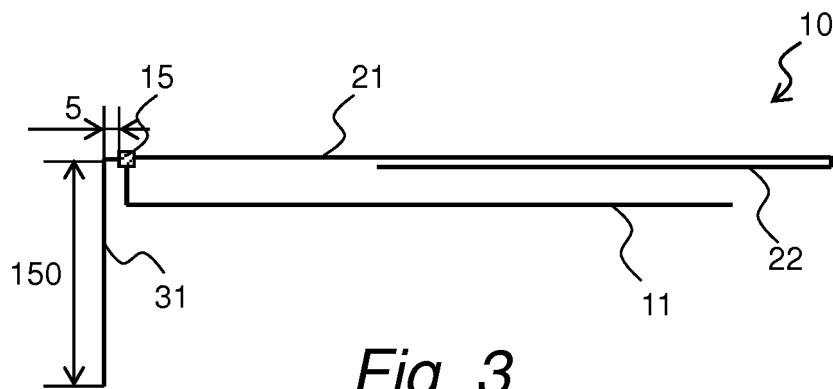


Fig. 3

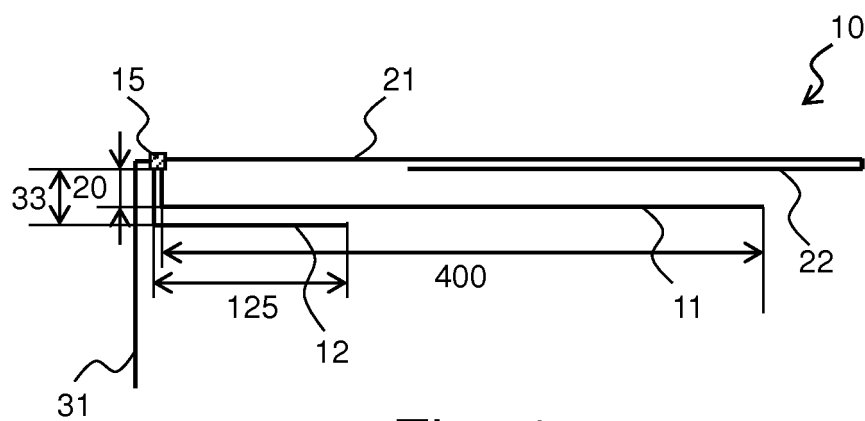


Fig. 4

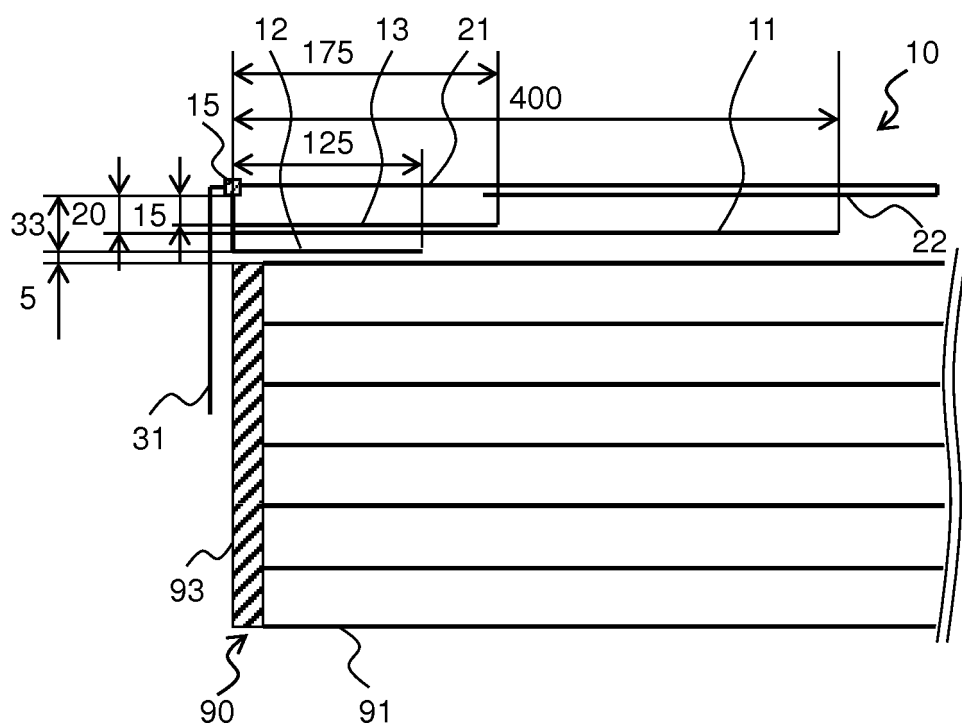


Fig. 5

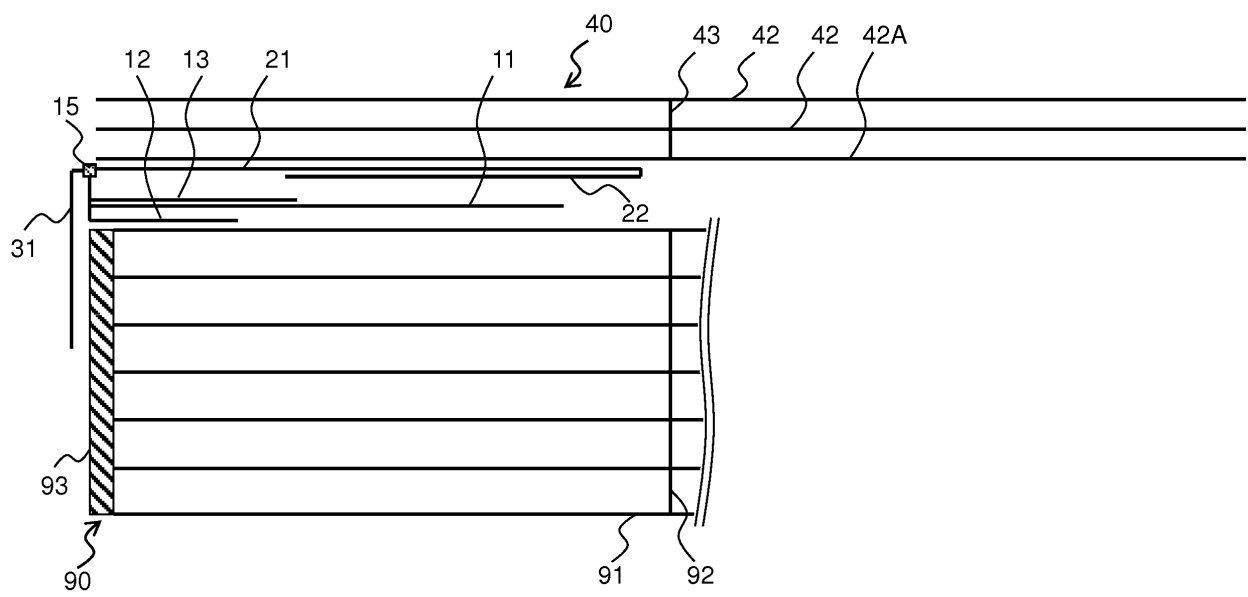


Fig. 6

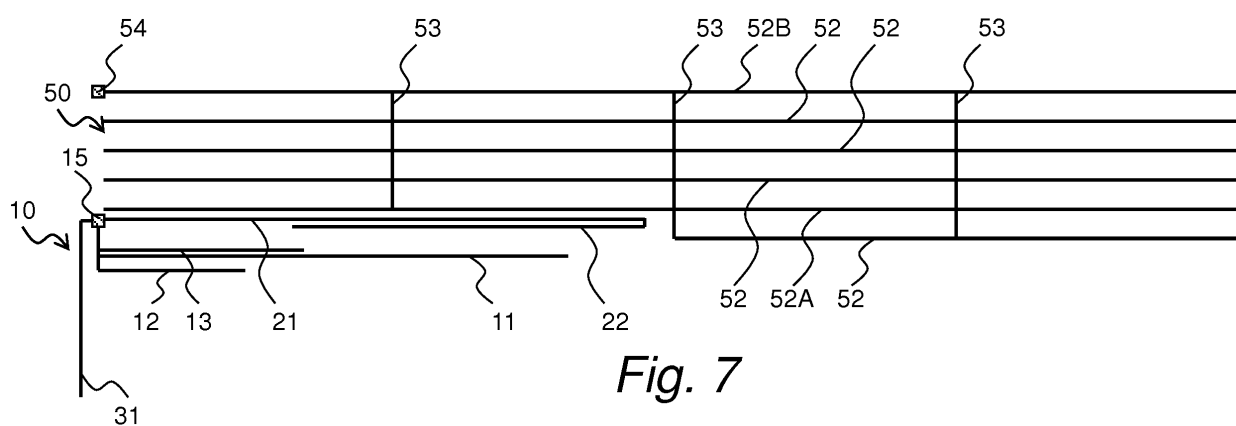


Fig. 7

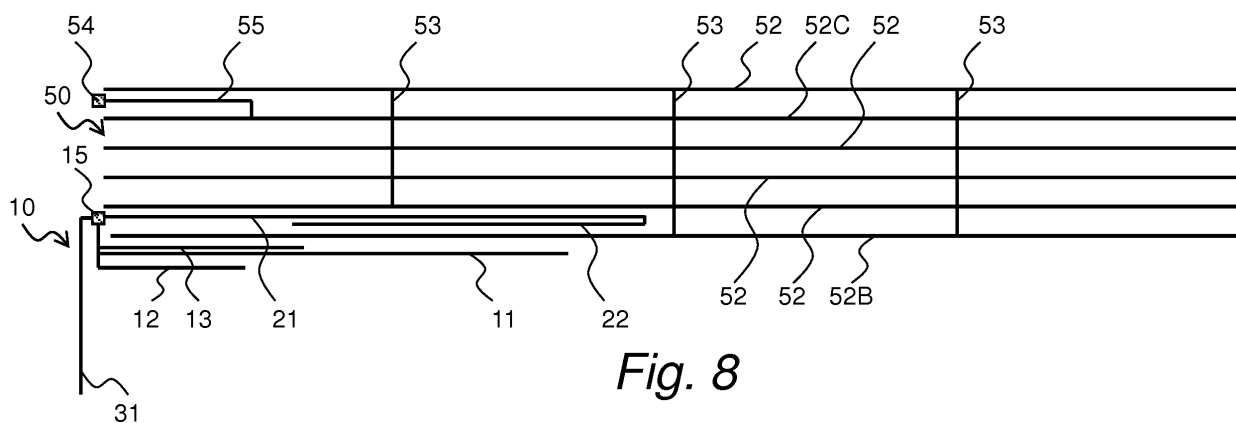


Fig. 8

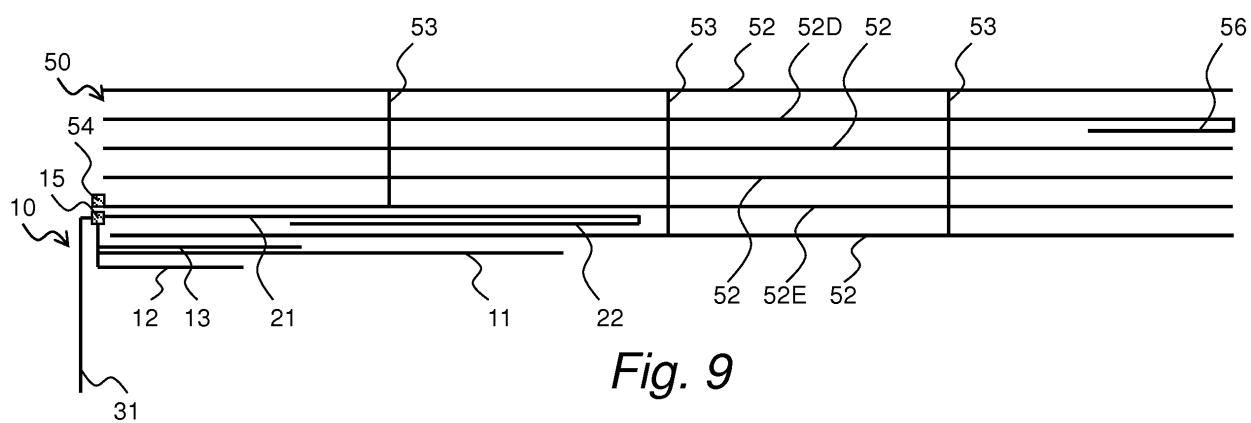


Fig. 9

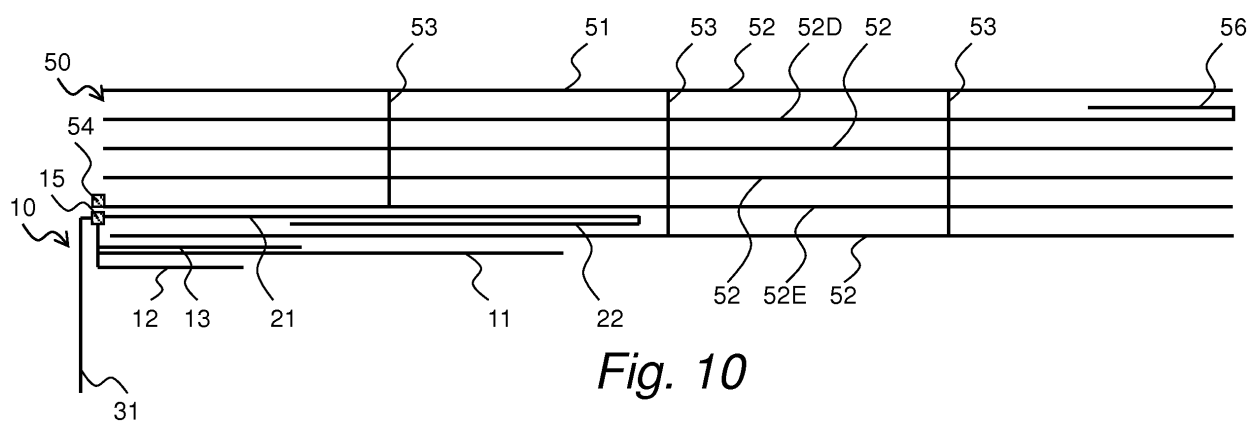


Fig. 10

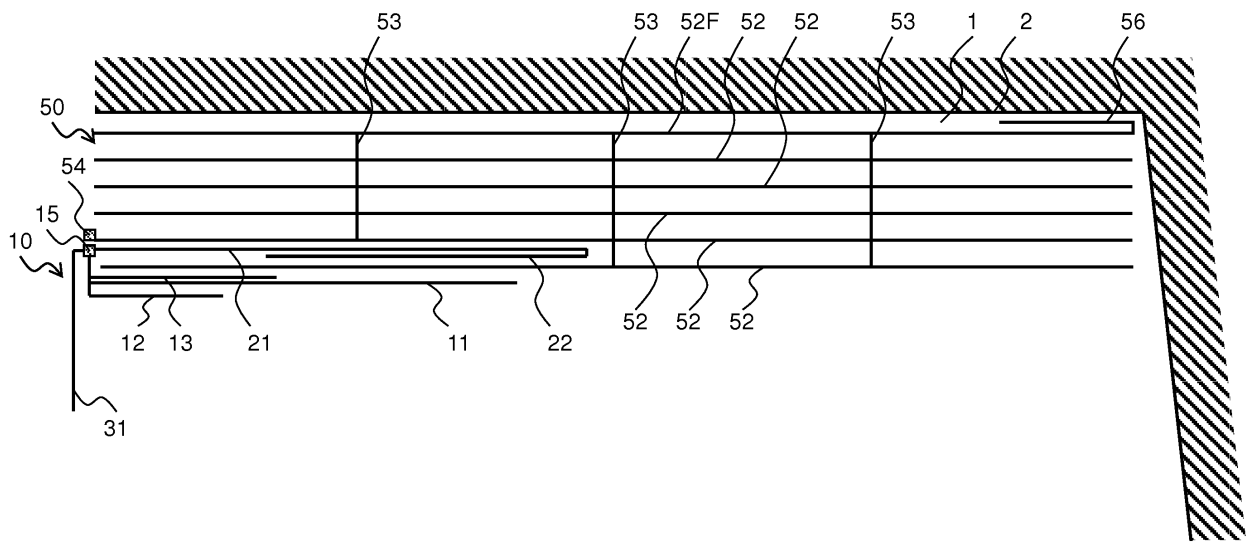


Fig. 11

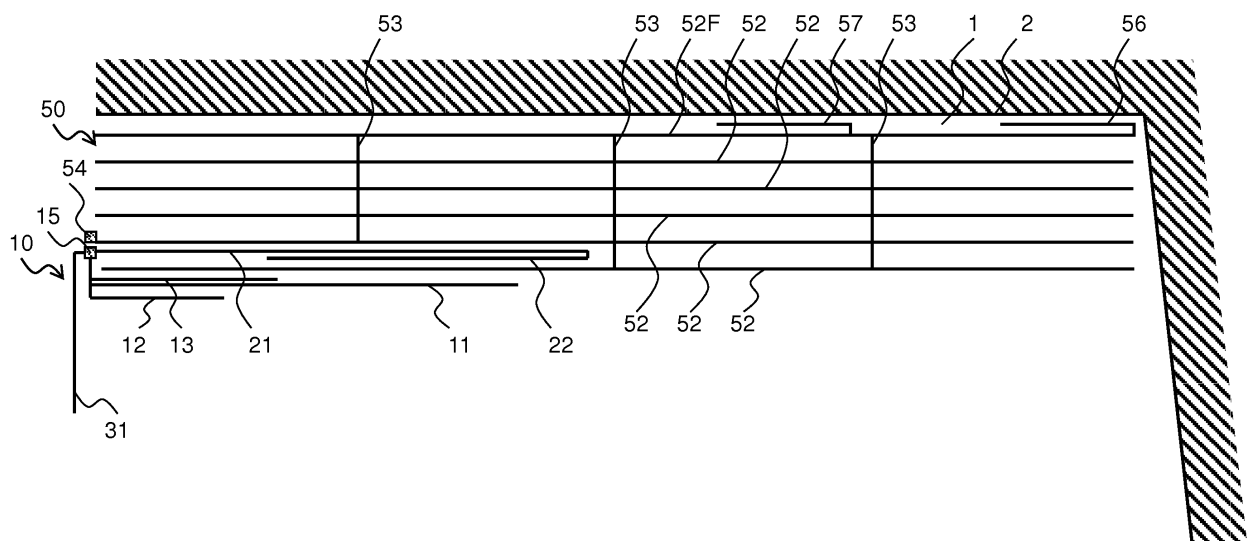


Fig. 12

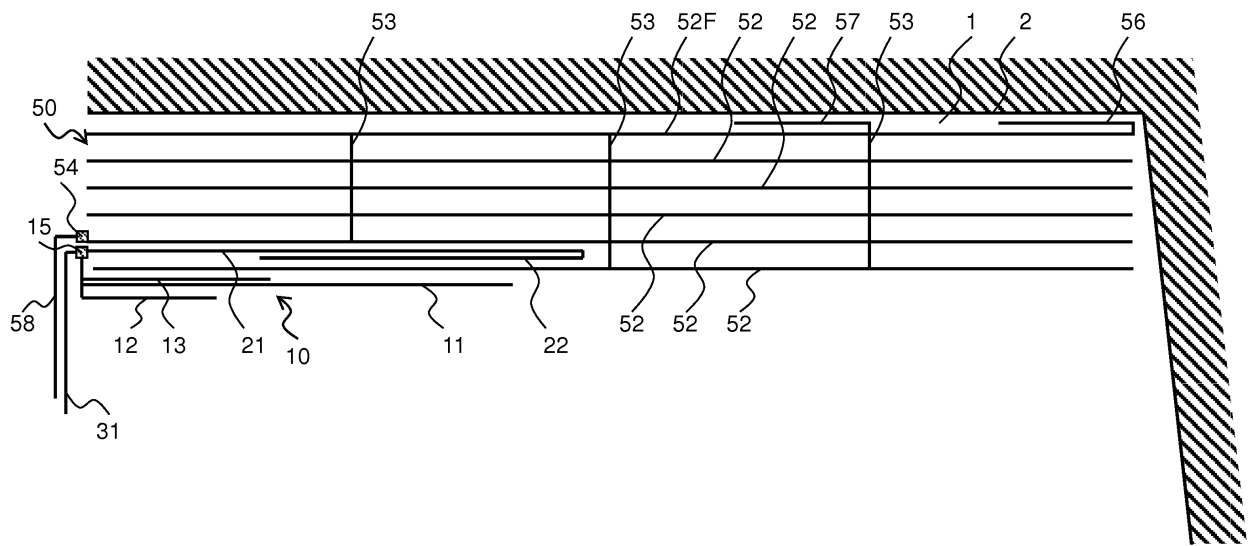


Fig. 13

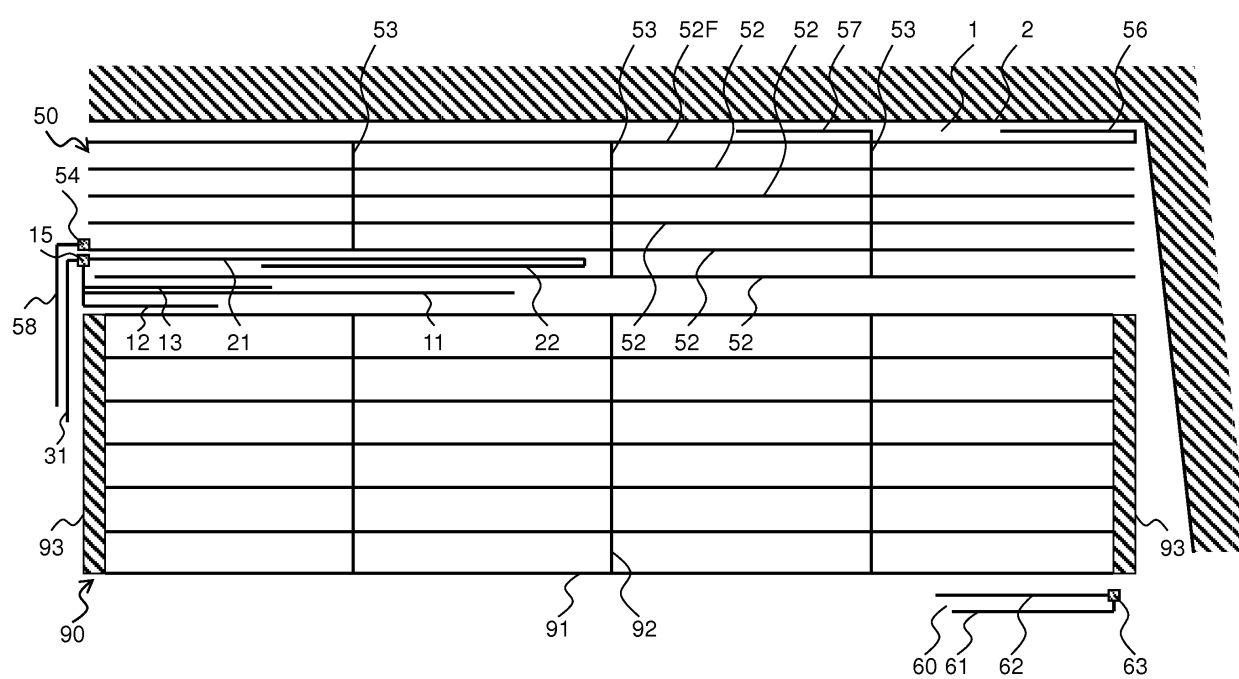


Fig. 14

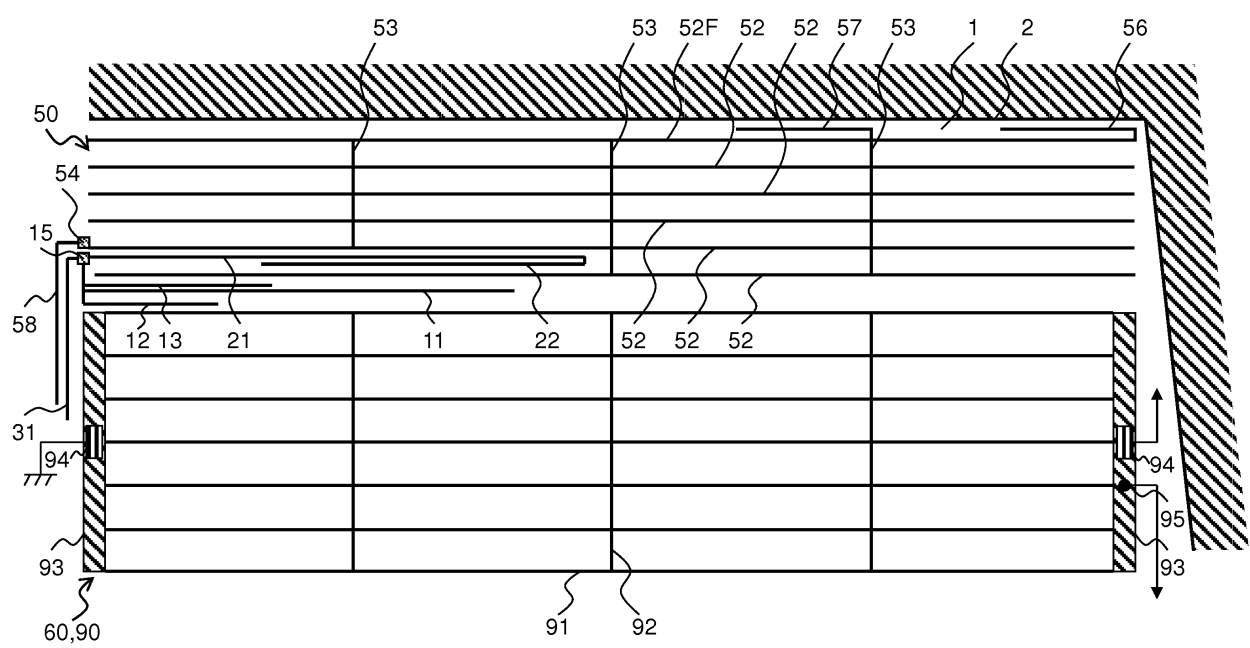


Fig. 15

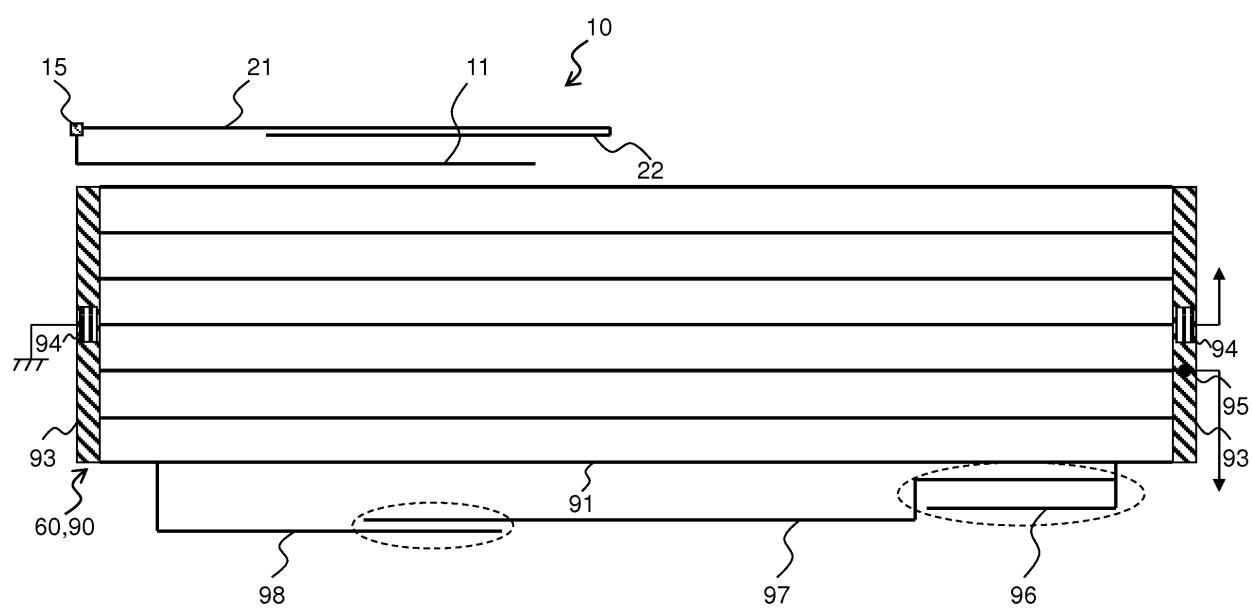


Fig. 16

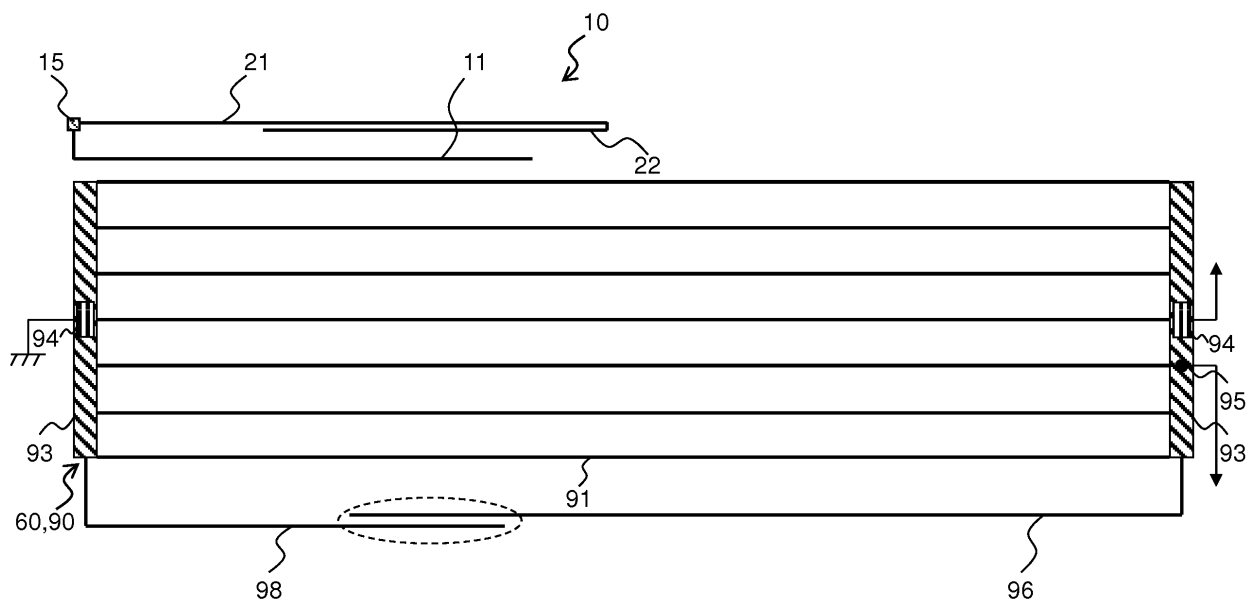


Fig. 17

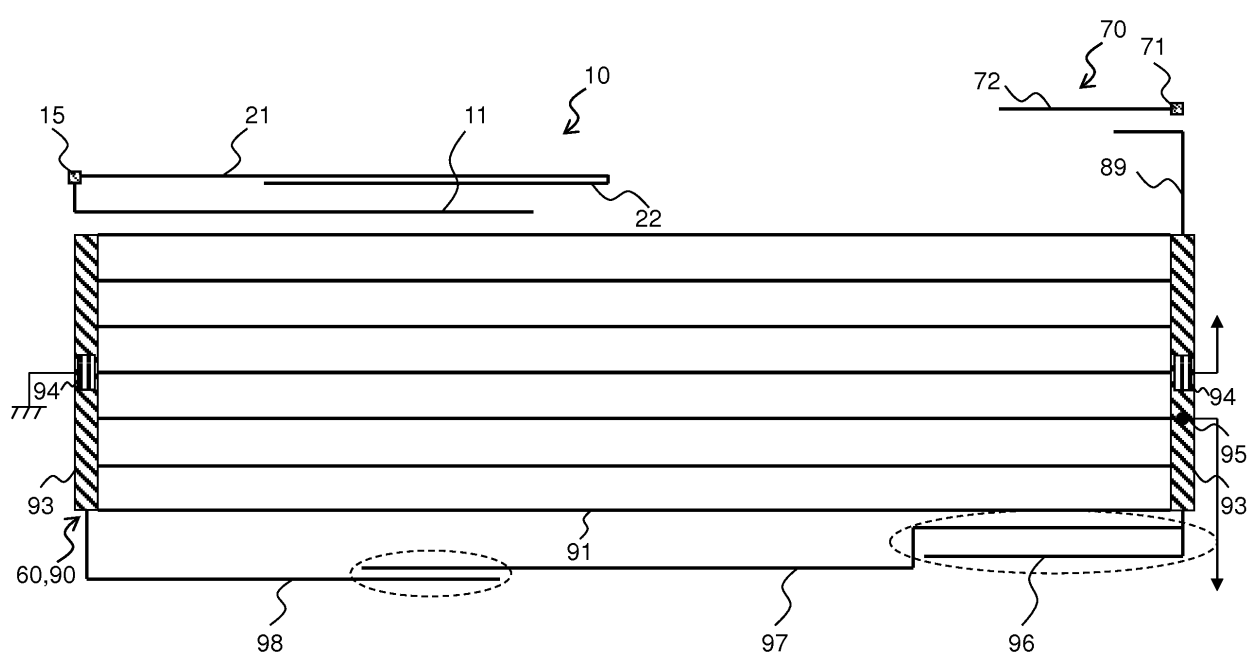


Fig. 18

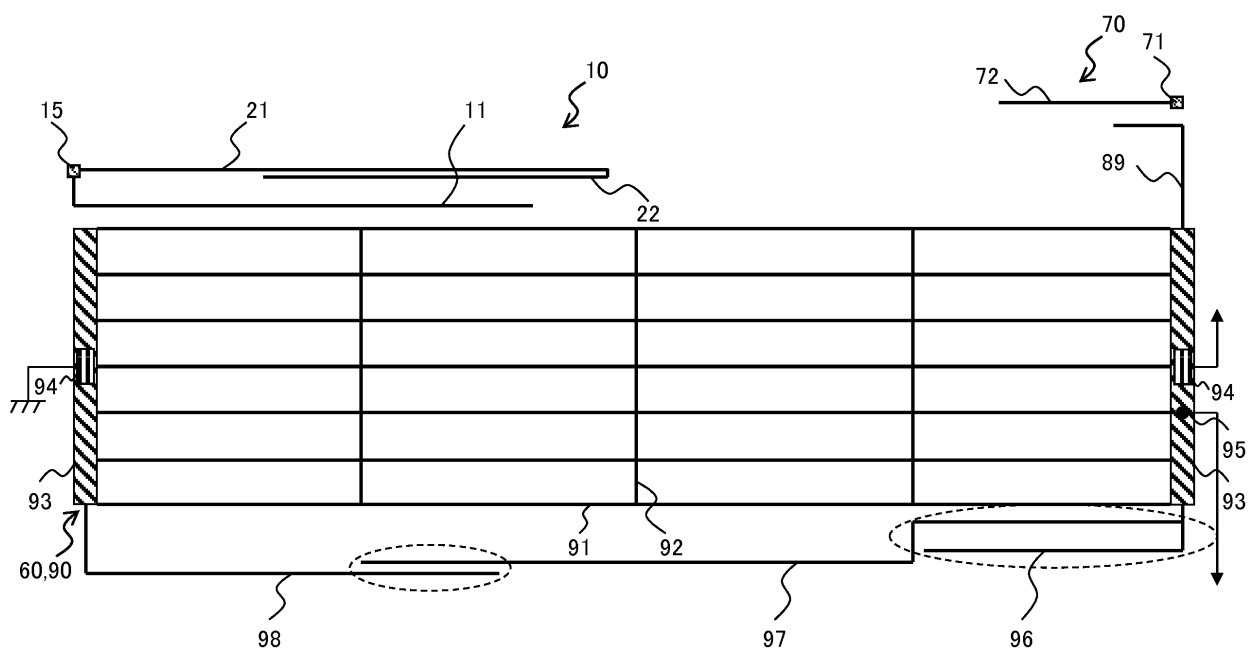


Fig. 19

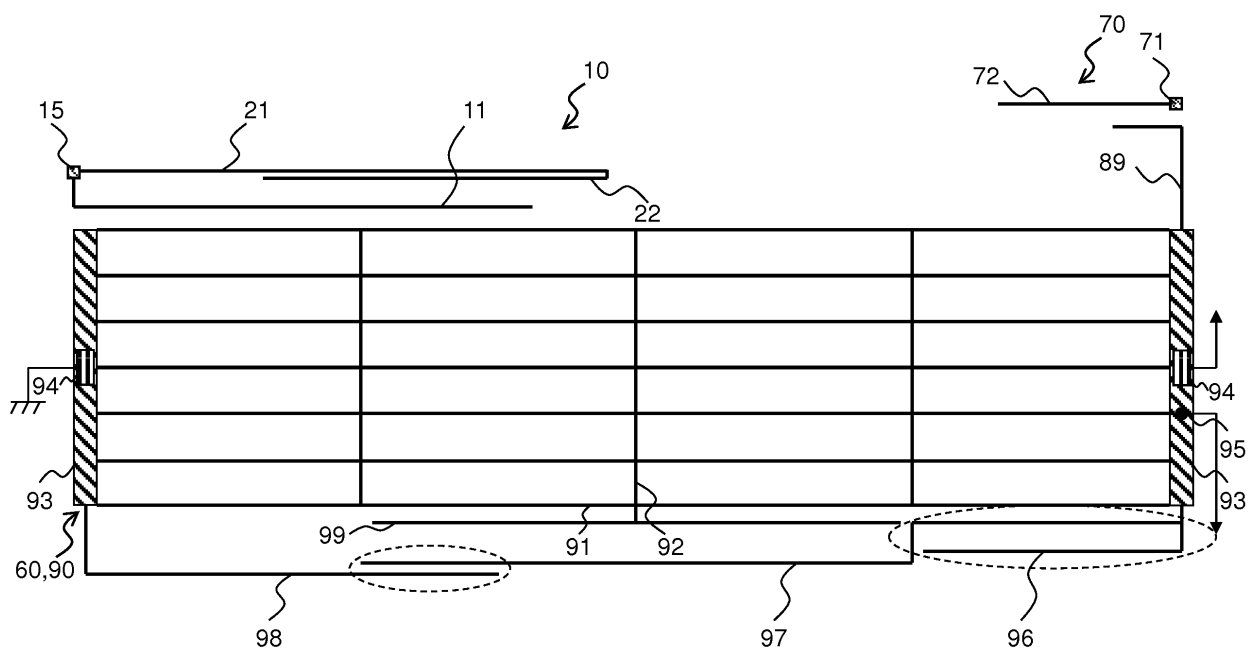


Fig. 20

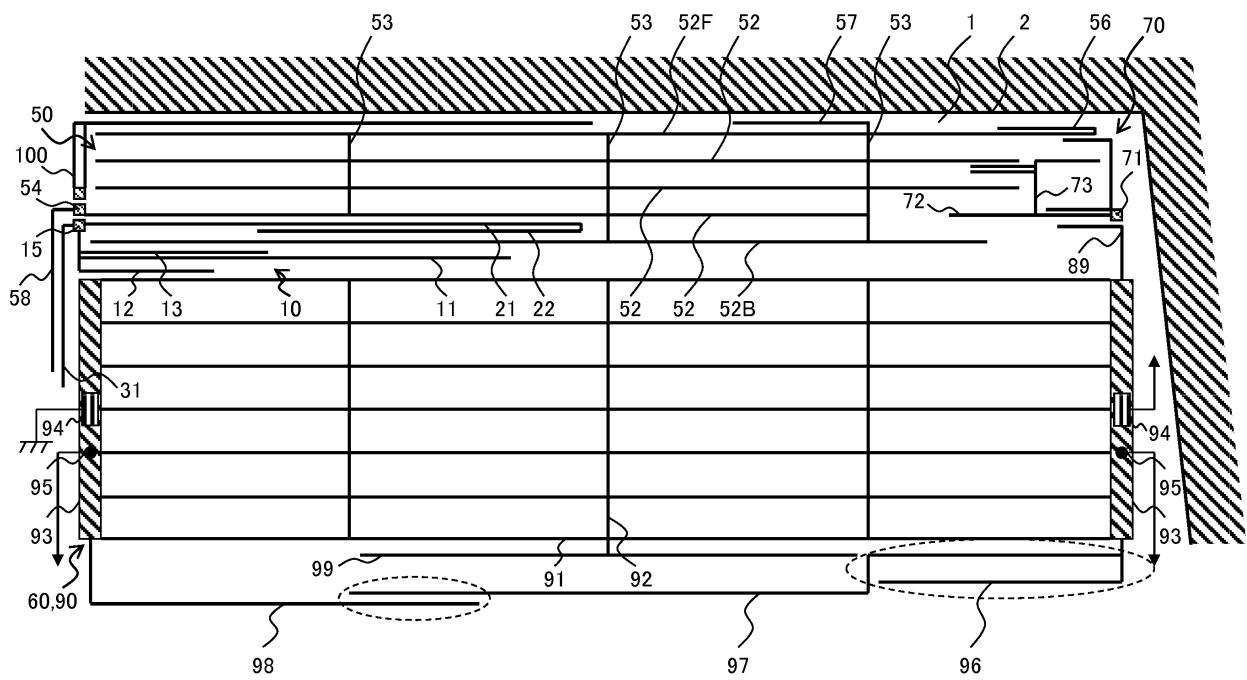
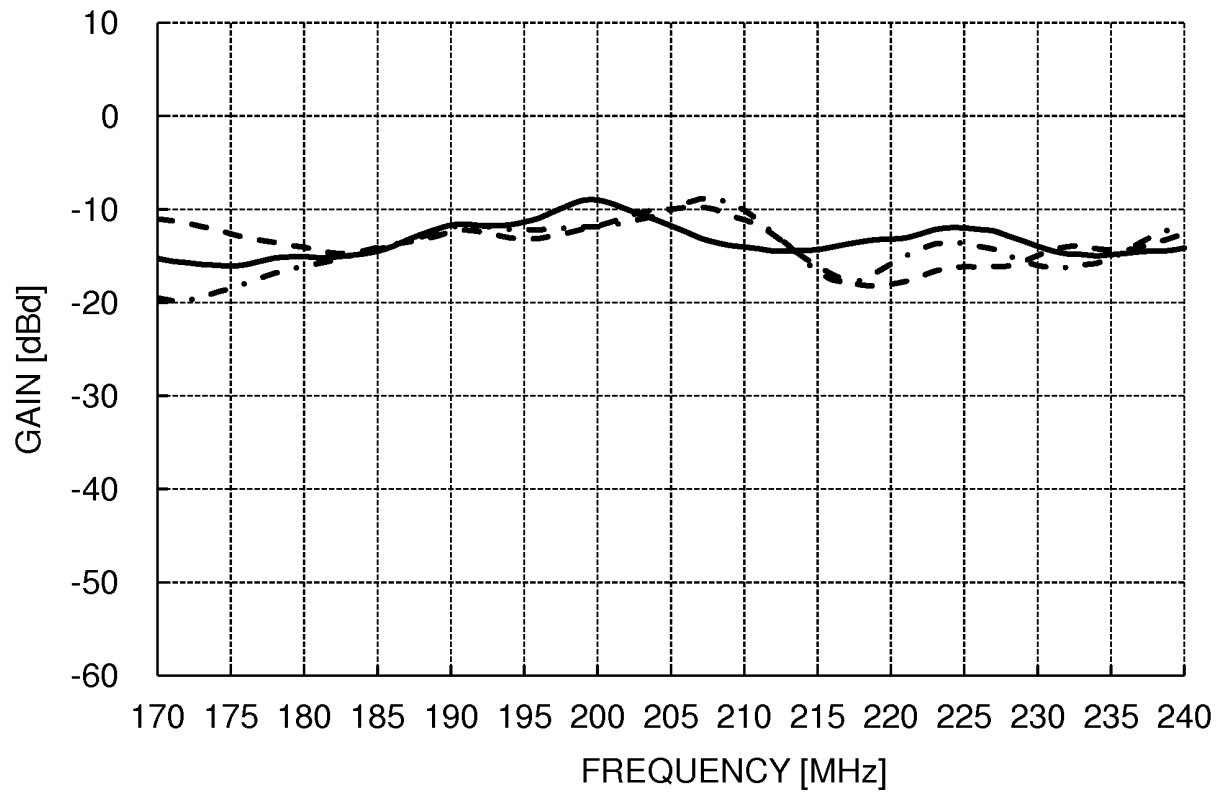
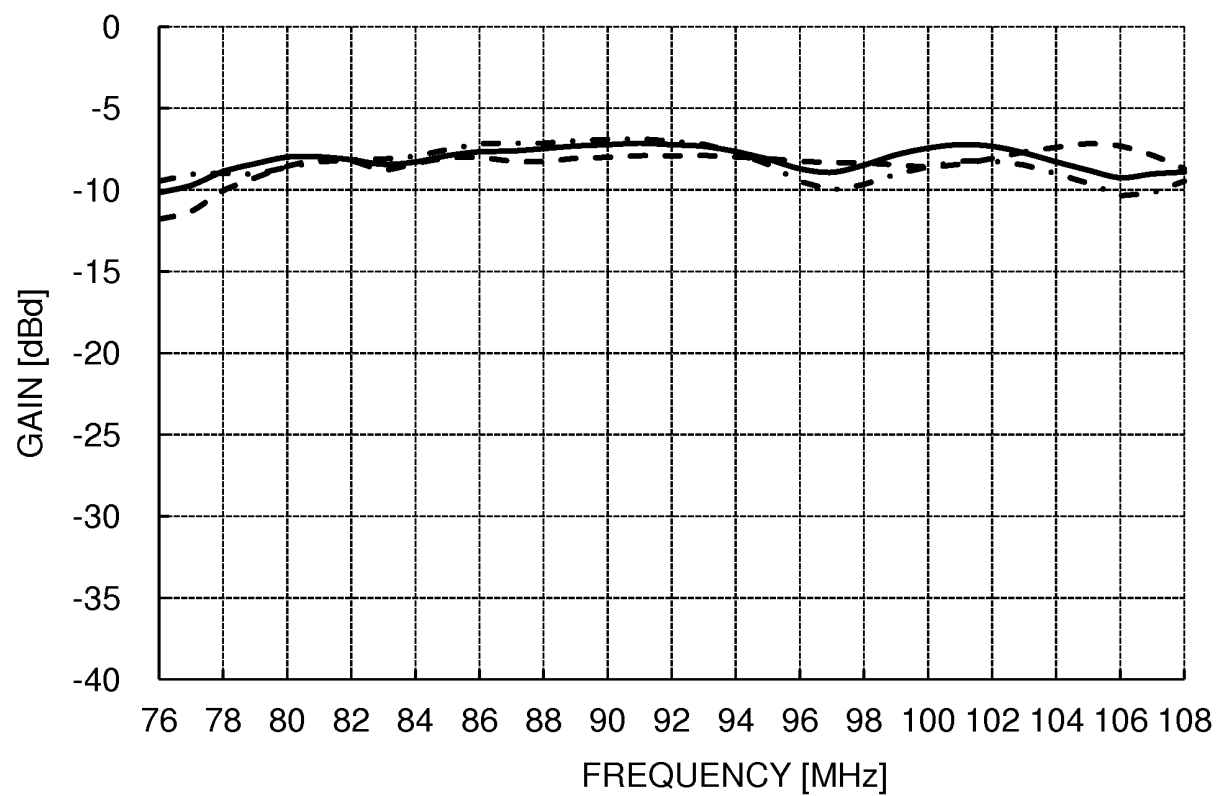
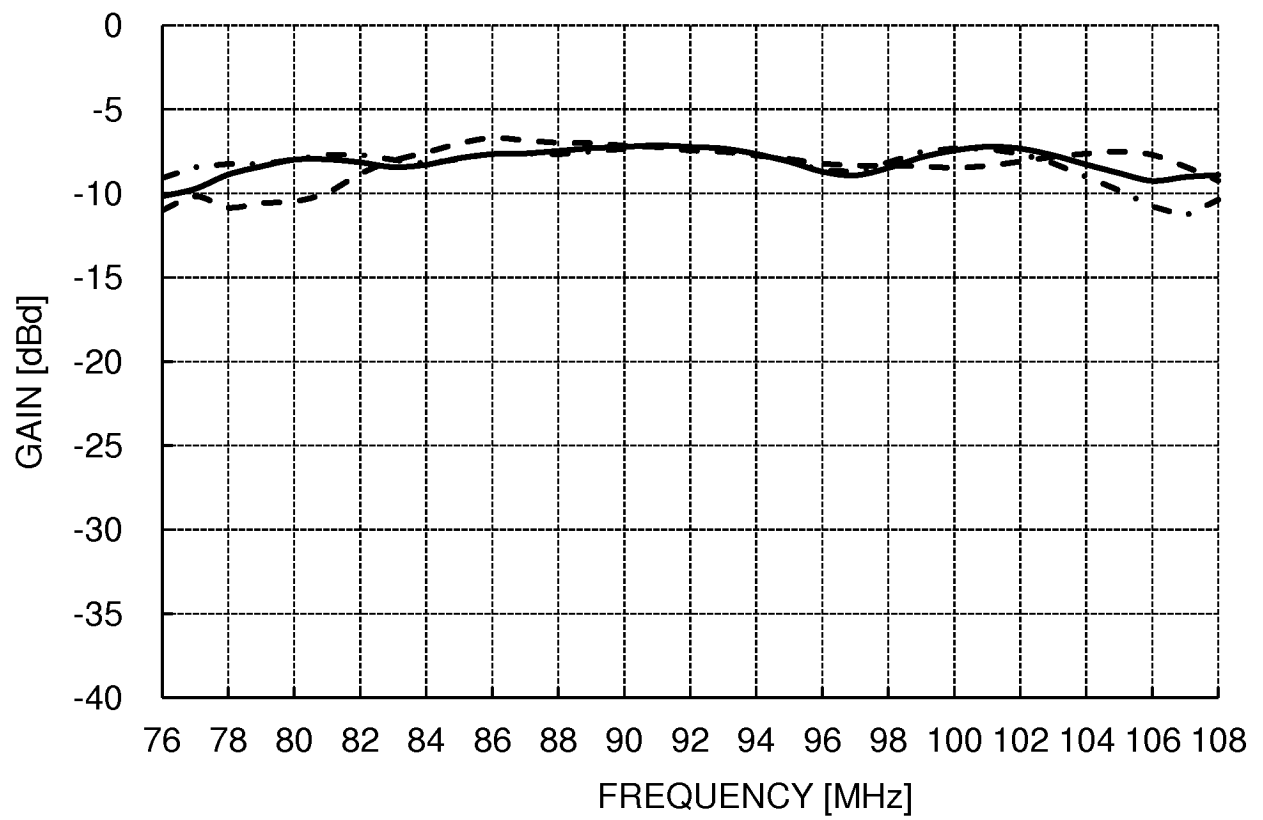


Fig. 21

*Fig. 22**Fig. 23*

*Fig. 24*

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/081370

A. CLASSIFICATION OF SUBJECT MATTER

H01Q1/32(2006.01)i, B60J1/00(2006.01)i, H01Q9/42(2006.01)i, H01Q21/30(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, B60J1/00, H01Q9/42, H01Q21/30

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 1996-2015
Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

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.
X	JP 9-153716 A (Central Glass Co., Ltd.),	1-5, 8-10, 14
Y	10 June 1997 (10.06.1997),	16, 17
A	paragraphs [0019] to [0022]; fig. 3, 5 (Family: none)	6, 7, 11-13, 15, 18-21
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 71979/1985 (Laid-open No. 189611/1986) (Mitsubishi Motors Corp.), 26 November 1986 (26.11.1986), pages 4, 5; fig. 1 (Family: none)	16, 17

☒ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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Date of the actual completion of the international search
22 January 2015 (22.01.15)

Date of mailing of the international search report
10 February 2015 (10.02.15)

Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/081370

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 11-284421 A (Central Glass Co., Ltd.), 15 October 1999 (15.10.1999), entire text; all drawings (Family: none)	1-21

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2010081567 A [0004] [0006]
- JP H06291530 A [0005] [0006]
- JP 2014012484 A [0269]