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- **KATADA, Yuji**
Matsusaka city
Mie 515-0001 (JP)
- **KOBAYASHI, Hisashi**
Matsusaka city
Mie 515-0001 (JP)
- **KITAMURA, Akifumi**
Matsusaka city
Mie 515-0001 (JP)

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(71) Applicant: **CENTRAL GLASS COMPANY, LIMITED**
Ube-shi, Yamaguchi 755-0001 (JP)

(74) Representative: **Moore, Graeme Patrick et al**
Mewburn Ellis LLP
City Tower
40 Basinghall Street
London EC2V 5DE (GB)

(72) Inventors:
• **KAIHATSU, Masanori**
Matsusaka city
Mie 515-0001 (JP)

(54) **GLASS ANTENNA**

(57) It is provided a glass antenna arranged on a window glass for a vehicle, comprising a power feeding point connected to a receiver, a first element extending from the power feeding point. The first element includes an overlap portion arranged along a second element that is not connected to the power feeding point so as to be spaced apart from the second element with a predeter-

mined spacing, and a non-overlap portion prevented from being arranged along the second element. Each length of the overlap portion and the non-overlap portion are adjusted so that the overlap portion is tuned to a first frequency band, and the non-overlap portion is tuned to a second frequency band.

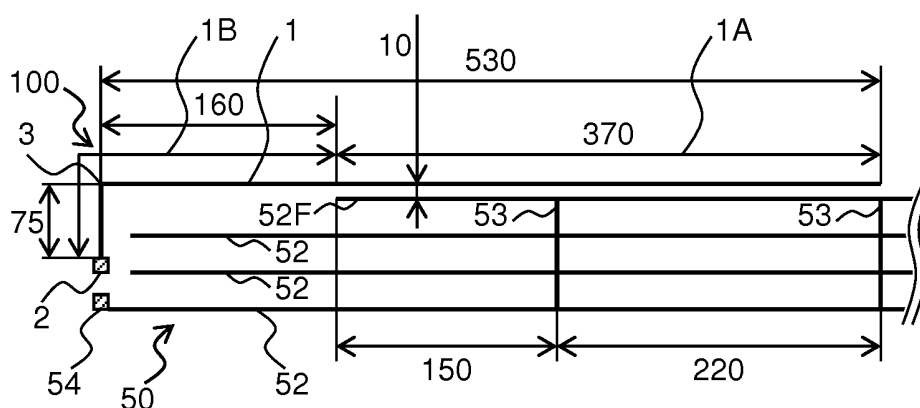


Fig. 3

Description

BACKGROUND OF THE INVENTION

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

[0002] In countries all over the world, radio and television broadcasting frequencies and a frequency used for a remote keyless entry (RKE) system differ among countries and regions, and hence it is necessary to develop an antenna having elements that differ in length for each delivery destination. However, in order to develop various kinds of antennas, a large number of work man-hours are required, and hence an antenna configured to support a plurality of bands is desired. For example, the frequency used for the remote keyless entry system is 315 MHz in Japan and the United States of America, and is 433.92 MHz in Europe. Therefore, when a satisfactory sensitivity cannot be obtained in a plurality of bands, it is necessary to adjust the lengths of the elements for each delivery destination.

[0003] As an antenna for obtaining a satisfactory sensitivity with such a plurality of frequencies, in JP H06-291530 A, there is disclosed an antenna of a typical two-frequency switching type. In order to receive two radio waves in an 800 MHz band and a 1500 MHz band, the antenna disclosed in JP H06-291530 A includes two elements having lengths suitable for the respective frequencies, and has the two elements connected to each other in a bifurcated shape or a V shape.

[0004] In a high frequency band targeted by the antenna disclosed in JP H06-291530 A, an antenna pattern can be formed to have a small size. However, there is a problem of an increase in antenna pattern of an antenna configured to receive a relatively low frequency (315 MHz or 433.92 MHz) with a high sensitivity, e.g., an antenna for a remote keyless entry system.

[0005] The antenna pattern is generally arranged in a part of a defogger on a rear window, in which a heating wire is not arranged, or a part that does not block the view of a human. Therefore, it is difficult to arrange a noticeably large pattern on a glass sheet.

SUMMARY OF THE INVENTION

[0006] Therefore, this invention has an object to provide a glass antenna capable of obtaining satisfactory reception performance in two frequency bands even when being arranged in a narrow place on a window glass for an automobile.

[0007] That is, according to one embodiment of this invention, there is provided a glass antenna arranged on a window glass for a vehicle, comprising a power feeding point connected to a receiver, a first element extending from the power feeding point. The first element includes an overlap portion arranged along a second element that

is not connected to the power feeding point so as to be spaced apart from the second element with a predetermined spacing, and a non-overlap portion (1B) prevented from being arranged along the second element. Each length of the overlap portion and the non-overlap portion are adjusted so that the overlap portion is tuned to a first frequency band, and the non-overlap portion is tuned to a second frequency band.

[0008] Further, in the glass antenna according to the one embodiment of this invention, the second element includes an element configured to form an antenna different from an antenna including the first element.

[0009] Further, in the glass antenna according to the one embodiment of this invention, the glass antenna is an antenna for reception of a signal on a UHF band, and the antenna including the second element is an antenna for reception of an AM radio broadcast on a medium wave band.

[0010] Further, in the glass antenna according to the one embodiment of this invention, the first element is bent at a midpoint.

[0011] Further, in the glass antenna according to the one embodiment of this invention, a part between a bent portion of the first element and the power feeding point is formed of a plurality of wires.

[0012] Further, in the glass antenna according to the one embodiment of this invention, the first frequency band has a wavelength of a center frequency set as λ_1 . The second frequency band has a wavelength of a center frequency set as λ_2 . The overlap portion has a length of approximately $\alpha\lambda_1/2$. The non-overlap portion has a length of approximately $\alpha\lambda_2/2$. The parameter α represents a wavelength shortening rate of the window glass.

[0013] Further, in the glass antenna according to the one embodiment of this invention, the first frequency band is lower than the second frequency band.

[0014] Further, in the glass antenna according to the one embodiment of this invention, the first frequency band has a center frequency of approximately 315 MHz. The second frequency band has a center frequency of approximately 433.92 MHz.

[0015] Further, in the glass antenna according to the one embodiment of this invention, the overlap portion has a spacing of equal to or smaller than 10 millimeters between the first element and the second element.

[0016] Further, in the glass antenna according to the one embodiment of this invention, the first element is arranged in a position spaced apart from an edge of a body flange of an automobile by equal to or larger than 5 millimeters and equal to or smaller than 10 millimeters when the glass antenna is mounted on the automobile so that the body flange and the first element are capacitively coupled to each other.

[0017] According to a representative embodiment of this invention, it is possible to obtain a high sensitivity in a plurality of frequency bands.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

FIG. 1 is a front view for illustrating an antenna pattern according to an example 1 of this invention.
 FIG. 2 is a front view for illustrating an antenna pattern according to an example 2 of this invention.
 FIG. 3 is a front view for illustrating an antenna pattern according to an example 3 of this invention.
 FIG. 4 is a front view for illustrating an antenna pattern according to an example 4 of this invention.
 FIG. 5 is a front view for illustrating an antenna pattern according to an example 5 of this invention.
 FIGs. 6 and 7 are drawings for illustrating frequency characteristics of the antenna according to the example 5.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] FIG. 1 to FIG. 5 are diagrams of a glass antenna according to each embodiment of this invention when viewed from the inside of a vehicle.

[0020] As illustrated in FIG. 1, a glass antenna 100 according to the embodiment of this invention is provided to a rear glass of an automobile, and includes a power feeding point 2 and a first element 1 extending from the power feeding point 2. A second element 52F is arranged in proximity to a part of the first element 1. Therefore, the first element 1 can be classified into an overlap portion 1A arranged in proximity to the second element 52F and a non-overlap portion 1B that is not arranged in proximity to the second element 52F.

[0021] The power feeding point 2 is connected to a reception amplifier 6 through a connecting line (for example, low voltage cable for automobile) 5, and the reception amplifier 6 is connected to a receiver by a high-frequency cable (for example, coaxial cable). Further, the reception amplifier 6 is connected to the ground (vehicle body).

[0022] As illustrated in FIG. 1, the second element 52F may be a conductor line that does not form another antenna, or as illustrated in FIG. 2, the second element 52F may be a part of another antenna.

[0023] Further, as illustrated in FIG. 3 and FIG. 5, the first element 1 may include a bent portion 3, and the non-overlap portion 1B may be bent at the bent portion 3.

[0024] Further, as illustrated in FIG. 4, the second element 52F may be bent along the first element 1 so as to correspond to the bending of the first element 1.

[0025] Further, as illustrated in FIG. 5, in the first element 1, the bent portion 3 and the power feeding point 2 are connected to each other with a plurality of conductive lines.

[0026] In addition, as illustrated in FIG. 5, the first element 1 may be arranged in proximity to a body flange 82 of the vehicle body (for example, in parallel with the body

flange 82 with a spacing of 5 millimeters), and the antenna 100 and the body flange 82 (that is, ground) may be capacitively coupled to each other.

[0027] The antenna according to the embodiment of this invention is formed by printing a pattern of the antenna with conductive ceramic paste in a predetermined position on an indoor surface side of a window glass sheet with each wire having a width of approximately 0.7 millimeter, drying the pattern, and then baking the pattern in a heating furnace. Further, the antenna may be formed of a conductive pattern formed on a resin film that transmits light, and may be bonded to a glass sheet.

[0028] The embodiment of this invention is described above by taking a mode of providing the antenna on a rear glass 81 of the automobile, but the antenna according to the embodiment of this invention may be provided on another part (for example, windshield or side glass).

[0029] A length of each of elements of the antenna according to the embodiment of this invention is adjusted to a length suitable to receive a signal on a UHF band to be used for a remote keyless entry system as described later in each embodiment. It should be noted that the antenna according to the embodiment may be formed as an antenna suitable to receive a signal on another frequency band.

[0030] Next, an action of the glass antenna according to the embodiment of this invention is described.

[0031] The antenna according to this embodiment includes the power feeding point 2 and the first element 1 extending from the power feeding point 2. The first element 1 includes: the overlap portion 1A arranged along the second element 52F that is not connected to the power feeding point 2 so that the second element 52F is arranged with a predetermined spacing; and the non-overlap portion 1B prevented from being arranged along the second element 52F. The length of each of the overlap portion 1A and the non-overlap portion 1B is adjusted so as to enable a first frequency band to be received in a preferred manner by one of the overlap portion 1A and the non-overlap portion 1B and to enable a second frequency band to be received in a preferred manner by another one of the overlap portion 1A and the non-overlap portion 1B. Therefore, it is possible to receive two frequency bands with a high sensitivity, and to form an antenna that can be arranged in a narrow place.

[0032] In other words, the antenna according to this embodiment has such a simple configuration as to include the power feeding point 2 and the first element 1 in a main body portion, but has the second element 52F arranged along a part of the first element 1, to thereby be enabled to receive two frequency bands with a high sensitivity through the appropriate adjustment of the length of the overlap portion 1A and the length of the non-overlap portion 1B.

[0033] Further, the second element 52F may be an element configured to form a part or all of an antenna different from the antenna including the first element 1. Therefore, even in a place where a different antenna is

arranged, through use of an element of the different antenna, the antenna according to this embodiment can obtain satisfactory reception performance in two frequencies. Further, the antenna according to this embodiment may be arranged in proximity to the different antenna, and can therefore be arranged even in a narrow place.

[0034] Further, the first element 1 is bent at a midpoint (bent portion 3), and hence the antenna according to this embodiment can be mounted on a glass on which a different antenna is mounted with only a narrow place remaining. For example, in a case where the antenna according to this embodiment is arranged in a narrow place, even when an overlap portion can be adjusted to have an appropriate length, if an element is formed to extend straight, the antenna may be caused to lie off the glass sheet, or may interfere with a corner portion of the body flange, and hence the non-overlap portion 1B may fail to be adjusted to have an appropriate length. Therefore, by bending the first element 1, it is possible to increase the length of the non-overlap portion 1B.

[0035] Further, the power feeding point 2 is sometimes arranged in a predetermined position close to a side of a window glass for an automobile. Therefore, as illustrated in FIG. 4, the second element 52F is arranged so as to be bent along the first element 1, and the lengths of bent parts of the first element 1 and the second element 52F are adjusted, to thereby be able to adjust the position of the power feeding point 2 on the glass sheet.

[0036] Further, the bent portion 3 of the first element 1 and the power feeding point 2 are connected to each other through a plurality of wires, to thereby be able to improve the sensitivity.

[0037] Further, a spacing between the first element 1 and the second element 52F in the overlap portion 1A is set to equal to or smaller than 10 millimeters, and hence the first element 1 and the second element 52F are connected to each other strongly, which facilitates the obtaining of a satisfactory sensitivity in two frequency bands.

[0038] Further, the first element 1 is arranged in a position spaced apart from the body flange 82 by from 5 millimeters to 10 millimeters, to thereby be able to obtain a high sensitivity in a desired frequency band.

Embodiments

[0039] Various Embodiments of this invention are described below.

<Example 1>

[0040] FIG. 1 is a front view of the glass antenna to be provided to the rear glass of the automobile, for illustrating an antenna pattern according to an example 1 of this invention.

[0041] The glass antenna 100 according to the example 1 includes the power feeding point 2 and the first element 1 extending from the power feeding point 2 in a

substantially horizontal direction (rightward). The second element 52F is arranged in proximity to a part of the first element 1 (for example, in parallel with the part of the first element 1 with a spacing of 10 millimeters). Therefore, the first element 1 can be classified into the overlap portion 1A arranged in proximity to the second element 52F and the non-overlap portion 1B that is not arranged in proximity to the second element 52F.

[0042] The second element 52F according to the example 1 is a conductor line that does not form another antenna and is not connected to the ground.

[0043] The length of each of elements of the glass antenna according to the example 1 is adjusted to a length suitable to receive signals on a frequency band 1 ((wavelength of center frequency)= λ_1) and a frequency band 2 ((wavelength of center frequency)= λ_2) so that the first element 1 has a length of 605 millimeters, the overlap portion 1A has a length of 370 millimeters, and the non-overlap portion 1B has a length of 235 millimeters.

[0044] In the example 1, one first element 1 is formed of the overlap portion 1A and the non-overlap portion 1B. Therefore, it is possible to form an antenna capable of receiving two frequency bands with a high sensitivity even in a narrow place.

<Example 2>

[0045] FIG. 2 is a front view of the glass antenna to be provided to the rear glass of the automobile, for illustrating an antenna pattern according to an example 2 of this invention.

[0046] The glass antenna according to the example 2 is different from the glass antenna according to the example 1 in that the second element 52F forms a part of another antenna (second antenna 50).

[0047] As illustrated in FIG. 2, the second antenna 50 includes a plurality of horizontal wires 52, a plurality of vertical wires 53 connecting the horizontal wires 52 to one another, and a second power feeding point 54 provided at an end portion of the horizontal wire 52. One of the horizontal wires 52 (for example, uppermost horizontal wire 52F) is arranged in proximity to the first element 1. The second antenna 50 has the respective wires arranged so as to have an area suitable to receive an AM radio broadcast band (from 526.5 kHz to 1,606.5 kHz).

[0048] Components of the example 2 other than the above-mentioned components are the same as those of the example 1, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0049] In the example 2, even in a narrow place where another antenna is arranged, through use of the element 52F of the another antenna, it is possible to obtain satisfactory reception performance in two frequencies.

<Example 3>

[0050] FIG. 3 is a front view of the glass antenna to be provided to the rear glass of the automobile, for illustrat-

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

[0051] The glass antenna according to the example 3 is different from the glass antenna according to the example 2 in that the first element 1 is bent. In other words, the first element 1 according to the example 3 extends from the power feeding point 2 in an upward direction, is bent toward a horizontal direction (rightward) at the bent portion 3 in the non-overlap portion 1B, and extends in proximity to the second element 52F.

[0052] The length of each of elements of the example 3 is adjusted to a length suitable to receive a band for the remote keyless entry system so that the first element 1 has a length of 605 millimeters, the overlap portion 1A has a length of 370 millimeters, and the non-overlap portion 1B has a length of 235 (160+75) millimeters. In other words, when a wavelength shortening rate α of the rear glass 81 is 0.7 and the center frequency (wavelength= λ_1) of an RKE band in Japan and the United States of America is 315 MHz, the length of the overlap portion 1A is approximately $\alpha\lambda_1/2$. Further, when the center frequency (wavelength= λ_2) of an RKE band in Europe is 433.92 MHz, the length of the non-overlap portion 1B is approximately $\alpha\lambda_2/2$.

[0053] It should be noted that the overlap portion 1A is adjusted to a low frequency band and the non-overlap portion 1B is adjusted to a high frequency band, but the overlap portion 1A may be adjusted to a high frequency band and the non-overlap portion 1B may be adjusted to a low frequency band.

[0054] Components of the example 3 other than the above-mentioned components are the same as those of the example 2, and are therefore denoted by like reference symbols, and descriptions thereof are omitted.

[0055] In the example 3, the first element 1 is bent at the bent portion 3. Therefore, the antenna according to this example can be mounted on a glass having another antenna mounted with only a narrow place remaining, and it is possible to obtain satisfactory reception performance in two frequencies.

<Example 4>

[0056] FIG. 4 is a front view of the glass antenna to be provided to the rear glass of the automobile, for illustrating an antenna pattern according to an example 4 of this invention.

[0057] The glass antenna according to the example 4 is different from the glass antenna according to the example 3 in that the second element 52F is bent. In other words, the second element 52F according to the example 4 extends along the first element in a horizontal direction (substantially horizontally), is further bent along the bent first element 1, and extends in a vertical direction (substantially vertically).

[0058] Components of the example 4 other than the above-mentioned components are the same as those of the example 3, and are therefore denoted by like refer-

ence symbols, and descriptions thereof are omitted.

[0059] In the example 4, the second element 52F is arranged so as to be bent along the first element 1. Therefore, through adjustment of the lengths of the bent parts of the first element 1 and the second element 52F, it is possible to adjust the position of the power feeding point 2 on the glass sheet.

<Example 5>

[0060] FIG. 5 is a front view of the glass antenna to be provided to the rear glass 81 of the automobile, for illustrating an antenna pattern according to an example 5 of this invention.

[0061] The glass antenna according to the example 5 is different from the glass antenna according to the example 3 in that an antenna having a configuration similar to the configurations of the glass antennas according to the examples described above is implemented as a fifth antenna 100, and further includes a first antenna 10, the second antenna 50, a third antenna 60, and a fourth antenna 70. In the fifth antenna 100 according to the example 5, the bent portion 3 and the power feeding point 2 are connected to each other with a plurality of conductive lines.

[0062] The fifth antenna 100 includes the power feeding point 2 and the first element 1 extending from the power feeding point 2 in a substantially horizontal direction (rightward). The second element 52F is arranged in proximity to a part of the first element 1 (for example, in parallel with the part of the first element 1 with a spacing of 10 millimeters). Therefore, the first element 1 can be classified into the overlap portion 1A arranged in proximity to the second element 52F and the non-overlap portion 1B that is not arranged in proximity to the second element 52F.

[0063] Further, the first element 1 is arranged so that two parallel conductor lines extend from the power feeding point 2 in the upward direction, are bent toward the horizontal direction (rightward) at the bent portion 3 in the non-overlap portion 1B, and extend in proximity to the second element 52F. In other words, the bent portion 3 and the power feeding point 2 are connected to each other with two conductive lines. The number of conductors between the bent portion 3 and the power feeding point 2 may be equal to or larger than three.

[0064] The second element 52F forms a part of the second antenna 50.

[0065] Components of the fifth antenna 100 of the example 5 other than the above-mentioned components are the same as those of the glass antenna of the example 3, and therefore descriptions thereof are omitted.

[0066] Next, the components of the glass antenna according to the example 5 other than the fifth antenna 100 are described.

[0067] The first antenna 10 includes the first power feeding point 15, a horizontal first element 11, a horizontal second element, a vertical element 31, and auxiliary el-

elements 12 and 13.

[0068] The horizontal first element 11 is connected to the first power feeding point 15, and extends in a substantially horizontal direction (leftward direction in FIG. 5). The horizontal second element is connected to the first power feeding point 15, and extends along and in substantially parallel with the horizontal first element 11 in the same direction as an extending direction of the horizontal first element 11 (rightward direction in FIG. 5). The horizontal second element is formed of a main body portion 21 extending from the first power feeding point 15 and a folded portion 22 that is folded back at an end portion of the main body portion 21 in the downward direction and extends along and in substantially parallel with the main body portion 21 in a direction approaching the first power feeding point 15.

[0069] The vertical element 31 extends from the first power feeding point 15 in a direction different from the extending direction of the horizontal first element 11 or an extending direction of the horizontal second element. The auxiliary element 12 is arranged so as to extend downward from an intersection point of the vertical portion and the horizontal portion of the first element and then extend along and in substantially parallel with the horizontal first element 11. Further, the auxiliary element 12 is arranged along and in proximity to a defogger 90 (for example, in parallel with the defogger 90 with a spacing of 5 millimeters) so as to be capacitively coupled to an uppermost heating wire 91 of the defogger 90. The auxiliary element 13 is arranged so as to extend rightward from the vertical portion of the first element and extend along and in substantially parallel with the horizontal first element 11.

[0070] The length of each of elements of the first antenna 10 is adjusted so as to receive the FM radio broadcast band and DAB Band III in a preferred manner.

[0071] The second antenna 50 includes the plurality of horizontal wires 52, the plurality of vertical wires 53 connecting the horizontal wires 52 to one another, the second power feeding point 54 provided at the end portion of the horizontal wire 52, and folded portions 56 and 57. One of the horizontal wires 52 is arranged between the auxiliary element 13 of the first antenna 10 and the folded portion 22. The folded portions 56 and 57 extend from the uppermost horizontal wire 52 in the upward direction, are folded back in the horizontal direction, and extend along and in proximity to the horizontal wire 52 (for example, in parallel with the horizontal wire 52 with a spacing of 5 millimeters). The folded portions 56 and 57 are arranged in proximity to the body flange 82 of the vehicle body (for example, in parallel with the body flange 82 with a spacing of 5 millimeters), and the second antenna 50 and the body flange 82 (that is, ground) are capacitively coupled to each other. Each wire of the second antenna 50 is adjusted to have a length suitable to receive the AM radio broadcast band (from 526.5 kHz to 1,606.5 kHz).

[0072] The third antenna 60 is formed of wires of the

defogger 90, and the defogger 90 functions as the third antenna.

[0073] The defogger 90 functioning as the third antenna 60 includes a pair of bus bars 93 provided on the left and right of the rear glass 81, the plurality of heating wires 91 (horizontal wires) connecting the two bus bars 93 to each other, and a vertical wire 92 connecting the plurality of heating wires 91 to one another. The number of vertical wires 92 may be one or a plurality.

[0074] Defogger coils 94 and a third power feeding point 95 are provided to the bus bars 93. In other words, one bus bar 93 is connected to the power supply via the defogger coil 94, and the other bus bar 93 is connected to the ground via the defogger coil 94. By the defogger coils 94, noise in a received frequency band flowing into the third antenna 60 from the power supply and the ground is suppressed.

[0075] The defogger coil 94 and the third power feeding point 95 are arranged in a central portion of the bus bar 93 so that the defogger coil 94 is positioned on the upper side and the third power feeding point 95 is positioned on the lower side, but the defogger coil 94 and the third power feeding point 95 may be arranged in any positions on the bus bar 93. In addition, an arrangement order (vertical positional relationship) of the defogger coil 94 and the third power feeding point 95 is not limited to the order illustrated in FIG. 5.

[0076] The first antenna 10 and the third antenna 60 may form a diversity antenna to diversity-receive at least one of an FM radio broadcast wave or a broadcast wave of DAB Band III. In this case, when the third antenna 60 (defogger 90) receives the FM radio broadcast wave and the broadcast wave of DAB Band III, the power feeding point 95 may be provided to the bus bar 93 farther from the first antenna 10 (for example, on the right side).

[0077] Further, the first antenna 10 and the fourth antenna 70 may form a diversity antenna to diversity-receive a DAB broadcast wave.

[0078] Further, the third antenna 60 includes parallel auxiliary wires 96, 97, and 98 extending from the bus bar 93 and a fourth auxiliary element 89.

[0079] The end portions of the respective parallel auxiliary wires 96, 97, and 98 are in positions spaced apart from one another. Further, a part of the parallel auxiliary wire 96 and a part of the parallel auxiliary wire 97 are arranged along, in proximity to, and in substantially parallel with each other. In addition, a part of the parallel auxiliary wire 97 and a part of the parallel auxiliary wire 98 are arranged along, in proximity to, and in substantially parallel with each other. In this manner, two of the respective parallel auxiliary wires 96, 97, and 98 are arranged with an overlap, and the respective parallel auxiliary wires are thus capacitively coupled to each other at the end portions. It should be noted that not parts of but almost all of the parallel auxiliary wires may be arranged along and in proximity to each other.

[0080] The fourth auxiliary element 89 extends upward from the bus bar 93 on the right side (near the fourth

antenna 70), and is bent in the leftward direction to further extend. The fourth auxiliary element 89 may extend from the horizontal wire 91 on the outermost side.

[0081] The fourth antenna 70 is formed of a fourth power feeding point 71, a plurality of horizontal elements 72, and a plurality of vertical elements 73, and is adjusted to have a length suitable to receive a TV broadcast band (from 470 MHz to 770 MHz). In this case, the third antenna 60 and the fourth antenna 70 may form a diversity antenna to diversity-receive a TV broadcast.

[0082] Each of the power feeding points 2, 15, 54, 71, and 95 is connected to the reception amplifier through the connecting line (for example, low voltage cable for automobile), and the reception amplifier is connected to the receiver by the high-frequency cable (for example, coaxial cable). Further, the reception amplifier is connected to the ground (vehicle body).

[0083] It should be noted that the glass antenna according to any one of the examples described above may be used as the fifth antenna 100 according to the example 5 instead of the configuration described with reference to FIG. 5.

[0084] In the example 5, a plurality of antennas are mounted. Therefore, even when a plurality of antennas are mounted on a glass with only a narrow place remaining as in this embodiment, the fifth antenna 100 can obtain satisfactory reception performance in two frequencies.

<Characteristics of Antenna>

[0085] Next, characteristics of the antenna according to the example 5 are described.

[0086] The descriptions made below with reference to FIG. 6 and FIG. 7 each relate to a sensitivity of an antenna exhibited when the arrangement or the length of an element described below is changed without changing the configuration of other elements. Further, the sensitivity of the antenna has a value obtained by measuring omnidirectional (360-degree) sensitivities of the antenna within a horizontal plane and calculating an average thereof.

[0087] FIG. 6 is an illustration of a gain (sensitivity) of the antenna in a low frequency band (315 MHz) exhibited when the length of the overlap portion 1A is changed in the antenna according to the example 5. The length of another element is fixed at the above-mentioned length. According to FIG. 6, when the overlap portion 1A is set to have a length of 370 millimeters, the highest sensitivity is obtained. At this time, when the wavelength λ_1 is set to 315 MHz, the length of the overlap portion 1A is approximately $\alpha\lambda_1/2$.

[0088] FIG. 7 is an illustration of a gain (sensitivity) of the antenna in a high frequency band (433.92 MHz) exhibited when the length of the non-overlap portion 1B of the first element 1 is changed in the antenna according to the example 5. The length of another element is fixed at the above-mentioned length. According to FIG. 7,

when the non-overlap portion 1B is set to have a length of 235 millimeters, the highest sensitivity is obtained. At this time, when the wavelength λ_2 is set to 433.92 MHz, the length of the non-overlap portion 1B is approximately $\alpha\lambda_2/2$.

[0089] While the present invention has been described in detail and pictorially in the accompanying drawings, the present invention is not limited to such detail but covers various obvious modifications and equivalent arrangements, which fall within the purview of the appended claims.

[0090] The present application claims priority from Japanese patent application JP 2014-14001 filed on January 29, 2014, the content of which is hereby incorporated by reference into this application.

Claims

1. A glass antenna arranged on a window glass for a vehicle, comprising:

a power feeding point (2) connected to a receiver;
a first element (1) extending from the power feeding point, wherein:

the first element includes:

an overlap portion (1A) arranged along a second element (52F) that is not connected to the power feeding point so as to be spaced apart from the second element with a predetermined spacing; and
a non-overlap portion (1B) prevented from being arranged along the second element; and

each length of the overlap portion and the non-overlap portion are adjusted so that the overlap portion is tuned to a first frequency band, and the non-overlap portion is tuned to a second frequency band.

2. The glass antenna according to claim 1, wherein the second element (52F) includes an element configured to form an antenna (50) different from an antenna (100) including the first element (1).

3. The glass antenna according to claim 2, wherein:

the glass antenna is an antenna for reception of a signal on a UHF band; and
the antenna (50) including the second element (52F) is an antenna for reception of an AM radio broadcast on a medium wave band.

4. The glass antenna according to claim 1, wherein the first element is bent at a midpoint (3). 5

5. The glass antenna according to claim 4, wherein a part between a bent portion (3) of the first element and the power feeding point (2) is formed of a plurality of wires. 10

6. The glass antenna according to claim 1, wherein: 15
 - the first frequency band has a wavelength of a center frequency set as $\lambda 1$;
 - the second frequency band has a wavelength of a center frequency set as $\lambda 2$; and
 - the overlap portion has a length of approximately $\alpha \lambda 1/2$, and the non-overlap portion has a length of approximately $\alpha \lambda 2/2$, where α represents a wavelength shortening rate of the window glass. 20

7. The glass antenna according to claim 6, wherein the first frequency band is lower than the second frequency band. 25

8. The glass antenna according to claim 6, wherein: 30
 - the first frequency band has a center frequency of approximately 315 MHz; and
 - the second frequency band has a center frequency of approximately 433.92 MHz. 35

9. The glass antenna according to claim 1, wherein the overlap portion has a spacing of equal to or smaller than 10 millimeters between the first element (1) and the second element (52F). 40

10. The glass antenna according to claim 1, wherein the first element is arranged in a position spaced apart from an edge of a body flange (82) of an automobile by equal to or larger than 5 millimeters and equal to or smaller than 10 millimeters when the glass antenna is mounted on the automobile so that the body flange and the first element are capacitively coupled to each other. 45

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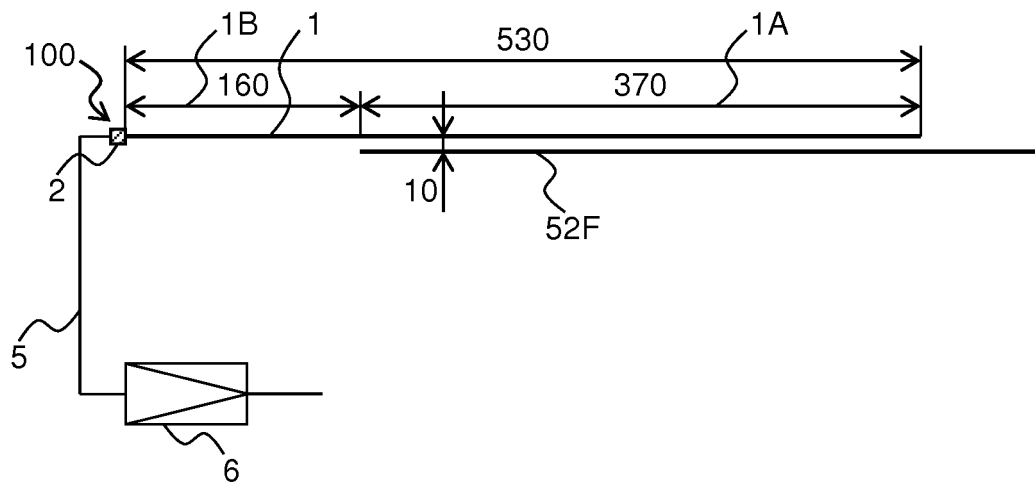


Fig. 1

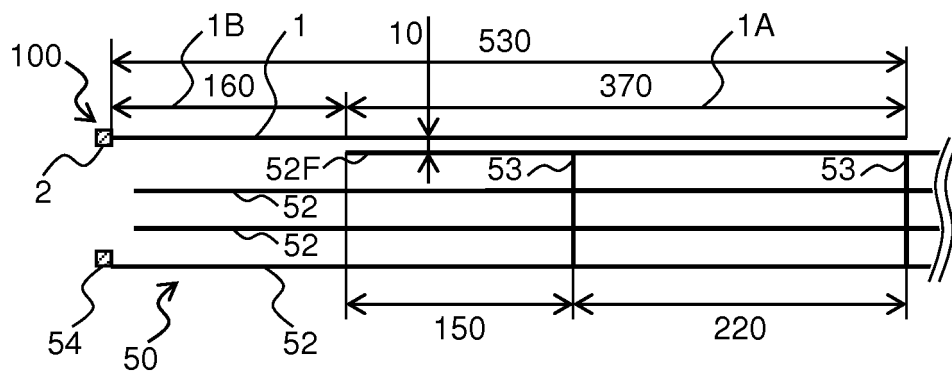


Fig. 2

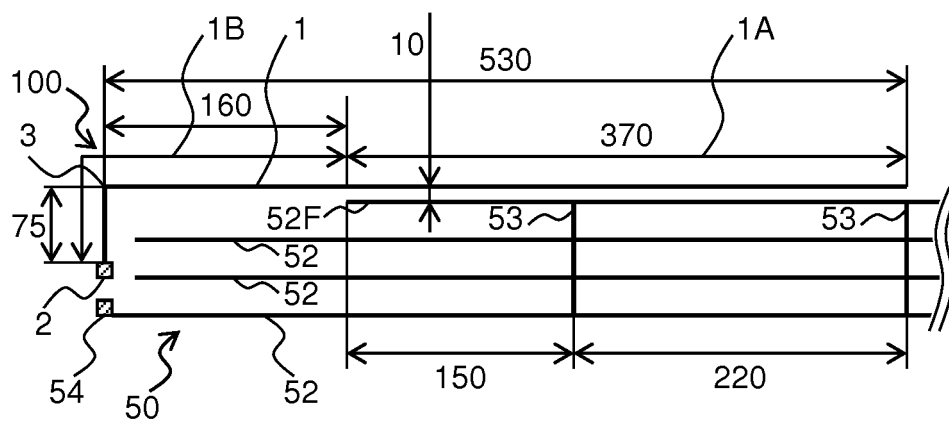


Fig. 3

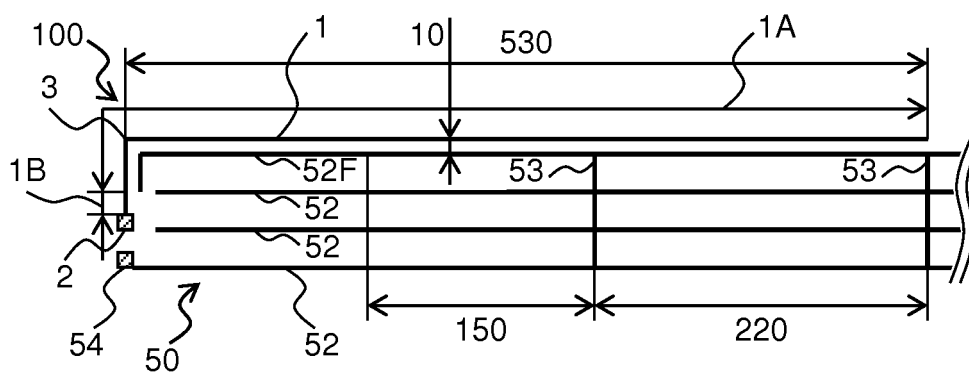


Fig. 4

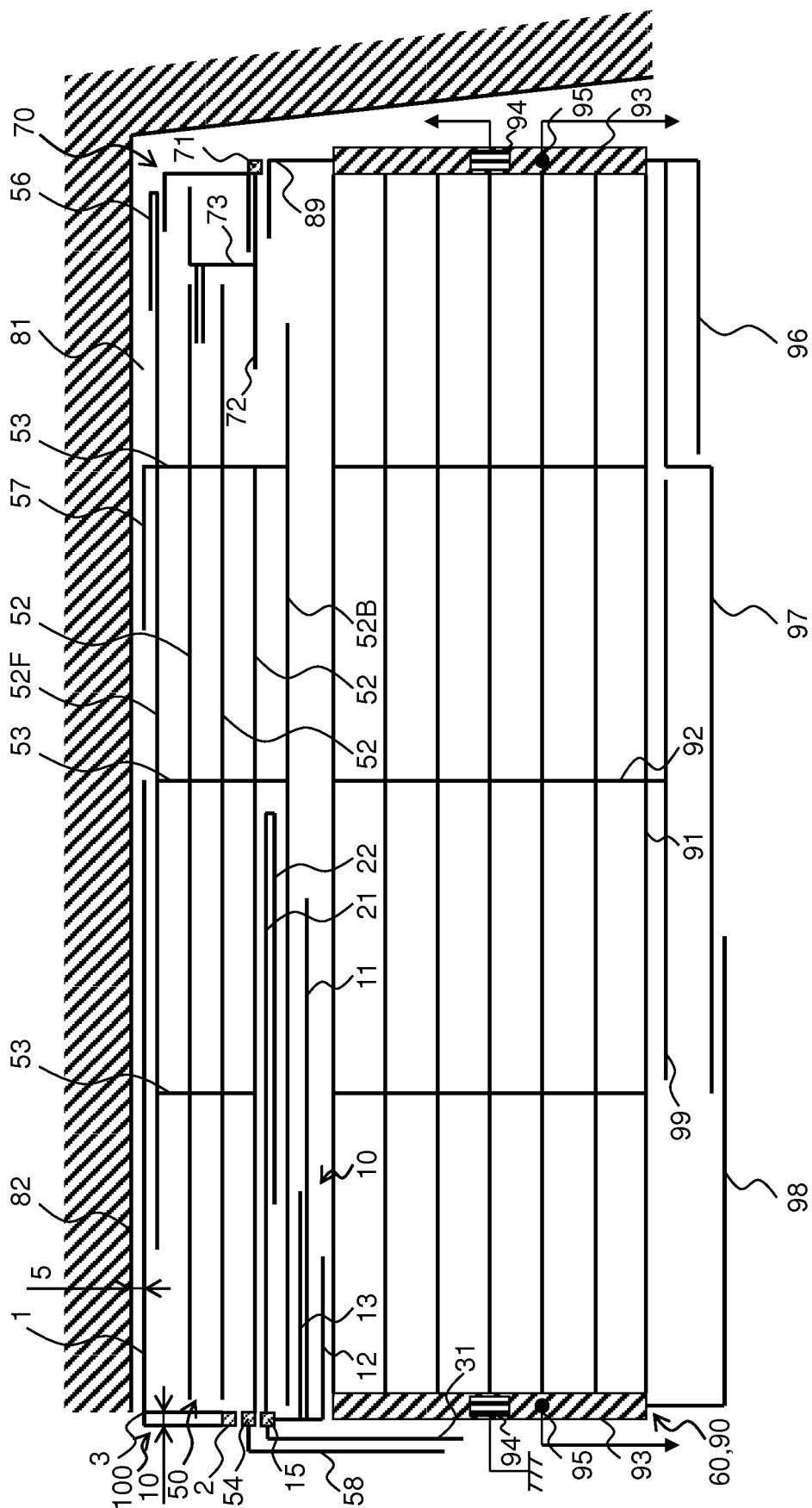


Fig. 5

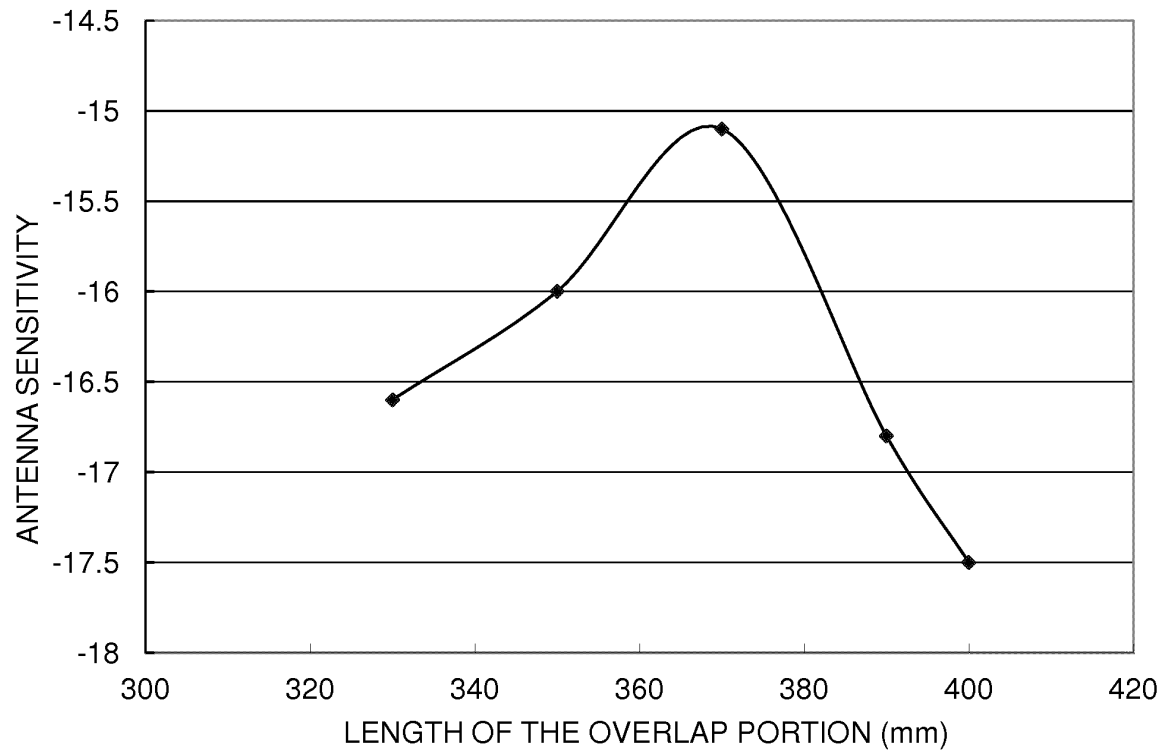


Fig. 6

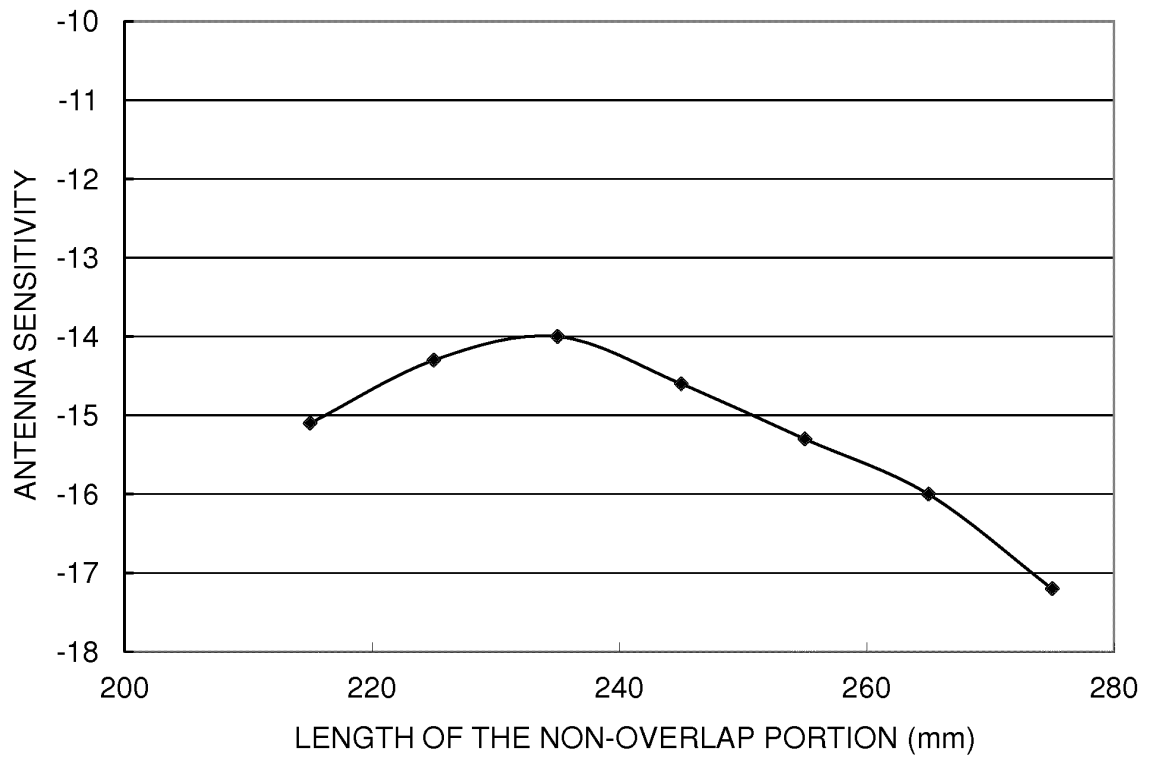


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/081374

A. CLASSIFICATION OF SUBJECT MATTER

H01Q1/32(2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01Q1/32

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015
 Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2008-182682 A (Asahi Glass Co., Ltd.), 07 August 2008 (07.08.2008), entire text; all drawings & US 2008/0158073 A1 & EP 1939978 A1 & CN 101212077 A	1-10
A	JP 2000-286625 A (Asahi Glass Co., Ltd.), 13 October 2000 (13.10.2000), entire text; all drawings (Family: none)	1-10
A	JP 2012-044254 A (Central Glass Co., Ltd.), 01 March 2012 (01.03.2012), entire text; all drawings & WO 2012/020605 A1	1-10

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

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Date of the actual completion of the international search
29 January 2015 (29.01.15)Date of mailing of the international search report
10 February 2015 (10.02.15)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/081374

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2013-131889 A (Central Glass Co., Ltd.), 04 July 2013 (04.07.2013), entire text; all drawings & WO 2013/094470 A1	1-10
A	JP 2007-096475 A (Toshiba Corp.), 12 April 2007 (12.04.2007), entire text; all drawings (Family: none)	1-10

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

REFERENCES CITED IN THE DESCRIPTION

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- JP 2014014001 A [0090]