



(11) **EP 3 300 168 A1**

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

(43) Date of publication:
28.03.2018 Bulletin 2018/13

(51) Int Cl.:
H01Q 1/32 (2006.01) **B60J 1/00** (2006.01)
B60S 1/02 (2006.01) **H01Q 1/22** (2006.01)

(21) Application number: **16799772.5**

(86) International application number:
PCT/JP2016/063637

(22) Date of filing: **06.05.2016**

(87) International publication number:
WO 2016/190064 (01.12.2016 Gazette 2016/48)

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

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(30) Priority: **22.05.2015 JP 2015104166**

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(54) **VEHICLE WINDOW GLASS AND GLASS ANTENNA FOR DAB**

(57) The present invention provides a technology that is able to improve the reception performance of DAB broadcasts. A vehicle window glass according to one aspect of the present invention is provided with a glass plate

and a DAB glass antenna formed on one surface of the glass plate, and the DAB glass antenna includes a power supply part that is disposed on a lower edge side of the glass plate and a first element that extends vertically.

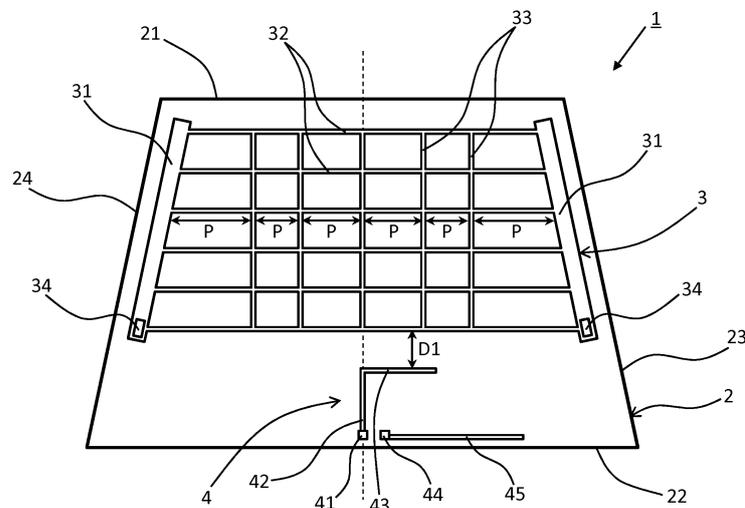


FIG.1

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Description

Technical Field

[0001] The present invention relates to a vehicle window glass and a DAB glass antenna.

Background Art

[0002] Devices such as a defogger for removing condensation or ice and an antenna for receiving predetermined radio waves may be provided on the surface of a vehicle window glass (particularly the rear glass) that is to be attached to a car. For example, Patent Literature 1 proposes a vehicle window glass on which a glass antenna for receiving DAB (Digital Audio Broadcasting; hereinafter, referred to as "DAB") broadcasts is provided together with a defogger.

Citation List

Patent Literature

[0003] Patent Literature 1: 2012/153664A1

Summary of Invention

Technical Problem

[0004] Heretofore, the development of technologies that improve the reception performance of glass antennas has been progressing.

[0005] In particular, in order for DAB broadcasts, which are transmitted with vertically polarized waves, to be received with high sensitivity, a glass antenna having a certain vertical length will be provided. On the other hand, in the case where a defogger is provided together with the glass antenna, the area over which the glass antenna can be disposed is narrowed by an amount equivalent to the area occupied by the defogger. Thus, the vertical length at which the glass antenna can be installed is restricted, and it is difficult to provide a glass antenna that enables DAB broadcasts, which are transmitted with vertically polarized waves, to be received with high sensitivity.

[0006] Furthermore, with types of cars in which the attachment angle of the rear glass is close to vertical or comparatively large such as hatchback cars, the glass area of the rear glass is comparatively small. Thus, in the case where a defogger and a glass antenna are provided on this rear glass, the area in which the glass antenna can be disposed is extremely limited, and it is difficult to provide a glass antenna capable of receiving DAB broadcasts with high sensitivity.

[0007] The present invention, in one aspect, was made in view of such situations, and an object thereof is to provide a technology that is able to improve the reception performance of DAB broadcasts.

Solution to Problem

[0008] The present invention adopts the following configurations, in order to solve the abovementioned problems.

[0009] That is, a vehicle window glass according to one aspect of the present invention is provided with a glass plate, and a DAB glass antenna formed on one surface of the glass plate, the DAB glass antenna including a power supply part that is disposed on a lower edge side of the glass plate and a first element that extends vertically.

[0010] Generally, since antennas are less likely to be affected by obstacles when installed higher up rather than being installed lower down, it is considered better to install antennas in a high place. Thus, DAB glass antennas are conventionally disposed on the upper edge side of the window glass. In contrast, the inventors discovered, as a result of their diligent efforts, that the sensitivity of a DAB glass antenna improves when the DAB glass antenna is disposed on the lower edge side of the window glass rather than being disposed on the upper edge side of the glass plate. In view of this, with the above configuration, the DAB glass antenna is disposed on the lower edge side of the window glass, by disposing the power supply part of the DAB glass antenna on the lower edge side of the glass plate. Consequently, with this configuration, the reception performance of DAB broadcasts can be improved, by disposing the DAB glass antenna on the lower edge side of the window glass.

[0011] In addition, in the case where an amplifier is provided between the power supply part and a receiver, this amplifier is generally disposed on the lower edge side of the window glass. Thus, when the power supply part is disposed on the upper edge side of the window glass, the possibility arises of needing to partially cut away the frame of the vehicle body in order to extend wiring from the power supply part to the amplifier, and in the case where the frame of the vehicle body is partially cut away, the strength of the vehicle body will be reduced. In contrast, according to the above configuration, the power supply part is disposed on the lower edge side of the window glass, thus enabling possibilities such as the above to be eliminated. Also, the distance between the amplifier and the power supply part can be shortened, enabling the reception performance of the DAB glass antenna to be enhanced.

[0012] Also, as another form of the window glass according to the above first aspect, the first element may extend vertically upward from the power supply part. With this configuration, the first element is directly connected to the power supply part, thus enabling the overall dimensions of the DAB glass antenna to be compacted.

[0013] Also, as another form of the window glass according to the above first aspect, the vehicle window glass may be further provided with a defogger including a pair of bus bar parts that oppose each other and a plurality of hot wire parts that each extend horizontally

and are arranged vertically, and in which both end portions of each hot wire part are respectively coupled to a different one of the pair of bus bar parts. The defogger may be disposed upwardly of the DAB glass antenna, and the DAB glass antenna may further include a second element that extends horizontally and is coupled to the first element. With this configuration, since a defogger is provided, the area over which the DAB glass antenna can be installed on the surface of the glass plate is restricted. In view of this, with the above configuration, the vertical length of the DAB glass antenna can be suppressed, while maintaining the reception performance of DAB broadcasts, by providing a second element that extends horizontally in the DAB glass antenna. Accordingly, with this configuration, a DAB glass antenna in which the reception performance is secured can be provided in a window glass provided with a defogger.

[0014] Also, as another form of the window glass according to the above first aspect, the defogger may further include one or more vertical filament parts that extend vertically so as to intersect each of the plurality of hot wire parts. The inventors discovered that the sensitivity of the DAB glass antenna is improved, by providing vertical filament parts in the defogger. Accordingly, with this configuration, the reception performance of DAB broadcasts can be improved, by providing one or more vertical filament parts in the defogger.

[0015] Also, as another form of the window glass according to the above first aspect, the one or more vertical filament parts are disposed such that a standing wave is not produced in the defogger due to radio waves in a DAB frequency band. The inventors discovered that, depending on the disposition of the vertical filament parts, the radio waves in the DAB frequency band result in standing waves caused by the radio waves being produced in the defogger, and the sensitivity of the DAB glass antenna decreasing. Accordingly, with this configuration, the sensitivity of the DAB glass antenna can be prevented from decreasing, and the reception performance of DAB broadcasts can be improved.

[0016] Also, as another form of the window glass according to the above first aspect, the defogger may be installed so as to be separated by 46 mm or more vertically upward from an upper end of the DAB glass antenna. The inventors discovered that when the DAB glass antenna is moved closer than a range of 46 mm from the defogger (particularly in the case where there are no vertical filament parts), the sensitivity of the DAB glass antenna decreased due to interference from the defogger. In view of this, with the above configuration, the DAB glass antenna is separated from the defogger by 46 mm or more, by installing the defogger so as to be separated by 46 mm or more vertically upward from the upper end of the DAB glass antenna. Accordingly, with this configuration, the reception performance of DAB broadcasts can be improved, by separating the DAB glass antenna from the defogger by 46 mm or more.

[0017] Also, as another form of the window glass ac-

5 cording to the above first aspect, the first element of the DAB glass antenna may have a vertical length of 20 mm or more. Generally, in order to receive DAB broadcasts, which are transmitted with vertically polarized waves, an antenna that is vertically long in length is desirably used. The area over which the glass antenna is provided may, however, be restricted due to the provision of a defogger or the like, in which case it may not be possible to form the DAB glass antenna at the desired vertical length. In response to this, the inventors discovered that the reception performance of DAB broadcasts can be maintained if the vertical length of the DAB glass antenna is 20 mm or more. Accordingly, with this configuration, the reception performance of DAB broadcasts can be maintained, while shortening the vertical length of the DAB glass antenna.

[0018] Also, as another form of the window glass according to the above first aspect, the vehicle window glass may be attached to a window frame of a vehicle such that, when parallel light strikes the window glass horizontally, a projected area of the window glass that occurs as a result is 0.5 mm², and an attachment angle of the window glass when referenced on a horizontal direction is from 45 degrees to 75 degrees inclusive. With such a window having a small attachment area, the area over which the DAB glass antenna can be installed is restricted. In particular, in the case where the DAB glass antenna is provided together with a defogger, the area over which the DAB glass antenna can be installed is restricted. However, according to the present invention, the sensitivity of the DAB glass antenna can be enhanced, thus enabling installation even on such a window having a small attachment area. In other words, the present invention particularly exhibits an effect with such a window having a small attachment area. Note that a window glass having such an attachment area and attachment angle is, for example, the rear glass of a hatchback car. Here, the rear glass is generally curved. In the case where the window glass is curved, the attachment angle varies at each point on the window glass. With the above configuration, this curved window glass is attached such that the attachment angle will be from 45 degrees to 75 degrees inclusive at an arbitrary point on the window glass, when the horizontal direction is given as 0 degrees.

[0019] Also, a DAB glass antenna according to one aspect of the present invention is a DAB glass antenna to be formed on one surface of a glass plate that is to be used as a vehicle window glass, and is provided with a power supply part to be disposed on a lower edge side of the glass plate, and a first element that extends vertically. As described above, with this configuration, the reception performance of DAB broadcasts can be improved.

Advantageous Effects of Invention

[0020] According to the present invention, the recep-

tion performance of DAB broadcasts can be improved.

Brief Description of Drawings

[0021]

FIG. 1 schematically illustrates a window glass according to an embodiment.

FIG. 2 schematically shows an exemplary usage of the window glass according to the embodiment.

FIG. 3A schematically illustrates a window glass according to another form.

FIG. 3B schematically illustrates a window glass according to another form.

FIG. 3C schematically illustrates a window glass according to another form.

FIG. 3D schematically illustrates a window glass according to another form.

FIG. 4 schematically illustrates a window glass according to another form.

FIG. 5A schematically illustrates a working example in which a DAB glass antenna is provided on the lower edge portion side of the glass plate.

FIG. 5B schematically illustrates a comparative example in which a DAB glass antenna is provided on the upper edge portion side of the glass plate.

FIG. 6A shows the results of measuring sensitivity (gain) of working examples with respect to each frequency of DAB band 3.

FIG. 6B shows the average values for sensitivity (gain) of working examples in the frequency band of DAB band 3.

FIG. 7A shows the results of measuring sensitivity (gain) of comparative examples with respect to each frequency of DAB band 3.

FIG. 7B shows the average values for sensitivity (gain) of comparative examples in the frequency band of DAB band 3.

FIG. 8 schematically illustrates a working example in which an L-shaped DAB glass antenna is provided on the lower edge portion side of the glass plate.

FIG. 9A shows the results of measuring sensitivity (gain) of working examples with respect to each frequency of DAB band 3.

FIG. 9B shows the average values for sensitivity (gain) of working examples in the frequency band of DAB band 3.

FIG. 10 schematically illustrates a working example in which a defogger is provided on a glass plate on which the L-shaped DAB glass antenna is provided on the lower edge portion side.

FIG. 11A shows the results of measuring sensitivity (gain) of working examples with respect to each frequency of DAB band 3.

FIG. 11B shows the average values for sensitivity (gain) of working examples in the frequency band of DAB band 3.

FIG. 12 schematically illustrates a working example

in which vertical filament parts are provided in the defogger.

FIG. 13A shows the results of measuring sensitivity (gain) of working examples with respect to each frequency of DAB band 3.

FIG. 13B shows the average values for sensitivity (gain) of working examples in the frequency band of DAB band 3.

FIG. 14 schematically illustrates a working example in which a DAB glass antenna in which the lengths of a vertical element and a horizontal element have been respectively adjusted is provided on the lower edge portion side of a glass plate on which a defogger having five vertical filament parts is provided.

FIG. 15A shows the results of measuring sensitivity (gain) of working examples with respect to each frequency of DAB band 3.

FIG. 15B shows the average values for sensitivity (gain) of working examples in the frequency band of DAB band 3.

FIG. 16 schematically illustrates a reference example in which an L-shaped DAB glass antenna is provided on the upper edge portion side of the glass plate.

FIG. 17A shows the results of measuring sensitivity (gain) of reference examples with respect to each frequency of DAB band 3.

FIG. 17B shows the average values for sensitivity (gain) of reference examples in the frequency band of DAB band 3.

FIG. 18 schematically illustrates a working example in which a defogger is provided on a glass plate on which an L-shaped DAB glass antenna is provided on the upper edge portion side.

FIG. 19A shows the results of measuring sensitivity (gain) of reference examples with respect to each frequency of DAB band 3.

FIG. 19B shows the average values for sensitivity (gain) of reference examples in the frequency band of DAB band 3.

FIG. 20 schematically illustrates a reference example in which vertical filament parts are provided in the defogger.

FIG. 21A shows the results of measuring sensitivity (gain) of reference examples with respect to each frequency of DAB band 3.

FIG. 21B shows the average values for sensitivity (gain) of reference examples in the frequency band of DAB band 3.

FIG. 22 schematically illustrates a reference example in which a vertical filament part is provided in the defogger.

FIG. 23A shows a simulation result of current distribution at the time when 170-MHz radio waves are received in a reference example in which one vertical filament part is provided.

FIG. 23B shows a simulation result of current distribution at the time when 240-MHz radio waves are

received in a reference example in which one vertical filament part is provided.

FIG. 24A shows a simulation result of current distribution at the time when 170-MHz radio waves are received in a reference example in which three vertical filament parts are provided.

FIG. 24B shows a simulation result of current distribution at the time when 240-MHz radio waves are received in a reference example in which three vertical filament parts are provided.

FIG. 25 shows simulation results of current distribution of sensitivity (gain) of reference examples with respect to each frequency of DAB band 3.

FIG. 26 schematically illustrates a working example in which a power supply part is provided toward a side edge.

FIG. 27 shows the results of measuring sensitivity (gain) of working examples with respect to each frequency of DAB band 3.

Description of Embodiments

[0022] Hereinafter, an embodiment according to one aspect of the present invention (hereinafter, also referred to as "the present embodiment") will be described based on the drawings. The present embodiment that will be described below is, however, in all respects merely illustrative of the present invention. Needless to say, various improvements and modifications can be made without departing from the scope of the invention. In other words, in implementing the present invention, specific configurations that depend on the embodiment may be adopted as appropriate.

1. Exemplary Configuration

Window Glass

[0023] First, a window glass 1 according to the present embodiment will be described using FIG. 1. FIG. 1 is a plan view schematically illustrating the window glass 1 according to the present embodiment. Note that FIG. 1 schematically illustrates the window glass 1 as seen from the vehicle interior side. That is, the far side in FIG. 1 is the vehicle exterior side, and the near side in FIG. 1 is the vehicle interior side. Hereinafter, for convenience of description, the up-down direction in FIG. 1 will be referred to as "up-down", the right direction in FIG. 1 will be referred to as "left", and the left direction in FIG. 1 will be referred to as "right". Note that the left-right direction in FIG. 1 corresponds to the "horizontal direction" in the present invention, and the up-down direction in FIG. 1 corresponds to the "vertical direction" in the present invention. Here, the vertical direction indicates a direction that is, for example, vertical to the ground when the window glass 1 is attached to the vehicle body. Also, the parallel direction indicates a direction that is, for example, horizontal to the ground when the window glass 1 is at-

tached to the vehicle body. Note that, in the case where the surface is inclined, the vertical direction and the horizontal direction include approximate directions that have components of the respective directions.

[0024] The window glass 1 according to the present embodiment is a vehicle window glass that is to be attached to a car, and, specifically, is the rear glass of a car. The type of window glass of the present invention is, however, not limited to the rear glass, and can be selected as appropriate according to the embodiment. As illustrated in FIG. 1, the window glass 1 according to the present embodiment is provided with an approximately trapezoid glass plate 2, and is to be attached to a window frame that is provided in a rear portion of a car.

[0025] As illustrated in FIG. 1, a DAB glass antenna 4 for receiving DAB broadcasts is provided on the lower edge side of this glass plate 2, and a defogger 3 for defogging that has a predetermined pattern is provided upwardly of this DAB glass antenna 4. The defogger 3 and the DAB glass antenna 4 may be provided on either the surface on the vehicle interior side or the surface on the vehicle exterior side of the glass plate 2. Hereinafter, the constituent elements thereof will be described.

25 Glass Plate

[0026] First, the glass plate 2 will be described. As illustrated in FIG. 1, the glass plate 2 according to the present embodiment has an upper edge portion 21 that extends in the left-right direction, a lower edge portion 22 that opposes this upper edge portion 21 on the lower side, a left side edge portion 23 that couples the left end portions of the upper edge portion 21 and the lower edge portion 22, and a right side edge portion 24 that couples the right end portions of the upper edge portion 21 and the lower edge portion 22.

[0027] The glass plate 2 according to the present embodiment is utilized as the window glass of a car, and is configured in a shape that depends on the window frame of the car to which the window glass is to be attached. The type of car to which the glass plate 2 is to be attached may be selected as appropriate according to the embodiment, and may, for example, be a hatchback car. For example, the glass plate 2 may be utilized as the rear glass of a hatchback car. Also, the glass plate 2 may be formed in a curved shape. For example, the glass plate 2 may be formed in a shape that curves from a peripheral portion to a central portion, such that the surface on the vehicle interior side is concave and the surface on the vehicle exterior side is convex.

[0028] With such a glass plate 2, various configurations are possible, according to the embodiment. Also, a well-known glass plate for cars can be utilized for this glass plate 2. For example, heat absorbing glass, common clear glass, common green glass or UV green glass may be utilized for the glass plate 2. Such a glass plate 2 can, however, be adjusted such that solar absorptivity, visible light transmissivity and the like satisfy safety standards.

Hereinafter, an example of the composition of clear glass and an example of the composition of heat absorbing glass are shown.

Clear Glass

[0029]

SiO₂: 70 to 73 mass%
 Al₂O₃: 0.6 to 2.4 mass%
 CaO: 7 to 12 mass%
 MgO: 1.0 to 4.5 mass%
 R₂O: 13 to 15 mass% (R is an alkaline metal)
 Total iron oxide converted to Fe₂O₃ (T-Fe₂O₃): 0.08 to 0.14 mass%

Heat Absorbing Glass

[0030] The composition of heat absorbing glass can, for example, be given as a composition including total iron oxide (T-Fe₂O₃) converted to Fe₂O₃ at a ratio of 0.4 to 1.3 mass%, CeO₂ at a ratio of 0 to 2 mass%, and TiO₂ at a ratio of 0 to 0.5 mass%, based on the composition of clear glass, and in which the skeletal component (mainly SiO₂ and Al₂O₃) of the glass is reduced by an amount equivalent to the increase in T-Fe₂O₃, CeO₂ and TiO₂.

[0031] Note that the type of glass plate 2 is not restricted to clear glass, heat absorbing glass or the like, and can be selected as appropriate according to the embodiment. For example, the glass plate 2 may be a resin window consisting of acrylic resin, polycarbonate resin or the like.

Defogger

[0032] Next, the defogger 3 for defogging will be described. As illustrated in FIG. 1, the defogger 3 according to the present embodiment is provided on the upper edge portion 21 side of the glass plate 2 so as to be disposed upwardly of the DAB glass antenna 4 which will be discussed later, and has a predetermined pattern in order to remove condensation and ice on the window glass 1.

[0033] Specifically, the defogger 3 is provided with a pair of bus bar parts 31 that oppose each other in the left-right direction, and a plurality (6 in FIG. 1) of hot wire parts 32 that each extend in the left-right direction and are arranged in the up-down direction. Both ends of each hot wire part 32 are respectively coupled to a different one of the bus bar parts 31. Also, a connection part 34 for attaching a predetermined connection terminal is provided on each bus bar part 31.

[0034] The predetermined connection terminals are attached to these connection parts 34 by soldering or the like, and wiring (not shown) from the power supply of the car is connected to the bus bar parts 31 through the connection terminals. Thus, the driver of the car is able to supply electricity to the defogger 3, by operating an operation panel (not shown).

[0035] When electricity is supplied to the defogger 3, current flows in each hot wire part 32 via the bus bar parts 31. This results in each hot wire part 32 being heated by the energy of the flowing electricity, and the glass plate 2 is warmed at portions where each of these hot wire parts 32 are formed. Condensation and ice attached to the surface of the glass plate 2 can thereby be removed.

[0036] Also, in the defogger 3 according to the present embodiment, a plurality (5 in FIG. 1) of vertical filament parts 33 that each extend in the up-down direction so as to intersect each hot wire part 32 are provided. The defogger 3 is constituted by a conductive material having conductivity. Thus, in the case where this defogger 3 approaches the DAB glass antenna 4 which will be discussed later, the defogger 3 can affect the reception performance of the DAB glass antenna 4.

[0037] Here, as shown by tests (in particular, test 4 and test 8) which will be discussed later, the reception performance of the DAB glass antenna 4 can be ameliorated, by short-circuiting the hot wire parts 32 with the vertical filament parts 33. In view of this, the present embodiment is configured to enhance the reception performance of the DAB glass antenna 4, by providing a plurality of vertical filament parts 33 in the defogger 3. In the example of FIG. 1, one vertical filament part 33 is disposed in the center of the glass plate 2 in the left-right direction, and two vertical filament parts 33 each are symmetrically disposed in the left-right direction about the one vertical filament part 33. The defogger 3 according to the present embodiment is thereby symmetrically formed.

[0038] Note that the shape, number and disposition of the bus bar part 31, the shape, number and disposition of the hot wire part 32, the shape, number and disposition of the vertical filament part 33, and the position of the connection part 34 need not be limited to such an example, and can be designed as appropriate according to the embodiment. For example, the vertical filament part 33 may be a single part or may be omitted. As shown by test 9 which will be discussed later, however, the inventors discovered that, depending on the disposition of the vertical filament part 33, radio waves in the DAB frequency band result in standing waves being produced in the defogger 3, and the sensitivity of the DAB glass antenna 4 decreasing. Thus, the vertical filament part 33 is preferably disposed such that radio waves in the DAB frequency band do not result in standing waves caused by the radio waves being produced in the defogger 3. The sensitivity of the DAB glass antenna 4 is thereby prevented from decreasing, enabling the reception performance of DAB broadcasts to be improved.

[0039] Disposition of the vertical filament parts 33 such that standing waves of the DAB radio waves are not produced, specifically, involves the following. That is, in the case where, in each hot wire part 32, a distance P of the portion sandwiched between the bus bar part 31 and the vertical filament part 33 and the portion sandwiched between adjacent vertical filament parts 33 (hereinafter, this distance may also be referred to as the "pitch") is an

integer multiple of a half wavelength of the radio waves that are received, standing waves caused by the radio waves may be produced in each portion. Thus, standing waves caused by the radio waves in the DAB frequency band can be prevented from being produced in the defogger 3, by disposing the vertical filament parts 33, such that the distance P of each portion is not equal to an integer multiple of F shown in the following equation 1.

Equation 1

$$F = \frac{\lambda_0}{2} = K \times \frac{c}{2f}$$

Note that F indicates the half wavelength of the DAB radio waves. λ_0 shows the wavelength of DAB radio waves on the hot wire parts 32. K indicates the wavelength shortening rate on the hot wire part 32. The value of K (wavelength shortening rate) can be specified based on a physical property (relative permittivity) of the glass, the thickness of the glass, the frequency of the radio waves to be received, and the like. Generally, the K value of glass is set in a range of 0.6 to 0.8. Also, c indicates the velocity of light. f indicates the frequency of the DAB radio waves.

[0040] Hypothetically, assume 170 MHz to 240 MHz is substituted for f in the above equation 1, envisaging the case of DAB band 3. Also, assume 3.0×10^8 (m/s) is substituted for the velocity of light c and 0.7 is substituted for the wavelength shortening rate K, F will take a value in a range from 0.44 m to 0.62 m. Thus, if the vertical filament parts 33 are disposed such that the distance P of the portion sandwiched between the bus bar part 31 and the vertical filament part 33 and the portion sandwiched between adjacent vertical filament parts 33 is not equal to a value from 0.44 m to 0.62 m (and integer multiples thereof), standing waves caused by the radio waves of band 3 can be prevented from being produced in the defogger 3. Note that the above calculation was performed with simple numerical values for convenience of description. In determining the value F that the distance P of each portion is to avoid, the values of K, f and c are not limited to the above values, and may be selected as appropriate according to the embodiment.

[0041] This defogger 3 is formed by laminating a conductive material having conductivity so as to have a predetermined pattern on the surface of the glass plate 2. The material of the defogger 3 need only have conductivity, and can be selected as appropriate in the embodiment. Silver, gold, platinum and the like can be given as examples of the material of the defogger 3. This defogger 3 can be formed by, for example, printing and baking a conductive silver paste containing silver powder, glass frit and the like on the surface of the glass plate 2.

DAB Glass Antenna

[0042] Next, the DAB glass antenna 4 for receiving DAB broadcasts will be described. DAB is a broadcasting standard of digital radio that has been adopted in Europe and elsewhere. In DAB, band 3 having a frequency band of 174 MHz to 240 MHz and L band having a frequency band of 1452 MHz to 1492 MHz are mainly used. The DAB glass antenna 4 may be constituted as appropriate according to the frequency band to be received. Note that, according to factors such as the specifications of the car, each frequency band can be changed slightly. Thus, for example, the frequency band 174 MHz to 240 MHz of band 3 may be treated as a frequency band 170 MHz to 240 MHz. Herein, the frequency band 170 MHz to 240 MHz is also utilized as the frequency band of DAB band 3 for convenience of description.

[0043] The DAB glass antenna 4 according to the present embodiment has a rectangular power supply part 41 disposed on the lower edge portion 22 side of the glass plate 2, a filament vertical element 42 that extends vertically upward from the power supply part 41, and a filament horizontal element 43 that is coupled to the vertical element 42 and extends in the left direction (horizontal direction). As illustrated in FIG. 1, the horizontal element 43 is coupled, at the right end portion, to the upper end portion of the vertical element 42. The vertical element 42 and the horizontal element 43 thereby constitute an L-shaped antenna. Of this L-shaped antenna, the vertical element 42 corresponds to a "first element" of the present invention, and the horizontal element 43 is corresponds to a "second element" of the present invention.

[0044] As described above, conventional DAB glass antennas are disposed on the upper edge side of the window glass. In contrast, the inventors discovered the sensitivity of the DAB glass antenna is improved by disposing the DAB glass antenna on the lower edge side of the window glass rather than on the upper edge side of the glass plate, based on tests (in particular, test 1) which will be discussed later. In view of this, in the present embodiment, the DAB glass antenna 4 is disposed on the lower edge side of the window glass 1, by disposing the power supply part 41 of the DAB glass antenna 4 on the lower edge portion 22 side of the glass plate 2. The reception performance of DAB broadcasts by the DAB glass antenna 4 can thereby be improved.

[0045] Here, the vertical length (up-down direction) of the vertical element 42 and the horizontal length (left-right direction) of the horizontal element 43 may each be set as appropriate according to the frequency band to be received. Generally, in order to receive the signal of vertically polarized waves such as DAB, the vertical length of the vertical element 42 is preferably as long as possible.

[0046] However, in the present embodiment, since the defogger 3 is provided upwardly of the DAB glass antenna 4, the area over which the DAB glass antenna 4 can

be installed is restricted. In other words, the vertical length of the vertical element 42 that can be formed is restricted by an amount equivalent to the length of the defogger 3 in the up-down direction.

[0047] In view of this, in the present embodiment, the horizontal element 43 that is coupled to the vertical element 42 is provided, in order to secure the length of the DAB glass antenna 4. In the present embodiment, the vertical length of the vertical element 42 can thereby be suppressed, while maintaining the reception performance of the DAB glass antenna 4.

[0048] In the case where the vertical element 42 is markedly short, however, the reception performance of the DAB glass antenna 4 will markedly decrease. Thus, the vertical length of the vertical element 42 is desirably configured to be 20 mm or more, based on the tests (in particular, test 2, test 5 and test 6) which will be discussed later. Also, the total length of the vertical element 42 and the horizontal element 43 is desirably configured to be equivalent in length to a 1/2 wavelength of the radio waves to be received.

[0049] Also, as illustrated in FIG. 1, the DAB glass antenna 4 according to the present embodiment is disposed such that the upper end of the DAB glass antenna 4 is separated by a distance D1 downward from the defogger 3. In other words, the defogger 3 is disposed at a position that is the distance D1 vertically upward from the upper end of the DAB glass antenna 4. In the present embodiment, since the horizontal element 43 is coupled to the upper end portion of the vertical element 42, the upper edge portion of the horizontal element 43 together with the upper end portion of the vertical element 42 corresponds to the upper end of the glass antenna 4.

[0050] The distance D1 may be set as appropriate according to the embodiment. In the case where the distance D1 is too short, however, the defogger 3 constituted by a conductive material may possibly adversely affect the reception performance of the DAB glass antenna 4. Thus, the distance D1 is desirably set to 46 mm or more, in order to avoid the defogger 3 affecting the reception performance of the DAB glass antenna 4, based on the tests (in particular, test 3) which will be discussed later. Note that, in the case where the distance D1 is too long, the area over which the DAB glass antenna 4 can be installed will be narrowed, and the vertical length of the vertical element 42 will be greatly restricted. Thus, the upper limit of the distance D1 may be set as appropriate according to the vertical length of the vertical element 42.

[0051] Note that the DAB glass antenna 4 according to the present embodiment is constituted as a so-called dipole antenna. That is, the DAB glass antenna 4 is further provided with a rectangular ground connection part 44 disposed in proximity to the power supply part 41, and a ground filament part 45 that extends in the left direction (horizontal direction) from this ground connection part 44.

[0052] An internal conductor of coaxial cable (not shown) coupled to a receiver (not shown) mounted in the car is electrically connected to the power supply part 41,

and receives signals received with the vertical element 42 and the horizontal element 43. On the other hand, an external conductor of the coaxial cable is electrically connected to the ground connection part 44, and is grounded.

An amplifier (not shown) may be provided between the power supply part 41 and the receiver. DAB broadcasts can thereby be received with the receiver mounted in the car. Note that, in the case where an amplifier is provided between the power supply part 41 and the receiver, this amplifier is disposed on the lower edge portion 22 side of the window glass 1. The amplifier and the power supply part 41 can thereby be connected by wiring, without cutting away the frame of the vehicle body. Also, the distance between amplifier and the power supply part 41 can be shortened, thereby enabling loss in the wiring to be suppressed and the reception performance of the DAB glass antenna 4 to be enhanced.

[0053] The configuration of the DAB glass antenna 4 need not, however, be limited to such an example, and the ground connection part 44 and the ground filament part 45 may be omitted, and the DAB glass antenna 4 may be configured as a so-called monopole antenna. In this case, the external conductor of the coaxial cable may, for example, be grounded by being directly connected to the vehicle body of the car.

[0054] Such a DAB glass antenna 4 can be formed, similarly to the defogger 3, by laminating a conductive material having conductivity on the surface of the glass plate 2 so as to have a predetermined pattern. The material of the DAB glass antenna 4 need only have conductivity, and can be selected as appropriate in the embodiment. Silver, gold, platinum and the like can be given as examples of the material of the DAB glass antenna 4. This DAB glass antenna 4 can be formed by, for example, printing and baking a conductive silver paste containing silver powder, glass frit and the like on the surface of the glass plate 2.

Manufacturing Method

[0055] Next, the manufacturing method of the window glass 1 according to the present embodiment will be described. The glass plate 2 of the window glass 1 according to the present embodiment can be shaped by methods such as a press-molding method for shaping the glass plate with a press or a self-weight bending method for bending the glass plate 2 under its own weight.

[0056] Here, at the time of shaping the glass plate 2 with these respective methods, the glass plate 2 is heated to near softening point in a heating furnace. Before being placed in this heating furnace, the glass plate 2 is flat in shape, and the conductive silver paste containing silver powder, glass frit and the like is printed on the surface of this glass plate 2. The defogger 3 and the DAB glass antenna 4 can then be formed, by placing the glass plate 2 in the heating furnace to bake the silver paste printed on the glass plate 2 together with shaping the glass plate 2.

Exemplary Usage

[0057] Next, an exemplary usage of the window glass 1 according to the present embodiment will be described using FIG. 2. FIG. 2 schematically shows an exemplary usage of the window glass 1 according to the present embodiment. As illustrated in FIG. 2, the window glass 1 according to the present embodiment can be utilized as the rear glass of a hatchback vehicle 8.

[0058] This vehicle 8 is provided with a window frame 9 on the rear side, and the window glass 1 is attached to this window frame 9. For example, the window glass 1 is attached to the window frame 9 such that the projected area that occurs when parallel light strikes the window glass horizontally will be 0.5 mm^2 , and the attachment angle when referenced on the horizontal direction (when the horizontal direction is given as 0 degrees) will be from 45 degrees to 75 degrees inclusive. Note that, in the case where the window glass 1 is curved, the attachment angle varies at each point of the window glass 1. In this case, the window glass 1 is attached to the window frame 9 such that the attachment angle will be from 45 degrees to 75 degrees inclusive at an arbitrary point of the window glass 1. Also, the projected area can be measured as follows, for example. That is, the window glass 1 is attached to the window frame of the vehicle, and the window glass 1 is irradiated from the vehicle interior side with parallel light that is parallel to the ground. Light transmitted by the window glass 1 is then projected onto a screen outside the car that is installed vertically to the ground, and the area of the shadow of the window glass 1 projected onto this screen is measured. The projected area of the window glass 1 can thereby be measured.

[0059] In the case of attaching the window glass 1 to the window frame 9 having such an attachment area and attachment angle, the size of the window glass 1 is comparatively small. Thus, when the defogger 3 is provided on the window glass 1 together with the DAB glass antenna 4, the area over which the DAB glass antenna 4 can be installed will be restricted. However, as described above, according to the present embodiment, the vertical length of the vertical element 42 can be suppressed, while maintaining the reception performance of the DAB glass antenna 4. That is, even when the area over which the DAB glass antenna 4 can be installed is restricted, it is possible to maintain the reception performance of the DAB glass antenna 4. Accordingly, the present embodiment particularly exhibits an effect with a window having such an attachment area and attachment angle.

2. Modifications

[0060] Hereinabove, an embodiment of the present invention has been described in detail, but the aforementioned description is in all respects merely illustrative of the present invention. Needless to say, various improvements and modifications can be made without departing from the scope of the invention. In relation to the constituent

elements of the window glass 1, the glass plate 2, the defogger 3 and the DAB glass antenna 4, omission, replacement and addition of constituent elements may be made, as appropriate, according to the embodiment. For example, changes such as the following can be made. Note that, hereinafter, similar reference signs will be used in relation to constituent elements that are similar to the above embodiment, and description will be omitted as appropriate.

Glass Plate

[0061] For example, in relation to the above specific configuration of the glass plate 2, omission, change, replacement and addition of constituent elements may be made, as appropriate, according to the embodiment. The above glass plate 2 may, for example, have a shape that curves forward or may have a flat shape. Also, the glass plate 2 may be utilized in applications other than rear glass.

[0062] Also, the above glass plate 2 is constituted by a single glass plate. However, the above glass plate 2 may be constituted by laminated glass formed by joining an outer glass plate and an inner glass plate to each other via an intermediate film. Furthermore, the above glass plate 2 is formed in a trapezoidal shape. However, the shape of the glass plate 2 need not be limited to such a shape, and may be selected as appropriate according to the embodiment.

Defogger and DAB Glass Antenna

[0063] Also, for example, in relation to the respective specific configurations of the defogger 3 and the DAB glass antenna 4, omission, change, replacement and addition of constituent elements may be made, as appropriate, according to the embodiment.

[0064] For example, the above defogger 3 need not be formed symmetrically. Also, in the above embodiment, a plurality (5 in the drawings) of vertical filament parts 33 are disposed symmetrically. However, the plurality of vertical filament parts 33 need not be disposed symmetrically in such a manner. Also, in the above embodiment, five vertical filament parts 33 are provided. However, the number of the vertical filament parts 33 need not be limited to five, and may be one to four, or may be six or more. That is, the disposition and number of vertical filament parts 33 may be selected as appropriate according to the embodiment. The disposition and number of vertical filament parts 33 is, however, preferably selected, such that the pitch between adjacent vertical filament parts 33 and the pitch between the bus bar part 31 and the vertical filament part 33 adjacent to the bus bar part 31 are not equal to an integer multiple of F shown in the above equation 1. Also, the disposition interval between the hot wire parts 32 in the up-down direction may be uniform or may be non-uniform. Furthermore, the shapes of the power supply part 41 and the ground connection

part 44 need not be limited to being rectangular, and may be selected as appropriate according to the embodiment.

[0065] Also, for example, in the above DAB glass antenna 4, the position at which the vertical element 42 and the horizontal element 43 are each coupled need not be limited to an example such as the above, and may be selected as appropriate according to the embodiment. For example, the horizontal element 43 may be coupled, in a central portion, to any position of the vertical element 42. A T-shaped or cross-shaped antenna can thereby be constituted.

[0066] Furthermore, window glasses 1A to 1C illustrated in FIG. 3A and FIG. 3B may be constituted. FIG. 3A schematically illustrates a window glass 1A in which the defogger 3 is omitted from the above window glass 1. FIG. 3B schematically illustrates a window glass 1B in which the vertical filament parts 33 are omitted from the above window glass 1.

[0067] First, the window glass 1A illustrated in FIG. 3A will be described. As illustrated in FIG. 3A, the above defogger 3 may be omitted. In this case, the restriction of the installation area of the DAB glass antenna by the defogger 3 is eliminated. Thus, as illustrated in FIG. 3A, the horizontal element 43 may be omitted from the above DAB glass antenna 4, and the antenna may be constituted by the vertical element 42. A DAB glass antenna 4A illustrated in FIG. 3A is similar to the above DAB glass antenna 4, except for the horizontal element 43 being omitted.

[0068] Next, the window glass 1B illustrated in FIG. 3B will be described. As illustrated in FIG. 3B, the vertical filament parts 33 in the above defogger 3 may be omitted. A defogger 3B illustrated in FIG. 3B is similar to the above defogger 3, except for the vertical filament parts 33 being omitted. Note that, in this case, the effect of ameliorating the reception performance of the DAB glass antenna 4 by the vertical filament parts 33 can no longer be expected. Thus, in this case, in particular, the distance D1 is desirably set to 46 mm or more, such that the defogger 3B does not adversely affect the reception performance of the DAB glass antenna 4.

[0069] Also, for example, in the above embodiment, the power supply part 41 is disposed in the horizontal center, and the vertical element 42 is directly connected to the power supply part 41. However, the disposition of the power supply part 41 and the shape of the elements of the DAB glass antenna 4 need not be limited to such an example, and may be changed as appropriate according to the embodiment. The power supply part 41 may be disposed toward the left side edge portion 23 or toward the right side edge portion 24. Furthermore, the vertical element 42 need not be directly connected to the power supply part 41. As an example, changes shown in FIG. 3C and FIG. 3D can be made.

[0070] FIG. 3C schematically illustrates a window glass 1D in which a DAB glass antenna 4D is provided toward the right side edge portion 24. The DAB glass antenna 4D is provided with a power supply part 41D that

is disposed toward the right side edge portion 24, and a wiring part 46D that extends in the direction of the left side edge portion 23 from the power supply part 41D. The wiring part 46D is constituted, in order from the power supply part 41D side, by a first portion 461D that extends slightly upward from the power supply part 41D, a second portion 462D that extends on the left side from the upper end portion of the first portion 461D, a third portion 463D that extends slightly downward from the left end portion of the second portion 462D, and a fourth portion 464D that greatly extends on the left side from the lower end portion of the third portion 463D.

[0071] In this modification, a vertical element 42D is coupled to the left end portion of the fourth portion 464D of the wiring part 46D, and extends vertically upward from the left end portion of the fourth portion 464D. Also, a horizontal element 43D is coupled to the upper end portion of the vertical element 42D, and extends on the right side from the upper end portion of the vertical element 42D. This horizontal element 43D is shorter in the left-right direction than the fourth portion 464D of the wiring part 46D.

[0072] Also, a ground connection part 44D is disposed on the left side of the power supply part 41D. In this modification, as shown in FIG. 3C, the first portion 461D to the third portion 463D of the wiring part 46D are disposed so as to surround the upper side of the ground connection part 44D, and thus a filament part 47D that extends downward from the ground connection part 44D is provided. A ground filament part 45D extends horizontally from the lower end portion of this filament part 47D.

[0073] Otherwise, the window glass 1D has a similar configuration to the above window glass 1. Note that the wiring part 46D may be formed with a similar material to the elements (42D, 43D). Thus, all or part of the wiring part 46D may be configured to exhibit a similar function to the elements (42D, 43D).

[0074] Also, FIG. 3D schematically illustrates a window glass 1E having a DAB glass antenna 4E that differs in shape from the DAB glass antenna 4D shown in FIG. 3C. The DAB glass antenna 4E is provided with a power supply part 41E that is disposed toward the right side edge portion 24, and a ground connection part 44E that is disposed on the right side of this power supply part 41E.

[0075] A wiring part 46E extends horizontally from the power supply part 41E. A vertical element 42E is coupled to the left end portion of this wiring part 46E, and extends vertically upward from the left end portion of the wiring part 46E. Also, a horizontal element 43E is coupled to the upper end portion of the vertical element 42E, and extends on the right side from the upper end portion of the vertical element 42E. This horizontal element 43E is shorter in the left-right direction than the wiring part 46E. Similarly to the above modification, this wiring part 46E may be formed with a similar material to the elements (42E, 43E). Thus, all or a part of this wiring part 46E may be configured so as to issue a similar function to the elements (42E, 43E).

[0076] On the other hand, a filament part 47E extends slightly downward from the ground connection part 44E. Also, a ground filament part 45E extends horizontally from the lower end portion of this filament part 47E. This ground filament part 45E extends further to the left side edge portion 23 side than the vertical element 42E. Otherwise, the window glass 1E has a similar configuration to the above window glass 1.

[0077] As described above, the disposition of the power supply part 41 and the shape of the elements of the DAB glass antenna 4 can be changed as appropriate according to the embodiment.

Other Modifications

[0078] Also, as described above, amelioration of the reception performance of the DAB glass antenna 4 can be achieved by providing the vertical filament parts 33 in the defogger 3. Thus, in the case of achieving amelioration of the reception performance of the above DAB glass antenna 4 by providing the vertical filament parts 33 in the defogger 3, the above DAB glass antenna 4 may be disposed on the upper edge portion 21 side of the glass plate 2. Hereinafter, this example will be described using FIG. 4.

[0079] FIG. 4 schematically illustrates a window glass 1C in which a DAB glass antenna 5 is provided on the upper edge portion 21 side of the glass plate 2. The DAB glass antenna 5 illustrated in FIG. 4 is similar to the above DAB glass antenna 4, except for being disposed on the upper edge portion 21 side of the glass plate 2.

[0080] That is, the DAB glass antenna 5 is provided with a rectangular power supply part 51 that is disposed on the upper edge portion 21 side of the glass plate 2, a vertical element 52 that extends vertically downward from this power supply part 51, and a horizontal element 53 that is coupled to the vertical element 52 and extends in the left direction (horizontal direction). Also, the DAB glass antenna 5 is constituted as a dipole antenna, and is provided with a rectangular ground connection part 54 disposed in proximity to the power supply part 51, and a ground filament part 55 that extends in the left direction (horizontal direction) from this ground connection part 54.

[0081] Furthermore, a defogger 3C illustrated in FIG. 4 is similar to the above defogger 3, except for being disposed on the lower edge portion 22 side of the glass plate 2. Here, a distance D2 between the lower end of the DAB glass antenna 5 and the defogger 3C may be set as appropriate according to the embodiment. Based on each the tests (in particular, test 7) which will be discussed later, the distance D2 may be set to 85 mm or more. Note that, in this modification, the horizontal element 53 is coupled to the lower end portion of the vertical element 52. Thus, the lower end portion of the vertical element 52 and the lower edge portion of the horizontal element 53 correspond to the lower end of the DAB glass antenna 5.

Working Examples

[0082] Hereinafter, working examples of the present invention will be described. The present invention is, however, not limited to these working examples. In order to investigate the reception performance of the DAB glass antenna of the present invention, the following tests 1 to 9 were performed. Hereinafter, each test will be described.

(1) Test 1: Disposition of DAB glass antenna

[0083] First, in this test 1, as illustrated in FIG. 5A and FIG. 5B, the influence exerted on the reception performance of the DAB glass antenna by disposing a DAB glass antenna on the upper edge portion side or the lower edge portion side of the glass plate was investigated. FIG. 5A schematically illustrates a working example 1 in which a DAB glass antenna 4C is disposed on the lower edge portion 22 side of the glass plate 2. Also, FIG. 5B schematically illustrates a comparative example 1 in which the DAB glass antenna 5 is disposed on the upper edge portion 21 side of the glass plate 2.

[0084] As illustrated in FIG. 5A, a window glass of the working example 1 having a similar configuration to the window glass 1A of the modification illustrated in above-mentioned FIG. 3A was prepared. Specifically, the curved rear glass of a hatchback station wagon was prepared as the window glass according to the working example 1. The prepared window glass according to the working example 1 was then attached to the window frame on the rear side of the hatchback station wagon. The length of the upper edge of the window frame to which the glass plate 2 was attached was 920 mm, the length of the lower edge of the window frame was 1100 mm, and the height of the window frame in the up-down direction was 415 mm. The glass plate 2 was formed by a well-known manufacturing process so as to fit the size of this window frame. Also, the window glass according to the working example 1 was obtained, by constituting the DAB glass antenna 4A, such that the power supply part 41, the ground connection part 44 and the ground filament part 45 were disposed 5 mm upward from the lower edge of the window frame and the power supply part 41 and the vertical element 42 were disposed in the center of the glass plate 2 in the left-right direction. The power supply part 41 and the ground connection part 44 according to the working example 1 each had a rectangular shape that was 20 mm × 20 mm. Also, the length of the vertical element 42 in the up-down direction was 300 mm. Furthermore, the length of the ground filament part 45 in the left-right direction was 110 mm.

[0085] Furthermore, as illustrated in FIG. 5A, window glasses according to working examples 2 to 5 were obtained, by moving the DAB glass antenna 4A of this working example 1 to the right side edge portion 24 side at pitches of 100 mm. That is, the window glass according to the working example 2 was obtained, by moving the

DAB glass antenna 4A of the working example 1 horizontally 100 mm to the right side edge portion 24 side. Similarly, the window glasses according to the working examples 3, 4 and 5 were obtained by respectively moving the DAB glass antenna 4A of the working example 1 horizontally 200 mm, 300 mm and 400 mm to the right side edge portion 24 side. Note that with each of the DAB glass antennas 4A according to the working examples 2 to 4, the length of the vertical element 42 in the up-down direction was 300 mm, similarly to the working example 1. On the other hand, the length of the vertical element 42 of the DAB glass antenna 4A according to the working example 5 in the up-down direction was 290 mm. In the window glass according to this working example 5, the distance from the right side edge portion 24 of the glass plate 2 to the vertical element 42 was 141.5 mm.

[0086] In contrast, as illustrated in FIG. 5B, the window glass of the comparative example 1 was prepared, by disposing the DAB glass antenna 4A of the working example 1 on the upper edge portion 21 side of the glass plate 2. Specifically, the glass plate 2 was formed similarly to the above working example 1. Also, the window glass according to the comparative example 1 was obtained, by constituting the DAB glass antenna 5, such that the power supply part 51, the ground connection part 54 and the ground filament part 55 were disposed 5 mm downward from the upper edge of the window frame and the power supply part 51 and the vertical element 52 were disposed in the center of the glass plate 2 in the left-right direction. The power supply part 51 and the ground connection part 54 according to the comparative example 1 each had a rectangular shape that was 20 mm × 20 mm, similarly to the working example 1. Also, the length of the vertical element 52 in the up-down direction was 310 mm. Furthermore, the length of the ground filament part 55 in the left-right direction was 110 mm.

[0087] Also, as illustrated in FIG. 5B, the window glasses according to comparative examples 2 to 5 were obtained, by moving the DAB glass antenna 5 of this comparative example 1 to the right side edge portion 24 side at pitches of 100 mm. That is, the window glass according to the comparative example 2 was obtained, by moving the DAB glass antenna 5 of the comparative example 1 horizontally 100 mm to the right side edge portion 24 side. Similarly, the window glasses according to the comparative examples 3, 4 and 5 were obtained by respectively moving the DAB glass antenna 5 of the comparative example 1 horizontally 200 mm, 300 mm and 400 mm to the right side edge portion 24 side. Note that the length of the vertical element 52 of each of the DAB glass antennas 5 according to the comparative examples 2 to 4 in the up-down direction was 300 mm. On the other hand, the length of the vertical element 52 of the DAB glass antenna 5 according to the comparative example 5 in the up-down direction was 290 mm. In the window glass according to this comparative example 2, the distance from the right side edge portion 24 of the glass plate 2 to the

vertical element 52 was 60.5 mm.

[0088] The window glasses of the working examples 1 to 5 and the comparative examples 1 to 5 obtained in this manner were attached to a hatchback station wagon as described above. The sensitivity of each DAB glass antenna was then measured, by irradiating the station wagon with radio waves of DAB band 3 in a radio wave darkroom, and receiving the signal of DAB band 3 with each DAB glass antenna. A network analyzer (model E-5071C produced by Agilent) was utilized in measurement of the sensitivity of each DAB glass antenna. The specific conditions in performing measurement were as follows.

- Attachment angle of glass plate: 62 degree incline at a point on the lower edge in the up-down direction, 54 degree incline at a point in the center in the up-down direction, and 45 degree incline at a point on the upper edge in the up-down direction, relative to the horizontal direction
- Angular resolution: measured every 3 degrees while rotating station wagon 360 degrees
- Frequency resolution: measured every 1 MHz in a range of 174 MHz to 240 MHz
- Elevation angle between transmission position of radio waves and antenna: 1.7 degrees (0 degrees in a direction horizontal to ground, and 90 degrees at zenith) Note that the same conditions apply in the following tests 2 to 8 unless particularly stated otherwise. The sensitivity of each DAB glass antenna was defined by relative gain (dBd) based on a half-wavelength dipole antenna. Through cable was utilized, without providing an amplifier between the receiver and each DAB glass antenna. FIG. 6A, FIG. 6B, FIG. 7A and FIG. 7B show the results.

[0089] FIG. 6A shows the results of measuring sensitivity (gain) of the working examples 1 to 5 with respect to each frequency of DAB band 3. Also, FIG. 6B shows the average values for sensitivity (gain) of the working examples 1 to 5 in the frequency band of DAB band 3. On the other hand, FIG. 7A shows the measurement results of the comparative examples 1 to 5 with respect to each frequency of DAB band 3. Also, FIG. 7B shows the average values for sensitivity (gain) of the comparative examples 1 to 5 in the frequency band of DAB band 3.

[0090] When the average values (FIG. 6B) for sensitivity of the working examples 1 to 5 are compared with the average values (FIG. 7B) for sensitivity of the comparative examples 1 to 5, the sensitivity of the working examples 1 to 5 is better than the comparative examples 1 to 5 by about 1 dBd. That is, it is evident that the reception performance of DAB broadcasts (in particular, band 3) improves when the DAB glass antenna is disposed on the lower edge side rather than being disposed on the upper edge side of the window glass.

[0091] Note that, with reference to the measurement results, in the working examples 1 to 5, the reception performance of the working example 3 was most favo-

erable. Also, in the comparative examples 1 to 5, the reception performance of the comparative example 3 was most favorable. This is surmised to be due to the ground filament parts (45, 55) extending in the left direction. That is, it is evident that the reception performance of the DAB glass antenna can be enhanced, by shifting the DAB glass antenna by approximately the length of the ground filament part, in the opposite direction to the direction in which the ground filament part extends from the center of the glass plate in the left-right direction.

(2) Test 2: Length of vertical element and horizontal element

[0092] Next, in this test 2, as illustrated in FIG. 8, the influence exerted on the reception performance of the DAB glass antenna by changing the vertical length of the vertical element and the horizontal length of the horizontal element of a DAB glass antenna was investigated. FIG. 8 schematically illustrates window glasses according to working examples 7 to 11 that constitute an L-shaped antenna in this test 2.

[0093] First, the window glass according to a working example 6 having a similar configuration to the working example 1 was obtained, by setting a length L1 of the vertical element 42 in the working example 1 of the above test 1 to 240 mm, and the horizontal length of the ground filament part 45 to 300 mm. That is, with the DAB glass antenna 4 according to the working example 6, a length L2 of the horizontal element 43 is 0 mm. Note that the wiring that was connected to the ground connection part 44 was grounded at a position 150 mm from the terminal of the connection part provided on the vehicle body side.

[0094] Also, the window glasses of the working examples 7 to 11 were obtained, by shortening the length L1 of the vertical element 42 of the working example 6, and lengthening the length L2 of the horizontal element 43. In the DAB glass antenna 4 according to the working example 7, the length L1 of the vertical element 42 was 100 mm, and the length L2 of the horizontal element 43 was 120 mm. Also, in the DAB glass antenna 4 according to the working example 8, the length L1 of the vertical element 42 was 80 mm, and the length L2 of the horizontal element 43 was 140 mm. Also, in the DAB glass antenna 4 according to the working example 9, the length L1 of the vertical element 42 was 60 mm, and the length L2 of the horizontal element 43 was 160 mm. Also, in the DAB glass antenna 4 according to the working example 10, the length L1 of the vertical element 42 was 40 mm, and the length L2 of the horizontal element 43 was 180 mm. Also, in the DAB glass antenna 4 according to the working example 11, the length L1 of the vertical element 42 was 20 mm, and the length L2 of the horizontal element 43 was 190 mm. That is, in the working examples 7 to 11, an L-shaped antenna was constituted by the vertical element 42 and the horizontal element 43. With regard to the working examples 6 to 11, the sensitivity of the DAB glass antennas was measured with a similar

method to the above test 1. FIG. 9A and FIG. 9B show the results.

[0095] FIG. 9A shows the results of measuring sensitivity (gain) of the working examples 6 to 11 with respect to each frequency of DAB band 3. Also, FIG. 9B shows the average values for sensitivity (gain) of the working examples 6 to 11 in the frequency band of DAB band 3. As illustrated in FIG. 9A and FIG. 9B, it is evident that the reception performance of the DAB glass antenna decreases, in response to shortening the length L1 of the vertical element. As shown in FIG. 9B, the average value for sensitivity of the DAB glass antenna according to the working example 11 was - 8.4dBd. It is surmised that reception of DAB broadcasts is affected when the sensitivity decreases below this value. That is, it is evident from these results that a reception performance capable of receiving DAB broadcasts (in particular, band 3) can be secured, by setting the length of the vertical element to 20 mm or more.

(3) Test 3: Distance between defogger and DAB glass antenna

[0096] Next, in this test 3, as illustrated in FIG. 10, the influence exerted on the reception performance of the DAB glass antenna by changing the distance D1 between a DAB glass antenna and a defogger that is not provided with vertical filament parts was investigated. FIG. 10 schematically illustrates the window glass according to a working example 14 in which two hot wire parts 32 are provided in this test 3.

[0097] First, the window glass according to a working example 12A that has a similar configuration to the working example 7 is obtained by setting the length L2 of the horizontal element 43 in the working example 7 of the above test 2 to 120 mm. That is, the window glass according to the working example 12A has the same configuration as the window glass according to the working example 7, except for the length of the horizontal element 43 of the DAB glass antenna 4. Also, the window glass according to a working example 12B was obtained by setting the length L1 of the vertical element 42 of the working example 12A to 80 mm, and the length L2 of the horizontal element 43 to 140 mm.

[0098] Also, the window glass according to a working example 13 was obtained, by setting the length L2 of the horizontal element 43 of the working example 12A to 140 mm, and providing the defogger 3B that has the one hot wire part 32 on the window glass according to a working example 12. In the window glass according to the working example 13, the distance D1 between the defogger 3B and the DAB glass antenna 4 was 241 mm. Also, the length between the bus bar parts 31 of the defogger 3B was 900 mm near the upper end and 970 mm near the lower end. was. As illustrated in FIG. 10, window glasses according to working examples 14 to 20 were obtained, by increasing the number of the hot wire parts 32 of the defogger 3B according to this working example 13 down-

ward at pitches of 32.5 mm. That is, in the window glasses according to the working examples 14 to 20, the defogger 3B respectively having 2 to 8 hot wire parts 3 was formed, and the distance D1 between the defogger 3B and the DAB glass antenna 4 was respectively 208.5 mm, 176 mm, 143.5 mm, 111 mm, 78.5 mm, 46 mm and 13.5 mm. With regard to the working examples 12A, 12B and 13 to 20, the sensitivity of each DAB glass antenna was measured with a similar method to the above tests. FIG. 11A and FIG. 11B show the results. Note that "working example 12" of FIG. 11A shows the average value of measured values obtained with regard to the working example 12A and the working example 12B.

[0099] FIG. 11A shows the results of measuring sensitivity (gain) of the working examples 12 to 20 with respect to each frequency of DAB band 3. Also, FIG. 11B shows the average values for sensitivity (gain) of the working examples 13 to 20 in the frequency band of DAB band 3. As shown in FIG. 11A and FIG. 11B, the reception performance of the DAB glass antenna does not change greatly in the working examples 12 to 19, and deteriorates in the working example 20. That is, it is evident that when the defogger is moved closer than a range of 46 mm from the DAB glass antenna, the sensitivity of the DAB glass antenna decreases due to interference from the defogger. Accordingly, it is evident that the influence of the defogger on the reception performance of the DAB glass antenna can be prevented, by making the distance D1 between the defogger and the DAB glass antenna 46 mm or more. In particular, it is evident that, in the case where vertical filament parts are not provided in the defogger, deterioration of the reception performance of the DAB glass antenna can be prevented, by making the distance D1 between the defogger and the DAB glass antenna 46 mm or more.

(4) Test 4: Vertical filament part

[0100] Next, as illustrated in FIG. 12, in this test 4, the influence exerted on the reception performance of the DAB glass antenna by providing vertical filament parts was investigated. FIG. 12 schematically illustrates the window glass according to a working example 23 in which five vertical filament parts 33 are provided.

[0101] First, the window glass according to the working example 6 of the above test 2 in which a defogger is not provided and a linear antenna is constituted was prepared. Also, the window glass according to a working example 12C was prepared, by setting the length L1 of the vertical element 42 of the working example 12A of the above test 3 in which a defogger is not provided and an L-shaped antenna is constituted to 100 mm, and the length L2 of the horizontal element 43 to 140 mm. Furthermore, one hot wire part 32 was added to the lowermost portion of the defogger 3B of the working example 20 of the above test 3 in which a defogger is provided but vertical filament parts are not provided, making it a total of nine hot wire parts 32. The window glass accord-

ing to a working example 20A was then prepared, by shifting the defogger 3B upward, such that the distance between the hot wire part 32 of the lowermost portion and the DAB glass antenna 4 was 13.5 mm.

[0102] As illustrated in FIG. 12, window glasses according to working examples 21 to 23 were then obtained, by providing the vertical filament parts 33 in the defogger 3B according to this working example 20A. In the window glass according to the working example 21, the vertical filament part 33 was provided only in the center in the left-right direction. That is, in the window glass according to the working example 21, a total of one vertical filament part 33 was prepared.

[0103] Also, in the window glass according to the working example 22, one vertical filament part 33 was provided in the center in the left-right direction, and one vertical filament part 33 each was symmetrically disposed in the left-right direction about the one vertical filament part 33. That is, in the window glass according to the working example 22, a total of three vertical filament parts 33 were provided. Note that a distance W1 between each vertical filament part 33 disposed in the left-right direction and the vertical filament part 33 disposed in the center was 200 mm.

[0104] Furthermore, in the window glass according to the working example 23, one vertical filament part 33 was provided in the center in the left-right direction, and two vertical filament parts 33 each were symmetrically disposed in the left-right direction about the one vertical filament part 33. That is, in the window glass according to the working example 22, a total of five vertical filament parts 33 were provided. Note that the distance W1 between each vertical filament part 33 disposed on inner side in the left-right direction and the vertical filament part 33 disposed in the center was 200 mm. Also, a distance W2 between each vertical filament part 33 disposed on the outer side in the left-right direction and the vertical filament part 33 disposed in the center was 300 mm. With regard to the working examples 6, 12C, 20A, and 21 to 23, the sensitivity of each DAB glass antenna was measured with a similar method to the above tests. FIG. 13A and FIG. 13B show the results.

[0105] FIG. 13A shows the results of measuring sensitivity (gain) of the working examples 6, 12C, 20A and 21 to 23 with respect to each frequency of DAB band 3. Also, FIG. 13B shows the average values for sensitivity (gain) of the working examples 6, 12C, 20A and 21 to 23 in the frequency band of DAB band 3. As illustrated in FIG. 13A and FIG. 13B, the working examples 22 and 23 in which a plurality of vertical filament parts are provided had reception performances almost equivalent to the working example 6 in which a defogger was not provided. In particular, on comparison of the working examples 21 to 23, there was a tendency for the reception performance of the DAB glass antenna to be ameliorated, as the number of vertical filament parts was increased.

[0106] Here, the working examples 22 and 23 are substantially forms in which a plurality of vertical filament

parts are added to the defogger in the working example 20 of the above test 3. That is, in the working examples 22 and 23, the reception performance of the DAB glass antenna was ameliorated, despite the defogger being disposed in an area in which the reception performance of the DAB glass antenna is deteriorated in the above test 3. Accordingly, it is evident from this test 4 that the reception performance of the DAB glass antenna can be ameliorated, by providing a vertical filament part (in particular, a plurality of vertical filament parts) in the defogger, even when the defogger is disposed in an area in which the reception performance of the DAB glass antenna is deteriorated. Therefore, it is surmised that in the case where a vertical filament part is provided in the defogger, and, in particular, in the case where a plurality of vertical filament parts are provided in the defogger, the reception performance of the DAB glass antenna can possibly be ameliorated, even when the DAB glass antenna is disposed on the upper edge side of the window glass.

[0107] Note that, in the working example 21, the reception performance of the DAB glass antenna decreases at about 210 MHz. This is considered to be caused by the production of standing waves in the defogger 3 due to radio waves of a frequency of about 210 MHz.

[0108] That is, in the working example 21, the distance between the bus bar parts 31 was 900 mm in the vicinity of the upper end portion and 970 mm in the vicinity of the lower end portion. Also, since a vertical filament part 33 was added only in the center in the left-right direction, the pitch between each bus bar part 31 and the vertical filament part 33 was 450 mm to 485 mm (0.45 m to 0.485 m). The range of this pitch is included in the range of the above F (0.44 m to 0.62 m) that envisages the case of DAB band 3. In other words, according to the conditions of the above equation 1, it is considered that, in the working example 21, standing waves are produced in the defogger 3.

[0109] In view of this, the value of f will be from 216 MHz to 233 MHz when 0.45 m to 0.485 m (450 mm to 485 mm) is substituted for F in equation 1, 3.0×10^8 (m/s) is substituted for the velocity of light c , and 0.7 is substituted for K . The value of f is slightly shifted from the frequency of 210 MHz at which the reception performance decreased, and this is conceivably caused by setting the value of K to 0.7.

[0110] In contrast, in the working example 22, the pitches were 200 mm or 250 mm to 285 mm. With the working example 23, the pitches were 100 mm, 150 mm to 185 mm, or 200 mm. That is, in the working examples 22 and 23, the pitch between adjacent vertical filament parts 33 and the pitch between the bus bar part 31 and the vertical filament part 33 adjacent to the bus bar part 31 were not equal to an integer multiple of F in the above equation 1. Also, in these working examples 22 and 23, a decrease in the reception performance such as in the working example 21 did not occur at about 210 MHz. Accordingly, it is evident that the conditions that cause standing waves

to be produced in the defogger 3 and the reception performance of the DAB glass antenna to decrease can be derived from the above equation 1.

5 (5) Test 5: Length of vertical element when a plurality of vertical filament parts are provided

[0111] Next, as illustrated in FIG. 14, in this test 5, the influence exerted on the reception performance of the DAB glass antenna by changing the length of the vertical element in the case where five vertical filament parts are provided was investigated. FIG. 14 shows the state of this test 5.

[0112] First, the window glass according to the working example 23 of the above test 4 was prepared. In the window glass according to this working example 23, the distance $D1$ between the defogger 3 and the DAB glass antenna 4 was 13.5 mm, and the distance from the lower edge of the window glass to the defogger 3 was 138.5 mm. Window glasses according to working examples 24 to 27 were then obtained, by shortening the length $L1$ of the vertical element 42 of the DAB glass antenna 4 by 20 mm each while maintaining the distance $D1$, and newly providing hot wire parts 32 in the space created by the shortened length. Note that, in the window glasses according to the working examples 23 to 27, the total of the length $L1$ of the vertical element 42 and the length $L2$ of the horizontal element 43 was fixed at 240 mm. That is, in the window glasses according to the working examples 24 to 27, the length $L1$ of the vertical element 42 of the DAB glass antenna 4 was respectively 80 mm, 60 mm, 40 mm and 20 mm, and the length $L2$ of the horizontal element 43 was respectively 160 mm, 180 mm, 200 mm and 220 mm. Also, in the window glasses according to the working examples 24 to 27, the distance from the lower edge of the window glass to the defogger 3 was respectively 118.5 mm, 98.5 mm, 78.5 mm and 58.5 mm. With regard to the working examples 23 to 27, the sensitivity of each DAB glass antenna was measured with a similar method to the above tests. FIG. 15A and FIG. 15B show the results.

[0113] FIG. 15A shows the results of measuring sensitivity (gain) of the working examples 23 to 27 with respect to each frequency of DAB band 3. Also, FIG. 15B shows the average values for sensitivity (gain) of the working examples 23 to 27 in the frequency band of DAB band 3. On comparison of the above FIG. 9B and FIG. 11B, it is evident that in the case where five vertical filament parts are provided in the defogger, the receiving sensitivity of the DAB glass antenna can be secured, even when the length of the vertical element of the DAB glass antenna is 20 mm. Also, as shown in FIG. 11A and FIG. 11B, with the window glasses according to the working examples 23 to 25, the receiving sensitivity of the DAB glass antenna was particularly favorable, and with the window glass according to the working example 26, the receiving sensitivity of the DAB glass antenna decreased slightly. Thus, it is evident that a DAB glass an-

tenna with favorable receiving sensitivity is obtained, by setting the distance from the lower edge of the window glass to the defogger, or in other words, the vertical range over which the DAB glass antenna can be installed, to 78.5 mm or more (e.g., 80 mm). Note that, in the working examples 24 to 27, the pitch between adjacent vertical filament parts 33 and the pitch between the buster part 31 and the vertical filament part 33 adjacent to the bus bar part 31 are similar to the above working example 23. Thus, in the working examples 24 to 27, it is conceivable that the production of standing waves in the defogger 3 was avoided as a result of the pitches not being equal to an integer multiple of F in the above equation 1.

(6) Test 6: Case where DAB glass antenna is disposed on upper edge side of window glass

[0114] Next, in this test 6, as illustrated in FIG. 16, the influence exerted on the reception performance of the DAB glass antenna by changing the vertical length of the vertical element and the horizontal length of the horizontal element in the DAB glass antenna, in the case where the DAB glass antenna is disposed on the upper edge side of the window glass, was investigated. FIG. 16 schematically illustrates the window glasses according to reference examples 2 to 6 in which an L-shaped antenna is constituted in this test 6. Note that this test 6 is similar to the above test 2.

[0115] First, the window glass according to a reference example 1 having a similar configuration to the comparative example 1 of the above test 1 was obtained, by setting a length L3 of the vertical element 52 in the comparative example 1 to 240 mm, and the horizontal length of the ground filament part 55 to 310 mm. That is, with the DAB glass antenna 5 according to the reference example 1, a length L4 of the horizontal element 53 was 0 mm.

[0116] The window glasses of the reference examples 2 to 6 were then obtained, by shortening the length L3 of the vertical element 52 of the reference example 1, and lengthening the length L4 of the horizontal element 53. With the DAB glass antennas 5 according to the reference examples 2 to 6, the length L3 of the vertical element 52 was respectively 100 mm, 80 mm, 60 mm, 40 mm and 20 mm, and the length L4 of the horizontal element 53 was respectively 130 mm, 150 mm, 170 mm, 190 mm and 210 mm. That is, in the reference examples 2 to 6, an L-shaped antenna was constituted by the vertical element 52 and the horizontal element 53. With regard to the reference examples 2 to 6, the sensitivity of each DAB glass antenna was measured with a similar method to the above tests. FIG. 17A and FIG. 17B show the results.

[0117] FIG. 17A shows the results of measuring sensitivity (gain) of the reference examples 1 to 6 with respect to each frequency of DAB band 3. Also, FIG. 17B shows the average values for sensitivity (gain) of the reference examples 1 to 6 in the frequency band of DAB band 3.

As illustrated in FIG. 17A and FIG. 17B, it is evident that the reception performance of the DAB glass antenna decreases, in response to shortening the length L3 of the vertical element, even in the case where the DAB glass antenna is disposed on the upper edge side of the window glass. In particular, it is evident that, similarly to the above test 2, the length of the vertical element is preferably 20 mm or more, in order to secure a reception performance capable of receiving DAB (in particular, band 3) broadcasts.

(7) Test 7: Distance between defogger and DAB glass antenna disposed on upper edge side of window glass

[0118] Next, in this test 7, as illustrated in FIG. 18, the influence exerted on the reception performance of the DAB glass antenna by changing the distance D2 between a defogger that is not provided with vertical filament parts and a DAB glass antenna provided on the upper edge side of the window glass was investigated. FIG. 18 schematically illustrates the window glass according to a reference example 7 in which two hot wire parts 32 are provided in this test 7. Note that this test 7 is similar to the above test 3.

[0119] First, the window glass according to the reference example 7 was obtained, by adding the defogger 3B having two hot wire parts 32 to the window glass according to the reference example 2 of the above test 6. In the window glass according to the reference example 7, the interval between the two hot wire parts 32 was 32.5 mm. At this time, in the window glass according to the reference example 7, the distance D2 between the defogger 3B and the DAB glass antenna 5 was 247.5 mm. As illustrated in FIG. 18, the window glasses according to reference examples 8 to 12 were then obtained, by increasing the number of hot wire parts 32 of the defogger 3B according to this reference example 7 at a pitch of 32.5 mm. That is, in the window glasses according to the reference examples 8 to 12, defoggers 3B respectively having three to seven hot wire parts 32 were formed, and the distance D2 between the defogger 3B and the DAB glass antenna 5 was respectively 215 mm, 182.5 mm, 150 mm, 117.5 mm and 85 mm. With regard to the reference examples 7 to 12, the sensitivity of each DAB glass antenna was measured with a similar method to the above tests. FIG. 19A and FIG. 19B show the results.

[0120] FIG. 19A shows the results of measuring sensitivity (gain) of the reference examples 7 to 12 with respect to each frequency of DAB band 3. Also, FIG. 19B shows the average values for sensitivity (gain) of the reference examples 7 to 12 in the frequency band of DAB band 3. As illustrated in FIG. 19A and FIG. 19B, the reception performance of the DAB glass antenna did not change greatly among the reference examples 7 to 10, and decreased slightly in the reference examples 11 and 12. Referring to FIG. 19A, with the reference example 11, the sensitivity of the DAB glass antenna near the frequency 180 MHz and near 240 MHz decreased. Also,

with the reference example 12, the sensitivity of the DAB glass antenna decreased greatly in the range of frequencies 180 MHz to 200 MHz.

[0121] Thus, in the case where the DAB glass antenna is disposed on the upper edge side of the window glass, the sensitivity of the DAB glass antenna decreases due to interference from the defogger when the defogger is moved closer than a range of 85 mm from the DAB glass antenna. Accordingly, by comparing the above test 3 with this test 7, it is evident that the distance between the DAB glass antenna and the defogger which is provided so as to not interfere with reception of signals by the DAB glass antenna can be shortened more by disposing the DAB glass antenna on the lower edge side of the window glass rather than on the upper edge side of the window glass. In other words, it is shown from these results that the installation area of the DAB glass antenna can be vertically shortened and the reception performance can be improved by disposing the DAB glass antenna on the lower edge side of the window glass rather than on the upper edge side.

(8) Test 8: Influence of vertical filament parts when DAB glass antenna is provided on upper edge side of window glass

[0122] Next, in this test 8, as illustrated in FIG. 20, the influence exerted on the reception performance of the DAB glass antenna by providing vertical filament parts, in the case where the DAB glass antenna is disposed on the upper edge side of the window glass, was investigated. FIG. 20 illustrates the window glass according to reference examples 18 and 19 in which five vertical filament parts 33 are provided. Note that this test 8 is similar to the above test 4.

[0123] First, the reference example 1 of the above test 6 in which a defogger is not provided and a linear antenna is constituted was prepared. Also, the reference example 3 of the above test 6 in which a defogger is not provided and an L-shaped antenna is constituted was prepared. Furthermore, the window glass according to a reference example 13 in which the vertical filament parts are not provided was prepared, by providing a defogger that is substantially similar to the defogger 3B according to the reference example 12 of the above test 7 on the window glass according to the reference example 3. Specifically, in the defogger of the window glass according to the reference example 13, one hot wire part 32 was added to the uppermost portion of the defogger 3B according to the reference example 12 at a pitch of 20 mm. Thus, in the window glass according to the reference example 13, the distance D2 between the defogger 3B and the DAB glass antenna 5 was 85 mm, similarly to the above reference example 12. Note that the distance between the bus bar parts 31 of the defogger 3B according to this reference example 13 was 900 mm near the upper end and 970 mm near the lower end, similarly to the above working example 13.

[0124] As illustrated in FIG. 20, the window glasses according to reference examples 14 to 19 were then obtained, by providing the vertical filament parts 33 in the defogger 3B according to this reference example 13.

Specifically, in the window glass according to the reference example 14, the vertical filament part 33 was provided only in the center in the left-right direction. That is, in the window glass according to the reference example 14, a total of one vertical filament part 33 was provided.

[0125] Also, in each of the window glasses according to the reference examples 15 to 17, one vertical filament part 33 was provided in the center in the left-right direction, and one vertical filament part 33 each was symmetrically disposed in the left-right direction about the one vertical filament part 33 disposed in the center. That is, in each of the window glasses according to the reference examples 15 to 17, a total of three vertical filament parts 33 were provided. Note that, in the window glasses according to the reference examples 15 to 17, a distance W3 between each vertical filament part 33 disposed in the left-right direction and the vertical filament part 33 disposed in the center was respectively 100 mm, 200 mm and 300 mm.

[0126] Furthermore, in each of the window glasses according to the reference examples 18 and 19, one vertical filament part 33 was provided in the center in the left-right direction, and two vertical filament parts 33 each were symmetrically disposed in the left-right direction about the one vertical filament part 33. That is, in each of the window glasses according to the reference examples 18 and 19, a total of five vertical filament parts 33 were provided. Note that, in the window glasses according to the reference examples 18 and 19, the distance W3 between each vertical filament part 33 disposed on the inner side in the left-right direction and the vertical filament part 33 disposed in the center was respectively 100 mm and 200 mm. Also, in both of the window glasses according to the reference examples 18 and 19, a distance W4 between each vertical filament part 33 disposed on the outer side in the left-right direction and the vertical filament part 33 disposed in the center was 300 mm. With regard to the reference examples 1, 3 and 13 to 19, the sensitivity of each DAB glass antenna was measured with a similar method to the above tests. FIG. 21A and FIG. 21B show the results.

[0127] FIG. 21A shows the results of measuring sensitivity (gain) of the reference examples 3 and 13 to 19 of each frequency of DAB band 3. Also, FIG. 21B shows the average values for sensitivity (gain) of the reference examples 1, 3 and 13 to 19 in the frequency band of DAB band 3. As illustrated in FIG. 21A and FIG. 21B, in the reference examples 15 to 19 in which vertical filament parts were provided in the defogger, the reception performance (sensitivity) of the DAB glass antenna was ameliorated. In particular, in the reference examples 18 and 19 in which five vertical filament parts were provided in the defogger, the reception performance (sensitivity) of the DAB glass antenna was favorably ameliorated.

[0128] Here, according to the above tests 1, 6 and 7, it is shown that, in the case where the DAB glass antenna is disposed on the upper edge side of the window glass, the reception performance of DAB broadcasts deteriorates, and is readily affected by the defogger. In contrast, the reference examples 15 to 19 are similar to the form in which one or more vertical filament parts are added to the defogger in the reference example 12 of the above test 7. That is, the reference examples 15 to 19 are forms in which the DAB glass antenna is disposed on the upper edge side of the window glass, and the defogger is disposed in an area in which the reception performance of the DAB glass antenna in the above test 7 is deteriorated. Despite this, in the reference examples 15 to 19, the sensitivity of the DAB glass antenna was ameliorated, and a more favorable reception performance than the reference example 1 in which the defogger is not provided was obtained. Accordingly, it is evident from this test 8 that the reception performance of the DAB glass antenna can be ameliorated, by providing a vertical filament part (in particular, a plurality of vertical filament parts) in the defogger, even when the DAB glass antenna is disposed on the upper edge side of the window glass, and the defogger is disposed in an area in which the reception performance of the DAB glass antenna is deteriorated in the above test 7. Therefore, it is shown that the reception performance of the DAB glass antenna can be ameliorated, in the case where a vertical filament part is provided in the defogger, and, in particular, in the case where a plurality of vertical filament parts are provided in the defogger, even when the DAB glass antenna is disposed on the upper edge side of the window glass.

[0129] Furthermore, in the above reference example 13, since vertical filament parts are not provided, the pitch between the bus bar parts 31 was 0.9m to 0.97m (900 mm to 970 mm), and was included in a range of twice the above F (0.44 m to 0.62 m) that is derived from the above equation 1 envisaging the case of DAB band 3. Similarly, in the above reference example 14, since one vertical filament part 33 was provided in the center in the left-right direction, the pitch between each path bar part 31 and the vertical filament part 33 was 0.45 m to 0.485 m (450 mm to 485 mm). In other words, in the reference example 14, the pitch between each path bar part 31 and the vertical filament part 33 was included in the range of the above F (0.44 m to 0.62 m) that is derived from the above equation 1 envisaging the case of DAB band 3. In contrast, in the reference examples 15 to 19, since the vertical filament parts 33 are disposed as described above, the pitch between the bus bar part 31 and the vertical filament part 33 adjacent to the bus bar part 31 and the pitch between adjacent vertical filament parts 33 were both not an integer multiple of the above F.

[0130] Accordingly, in the reference examples 13 and 14, the existence of a frequency band in which the reception performance of the DAB glass antenna is low compared with the reference examples 15 to 19 was considered to be due to standing waves caused by the radio

waves having been produced in the defogger. In addition, it is evident from this that, similarly to the above test 4, conditions under which the reception performance of the DAB glass antenna decreases due to standing waves being produced in the defogger 3 can be derived, that is, it is possible to predict whether standing waves caused by the radio waves will be produced in the defogger, with the above equation 1.

(9) Test 9: Simulation of influence of vertical filament part

[0131] In the working example 21 of the above test 4, despite having provided one vertical filament part in the defogger, the reception performance of radio waves decreased more in the vicinity of 170 MHz than the working example 20A in which vertical filament parts were not provided in the defogger. In order to determine the cause, in this test 9, the kind of current distribution that occurs in a window glass on which a defogger having vertical filament parts is provided was investigated.

[0132] First, as illustrated in FIG. 22, a reference example 20 in which one vertical filament part 33 was provided in the defogger 3C was set. The conditions of the constituent elements according to the reference example 20 were as follows.

- Length of upper edge portion of glass plate 2: 1030 mm
- Length of lower edge portion of glass plate 2: 1200 mm
- Height of glass plate 2 in up-down direction: 600 mm
- Attachment angle of glass plate 2: 20 degree incline relative to vertical direction
- Number of hot wire parts 32: 12
- Pitch of hot wire parts 32: 24 mm
- Length of defogger 3C in left-right direction (length of hot wire parts 32): 1100 mm
- Number of vertical filament parts 33: one
- Position of vertical filament part 33: center
- Length of vertical element 52: 160 mm
- Length of horizontal element 53: 200 mm
- Distance D2 between DAB glass antenna 5 and defogger 3C: 10mm
- Line width of defogger 3C: 1 mm
- Line width of DAB glass antenna 5: 1 mm

[0133] Note that the DAB glass antenna 5 was disposed at a position 400 mm on the right side from the center of the glass plate 2.

[0134] Also, a reference example 21 in which two vertical filament parts 33 were further added as the reference example 20 was set. These two vertical filament parts 33 were disposed in positions separated by 300 pitch mm on both sides of the vertical filament part 33 disposed in the center.

[0135] With regard to the window glass of each reference example (20, 21) set in this manner, simulation that involved irradiating radio waves of DAB band 3 under

similar conditions to the above tests 1 to 8 was performed, as follows, using software for three-dimensional electro-magnetic field analysis on time domain.

- Angular resolution: measured every 3 degrees while rotating station wagon 360 degrees
- Frequency resolution: measured every 1 MHz in a range of 174 MHz to 240 MHz
- Elevation angle between transmission position of radio waves and antenna: 1.7 degrees (0 degrees in a direction horizontal to ground, and 90 degrees at zenith) FIG. 23A, FIG. 23B, FIG. 24A, FIG. 24B and FIG. 25 show the results.

[0136] FIG. 23A and FIG. 23B show the current distribution in the reference example 20. Specifically, FIG. 23A shows the current distribution when the reference example 20 was irradiated with 170 MHz radio waves. Also, FIG. 23B shows the current distribution when the reference example 20 was irradiated with 240 MHz radio waves. On the other hand, FIG. 24A and FIG. 24B show current distributions in the reference example 21. Specifically, FIG. 24A shows the current distribution when the reference example 21 was irradiated with 170 MHz radio waves. Also, FIG. 24B shows the current distribution when the reference example 21 was irradiated with 240 MHz radio waves. Furthermore, FIG. 25 shows simulation results of sensitivity (gain) of the reference examples (20, 21) with respect to each frequency.

[0137] As shown in FIG. 23A, when the reference example 20 in which one vertical filament part 33 is provided was irradiated with 170 MHz radio waves, standing waves caused by the radio waves were produced in the defogger of the reference example 20. On the other hand, as shown in FIG. 23B, such standing wave were not produced in the defogger of the reference example 20, when irradiated with 240 MHz radio waves. Also, as shown in FIG. 24A and FIG. 24B, with the reference example 21 in which three vertical filament parts 33 were provided, standing waves caused by the radio waves were not produced, even when irradiated with 170 MHz and 240 MHz radio waves.

[0138] Here, referring to FIG. 25, the sensitivity of the reference example 20 decreased in the vicinity of 170 MHz at which standing waves were produced. On the other hand, in a frequency band (e.g., 240 MHz) in which standing waves were not produced, the sensitivities of the reference examples 20 and 21 were comparable. That is, it is evident from this test 9 that, depending on the disposition of the vertical filament parts, standing waves caused by the radio waves are produced in the defogger, and the reception performance of the DAB glass antenna decreases as a result. Accordingly, it is shown from this test 9 that, in order to avoid reducing the reception performance of the DAB glass antenna, it is preferable to dispose the vertical filament parts such that such standing waves do not occur in the DAB frequency band.

[0139] Specifically, in the reference example 20, the pitch between each bus bar part 31 and the vertical filament part 33 is 0.55 m (550 mm), and is included in the above range of 0.44 m to 0.62 m that envisages the case of DAB band 3. On the other hand, in the reference example 21, the distance of the portion sandwiched between the bus bar part and the vertical filament part and the distance of the portion sandwiched between adjacent vertical filament parts were respectively 250 mm and 300 mm, and were not equal to an integer multiple of F in the above equation 1. Also, in the reference example 21, as described above, standing waves caused by the radio waves were not produced in the defogger. Thus, it is evident that it is possible to predict whether standing waves caused by the radio waves will be produced in the defogger with the above equation 1. That is, it is evident that a decrease in the reception performance of the DAB glass antenna can be prevented, by disposing the vertical filament parts such that the distance of the portion sandwiched between the bus bar part and the vertical filament part and the portion sandwiched between adjacent vertical filament parts is not equal to an integer multiple of F in the above equation 1. Note that this decrease in reception performance is surmised to be due to DAB radio waves being trapped in the defogger. In other words, it is surmised that a state is entered in which the defogger readily receives radio waves of that frequency band, and that, as a result, reception of radio waves by the DAB glass antenna is disturbed.

[0140] (10) Test 10: Reception performance of other forms In this test 10, working examples (28, 29) shown in FIG. 26 were prepared, in order to investigate the reception performance of the DAB glass antenna of the form illustrated in FIG. 3C. The conditions of the constituent elements according to the working examples (28, 29) were as follows.

- Length of upper edge portion of glass plate 2: 1180 mm
- Height of glass plate 2 in up-down direction: 340 mm
- Number of hot wire parts 32: nine
- Pitch of hot wire parts 32: 27 mm (lowermost portion only: 23 mm)
- Length of hot wire part 32 of lowermost portion: 1072 mm
- Number of vertical filament parts 33: three
- Distance between bus bar part 31 and vertical filament part 33 (uppermost portion): 260 mm
- Distance between center vertical filament part 33 and right side (left side) vertical filament part 33: 200 mm
- Height of defogger 3 in up-down direction: 212 mm
- Length of horizontal element 43D: 150 mm
- Length of ground filament part 45D: 485 mm Note that, in the window glass of the working example 28, the length of the vertical element 43D was 50 mm, and the distance D1 between the DAB glass antenna 4D and the defogger 3 was 5 mm. On the other hand,

in the window glass of the working example 29, the length of the vertical element 43D was 30 mm, and the distance D1 between the DAB glass antenna 4D and the defogger 3 was 25 mm. Also, with regard to the working examples (28, 29), the sensitivity of each DAB glass antenna was measured with a similar method to the above test 1 and the like, except for the following two conditions.

- Attachment angle of glass plate: 45 degree incline at point on lower edge in up-down direction; 41 degree incline at point in center in up-down direction; 37 degree incline at point on upper edge in up-down direction
- Frequency resolution: measured every 3 MHz in range of 174 MHz to 240 MHz

[0141] FIG. 27 shows the results of measuring sensitivity (gain) of the working examples (28, 29) with respect to each frequency of DAB band 3. In the case where the glass plate inclines relative to the vertical or the vertical element is short in length (above test 2), the reception performance of the DAB glass antenna can decrease greatly. However, in the working examples (28, 29), reception performance can be secured to a certain extent, despite the glass plate inclining comparatively from the vertical and the vertical element 43D being comparatively short in length. This is considered to be caused by factors such as the DAB glass antenna being disposed on the lower edge side of the window glass and the pitch between the bus bar part and the vertical filament part and between adjacent vertical filament parts being set so as to not be equal to an integer multiple of F in the above equation 1. In other words, it is evident that, according to the features of the present invention, reception performance can be secured to a certain extent, even in the case where the installation conditions of the DAB glass antenna are not favorable.

Reference Signs List

[0142]

- 1 Window glass
- 2 Glass plate
- 21 Upper edge portion
- 22 Lower edge portion
- 23 Left side edge portion
- 24 Right side edge portion
- 3 Defogger
- 31 Bus bar part
- 32 Hot wire part
- 33 Vertical filament part
- 34 Connection part
- 4 DAB glass antenna
- 41 Power supply unit
- 42 Vertical element (first element)
- 43 Horizontal element (second element)
- 44 Ground connection part

- 45 Ground filament part
- 5 DAB glass antenna
- 51 Power supply unit
- 52 Vertical element
- 53 Horizontal element
- 54 Ground connection part
- 55 Ground filament part

10 Claims

1. A vehicle window glass comprising:
 - a glass plate; and
 - a DAB glass antenna formed on one surface of the glass plate, wherein the DAB glass antenna includes a power supply part that is disposed on a lower edge side of the glass plate and a first element that extends vertically.
2. The vehicle window glass according to claim 1, wherein the first element extends vertically upward from the power supply part.
3. The vehicle window glass according to claim 1 or 2, further comprising:
 - a defogger including a pair of bus bar parts that oppose each other and a plurality of hot wire parts that each extend horizontally and are arranged vertically, and in which both end portions of each hot wire part are respectively coupled to a different one of the pair of bus bar parts, wherein the defogger is disposed upwardly of the DAB glass antenna, and the DAB glass antenna further includes a second element that extends horizontally and is coupled to the first element.
4. The vehicle window glass according to claim 3, wherein the defogger further includes one or more vertical filament parts that extend vertically so as to intersect each of the plurality of hot wire parts.
5. The vehicle window glass according to claim 4, wherein the one or more vertical filament parts are disposed such that a standing wave is not produced in the defogger due to radio waves in a DAB frequency band.
6. The vehicle window glass according to any one of claims 3 to 5, wherein the defogger is installed so as to be separated by 46 mm or more vertically upward from an upper end of the DAB glass antenna.
7. The vehicle window glass according to any one of

claims 1 to 6,
wherein the first element of the DAB glass antenna
has a vertical length or 20 mm or more.

8. The vehicle window glass according to any one of 5
claims 1 to 7,
wherein the vehicle window glass is to be attached
to a window frame of a vehicle such that, when par-
allel light strikes the window glass horizontally, a pro- 10
jected area of the window glass that occurs as a re-
sult is 0.5 mm², and an attachment angle of the win-
dow glass when referenced on a horizontal direction
is from 45 degrees to 75 degrees inclusive.

9. A DAB glass antenna to be formed on one surface 15
of a glass plate that is to be used as a vehicle window
glass, comprising:

a power supply part to be disposed on a lower
edge side of the glass plate; and 20
a first element that extends vertically.

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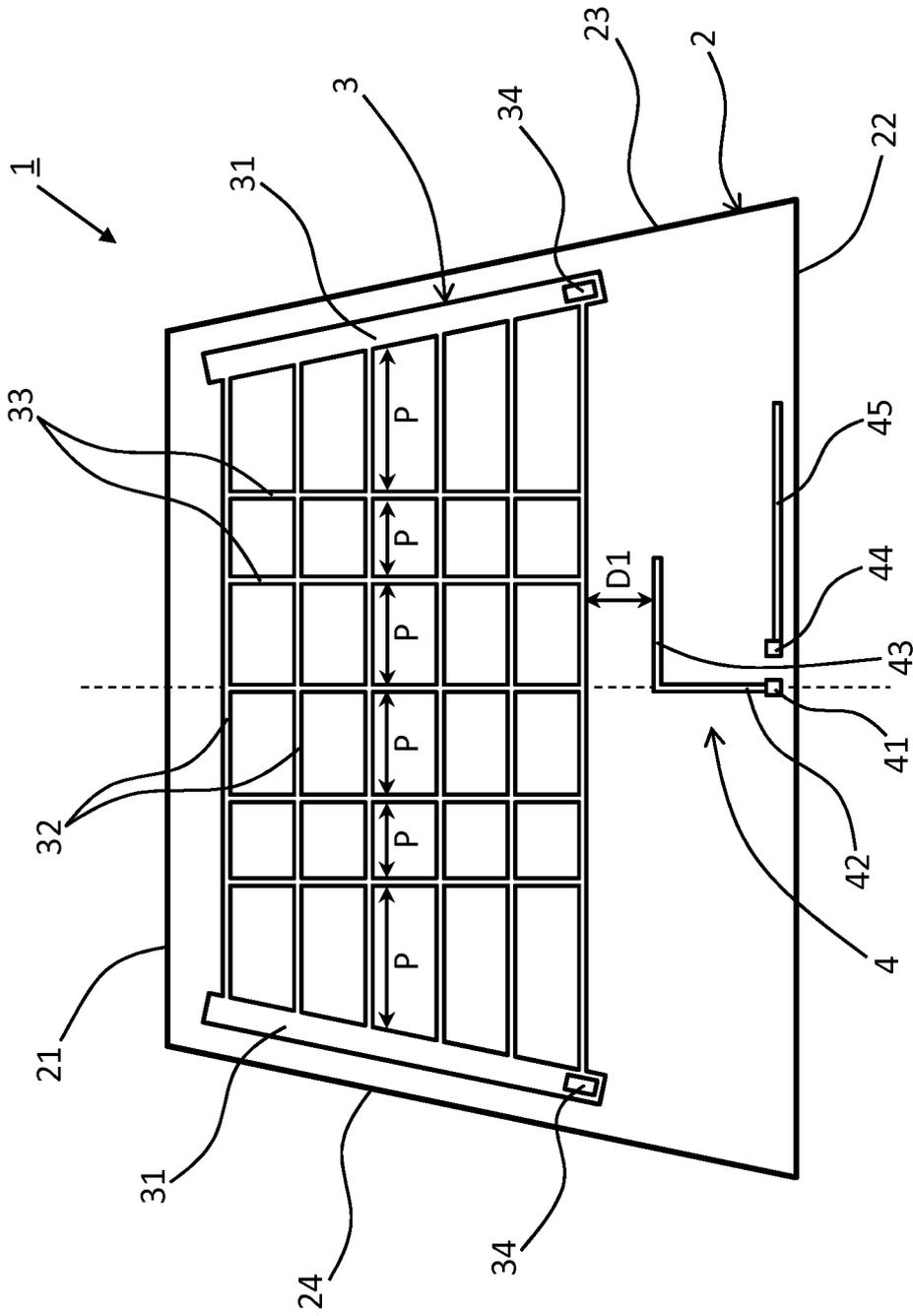


FIG.1

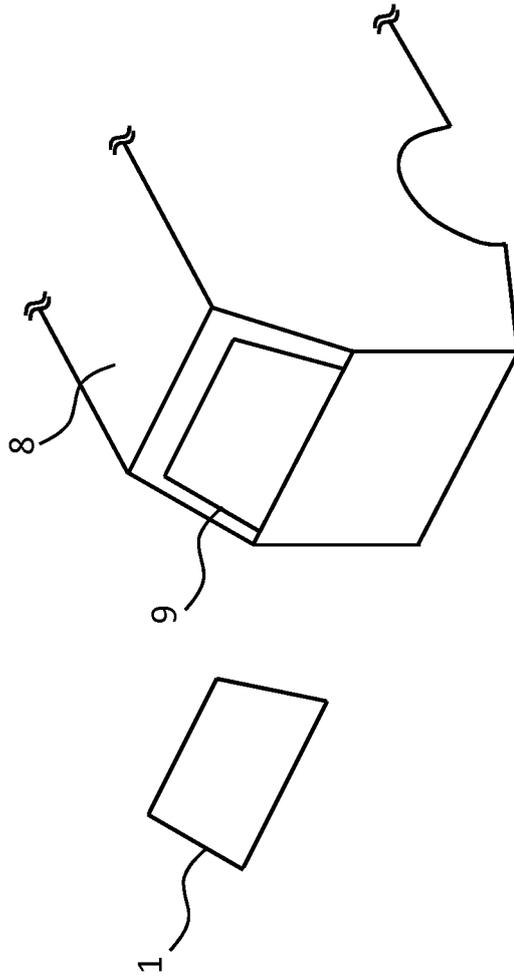


FIG.2

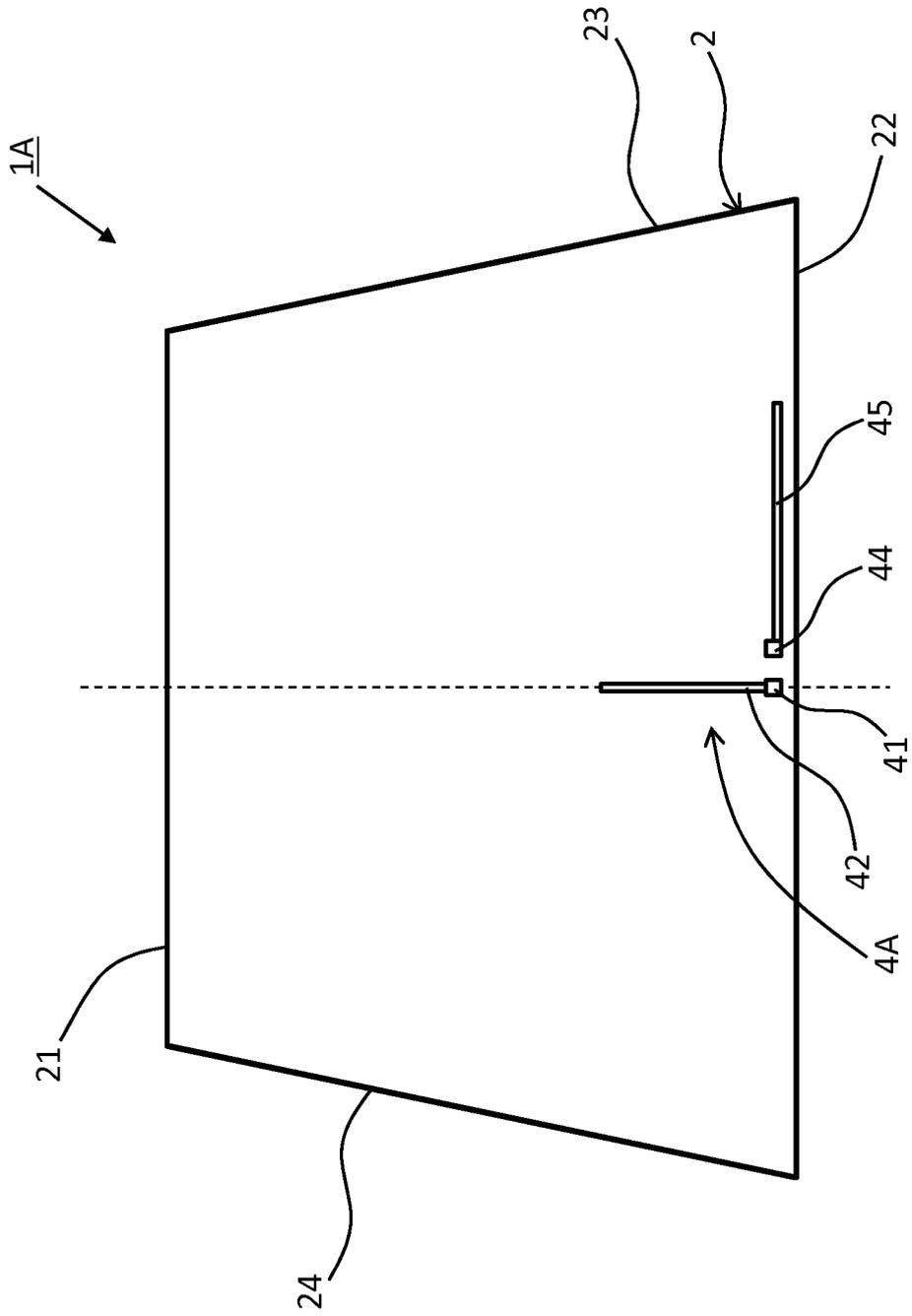


FIG.3A

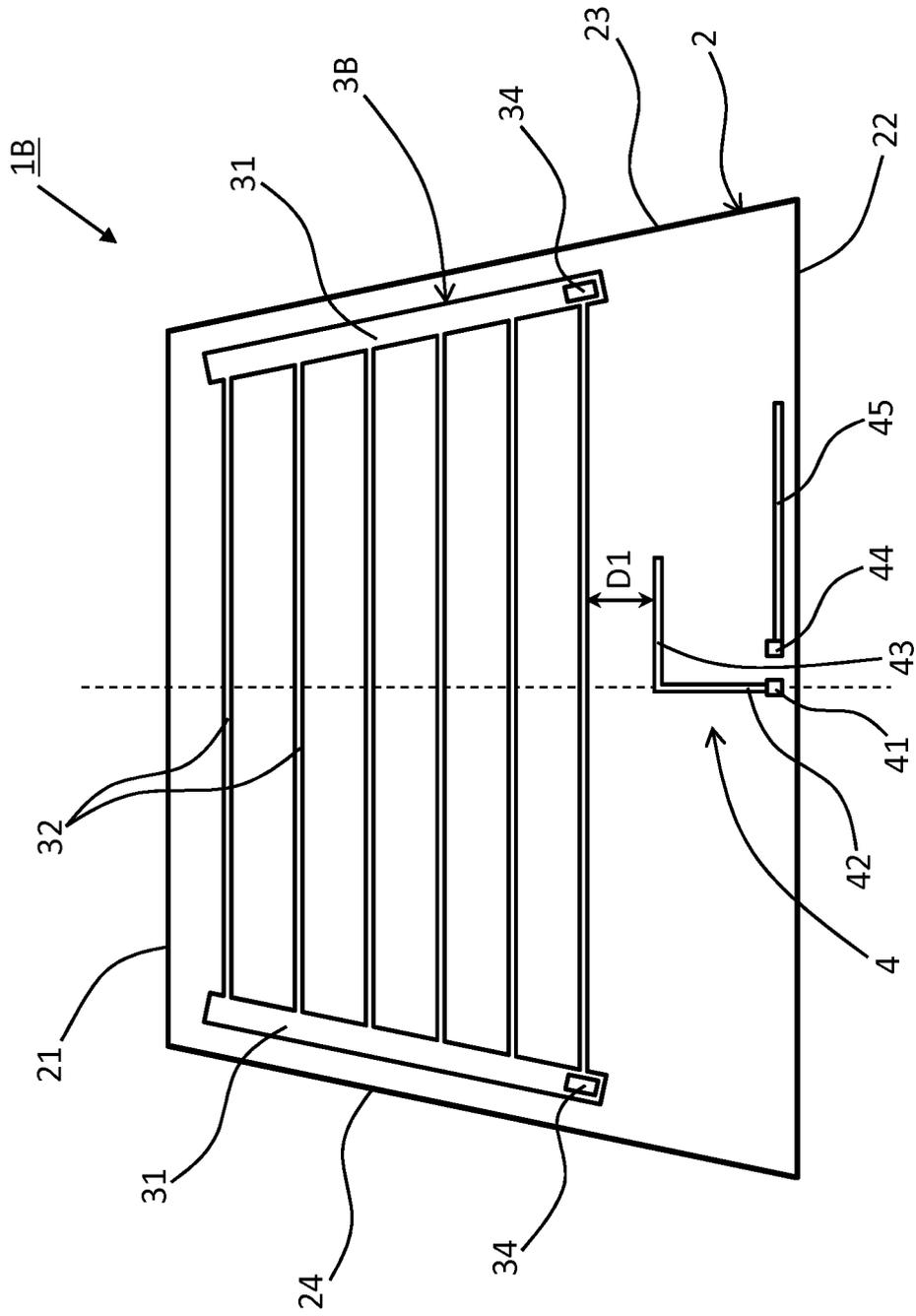


FIG.3B

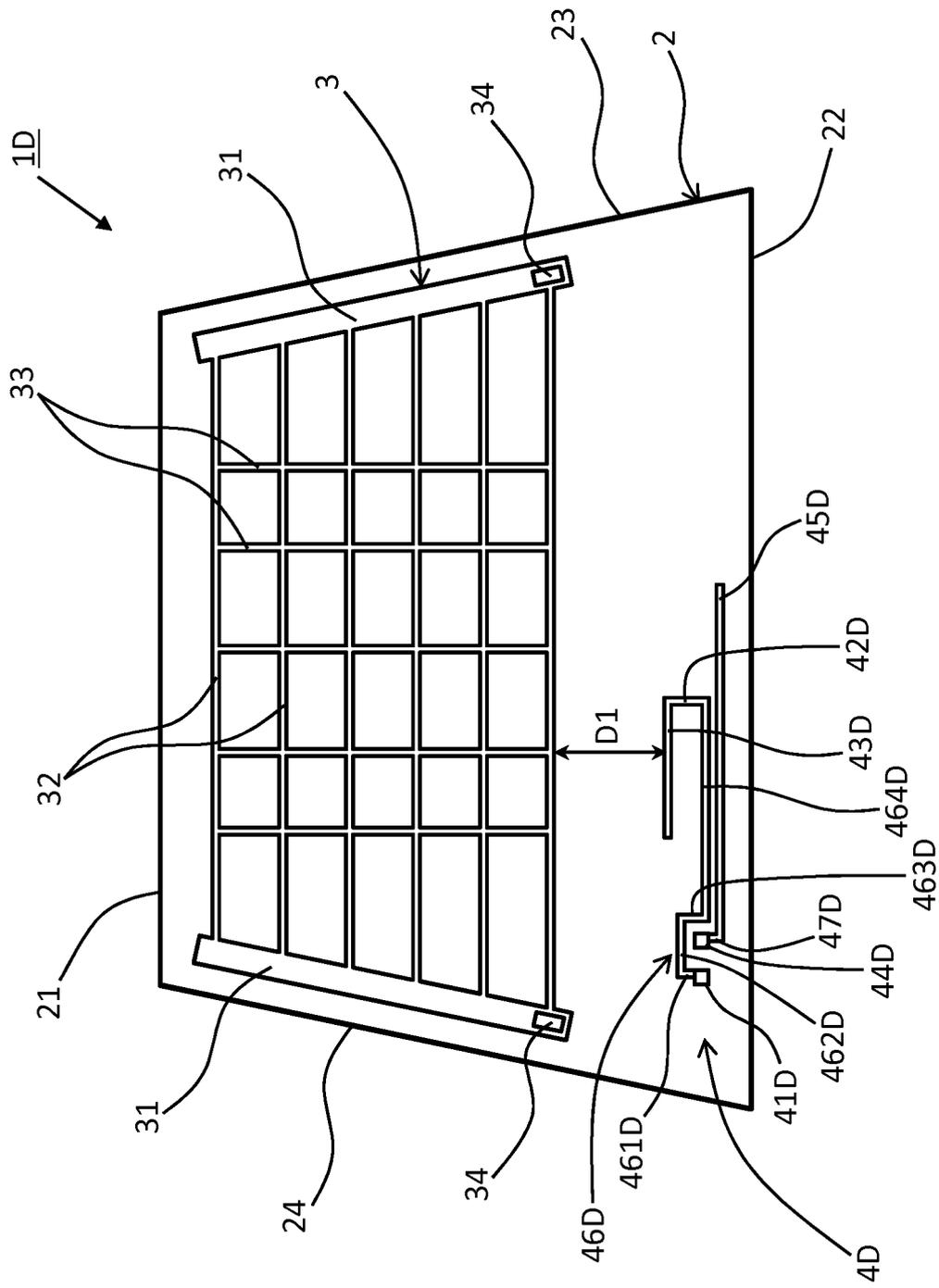


FIG.3C

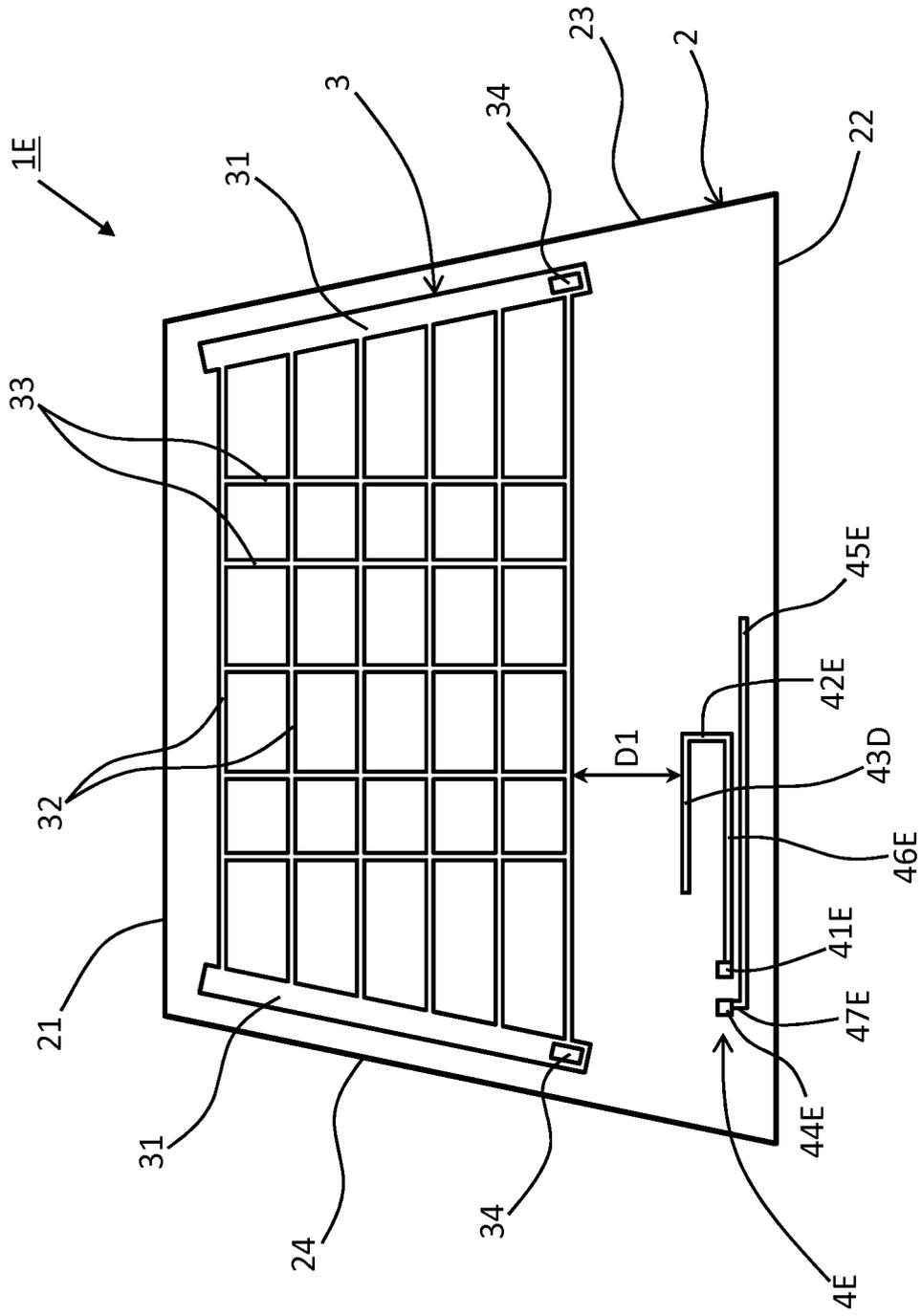


FIG.3D

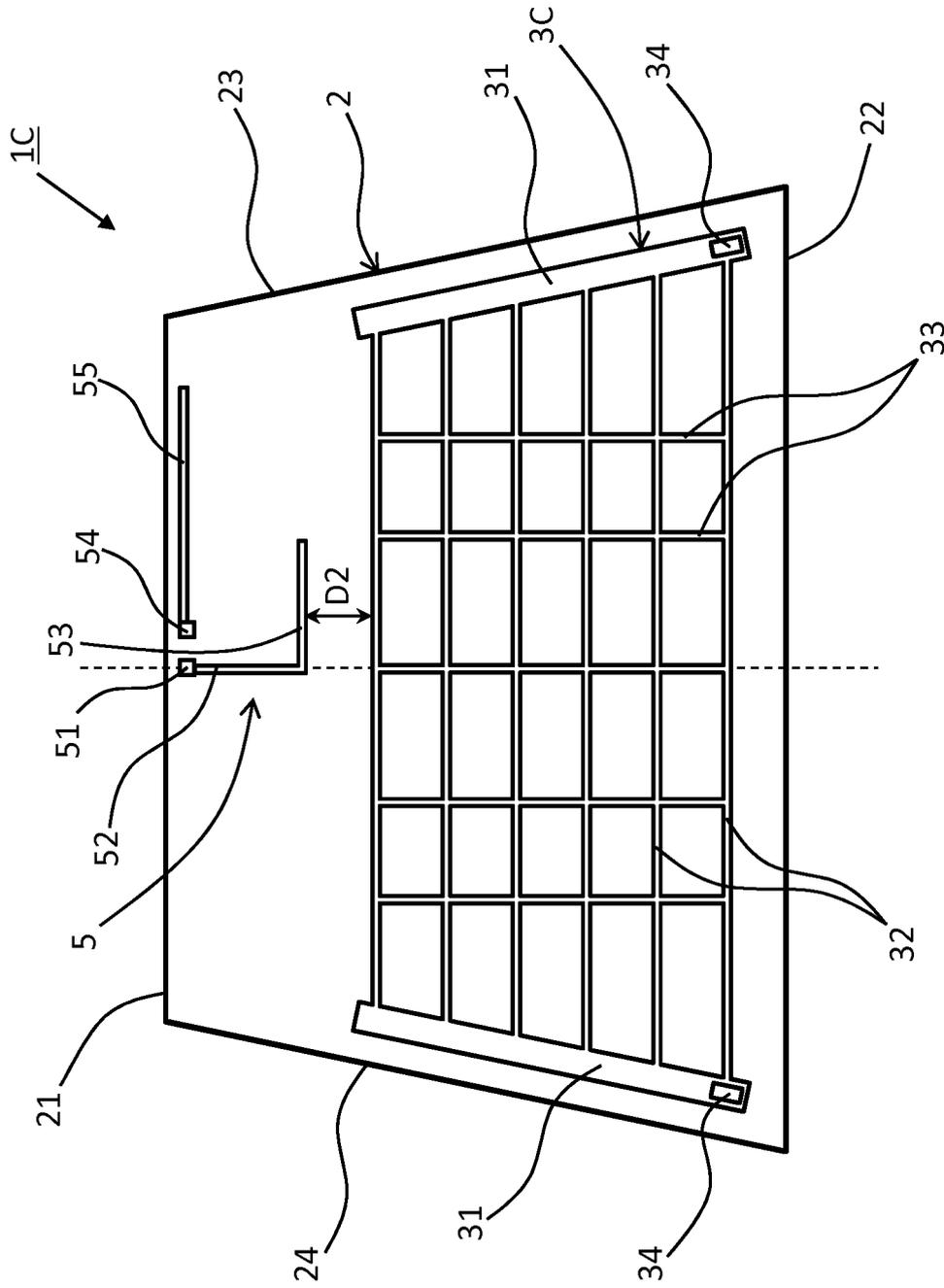


FIG.4

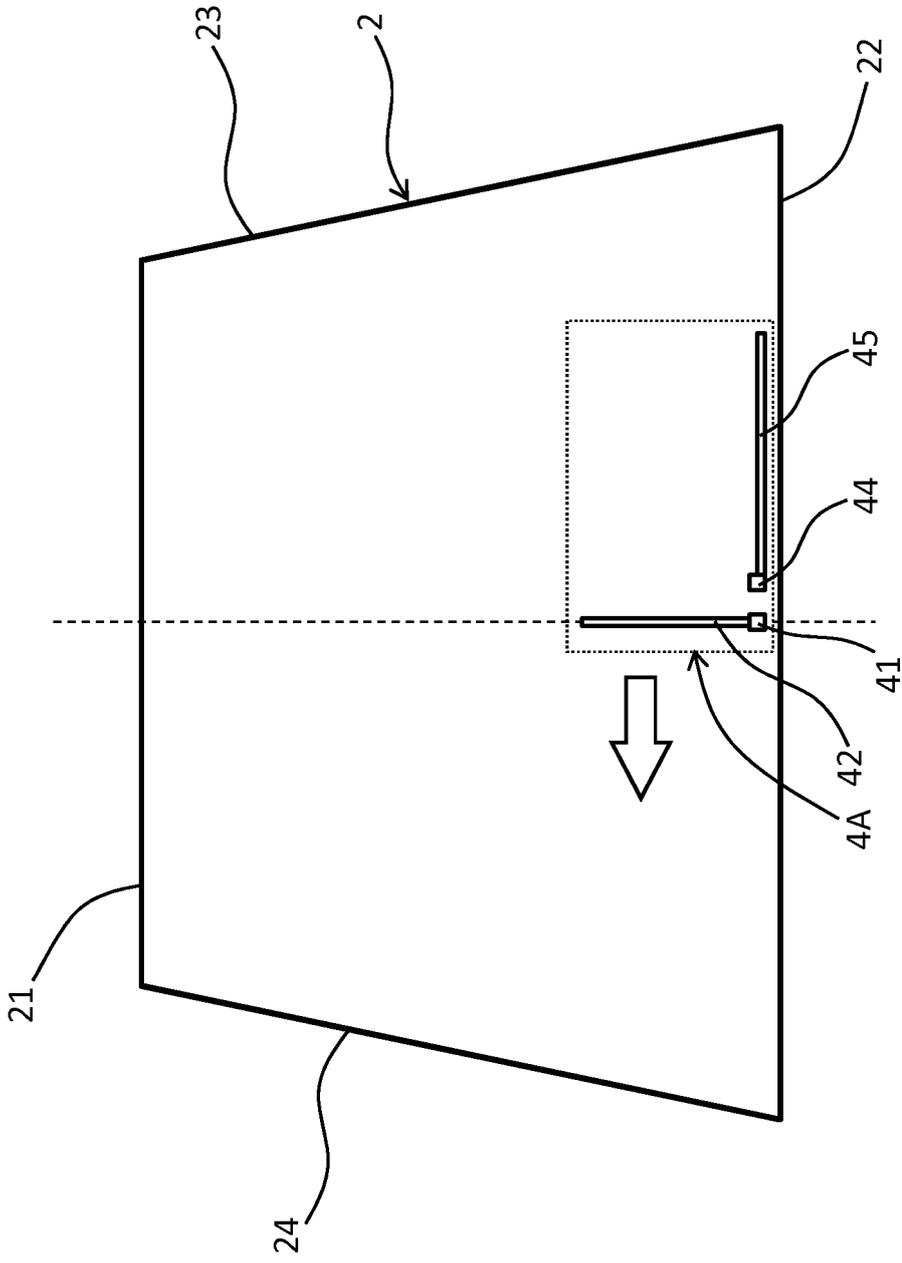


FIG.5A

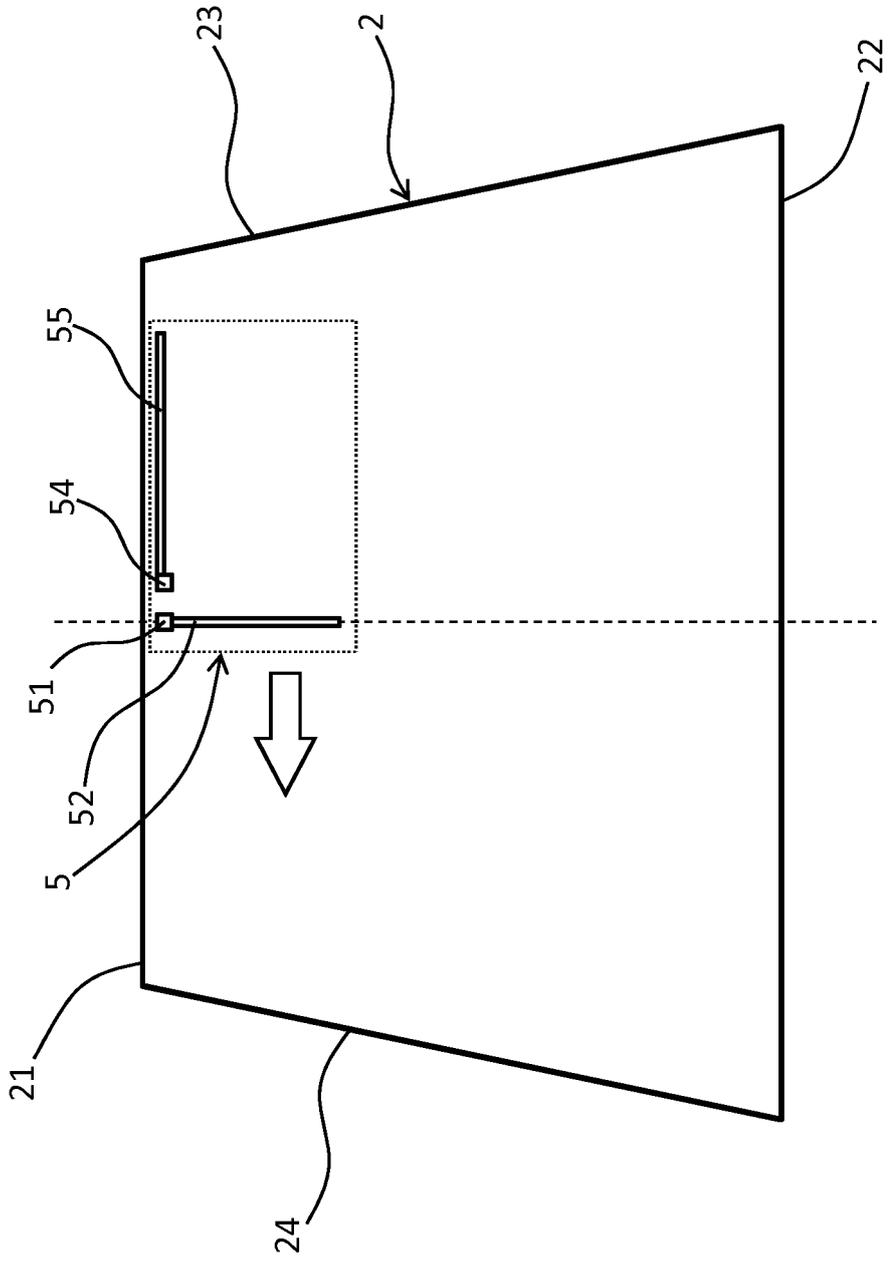


FIG. 5B

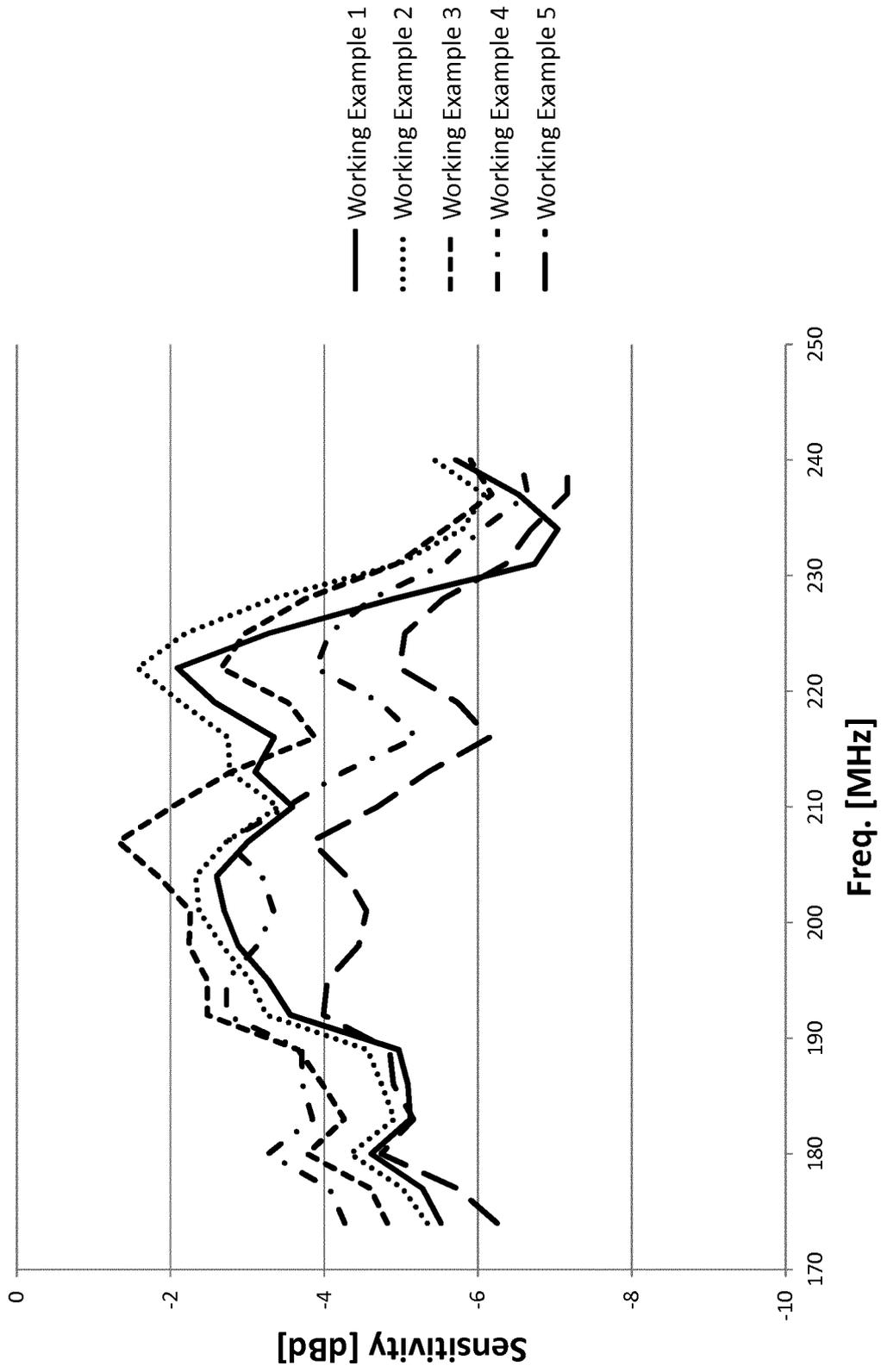


FIG.6A

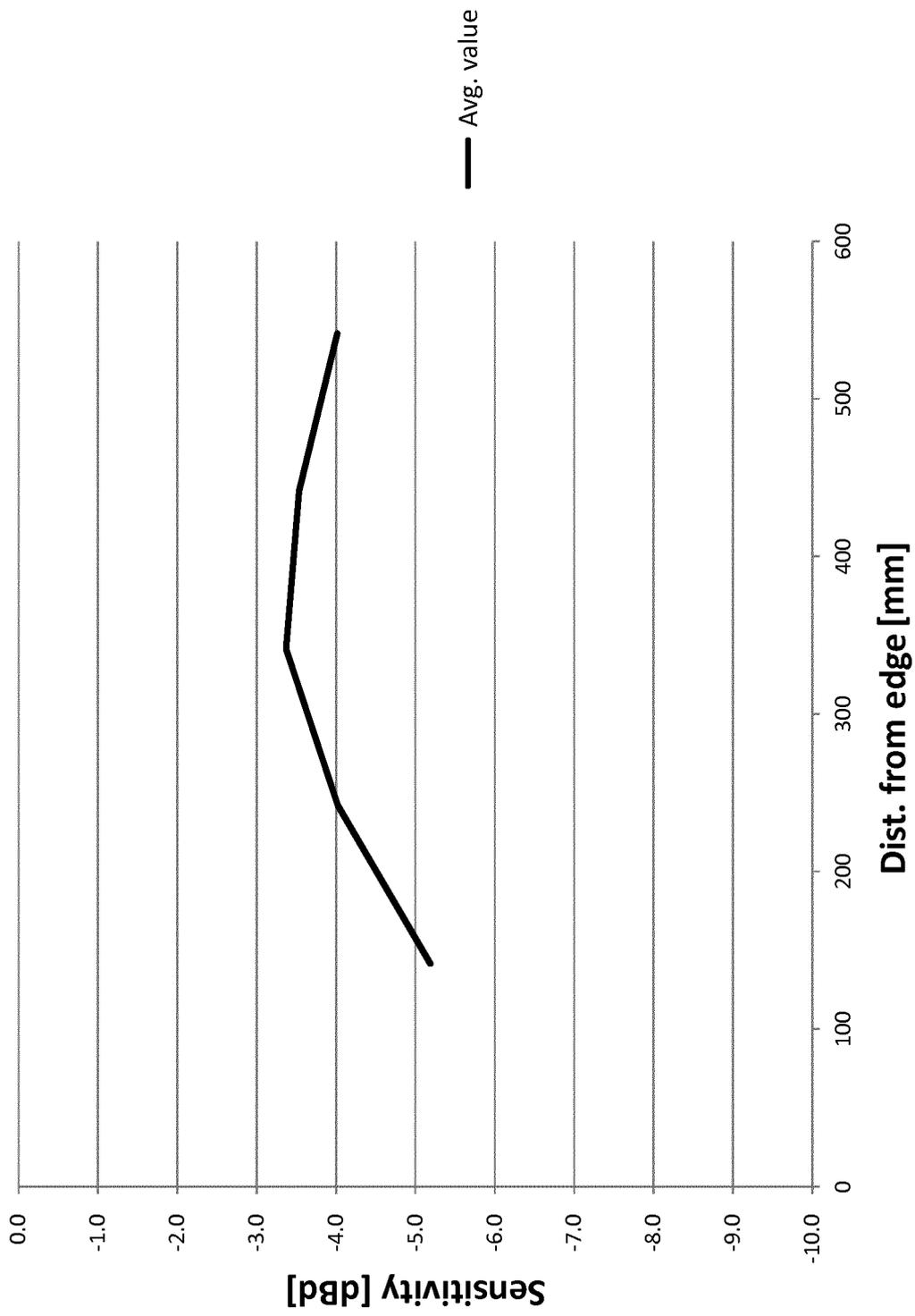


FIG.6B

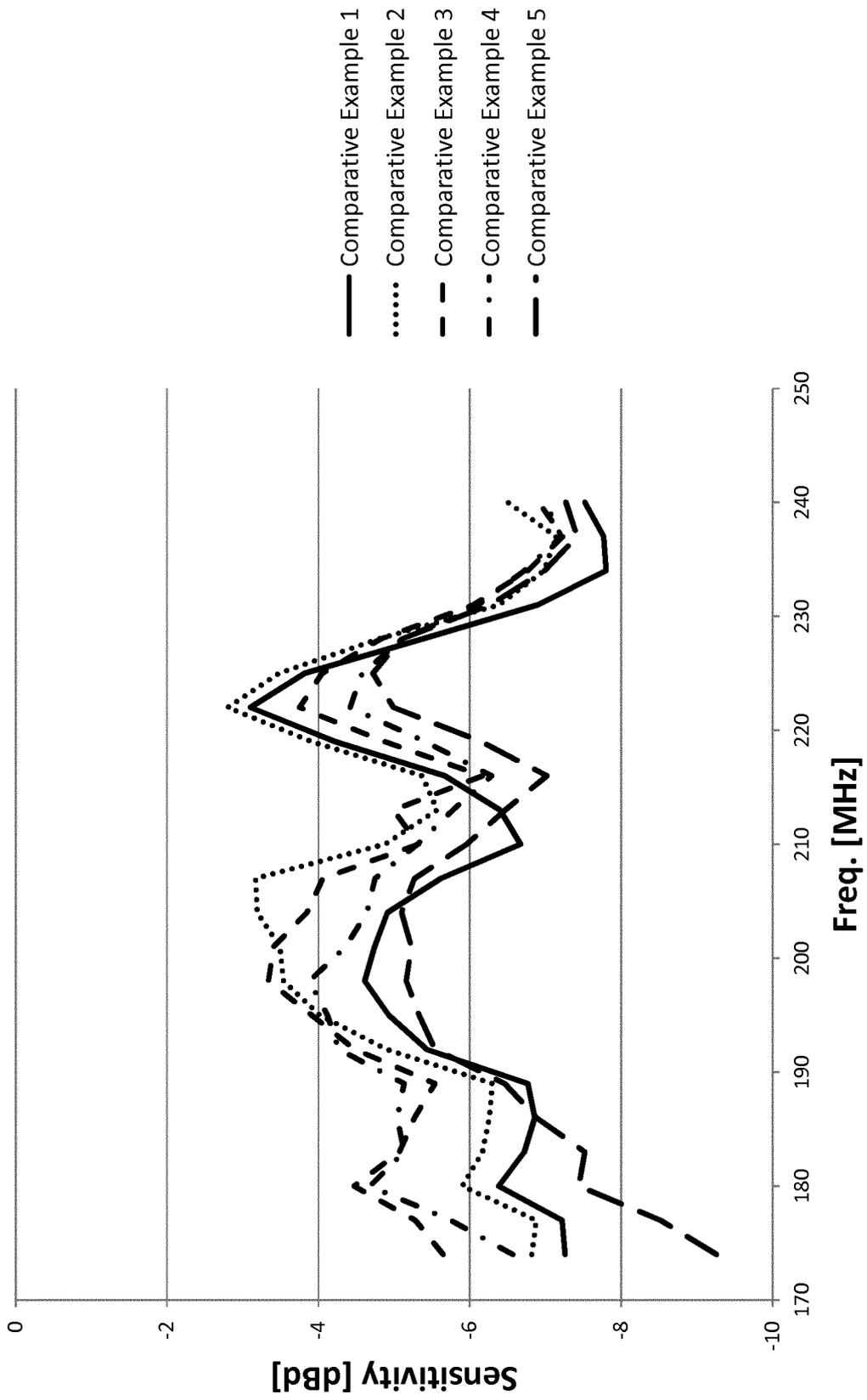


FIG. 7A

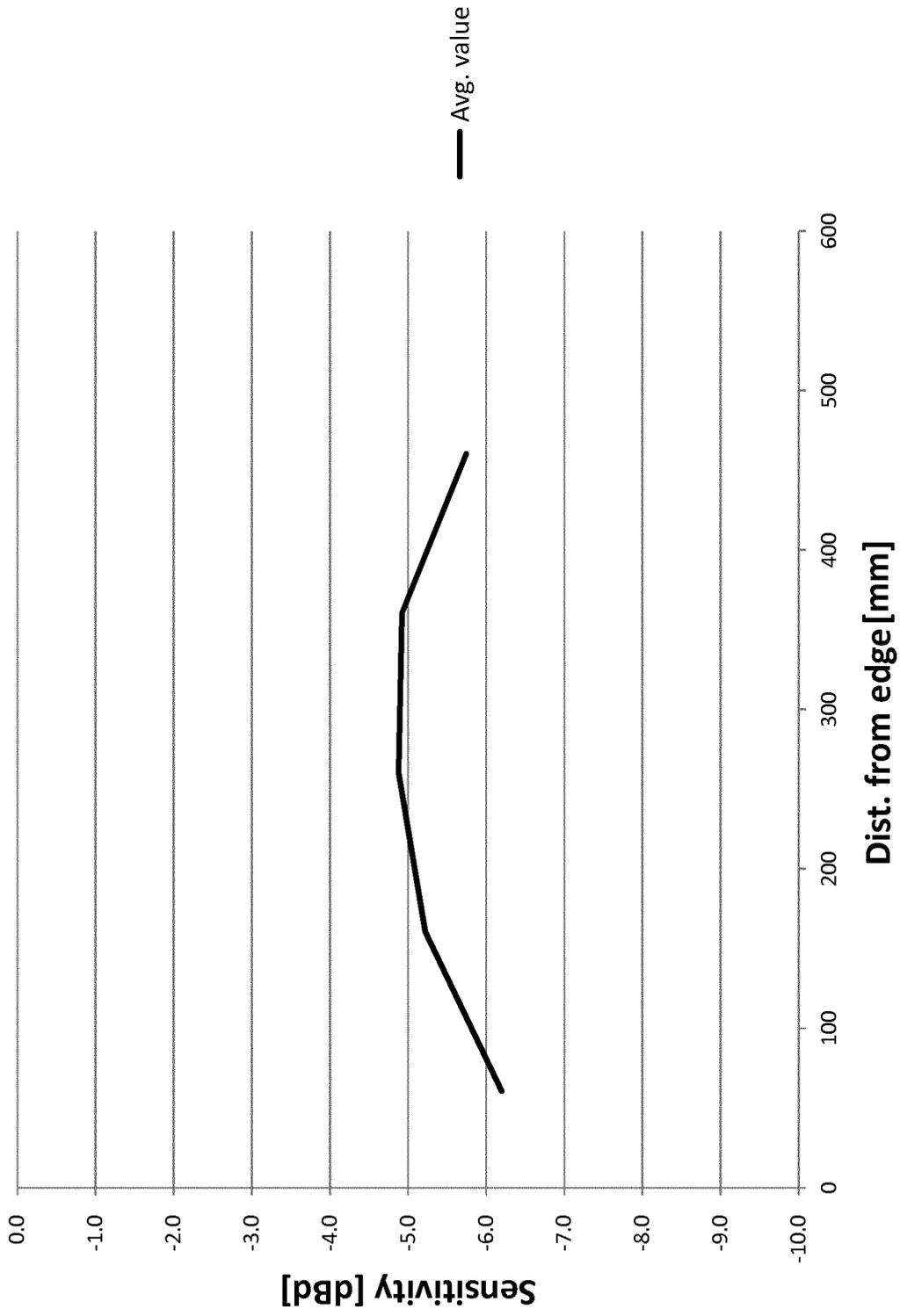


FIG.7B

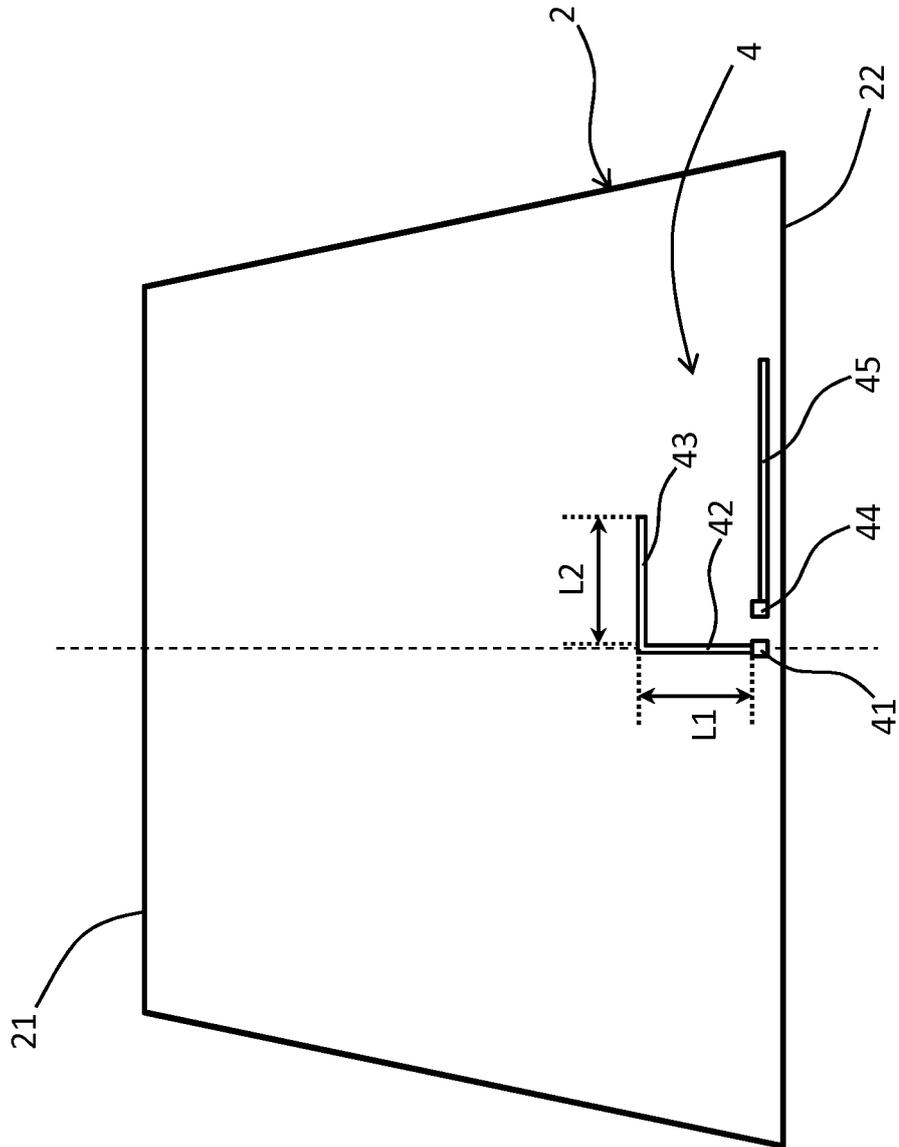


FIG.8

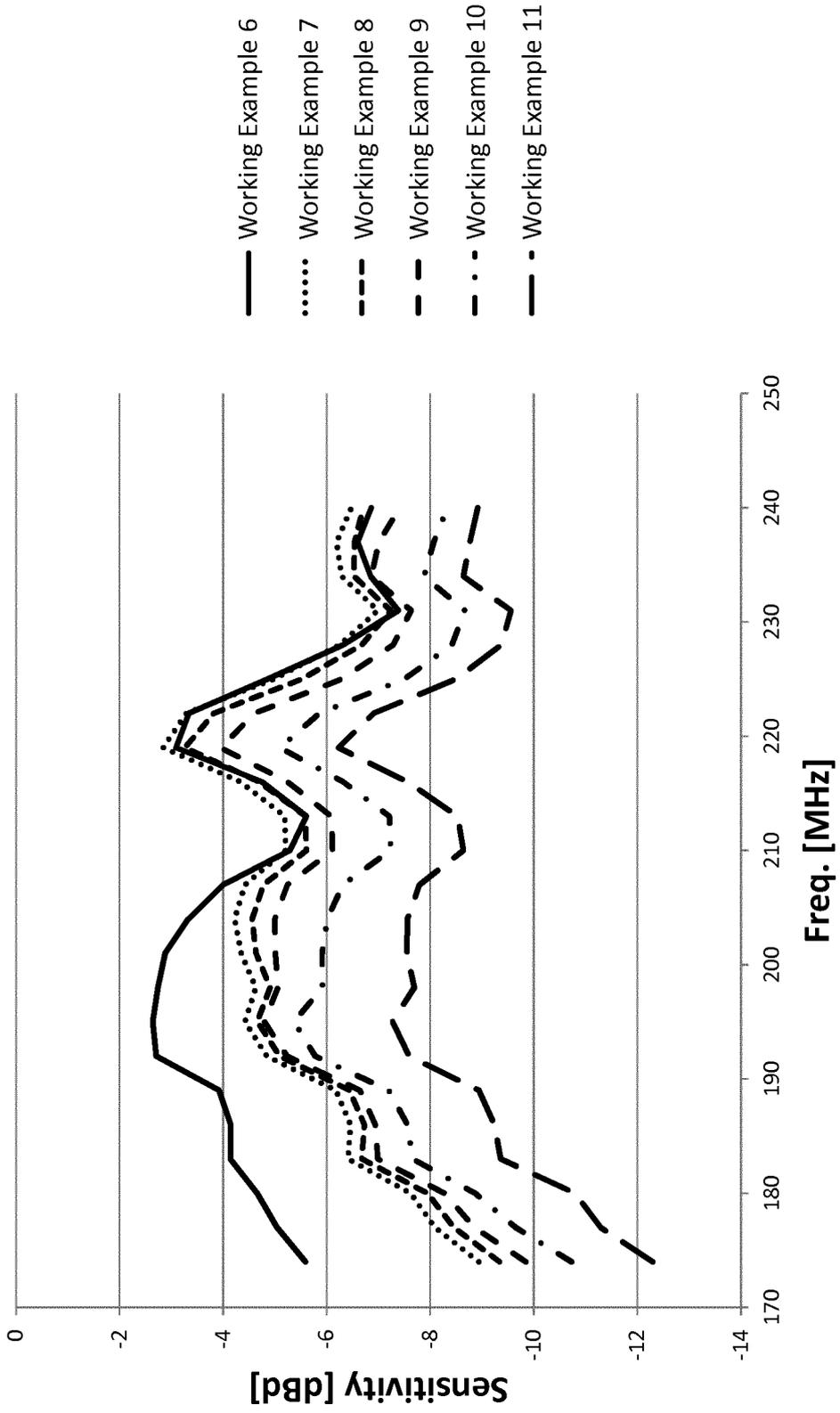


FIG.9A

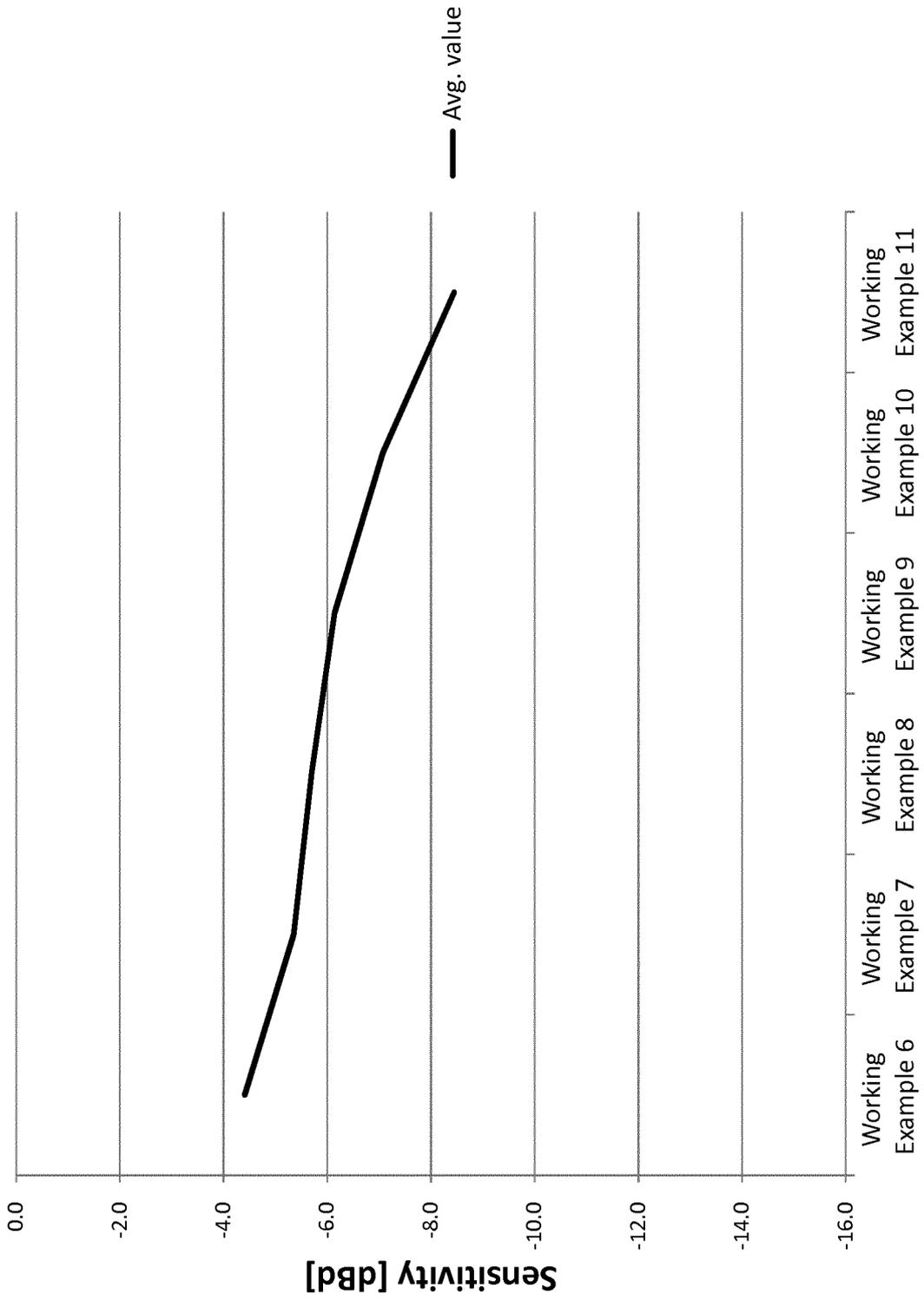


FIG.9B

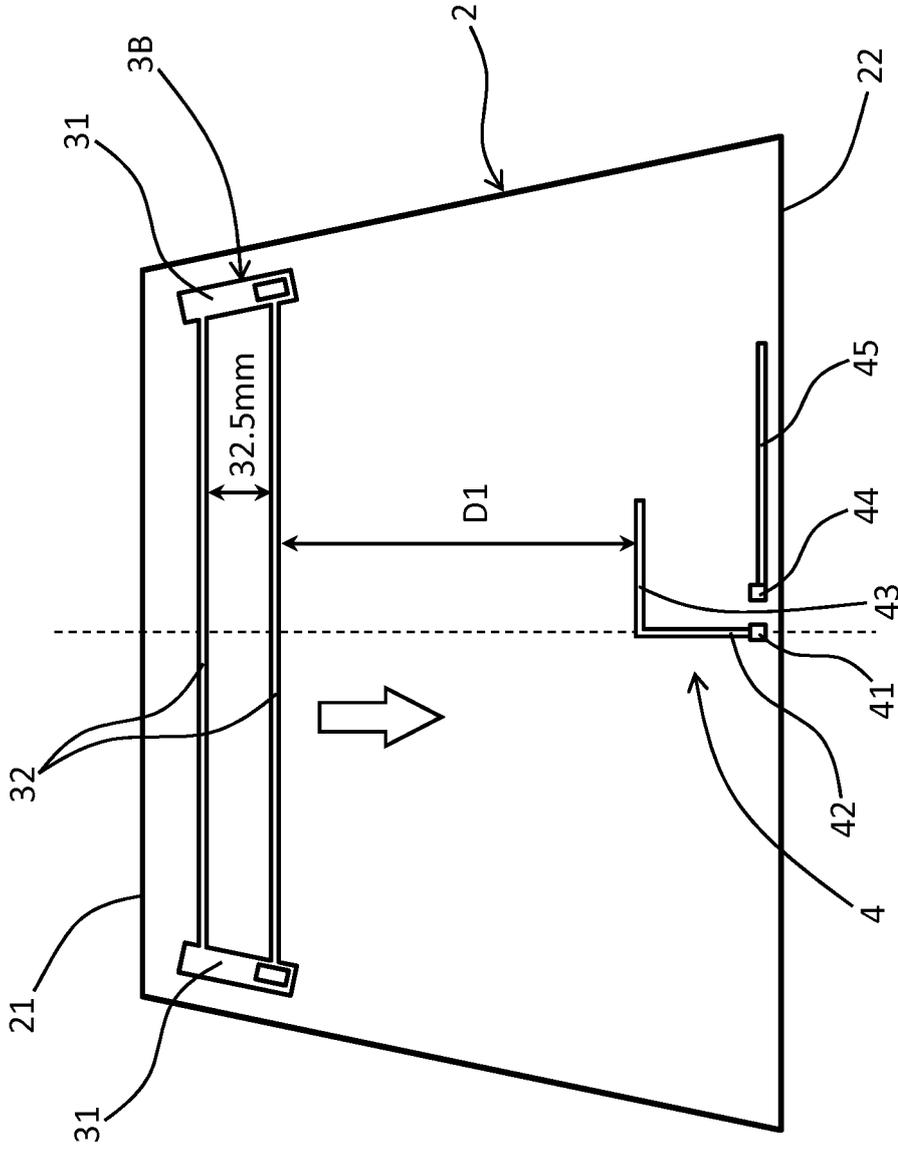


FIG.10

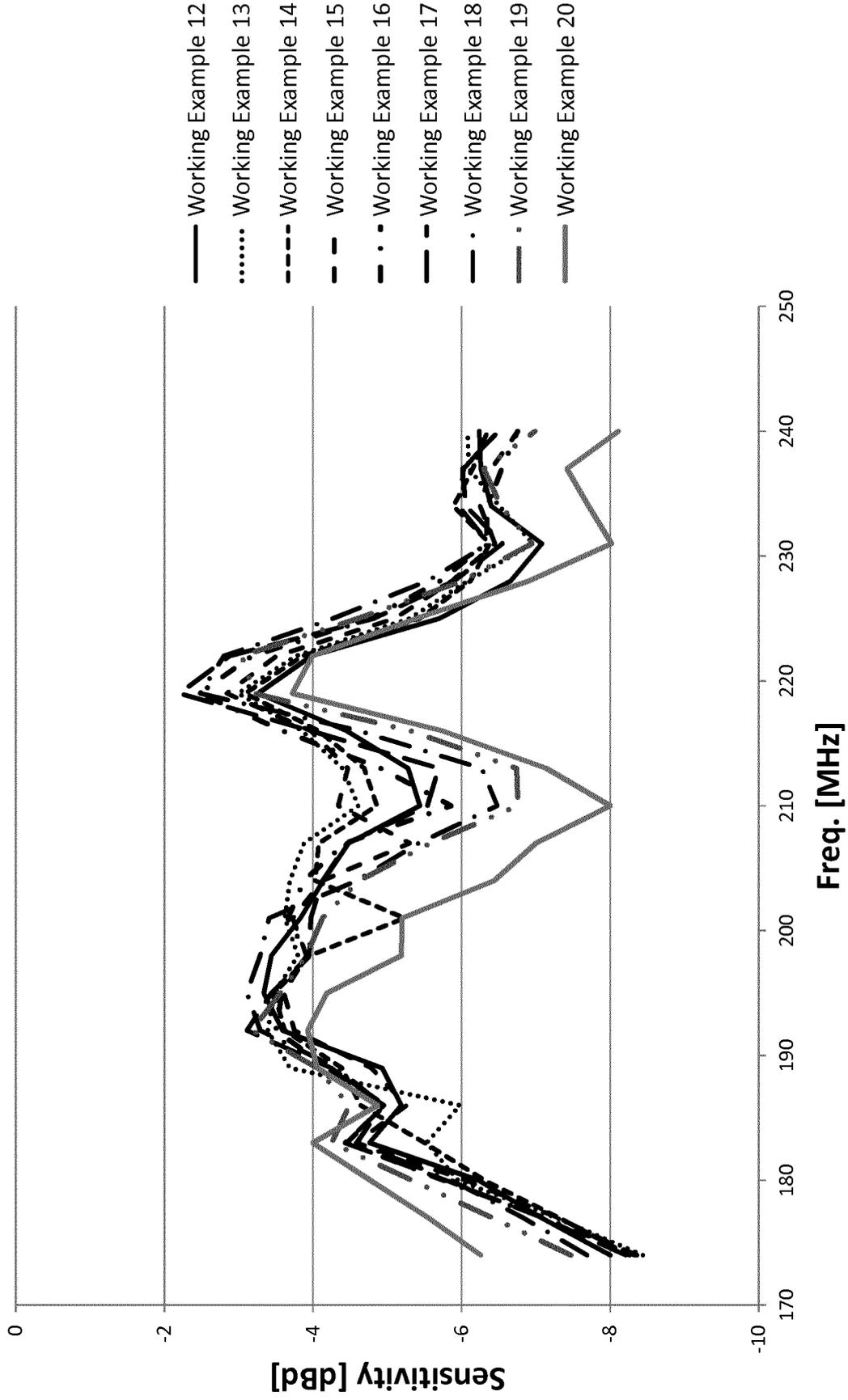


FIG.11A

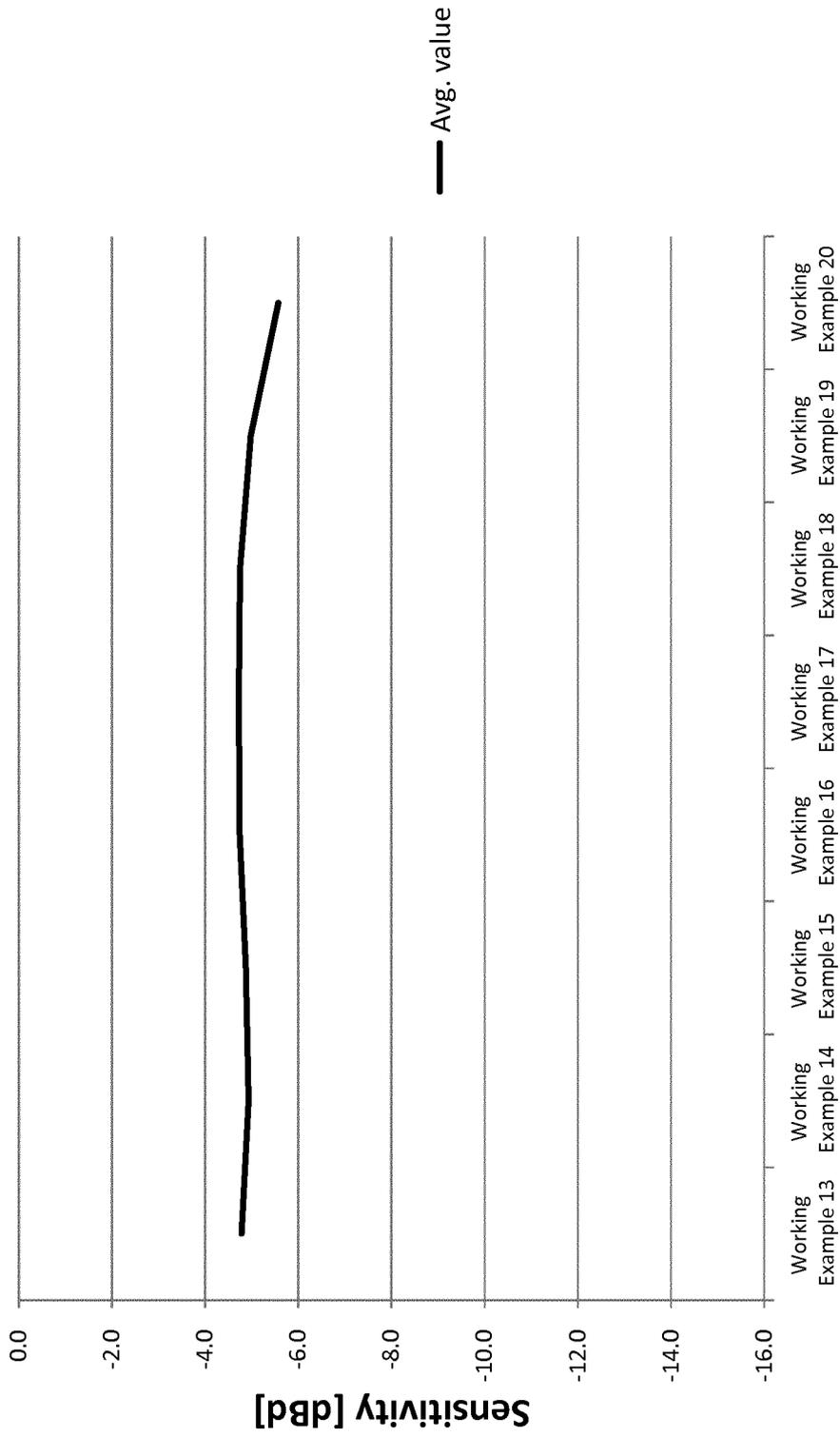


FIG.11B

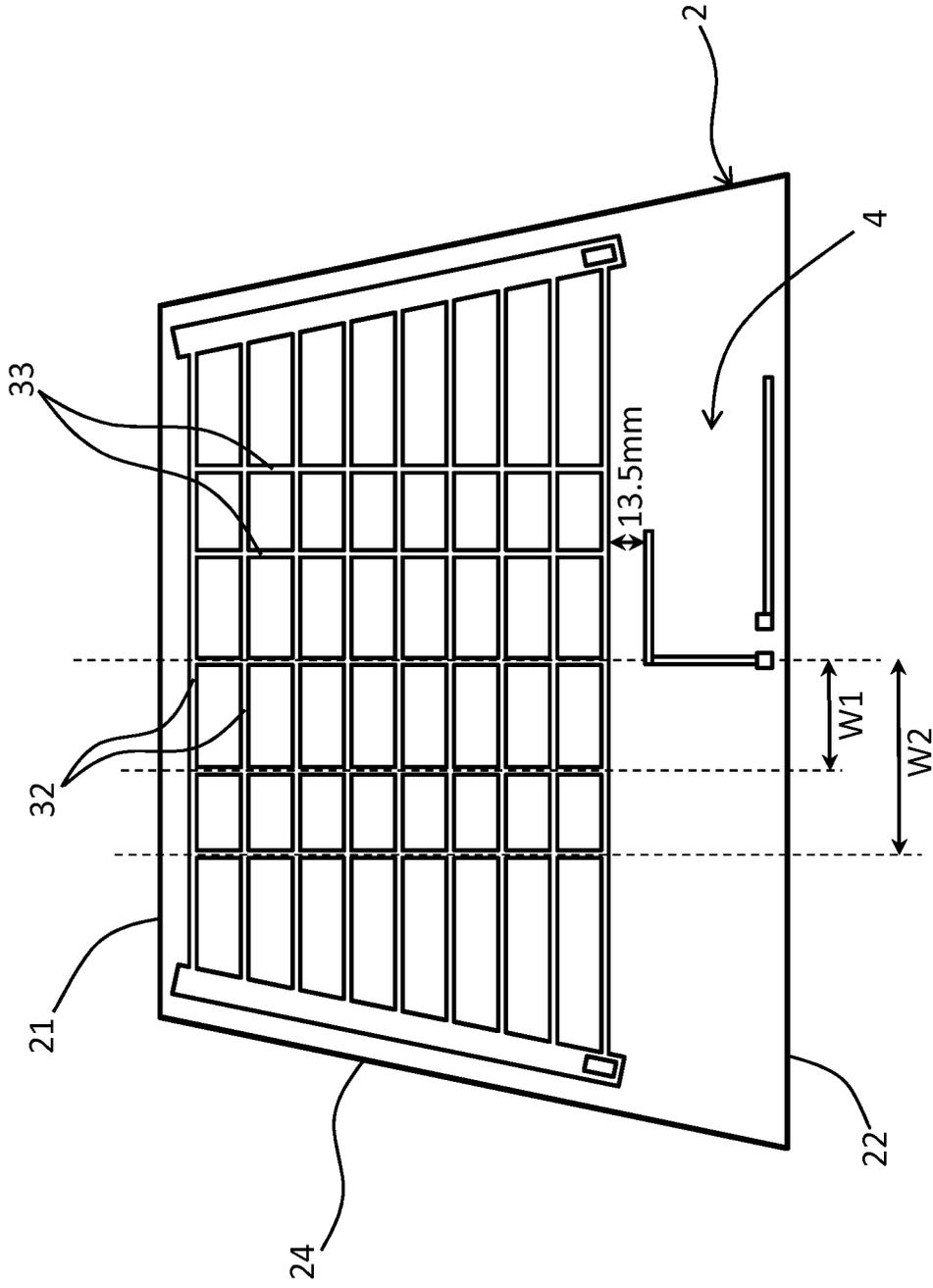


FIG.12

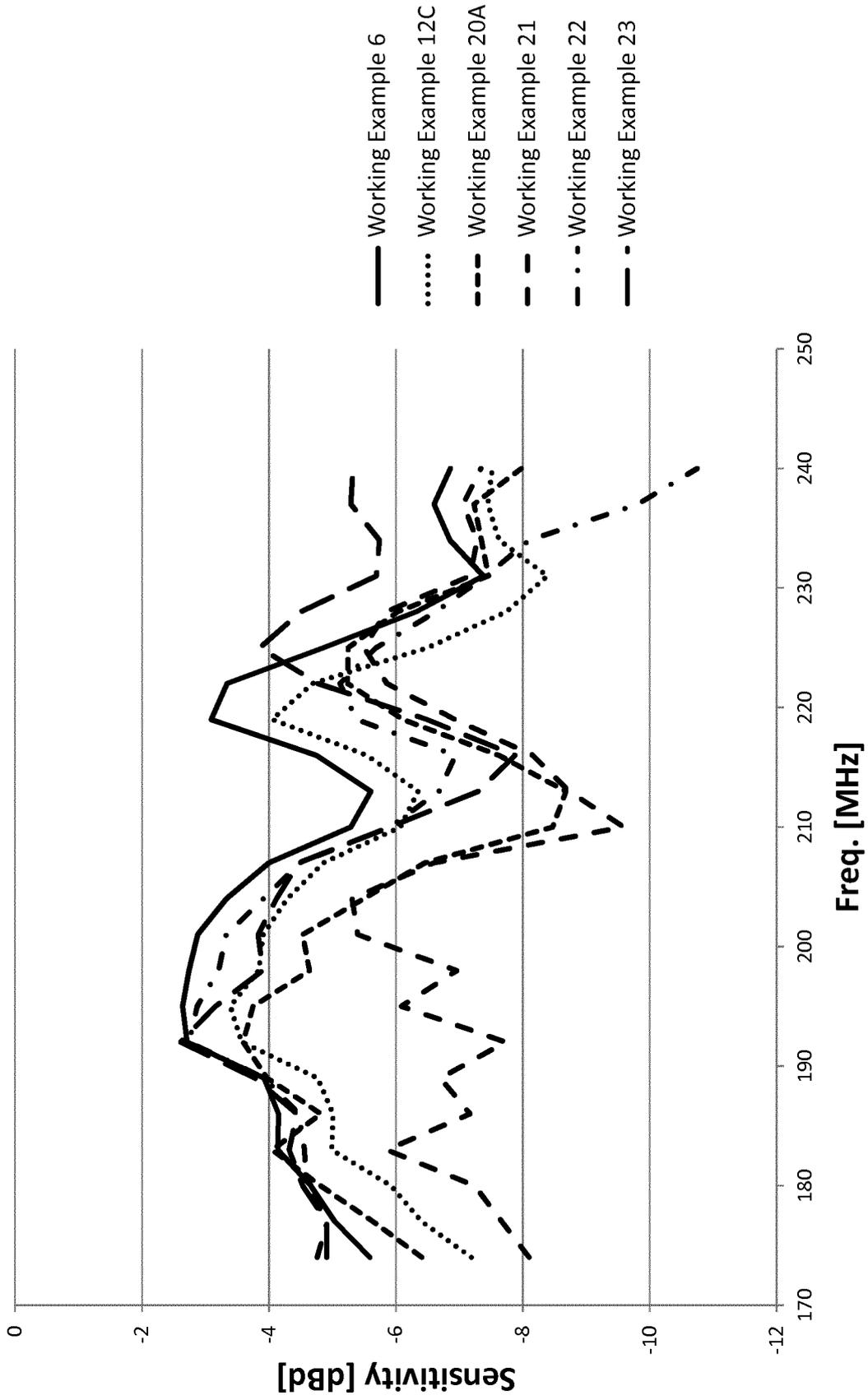


FIG.13A

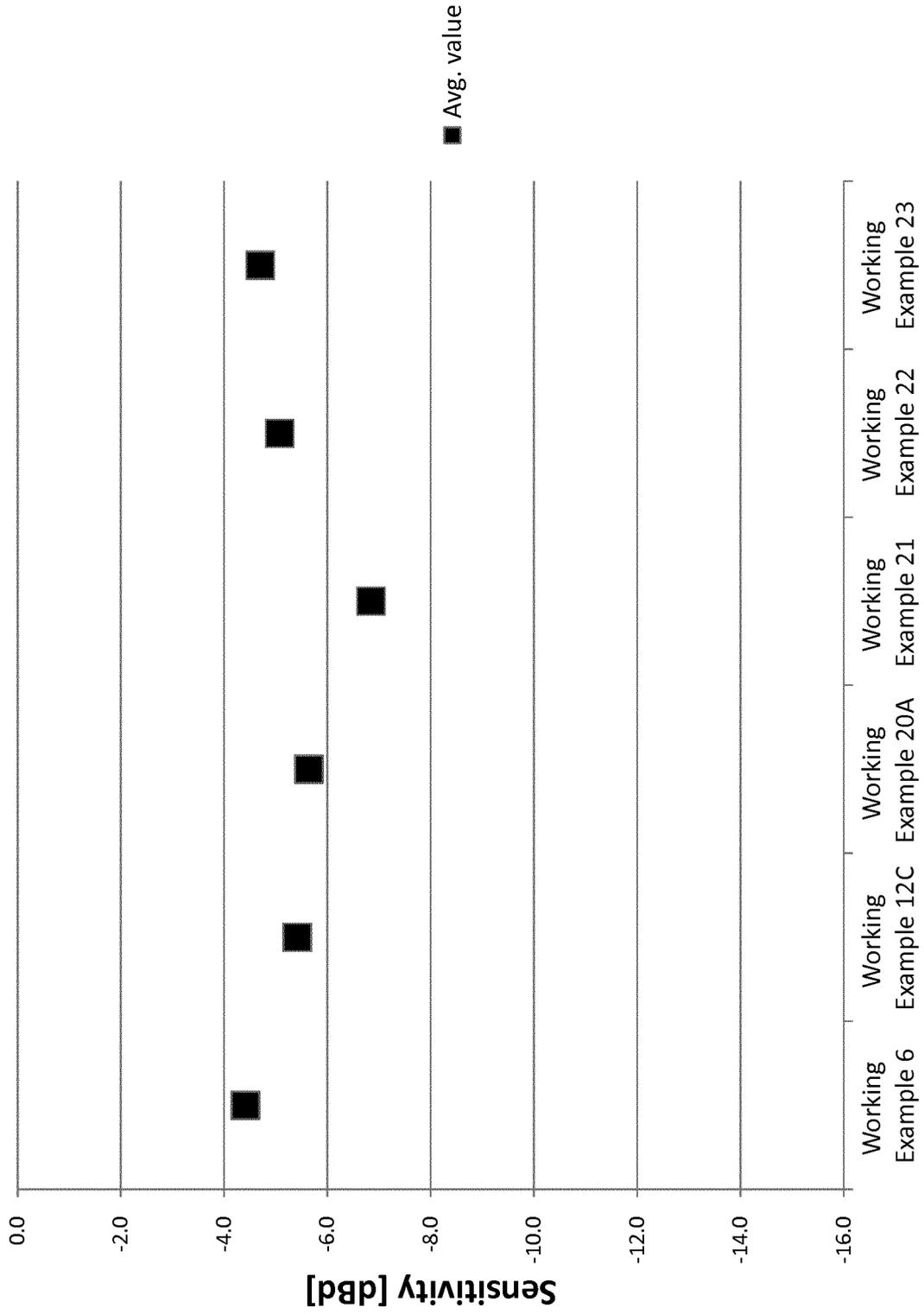


FIG.13B

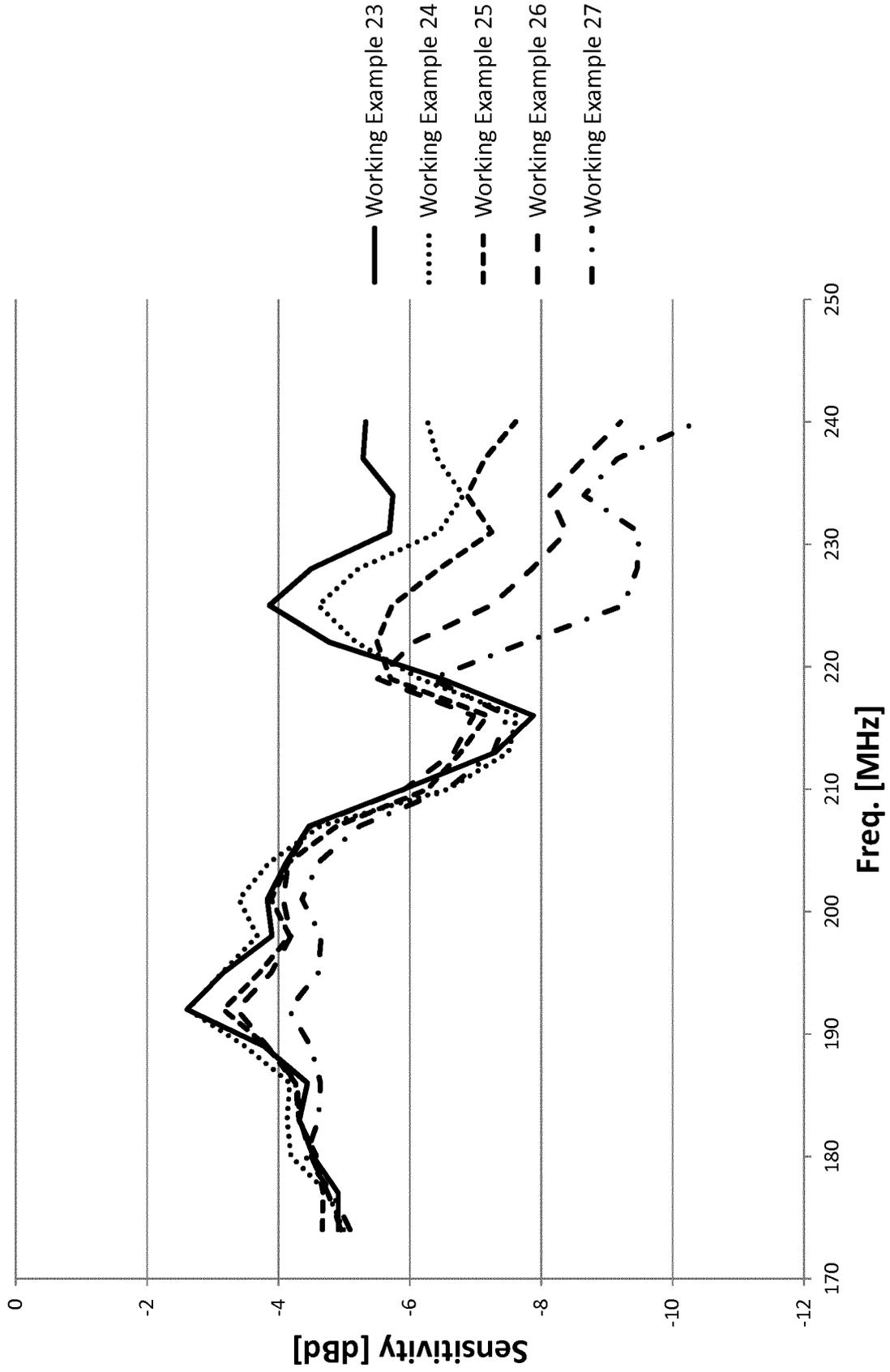


FIG.15A

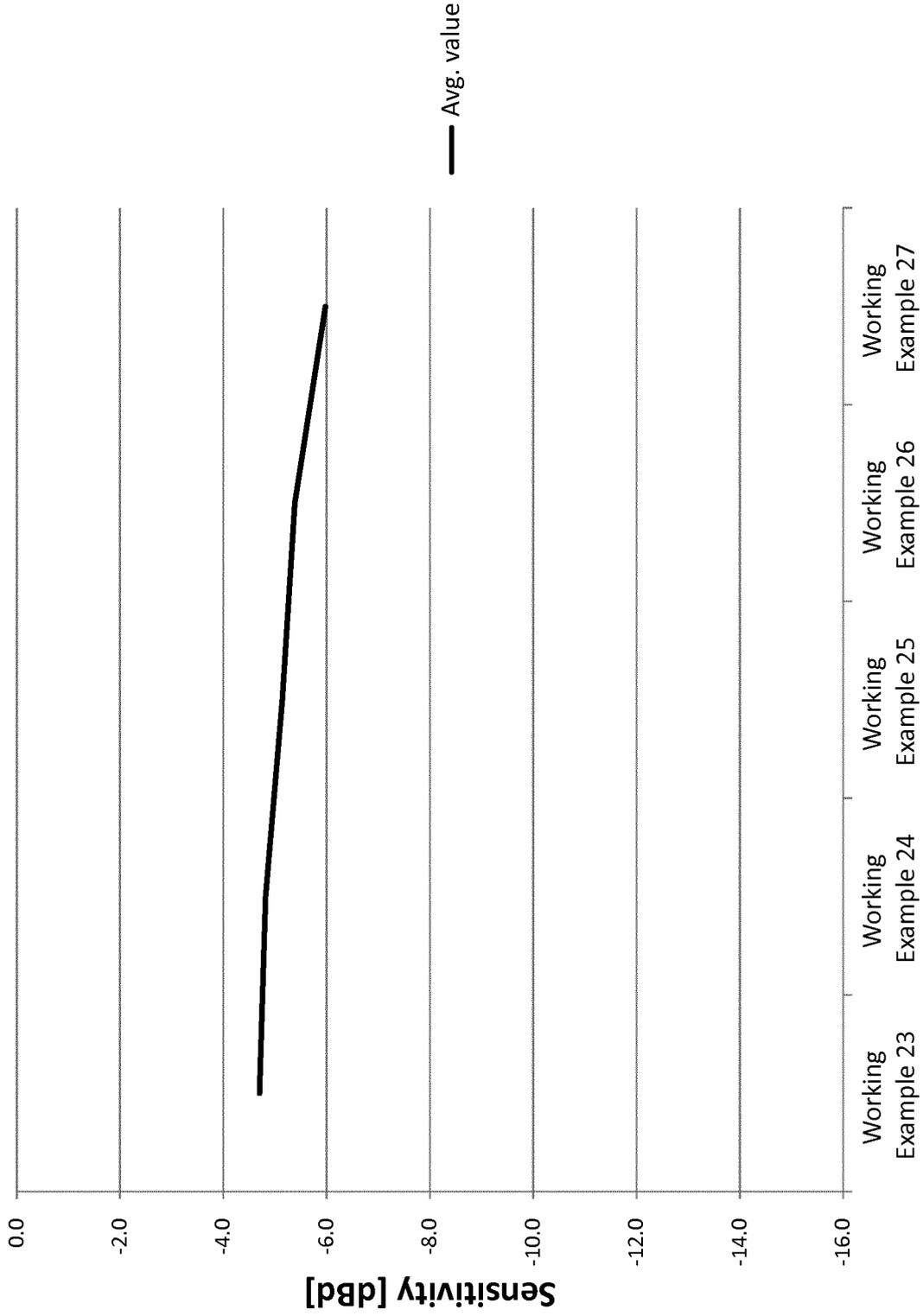


FIG.15B

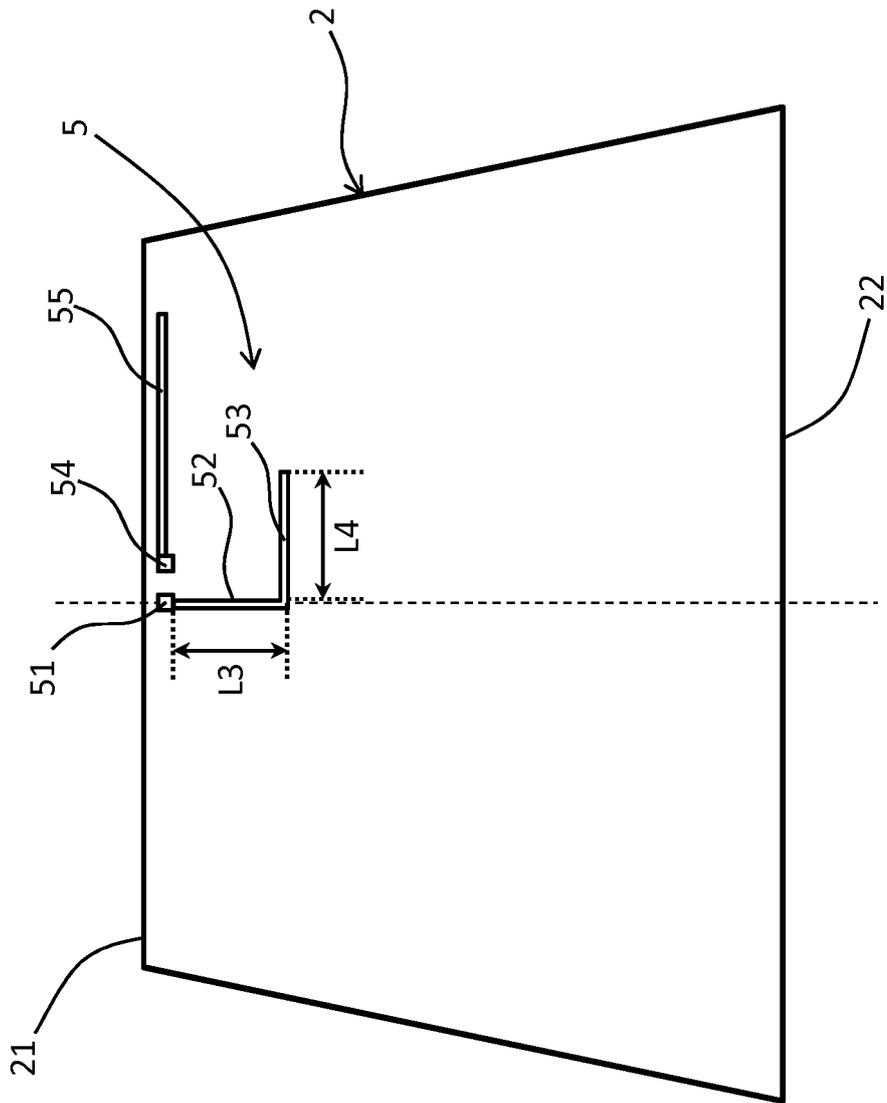


FIG.16

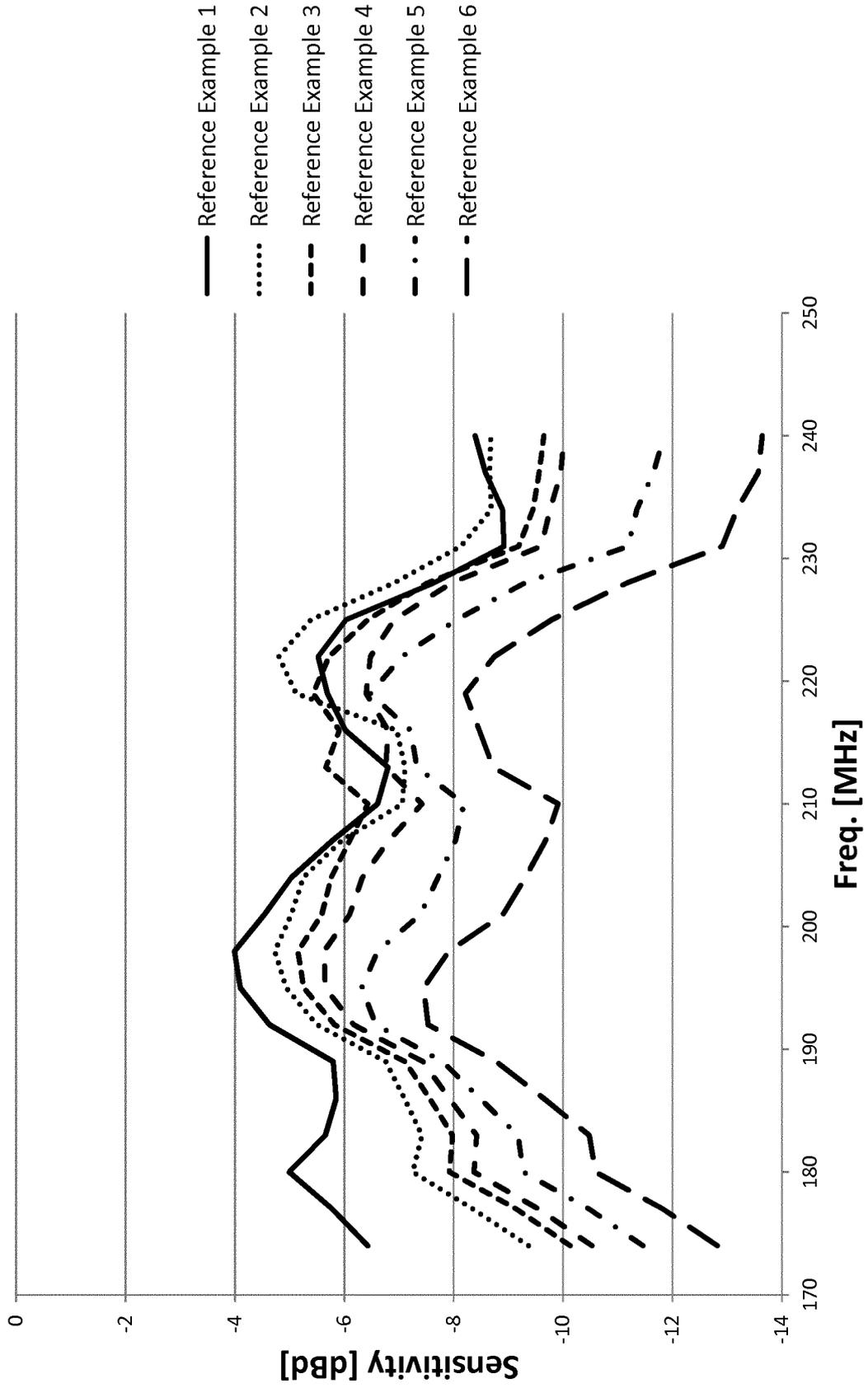


FIG.17A

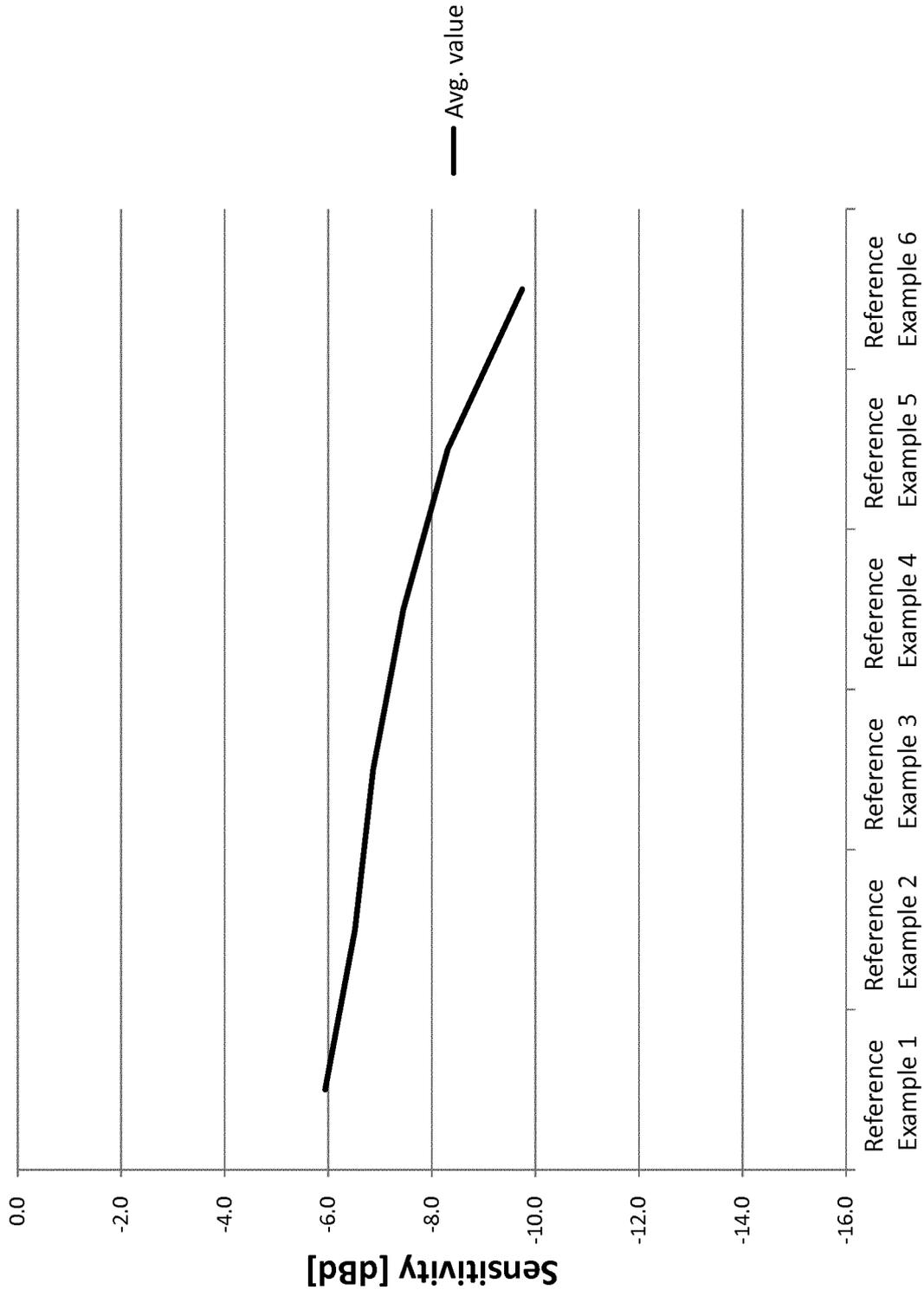


FIG.17B

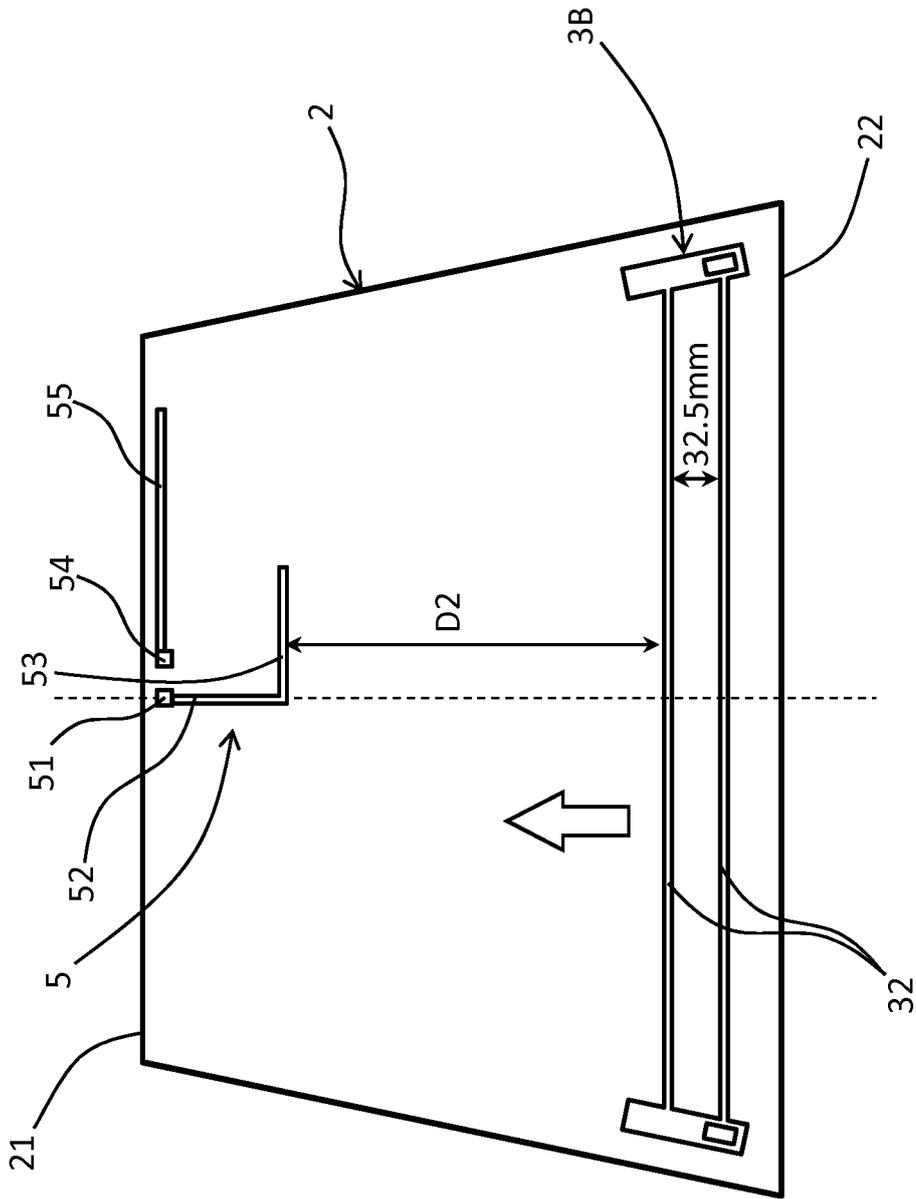


FIG.18

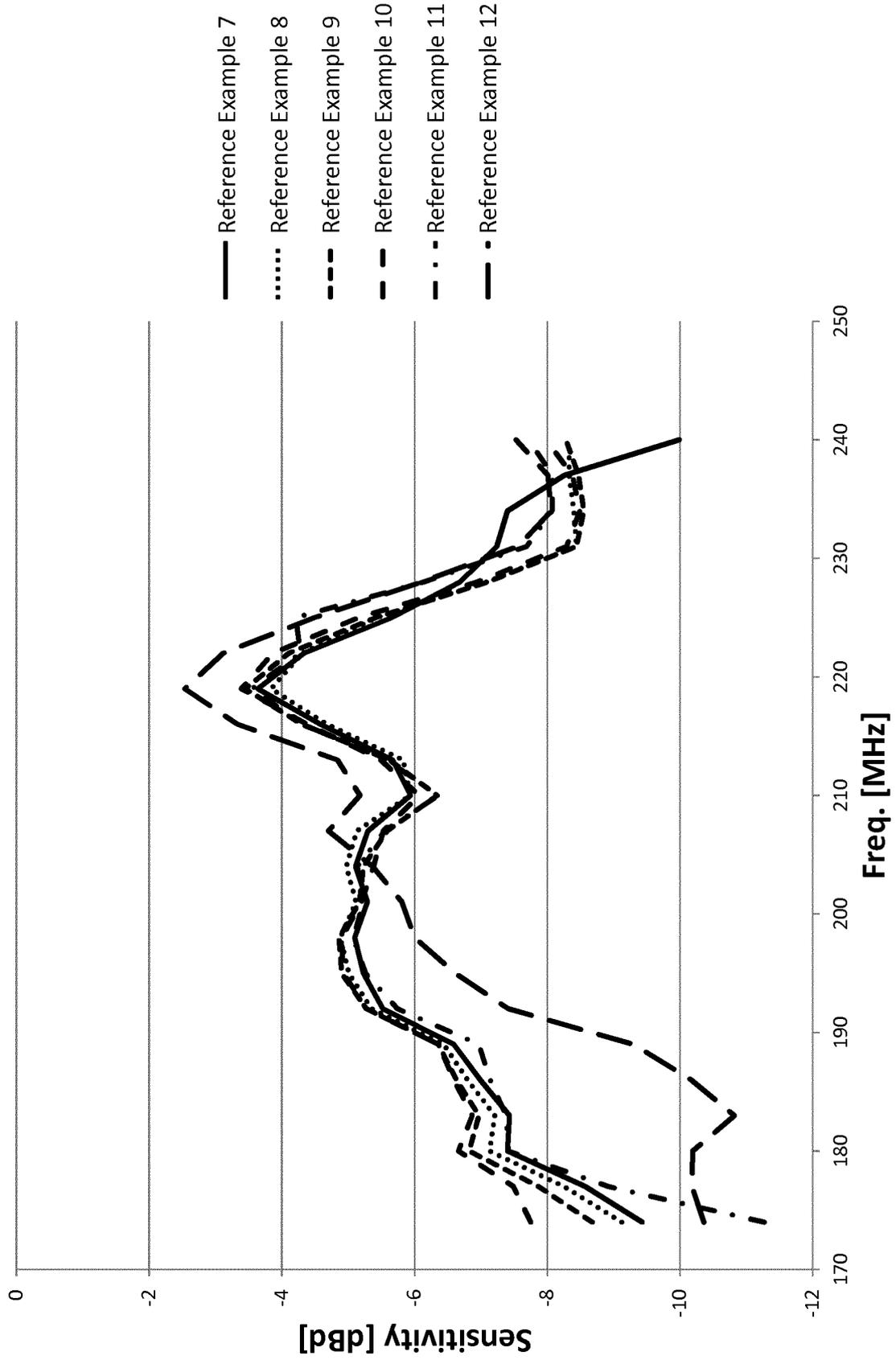


FIG.19A

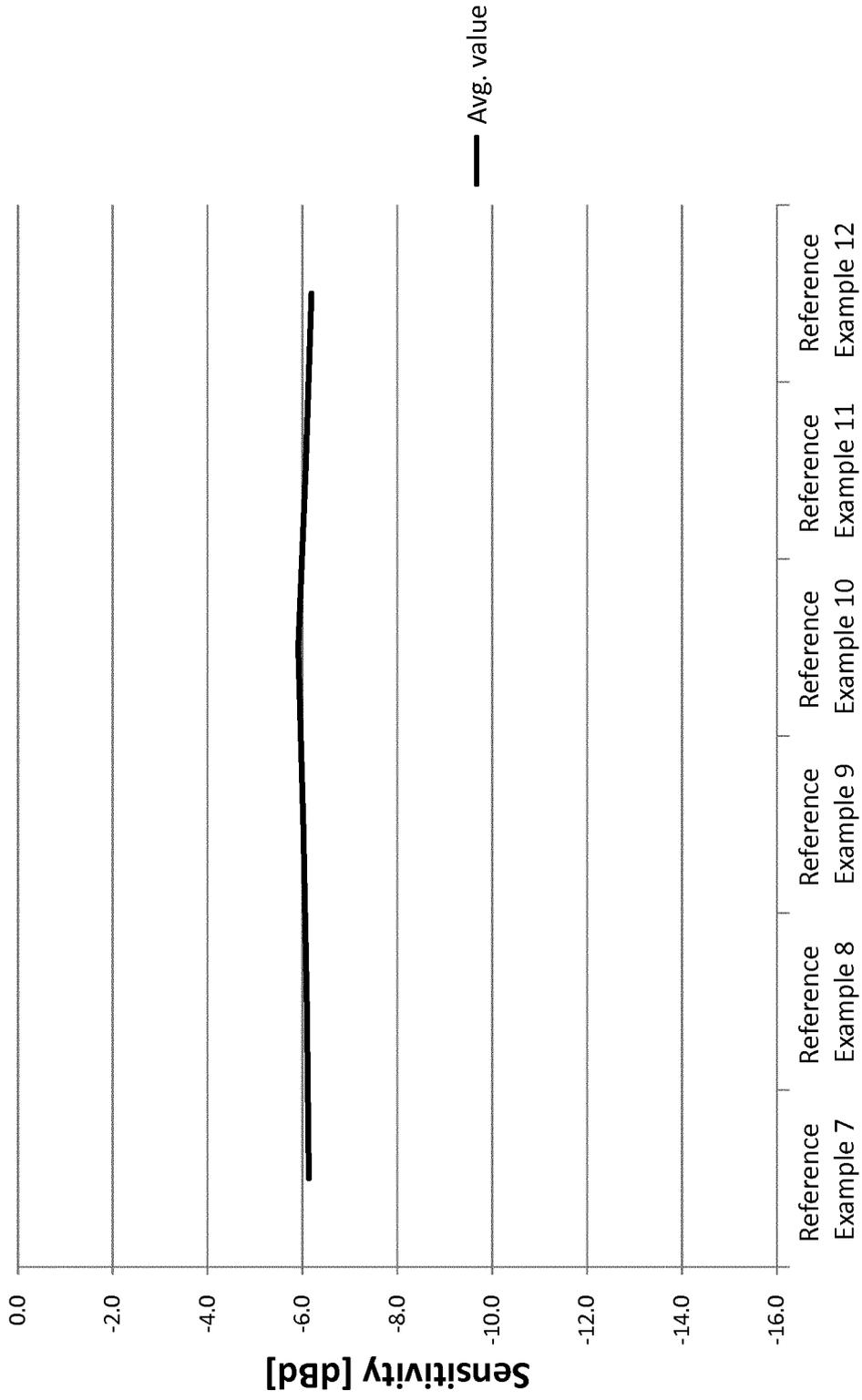


FIG.19B

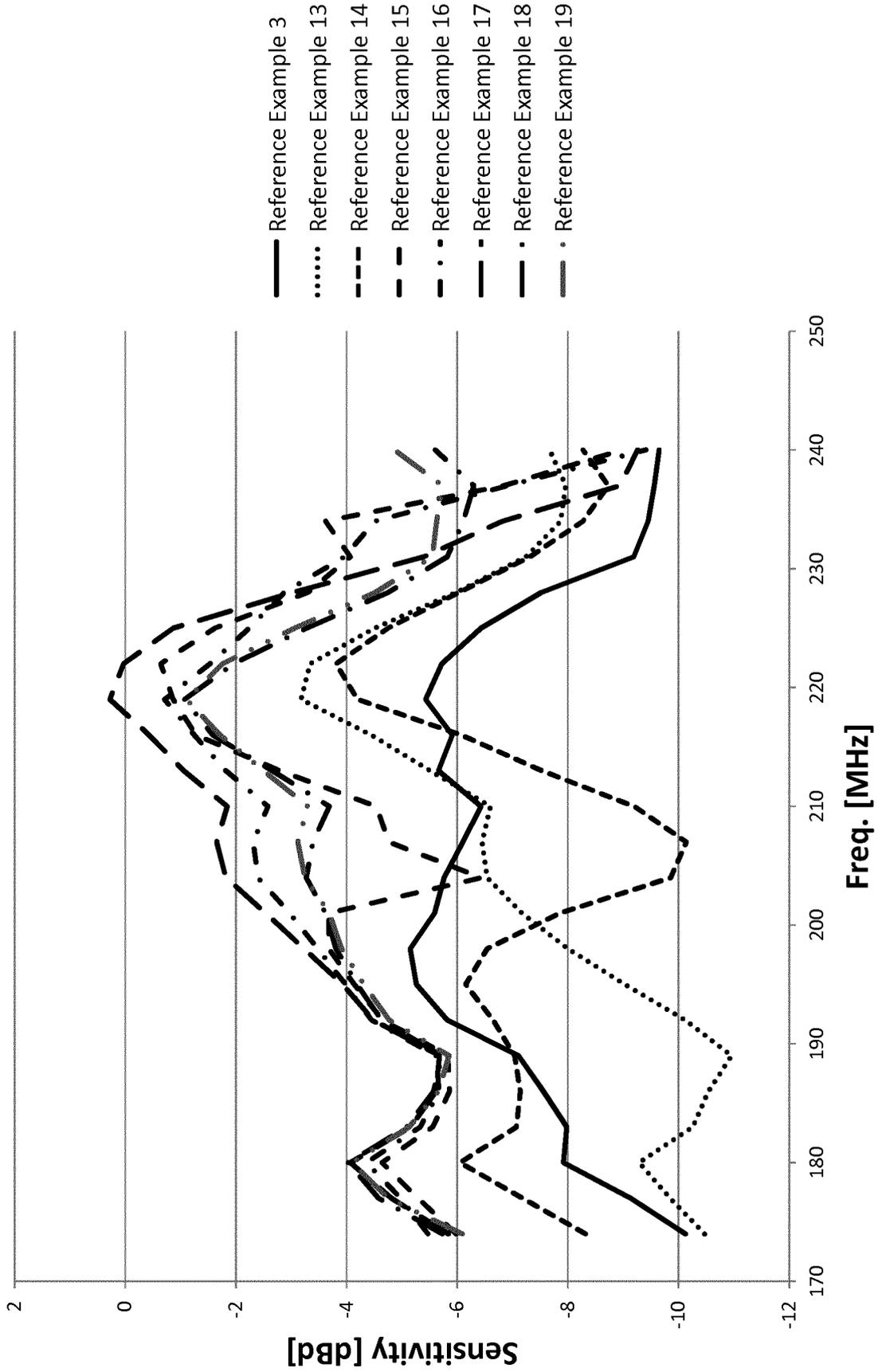


FIG.21A

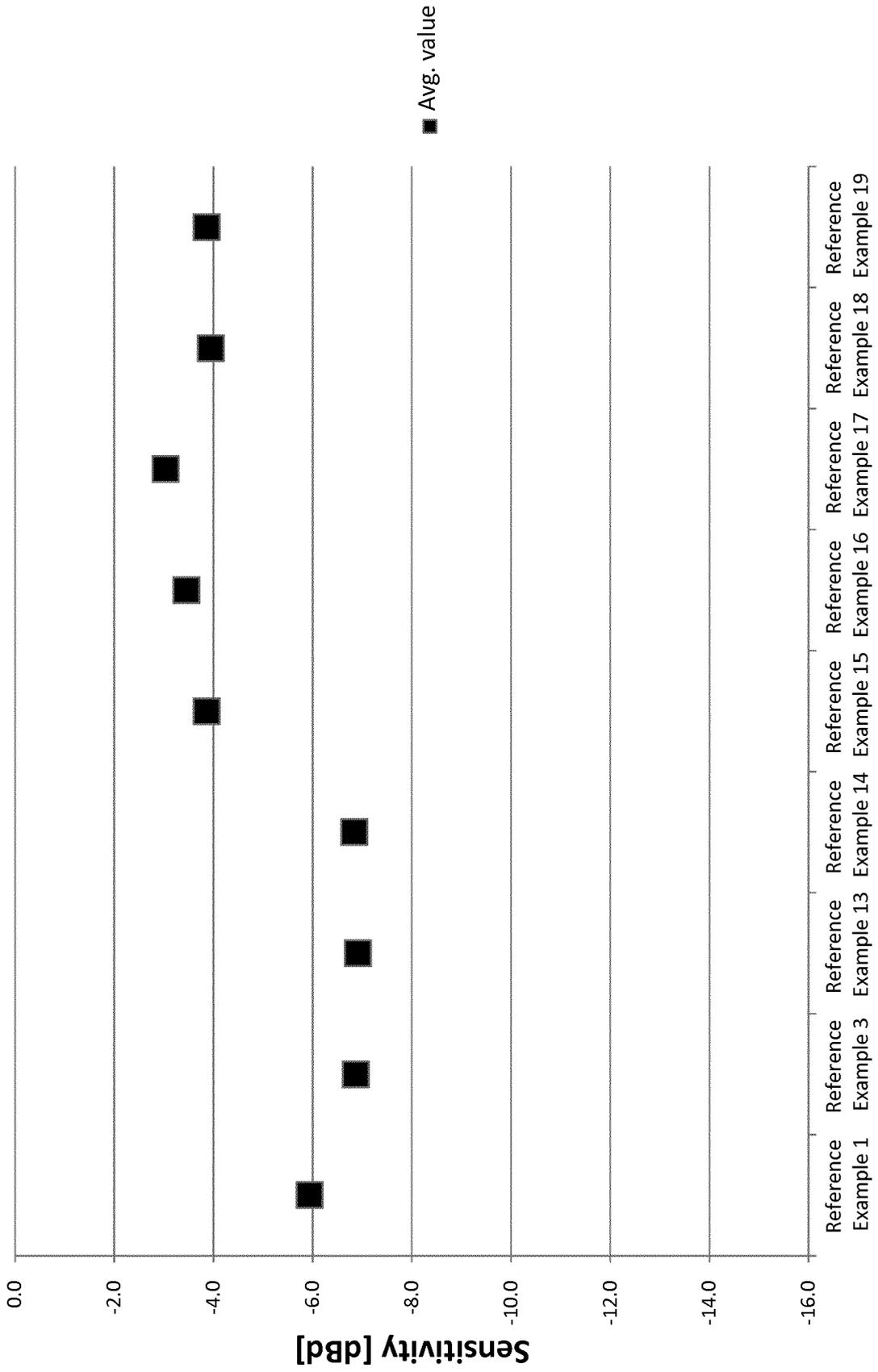


FIG.21B

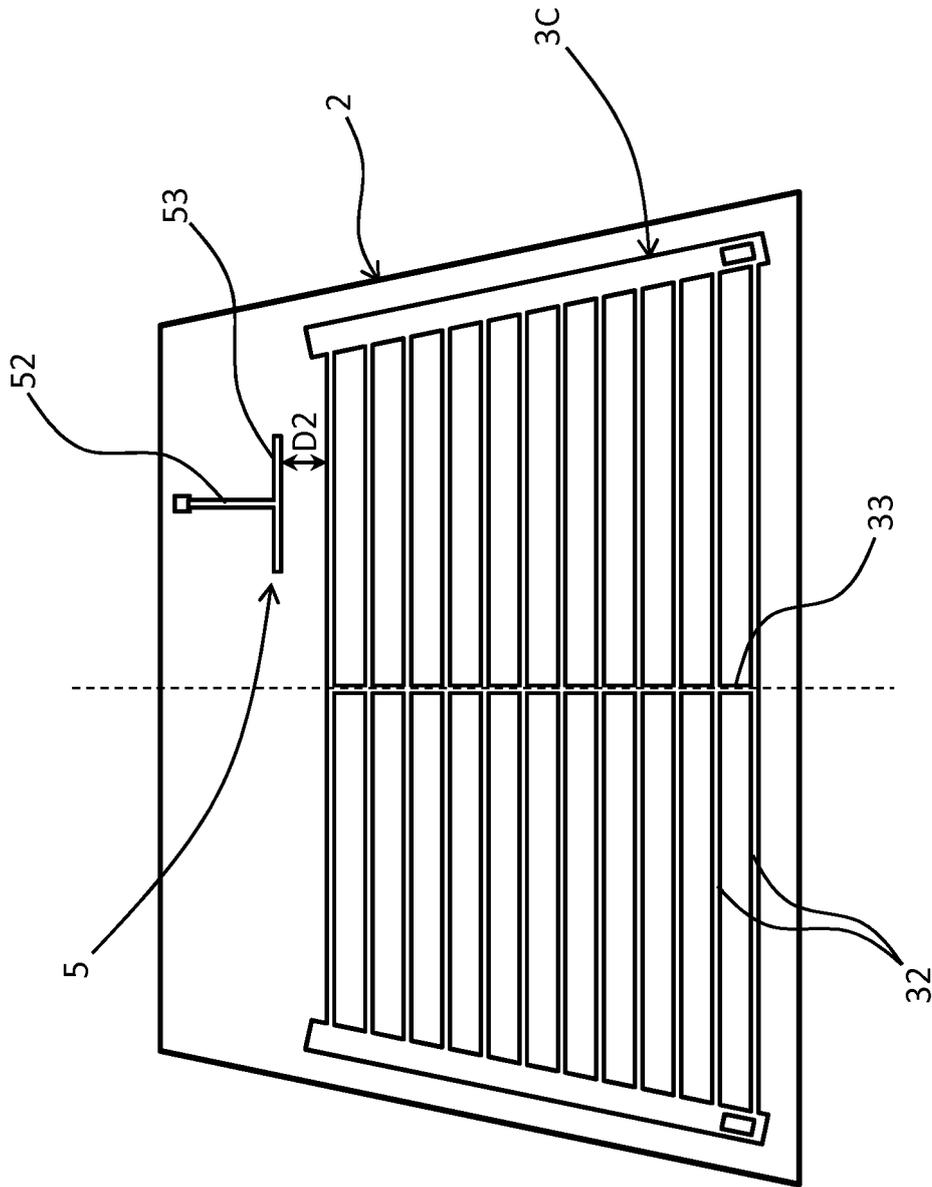


FIG.22

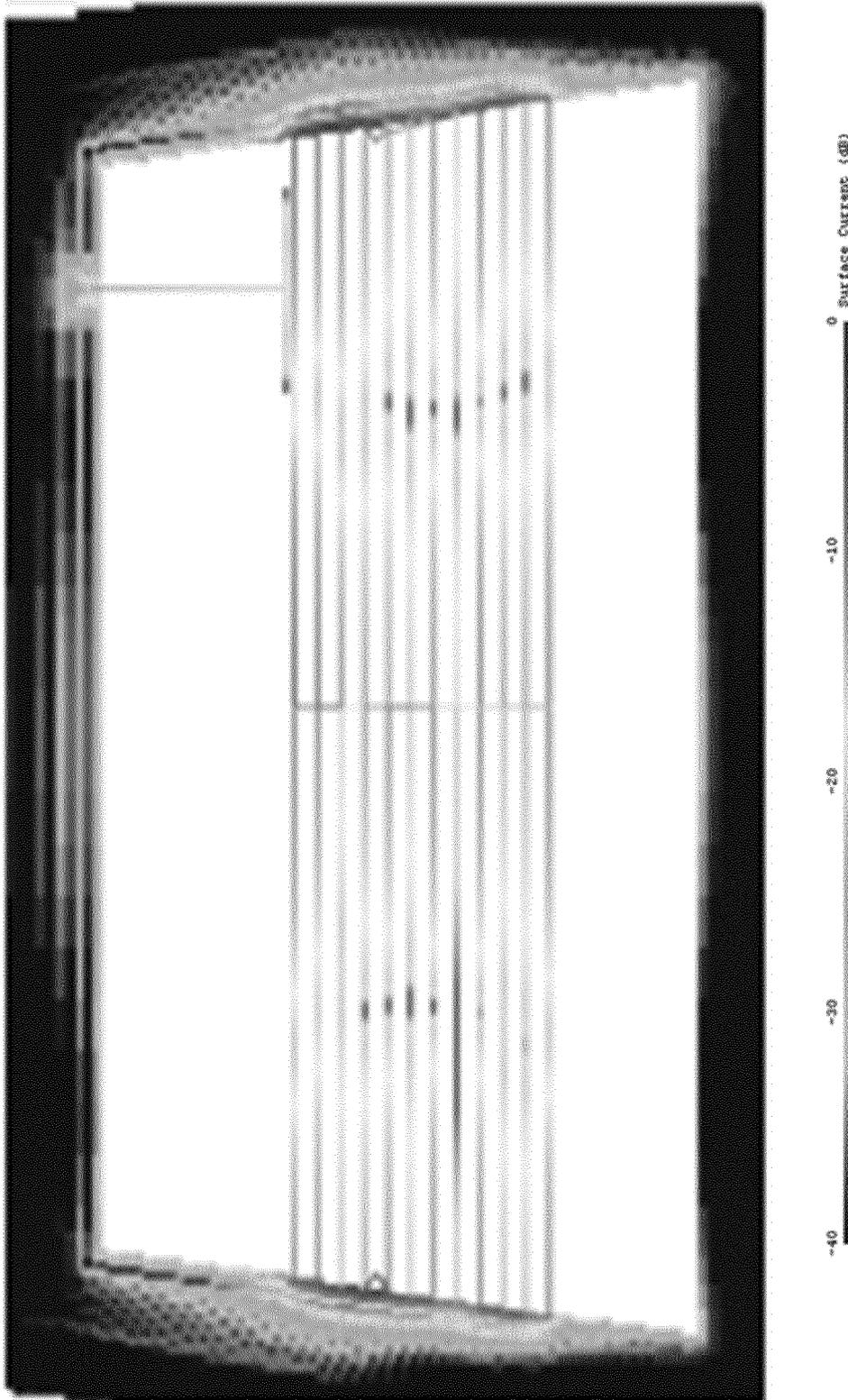


FIG.23A

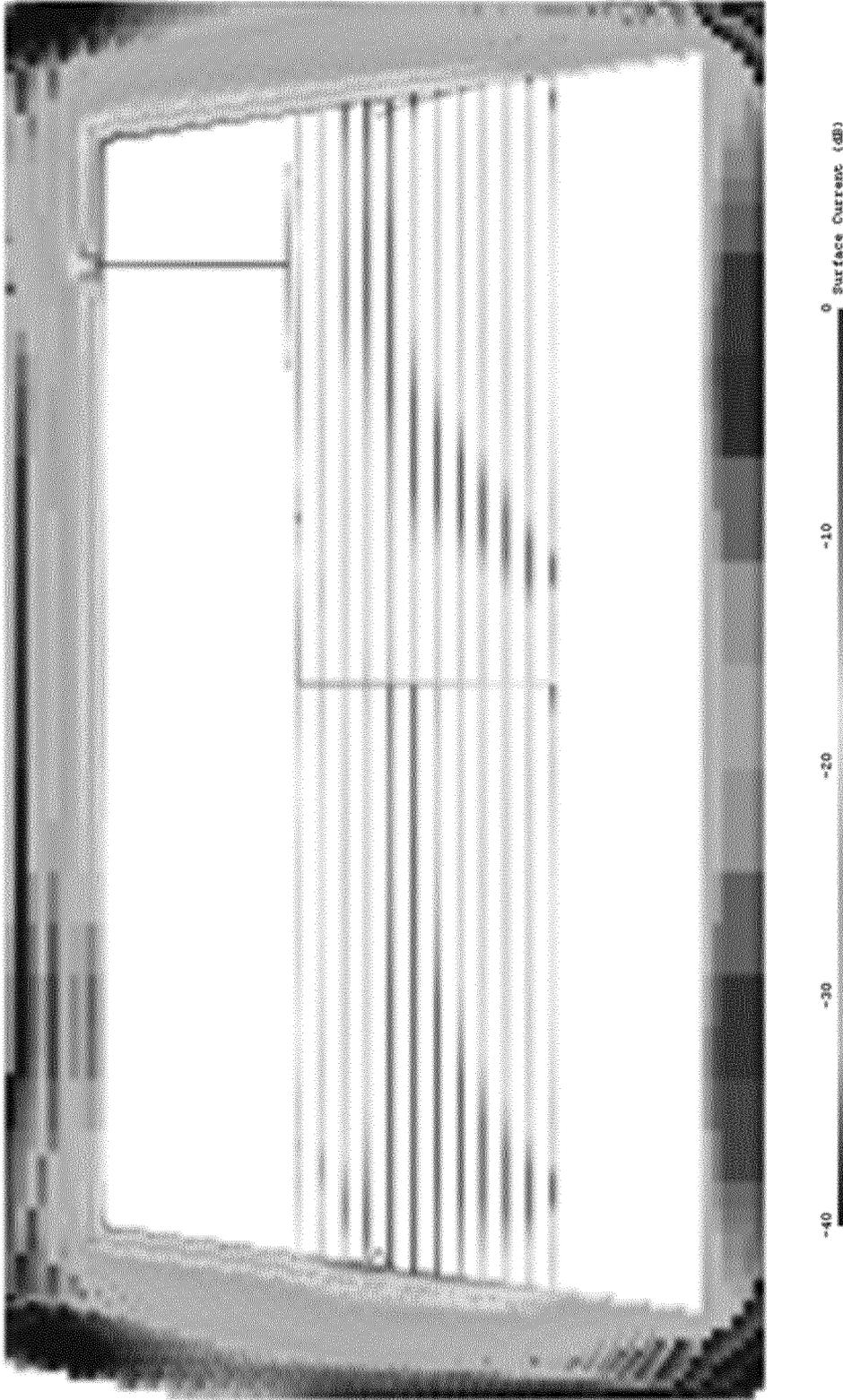


FIG.23B

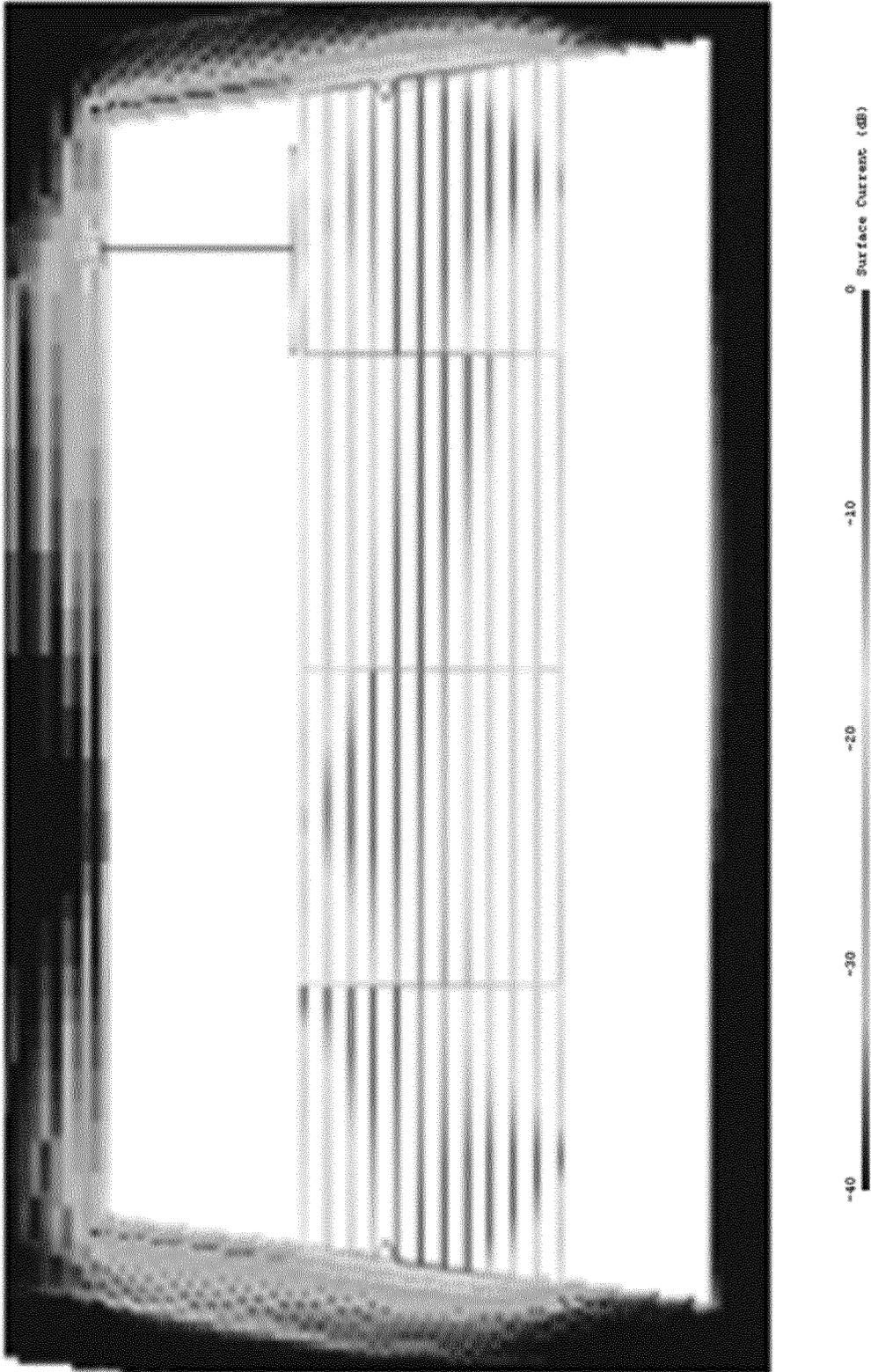


FIG.24A

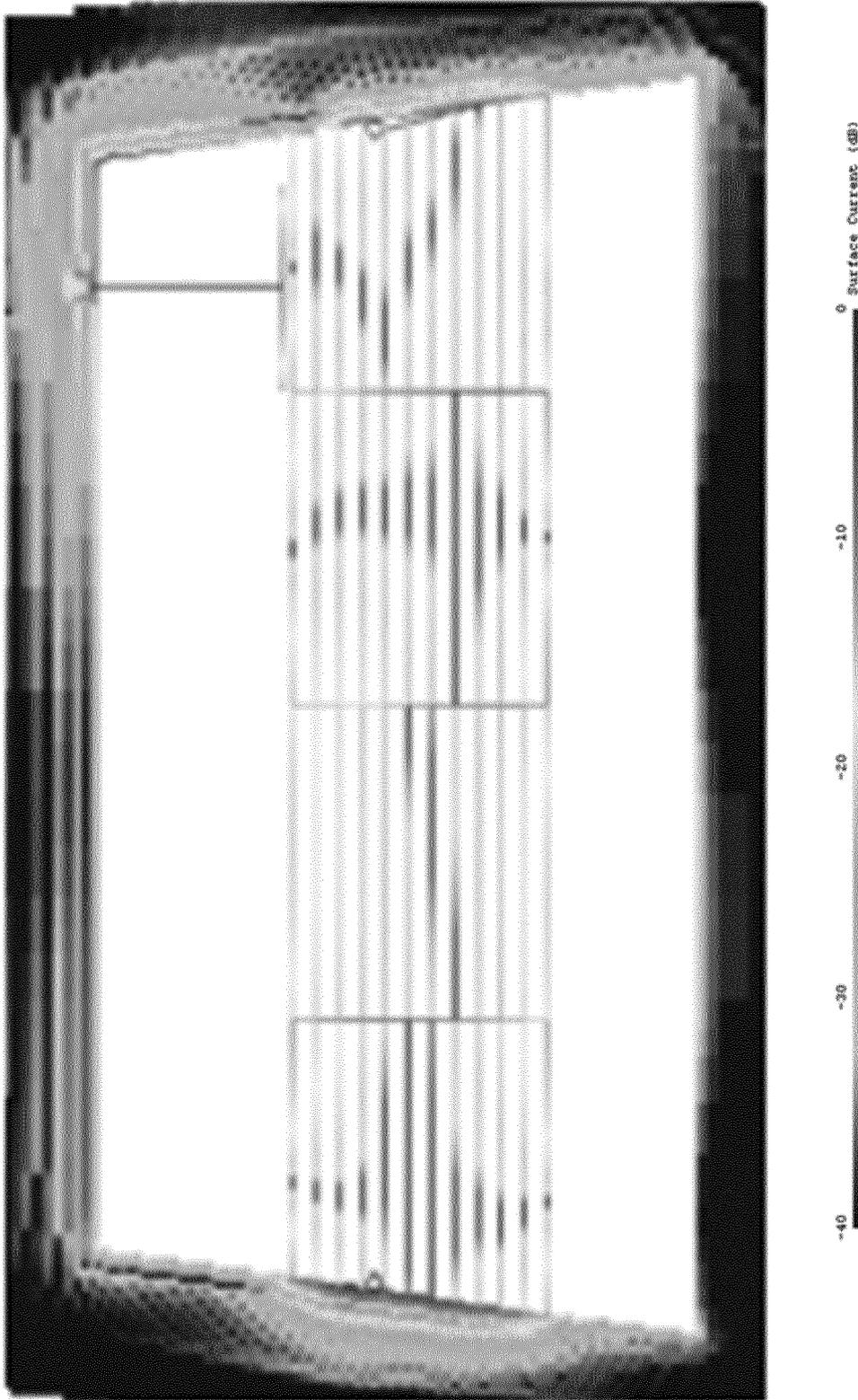


FIG.24B

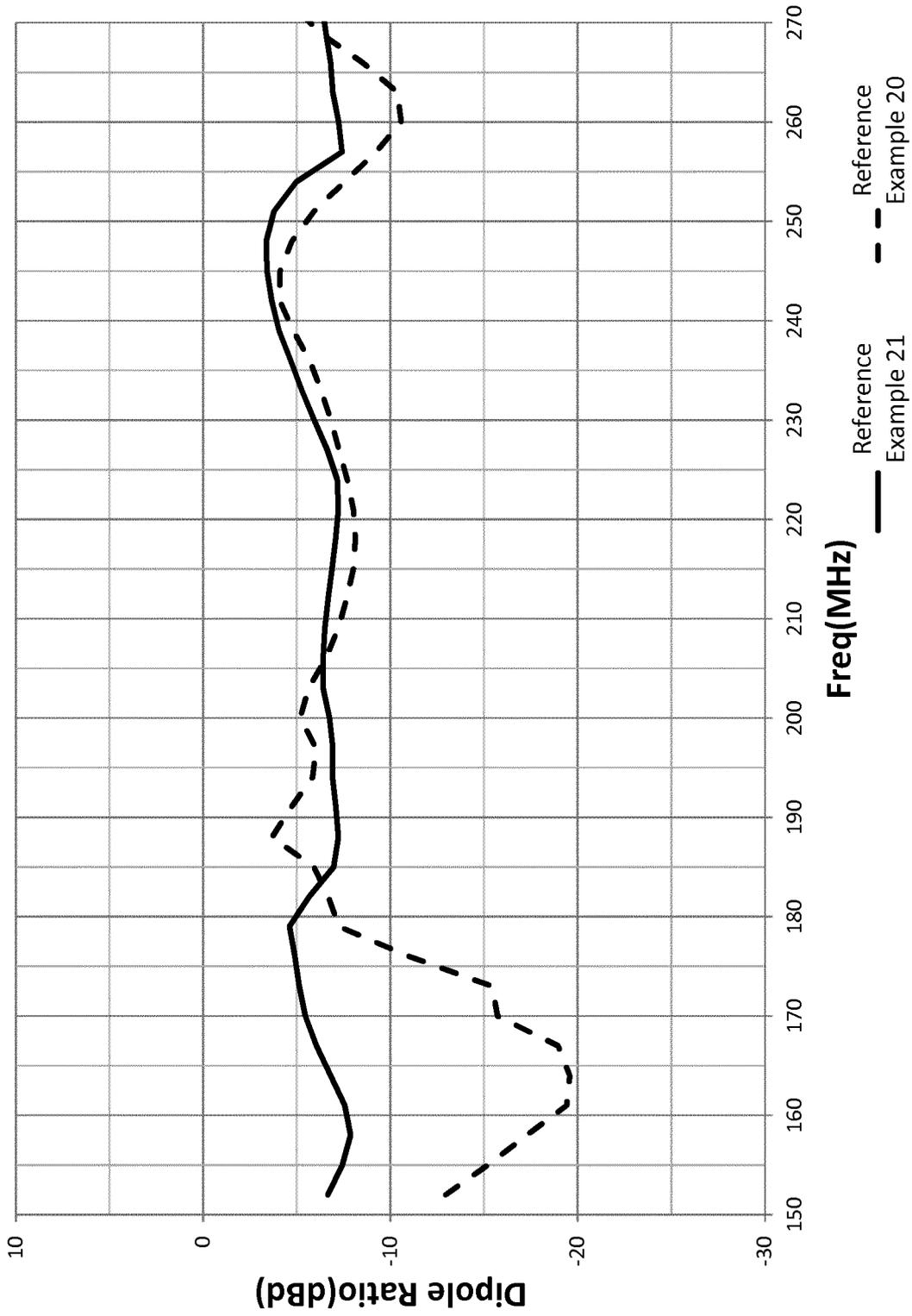


FIG.25

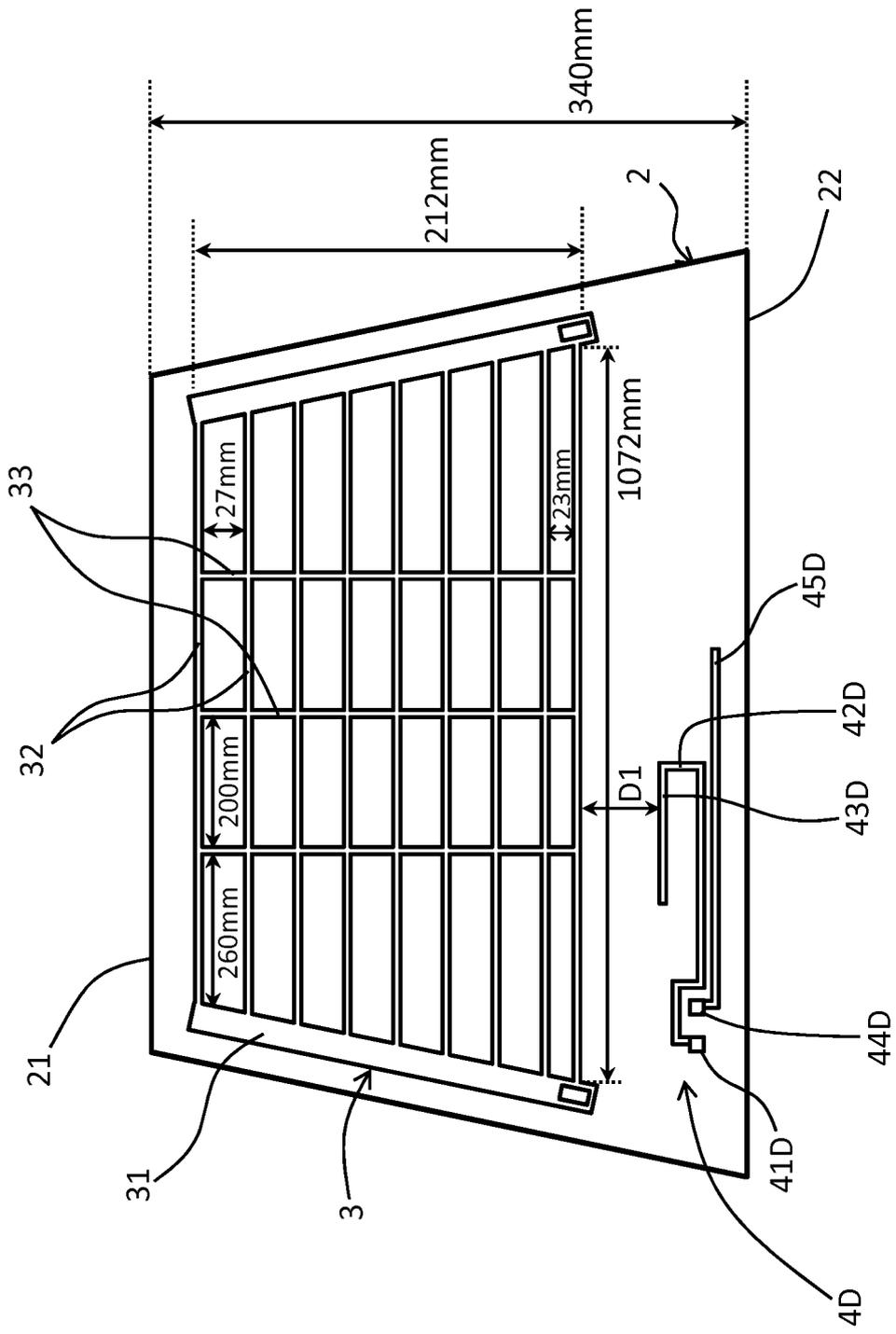


FIG. 26

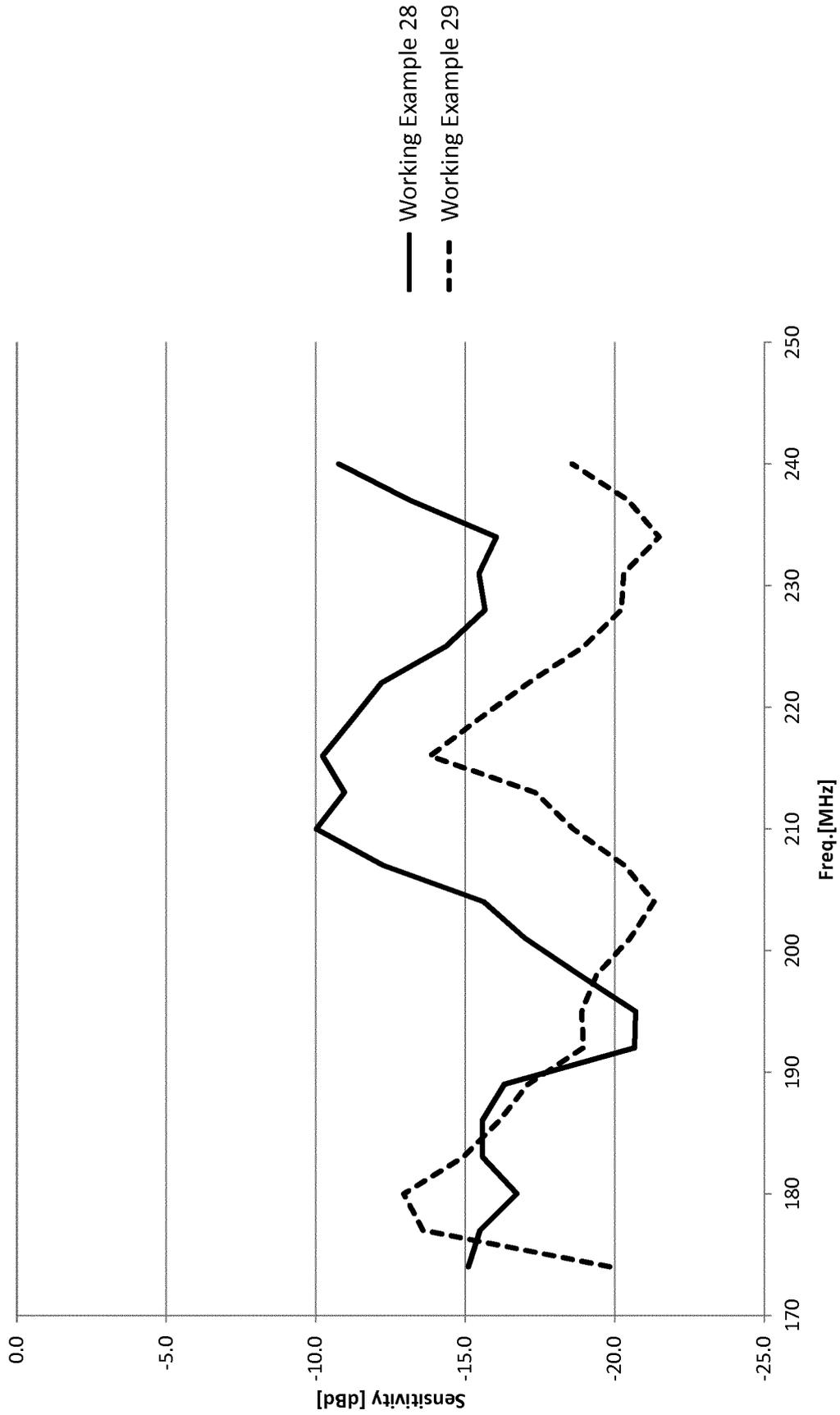


FIG.27

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/063637

5	<p>A. CLASSIFICATION OF SUBJECT MATTER H01Q1/32(2006.01)i, B60J1/00(2006.01)i, B60S1/02(2006.01)i, H01Q1/22(2006.01)i</p> <p>According to International Patent Classification (IPC) or to both national classification and IPC</p>													
10	<p>B. FIELDS SEARCHED</p> <p>Minimum documentation searched (classification system followed by classification symbols) H01Q1/32, B60J1/00, B60S1/02, H01Q1/22</p>													
15	<p>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched</p> <table border="0"> <tr> <td>Jitsuyo Shinan Koho</td> <td>1922-1996</td> <td>Jitsuyo Shinan Toroku Koho</td> <td>1996-2016</td> </tr> <tr> <td>Kokai Jitsuyo Shinan Koho</td> <td>1971-2016</td> <td>Toroku Jitsuyo Shinan Koho</td> <td>1994-2016</td> </tr> </table> <p>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)</p>		Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016	Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016				
Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016											
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016											
20	<p>C. DOCUMENTS CONSIDERED TO BE RELEVANT</p> <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td style="vertical-align: top;">25</td> <td>Y JP 2015-056716 A (Central Glass Co., Ltd.), 23 March 2015 (23.03.2015), paragraphs [0002], [0035], [0074]; fig. 5 (Family: none)</td> <td>1-9</td> </tr> <tr> <td style="vertical-align: top;">30</td> <td>Y WO 2011/158602 A1 (Central Glass Co., Ltd.), 22 December 2011 (22.12.2011), paragraphs [0019], [0059], [0065]; fig. 1, 2 & EP 2581983 A1 paragraphs [0019], [0059], [0065]; fig. 1, 2 & AU 2011266380 A & CN 102971907 A</td> <td>1-9</td> </tr> </tbody> </table>		Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	25	Y JP 2015-056716 A (Central Glass Co., Ltd.), 23 March 2015 (23.03.2015), paragraphs [0002], [0035], [0074]; fig. 5 (Family: none)	1-9	30	Y WO 2011/158602 A1 (Central Glass Co., Ltd.), 22 December 2011 (22.12.2011), paragraphs [0019], [0059], [0065]; fig. 1, 2 & EP 2581983 A1 paragraphs [0019], [0059], [0065]; fig. 1, 2 & AU 2011266380 A & CN 102971907 A	1-9			
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30	Y WO 2011/158602 A1 (Central Glass Co., Ltd.), 22 December 2011 (22.12.2011), paragraphs [0019], [0059], [0065]; fig. 1, 2 & EP 2581983 A1 paragraphs [0019], [0059], [0065]; fig. 1, 2 & AU 2011266380 A & CN 102971907 A	1-9												
40	<p><input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.</p>													
45	<table border="0"> <tr> <td>* Special categories of cited documents:</td> <td>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</td> </tr> <tr> <td>"A" document defining the general state of the art which is not considered to be of particular relevance</td> <td>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</td> </tr> <tr> <td>"E" earlier application or patent but published on or after the international filing date</td> <td>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</td> </tr> <tr> <td>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td> <td>"&" document member of the same patent family</td> </tr> <tr> <td>"O" document referring to an oral disclosure, use, exhibition or other means</td> <td></td> </tr> <tr> <td>"P" document published prior to the international filing date but later than the priority date claimed</td> <td></td> </tr> </table>		* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family	"O" document referring to an oral disclosure, use, exhibition or other means		"P" document published prior to the international filing date but later than the priority date claimed	
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50	<p>Date of the actual completion of the international search 27 May 2016 (27.05.16)</p>	<p>Date of mailing of the international search report 07 June 2016 (07.06.16)</p>												
55	<p>Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan</p>	<p>Authorized officer</p> <p>Telephone No.</p>												

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/063637

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2000-114839 A (Harada Industry Co., Ltd.), 21 April 2000 (21.04.2000), paragraphs [0013], [0014]; fig. 1 & EP 993067 A2 paragraphs [0015], [0016]; fig. 1 & US 6211832 B1	5
Y	JP 2006-197184 A (Asahi Glass Co., Ltd.), 27 July 2006 (27.07.2006), claim 1 (Family: none)	6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2012153664 A1 [0003]