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(54) **VEHICLE ANTENNA**

(57) It is provided a vehicle antenna provided on a window glass of a vehicle, comprising a hot-side element and a ground-side element. The hot-side element is connected to a hot-side feeding point and includes a conductive line extending in a direction away from a body flange. The ground-side element includes a ground-side first element extending clockwise from a ground-side

feeding point provided near the hot-side feeding point and a second element extending counterclockwise from the ground-side feeding point. The ground-side element forms a looped line with an opening which is surrounding the hot-side element by high frequency connecting end parts of the ground-side first element and the ground-side second element.

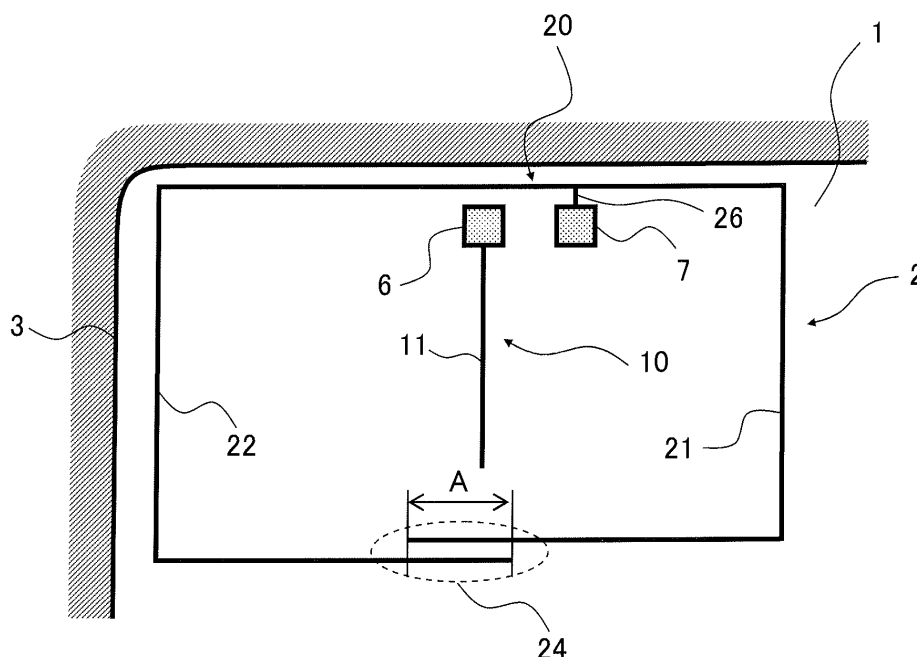


Fig. 1

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to an ungrounded antenna provided on a window glass of a vehicle and suitable for receiving terrestrial digital television broadcast waves and analog television broadcast waves in a UHF band.

[0002] In recent years, television broadcast waves in Japan has been transitioned from terrestrial analog television broadcasting in a VHF band having a frequency of 90 to 220 MHz and in a UHF band having a frequency of 470 to 770 MHz to terrestrial digital television broadcasting at a frequency of 470 to 710 MHz.

[0003] Also outside Japan, terrestrial digital television broadcasting at a frequency of 698 to 806 MHz and the like has been put to a practical use and antennas to be mounted on automotive vehicles and broadcast wave transmitting/receiving devices are also being made compatible with terrestrial digital broadcasting.

[0004] In transmitting and receiving such terrestrial digital television broadcast waves, reception sensitivity needs to be higher as compared with transmission and reception of terrestrial analog broadcasting, wherefore an ungrounded antenna is frequently adopted as an antenna system.

[0005] For example, JP2005-229140A discloses a vehicle antenna which is a wire antenna arranged on a window glass surface of a moving body such as an automotive vehicle or an insulating member surface of a body and includes a first element extending from a first feeding point and having a length of $1/4$ or $3/4$ wavelength of a transmitting/ receiving radio and a second element in the form of a closed loop extending from a second feeding point provided near the first feeding point to surround the first element and having a length of longer than one wavelength of the transmitting/ receiving radio.

[0006] Further, JP2005-159657A discloses a vehicle antenna which includes a first element in the shape of a polygonal or arcuate closed loop extending from a first feeding point arranged on a window glass surface of a moving body such as an automotive vehicle or an insulating member surface of a body and a second element provided to be closer to the first element than to a second feeding point provided near the first feeding point inside the first element, and in which the wire length of the first element is set to be longer than one wavelength of a transmitting/ receiving radio and longer than that of the second element, the wire length of the second element is set to be $3/4$ wavelength or $5/4$ wavelength of the transmitting/ receiving radio, and an outer conductor and an inner conductor of a coaxial cable are respectively connected to the first and second feeding points.

SUMMARY OF THE INVENTION

[0007] As described above, in each of the antennas

disclosed in JP2005-229140A and JP2005-159657A, an electric field at a end part of a hot-side element is stabilized and antenna performance is made less likely to be affected by human bodies and the like to obtain preferred reception sensitivity by surrounding the hot-side element easily affected by external influences by a ground-side element in the form of a closed loop. However, in the case of tuning a resonance frequency of the antenna by adjusting an impedance of the antenna, since the ground-side element is in the form of a closed loop, there have been problems that it is difficult to adjust the length of the ground-side element and a degree of freedom in tuning decreases as compared with an open looped wire.

[0008] The subject of the present invention is providing an antenna suitable for improving antenna performance and receiving terrestrial digital television broadcast waves.

[0009] The representative one of inventions is a vehicle antenna provided on a window glass of a vehicle, comprising a hot-side element and a ground-side element. The hot-side element is connected to a hot-side feeding point and includes a conductive line extending in a direction away from a body flange. The ground-side element includes a ground-side first element extending clockwise from a ground-side feeding point provided near the hot-side feeding point and a second element extending counterclockwise from the ground-side feeding point. The ground-side element forms a looped line with an opening which is surrounding the hot-side element by high frequency connecting end parts of the ground-side first element and the ground-side second element.

[0010] According to one embodiment of the present invention, antenna performance can be made less likely to be affected by an installation site of the antenna, human bodies and the like in an automotive vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

FIG. 1 is an elevation view illustrating an antenna pattern of Example 1 of the present invention.

FIG. 2 is an elevation view illustrating an antenna pattern of Example 2 of the present invention.

FIG. 3 is an elevation view illustrating an antenna pattern of Example 3 of the present invention.

FIG. 4 is an elevation view illustrating an antenna pattern of Example 4 of the present invention.

FIG. 5 is an elevation view illustrating an antenna pattern of Example 5 of the present invention.

FIG. 6 is a frequency characteristic diagram illustrating antennas of Example 1 and Comparative Examples 1 and 2.

FIG. 7 is an elevation view illustrating an antenna pattern of Comparative Examples 1 of the present invention.

FIG. 8 is an elevation view illustrating an antenna pattern of Comparative Examples 2 of the present

invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0012] A glass antenna of an embodiment of the present invention is an ungrounded glass antenna which is arranged on a window glass 1 of an automotive vehicle and configured to transmit and receive terrestrial digital television broadcast waves in and outside Japan and includes a hot-side element 10 extending from a hot-side feeding point and a ground-side element 20 extending from a ground-side feeding point.

[0013] The hot-side element 10 is an element which is located on a glass surface and includes a conductive line 11 extending from a hot-side feeding point 6 in a direction away from the closest side of a metal body flange 3.

[0014] On the other hand, the ground-side element 20 includes two conductive lines of a ground-side first element 21 extending from a ground-side feeding point 7 provided near the hot-side feeding point 6 in a clockwise direction to surround the hot-side element 10 and a ground-side second element 22 extending from the same ground-side feeding point 7 in a counterclockwise direction to surround the hot-side element 10. The ground-side element 20 is formed into a loop with an opening to surround the hot-side element 10 by closely overlapping end parts of the ground-side first and second elements 21, 22 to be capacitively coupled to each other.

[0015] Since the ground-side element 20 is in the form of the loop with the opening, the opening is in a non-conductive state in terms of direct current. However, in the case of receiving high-frequency radios, the opening is in a conductive state and effects equivalent to those of a conventional antenna pattern which is illustrated in FIG. 7 and a closed loop in terms of direct current can be obtained at high frequencies.

[0016] An overlap portion 24 in which the end part of the ground-side first element 21 and the end part of the ground-side second element 22 are overlapped that the ground-side first element 21 and the ground-side second element 22 of the ground-side element 20 are capacitively coupled and preferably provided on a position distant from the ground-side feeding point 7, e.g. a side opposite to a side on which the ground-side feeding point 7 is located as illustrated in FIGS. 1 to 4.

[0017] Further, as illustrated in FIG. 5, overlap portions 24, 25 may be so provided at a plurality of positions that the clockwise ground-side first element 21 and the counterclockwise ground-side second element 22 of the ground-side element 20 extend such that the end part of each of the elements do not overlap, an auxiliary conductive line 23 is provided between the end parts of each of the elements, one end part of the auxiliary conductive line 23 and the end part of the ground-side first element 21 are close to each other and overlapped so as to be capacitively coupled, and the other end part of the auxiliary conductive line 23 and the end part of the ground-side second element 22 are also close to each other and

overlapped so as to be capacitively coupled.

[0018] The length of the conductive line to the end of the hot-side element 10 extending from the hot-side feeding point 6 is preferably 1/4 wavelength of a substantially center frequency of a transmission/reception frequency band.

[0019] Further, as illustrated in FIG. 2, an auxiliary conductive line 12 perpendicular to the hot-side conductive line 11 of the hot-side element 10 may extend from the end of the hot-side conductive line 11. By changing the length and extending direction of this auxiliary conductive line 12, a resonance frequency and an impedance can be adjusted. For example, although an example in which the auxiliary conductive line 12 is bent at 90° from the hot-side conductive line 11 is illustrated in FIG. 2, this angle may be any angle.

[0020] Further, although an example in which the ground-side first element 21 includes three horizontal conductive lines and the ground-side second element 22 includes four horizontal conductive lines is illustrated in FIG. 2, there is no limitation to these numbers. Further, one of the ground-side first element 21 and the ground-side second element 22 may include one horizontal conductive line and the other may include a plurality of horizontal conductive line.

[0021] Furthermore, the total length (electrical length) of each of the conductive lines of the ground-side element 20 including the ground-side first element 21 and the ground-side second element 22, assuming the overlap as one conductive line, is preferably one to two wavelengths of the transmitting/receiving radio.

[0022] Further, the length of the conductive line which overlaps at the ends of the ground-side first element 21 and the ground-side second element 22 of the ground-side element 20 in the overlap portion 24 is preferably adjusted to lower VSWR of the antenna. Specifically, the length of a part where the end of the ground-side first element 21 and that of the ground-side second element 22 are close to each other and capacitively coupled (A in FIG. 1) only has to be a length of 10 mm to one wavelength.

[0023] As described above, the length of the overlapping part in the overlap portion 24 is 10 mm or longer for the following reason. If it is shorter than 10 mm, capacitive coupling becomes weaker and an effect of electrically assuming the ground-side first element 21 and the ground-side second element 22 as one conductive line decreases. Further, the length of the overlapping part is one wavelength or shorter because the conductive lines are complicated although preferable capacitive coupling is obtained if the length is one wavelength or longer.

[0024] Further, as illustrated in FIG. 2, one side of the ground-side first element 21 connected to the ground-side feeding point 7 may be configured by a plurality of conductive lines. These plurality of conductive lines may be arranged in parallel and each end part of the conductive lines may be connected to each other.

[0025] Further, one side of the ground-side second el-

element 22 of the ground-side element 20 connected to the ground-side feeding point 7 may be configured by a plurality of conductive lines, these plurality of conductive lines may be arranged in parallel and each end part of the conductive lines may be connected to each other.

[0026] Furthermore, an antenna pattern may be directly printed on the surface of the window glass 1 of the vehicle or a sheet printed with an antenna pattern may be bonded.

[0027] The shape of the ground-side element 20 is generally a rectangular shape illustrated in FIGS. 1, 2 and 5, but a part of the ground-side element 20 may have an arcuate shape in conformity with an arcuate shape of a corner part of the metal flange 3 as illustrated in FIG. 3. Further, the shape may have an elliptical shape as illustrated in FIG. 4. Further, the ground-side element 20 can also have a square, rhombic or polygonal shape although not illustrated.

[0028] It should be noted that an inner conductor and an outer conductor of an unillustrated coaxial cable are respectively connected to the hot-side feeding point 6 and the ground-side feeding point 7.

[0029] Furthermore, the ground-side element 20 may extend from the ground-side feeding point 7 via a lead conductive line 26 and be branched off into the ground-side first element 21 and the ground-side second element 22 extending in directions opposite to each other from the end of the lead conductive line 26. Alternatively, the ground-side first element 21 and the ground-side second element 22 may be directly connected to the ground-side feeding point 7 without via the lead conductive line 26 extending from the ground-side feeding point 7.

[0030] The window glass 1 of the automotive vehicle or the like may be any one of a front window glass, a rear window glass, a side window glass, a sunroof and the like. Further, this window glass is not limited to a glass plate, but may also be a transparent resin plate or a composite body of a glass plate and a transparent resin plate.

[0031] Further, the antenna of this embodiment may be used by directly printing the antenna pattern using a conductive paste on upper or lower marginal parts of a heating wire on the rear window glass above, a glass window surface of the front window glass, the side window glass, the roof window glass or the like or printing it on a thin transparent seal or transparent sheet and bonding the transparent seal or sheet to the inner side of the window glass surface or a part made of an insulating material.

[0032] Further, this antenna 2 may be provided only at one position of the window glass of the automotive vehicle, but an antennas may be provided at a plurality of positions of the same window glass or on each of a plurality of window glasses and diversity reception may be performed using these plurality of antennas. In this case, the plurality of antennas constituting the diversity antenna may have the same pattern or different patterns. By performing the diversity reception, reception sensitivity can be further improved.

[0033] Working mechanisms of the embodiment of the present invention are described below.

[0034] In the antenna of the embodiment of the present invention, the ground-side element 20 is in the form of the loop with the opening shaped to surround the hot-side element 10 by closely overlapping the ends of the two conductive line of the ground-side first element 21 extending clockwise from the ground-side feeding point 7 to surround the hot-side element 10 and the ground-side second element 22 extending counterclockwise from the ground-side feeding point 7 to surround the hot-side element 10 so as to be capacitively coupled to each other. Thus, the end of the ground-side first element 21 and that of the ground-side second element 22 are open, wherefore an impedance of the ground-side element 20 can be easily adjusted and the antenna can be easily tuned by adjusting the length of the overlapping part of each conductive line.

[0035] It should be noted that since the ground-side element 20 is in the open, non-conductive state in terms of direct current, but is in the conductive state in term of high frequency, a reception characteristic equivalent to that of a conventional antenna in which the ground-side element is in the form of a closed loop as illustrated in FIG. 7 can be obtained while an actual antenna area is made smaller. Specifically, it is possible to provide an antenna which does not hinder vision by a simple configuration.

[0036] Since the hot-side element 10 is surrounded by the ground-side element 20 in the shape of the open loop, it is possible to stabilize an electric field at a end part of the antenna easily susceptible to external influences, reduce the influence of the conductors close to each other and make the antenna performance less likely to be affected by the installation site of the antenna, human bodies and the like. Thus, it is possible to obtain an antenna with a stable characteristic in which an antenna impedance is hardly changed by the presence or absence of a person in the vehicle.

[0037] Further, the antenna of the embodiment of the present invention can obtain a characteristic equivalent to that of a configuration grounded to a metal body at terrestrial digital broadcasting band frequencies since the ground-side element 20 can be assumed as a grounded antenna by setting the total length of the conductive line of the loop shape of the ground-side element 20 at one to two wavelengths of the transmitting/receiving radio.

[0038] Various examples of the present invention are described below.

EXAMPLE 1

[0039] FIG. 1 illustrates the ungrounded glass antenna having an antenna pattern of Example 1 of the present invention and provided near an upper corner part of the rear window glass of the automotive vehicle.

[0040] The antenna of Example 1 includes the hot-side

element 10 connected to the hot-side feeding point 6 provided in the vicinity of the upper side of the opening of the metal flange 3 near the upper-left corner and extending substantially vertically downward away from the upper side of the metal flange, and the ground-side element 20 extending from the ground-side feeding point 7 provided near the hot-side feeding point 6.

[0041] The ground-side element 20 includes the ground-side first element 21 having a U shape opening rightward and extending clockwise from the ground-side feeding point 7 about the hot-side element 10 to surround the hot-side element 10 and the ground-side second element 22 having a U shape opening leftward and extending counterclockwise from the ground-side feeding point 7 to surround the hot-side element 10 and is in the shape of a substantially rectangular loop, in which the end of each element constituting the ground-side element 20 is open, by opposing the ends of the two ground-side elements 21, 22 to each other, closely overlapping the conductive lines of the end parts of the ground-side elements 21, 22 so that the ground-side elements 21, 22 are capacitively coupled, and arranging the ground-side element 20 to surround the hot-side element 10.

[0042] In the antenna of Example 1, the ground-side element 20 extends from the ground-side feeding point 7 via the lead conductive line 26 and is branched off into the ground-side first element 21 and the ground-side second element 22 extending in directions opposite to each other at the end of the lead conductive line 26.

[0043] The length of each conductive line of the antenna of Example 1 is illustrated as follows. The length of the conductive line of the hot-side element 10 from the hot-side feeding point 6 to the end is 60 mm which is a product of the $1/4$ wavelength of a radio at a substantially center frequency of 600 MHz of the transmitting/receiving frequency band and a shortening coefficient of wavelength (about 0.6) of the glass plate 1.

[0044] The length of a horizontal conductive line of the ground-side first element 21 extending to the right from the upper end of the lead conductive line 26 connected to the ground-side feeding point is 50 mm, the length of a vertical conductive line extending downward from the end of this horizontal conductive line is 85 mm and the length of a conductive line turned at the lower end of the vertical conductive line to form a U shape is 90 mm.

[0045] Further, the length of a horizontal conductive line of the ground-side second element 22 extending to the left (direction toward the corner) from the upper end of the lead conductive line 26 connected to the ground-side feeding point is 100 mm, a vertical conductive line extending downward from the end of the horizontal conductive line is 90 mm and the length of a conductive line turned at the lower end of the vertical conductive line to form a U shape is 95 mm.

[0046] Further, the length (A in FIG. 1) of the overlapping paths of the turned conductive line of the ground-side first element 21 and that of the ground-side second element 22 is 35 mm, and a spacing between

the respective conductive lines is 5 mm.

[0047] A spacing between the upper side of the flange opening and the horizontal conductive line of each of the ground-side first element 21 and the ground-side second element 22 is 5 mm and a spacing between the vertical conductive line of the ground-side second element 22 and a vertical side of the flange opening is 10 mm.

[0048] Each of the hot-side feeding point 6 and the ground-side feeding point 7 has a square shape having each side of 10 mm and a spacing between the respective feeding points is 15 mm.

[0049] The antenna of this Example was formed by printing each conductive line with a width of 0.7 mm using a conductive ceramic paste at a predetermined position on a vehicle interior side surface of the window glass plate and, after drying, baking each conductive line by a heating oven, and a center conductor of an unillustrated coaxial cable extending from an unillustrated turner was connected to the hot-side feeding point 6 and an outer conductor was connected to the ground-side feeding point 7.

[0050] When the antenna for receiving terrestrial digital television broadcast waves of Example 1 configured as described above was provided near the upper corner of the rear window glass of the automotive vehicle and received radios in a terrestrial digital television broadcast band having a frequency of 470 to 710 MHz, a good frequency characteristic having an average gain of -6.8 dB as illustrated by thick solid line in FIG. 6 was obtained, an improvement in reception gain in a band of 500 to 590 MHz and a band of 620 to 710 MHz was seen as compared with an average gain of -7.6 dB of an antenna of Comparative Example 1 (see FIG. 7) to be described later illustrated by thin solid line in FIG. 6 and an average gain of -7.6 dB of an antenna of Comparative Example 2 (see FIG. 8) to be described later illustrated by dotted line in FIG. 6, and a frequency characteristic at least equivalent to or better than those of Comparative Examples 1 and 2 was obtained.

[0051] Further, the antenna of Example 1 can provide an antenna which has hardly any change in antenna impedance caused by a human body even if a person is in the vehicle and does not hinder vision due to a simple configuration. A reception gain of the antenna of Example 1 is high and antenna tuning can be easily performed as compared with conventional ones.

EXAMPLE 2

[0052] Example 2 is a modified pattern of Example 1 as illustrated in FIG. 2. Unlike Example 1 described above, in an antenna of Example 2, the ground-side first element 21 connected to the ground-side feeding point 7 includes three horizontal conductive lines and each end of the three horizontal conductive lines are connected by vertical conductive lines. Further, the ground-side second element 22 connected to the ground-side feeding point 7 includes four horizontal conductive line and each

end of the four horizontal conductive lines are connected by vertical conductive lines. Furthermore, the auxiliary conductive line 12 bent in a horizontal direction at the lower end of the hot-side conductive line 11 of the hot-side element 10 is provided. Since the other configuration is the same as in Example 1 described above, the same components are denoted by the same reference signs and not described.

[0053] It should be noted that Example 2 has features that the ground-side first element 21 and the ground-side second element 22 include a plurality of horizontal conductive lines and the auxiliary conductive line 12 bent and extending from the hot-side conductive line 11 is provided. These two features may also be individually applied to antennas of other Examples.

[0054] When the antenna for receiving terrestrial digital television broadcast waves of Example 2 configured as described above was provided on the rear window glass of the automotive vehicle and received radios in a terrestrial digital television broadcast band having a frequency of 470 to 710 MHz, good reception performance can be obtained as in Example 1.

[0055] Further, the antenna of Example 2 can provide an antenna which has hardly any change in antenna impedance caused by a human body even if a person is in the vehicle and does not hinder vision due to a simple configuration. A reception gain of the antenna of Example 2 is high and antenna tuning can be easily performed as compared with conventional ones.

EXAMPLE 3

[0056] An antenna of Example 3 illustrated in FIG. 3 differs from Example 1 in that the shape of a left-upper corner part of the ground-side element is a substantially quarter arc shape. Since the other configuration is the same as in Example 1 described above, the same components are denoted by the same reference signs and not described.

[0057] The antenna of Example 3 is an antenna which has a round shape along a round shape of the upper corner of the opening of the flange of the window glass and in which the hot-side feeding point 6 and the ground-side feeding point 7 are juxtaposed near an arcuate corner on the upper-left side.

[0058] Unlike Example 1 described above, in the antenna of Example 3, the ground-side element 20 includes two elements, i.e. the ground-side first element 21 having a U shape opening leftward and extending clockwise from the ground-side feeding point 7 about the hot-side element 10 to surround the hot-side element 10 and the ground-side second element 22 having a U shape opening rightward, extending counterclockwise from the ground-side feeding point 7 to surround the hot-side element 10 and including an arcuate part, and is in the shape of a substantially rectangular loop, in which the end of each element constituting the ground-side element 20 is open and which includes an upper-left corner

part having a quarter arc shape, by opposing the ends of the two ground-side elements 21, 22 to each other, closely overlapping the conductive line of the end parts of the ground-side elements 21, 22 so that the ground-side elements 21, 22 are capacitively coupled and arranging the ground-side element 20 to surround the hot-side element 10.

[0059] When the antenna for receiving terrestrial digital television broadcast waves of Example 3 configured as described above was provided on the rear window glass of the automotive vehicle and received radios in a terrestrial digital television broadcast band having a frequency of 470 to 710 MHz, good reception performance can be obtained as in Example 1.

[0060] Further, the antenna of Example 3 can provide an antenna which has hardly any change in antenna impedance caused by a human body even if a person is in the vehicle and does not hinder vision due to a simple configuration. A reception gain of the antenna of Example 3 is high and antenna tuning can be easily performed as compared with conventional ones.

EXAMPLE 4

[0061] An antenna of Example 4 illustrated in FIG. 4 differs from Example 1 in that the shape of the ground-side element is a substantially circular shape. Since the configuration of the hot-side element 10 is the same as in Example 1 described above, the same components are denoted by the same reference signs and not described.

[0062] The ground-side element 20 differs from Example 1 in having a looped and substantially circular shape in which the end of each element constituting the ground-side element 20 is open by opposing the end parts of the two elements, i.e. the ground-side first element 21 having the shape of a right half ellipse (or circle, oval) and extending clockwise from the ground-side feeding point 7 about the hot-side element 10 to surround the hot-side element 10 and the ground-side second element 22 having the shape of a left half ellipse (or circle, oval) and extending counterclockwise from the ground-side feeding point 7 to surround the hot-side element 10, to each other, closely overlapping arcuate conductive lines of each end part of the two elements so as to be capacitively coupled and arranging the ground-side element 20 to surround the hot-side element 10.

[0063] When the antenna for receiving terrestrial digital television broadcast waves of Example 4 configured as described above was provided on the rear window glass of the automotive vehicle and received radios in a terrestrial digital television broadcast band having a frequency of 470 to 710 MHz, good reception performance can be obtained as in Example 1.

[0064] Further, the antenna of Example 4 can provide an antenna which has hardly any change in antenna impedance caused by a human body even if a person is in the vehicle and does not hinder vision due to a simple

configuration. A reception gain of the antenna of Example 4 is high and antenna tuning can be easily performed as compared with conventional ones.

EXAMPLE 5

[0065] Unlike Example 1 described above, in Example 5 of the present invention illustrated in FIG. 5, the substantially rectangular ground-side element 20 is in the shape of a substantially rectangular loop, in which the end of each element constituting the ground-side element 20 is open, by closely overlapping a part of each conductive line of the L-shaped ground-side first element 21, the ground-side second element 22 having a U shape opening rightward and the L-shaped auxiliary conductive line 23, and arranging them to surround the hot-side element 10. It should be noted that since the configuration of the hot-side element 10 is the same as in Example 1 described above, the same components are denoted by the same reference signs and not described.

[0066] The ground-side first element 21 is an L-shaped element connected to the ground-side feeding point 7 via the lead conductive line 26 and including a horizontal conductive line extending to the right and a vertical conductive line extending downward from the end of the horizontal conductive line. Further, the ground-side second element 22 is an element having a U shape opening rightward and including a horizontal conductive line, a vertical conductive line and a turned conductive line connected to the ground-side feeding point 7 via the lead conductive line 26 as in Example 1. Further, the L-shaped auxiliary conductive line 23 is provided between the ground-side first element 21 and the ground-side second element 22, and the overlap portions 24, 25 are provided in which one end of the auxiliary conductive line 23 and the ground-side first element 21 are close and capacitively coupled to each other and the other end of the auxiliary conductive line 23 and the ground-side second element 22 are close and capacitively coupled to each other.

[0067] When the antenna for receiving terrestrial digital television broadcast waves of Example 5 configured as described above was provided on the rear window glass of the automotive vehicle and received radios in a terrestrial digital television broadcast band having a frequency of 470 to 710 MHz, good reception performance can be obtained as in Example 1.

[0068] Further, the antenna of Example 5 can provide an antenna which has hardly any change in antenna impedance caused by a human body even if a person is in the vehicle and does not hinder vision due to a simple configuration. A high reception gain of the antenna of Example 5 is high and antenna tuning can be easily performed as compared with conventional ones.

COMPARATIVE EXAMPLE 1

[0069] Comparative example 1 illustrated in FIG. 7 is an antenna having a pattern disclosed in

JP2005-229140A and including a ground-side element 20' in the shape of a substantially rectangular closed loop to surround the hot-side element 10' extending in a vertical direction. The ground-side element 20' is connected to a ground-side feeding point 7' via a lead conductive line 26'.

[0070] The length of conductive line of the hot-side element 10' of an antenna 2' of Comparative Example 1 is 60 mm which is calculated by multiplying 1/4 wavelength of a radio at a substantially intermediate frequency 600MHz of a receiving frequency band by shortening coefficient of wavelength of a glass plate 1' of about 0.6, and the length of vertical sides of the ground-side element 20' having a substantially rectangular shape is 90 mm and the length of horizontal sides of the ground-side element 20' is 150 mm.

[0071] A spacing between the upper side of the ground-side element 20' and the upper side of an opening of a flange 3' is 5 mm, and a spacing between the vertical conductive line of the ground-side element 20' and a vertical side of the opening of the flange 3' is 10 mm.

[0072] Each of a hot-side feeding point 6' and a ground-side feeding point 7' has a square shape having each side of 10 mm and a spacing between each of the feeding points 6', 7' is 15 mm.

[0073] When the antenna 2' for receiving terrestrial digital television broadcast waves of Comparative Example 1 configured as described above was provided on the rear window glass 1' of an automotive vehicle and received radios in a terrestrial digital television broadcast band having a frequency of 470 to 710 MHz, a frequency characteristic illustrated by thin solid line in FIG. 6 was obtained and an average reception gain was -7.6 dB.

[0074] According to a frequency characteristic diagram of FIG. 6, the antenna of Comparative Example 1 has a lower gain than the antenna of Example 1 in a band of 500 to 590 MHz and a band of 620 to 710 MHz. Further, the antenna pattern in the shape of the closed loop of Comparative Example 1 cannot be easily adjusted since such an adjustment to adjust only the length of one side at the time of tuning is not easy due to the closed loop shape.

COMPARATIVE EXAMPLE 2

[0075] A pattern of an antenna of Comparative example 2 illustrated in FIG. 8 is a pattern in the shape of an open and substantially rectangular loop in which two conductive line of a ground-side first element 21" extending clockwise from a ground-side feeding point 7" to surround a hot-side element 10" and a ground-side second element 22" having a U shape opening rightward and extending counterclockwise from the ground-side feeding point 7" to surround the hot-side element 10" are arranged to form a substantially rectangular shape, and an end part of the ground-side second element 22" is bent downward before the end of the ground-side first element 21" so that the ends of the ground-side first element

21" and the ground-side second element 22" are not overlapped (i.e. the ground-side first element 21" and the ground-side second element 22" are not capacitively coupled). The end of the conductive line of the ground-side second element 22" is bent downward so that the entire length of the ground-side second element 22" coincides with that of the ground-side second element 22 (see FIG. 1) of Example 1. The ground-side first element 21" and the ground-side second element 22" are connected to the ground-side feeding point 7" via a lead conductive line 26". The hot-side element 10" is connected to a hot-side feeding point 6".

[0076] The length of vertical sides of the substantially rectangular shape of the ground-side element 20" of the antenna 2" of Comparative Example 2 is 90 mm and that of horizontal sides thereof is 150 mm as with the ground-side elements of Comparative Example 1 and Example 1. The length of a part of the ground-side second element 22" bent downward before the end of the ground-side first element 21" is 35 mm. The lengths of the conductive lines and the spacings other than the above are the same as in Example 1 and Comparative Example 1.

[0077] When the antenna 2" for receiving terrestrial digital television broadcast waves of Comparative Example 2 configured as described above was provided on a rear window glass of an automotive vehicle and received radios in a terrestrial digital television broadcast band having a frequency of 470 to 710 MHz, a frequency characteristic illustrated by dotted line in FIG. 6 was obtained and an average reception gain was -7.6 dB.

[0078] The frequency characteristic of the antenna of Comparative Example 2 has a lower reception gain than Example 1 in a band of 470 to 500 MHz, a band of 540 to 580 MHz and a band of 620 to 710 MHz when being compared with the frequency characteristic of the antenna of Example 1 illustrated by thick solid line in FIG. 6.

[0079] When the antenna of Comparative Example 2 and that of Example 1 were compared in this way, the reception gain was lower in the antenna of Comparative Example 2 than in Example 1 since no overlap portion was provided at an opening of the loop shape formed by the ground-side first element 21" and the ground-side second element 22" of the ground-side element 20". In the antenna of Example 1, a reduction in the reception gain can be suppressed by overlapping the two ground-side elements.

[0080] 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.

[0081] The present application claims priority from Japanese patent application JP 2010-165701 filed on July 23, 2010, the content of which is hereby incorporated by reference into this application.

Claims

1. A vehicle antenna provided on a window glass of a vehicle, comprising a hot-side element and a ground-side element,
characterized in that:

the hot-side element is connected to a hot-side feeding point and includes a conductive line extending in a direction away from a body flange; the ground-side element includes a ground-side first element extending clockwise from a ground-side feeding point provided near the hot-side feeding point and a second element extending counterclockwise from the ground-side feeding point; and the ground-side element forms a looped line with an opening which is surrounding the hot-side element by high frequency connecting end parts of the ground-side first element and the ground-side second element.

2. The vehicle antenna according to claim 1, wherein the ground-side first element and the ground-side second element are high frequency connected by arranging the end parts of the ground-side first element and the ground-side second element closely position so that the ground-side first element and the ground-side second element are capacitively coupled on a side opposite to a side near the ground-side feeding point among sides of the formed looped line.
3. The vehicle antenna according to claim 1, further comprising an auxiliary conductive line which is provided between the ground-side first element and the ground-side second element, wherein one end part of the auxiliary conductive line and the end part of the ground-side first element are arranged at close position so that the auxiliary conductive line and the ground-side first element are capacitively coupled, the other end part of the auxiliary conductive line and the end part of the ground-side second element are arranged at close position so that the auxiliary conductive line and the ground-side second element are capacitively coupled, and thereby the ground-side first element and the ground-side second element are high frequency connected and the ground-side element forms the looped line.
4. The vehicle antenna according to claim 2, wherein the length of sections in which the end parts of the ground-side first element and the ground-side second element close to the other conductive line is 10 mm to one wavelength.

5. The vehicle antenna according to claim 1, wherein the length of the hot-side element is substantially 1/4 wavelength of a transmitting/receiving radio signal.
6. The vehicle antenna according to claim 1, further comprising an auxiliary conductive line which is bent and extends from the end of the hot-side element. 5
7. The vehicle antenna according to claim 1, wherein the electrical length of the ground-side element is one to two wavelengths of a transmitting/receiving radio signal. 10
8. The vehicle antenna according to claim 1, wherein: 15
 - one side of the ground-side first element which is connected to the ground-side feeding point is composed of a plurality of parallel conductive lines; and
 - the ends of the plurality of conductive lines are connected. 20
9. The vehicle antenna according to claim 1, wherein:
 - one side of the ground-side second element which is connected to the ground-side feeding point is composed of a plurality of parallel conductive lines; 25
 - one end part of each of the plurality of conductive lines is connected to the ground-side feeding point; and 30
 - the end parts of the plurality of conductive lines are connected.
10. The vehicle antenna according to claim 1, wherein the vehicle antenna is formed by directly printed on a window glass surface of the vehicle or bonding a sheet printed with the pattern. 35

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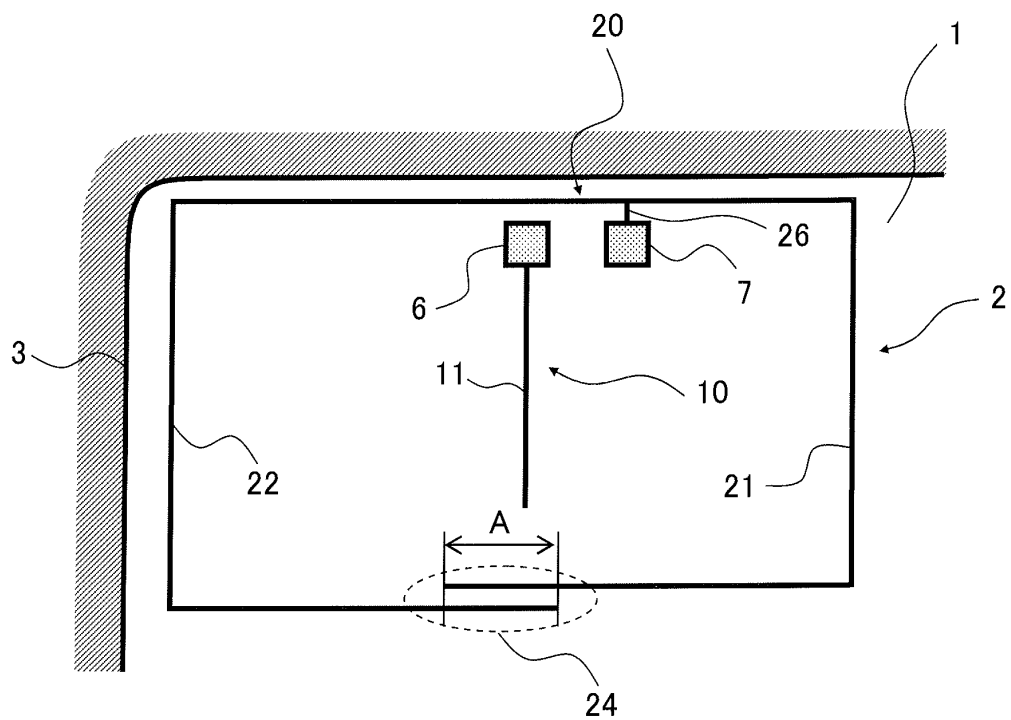


Fig. 1

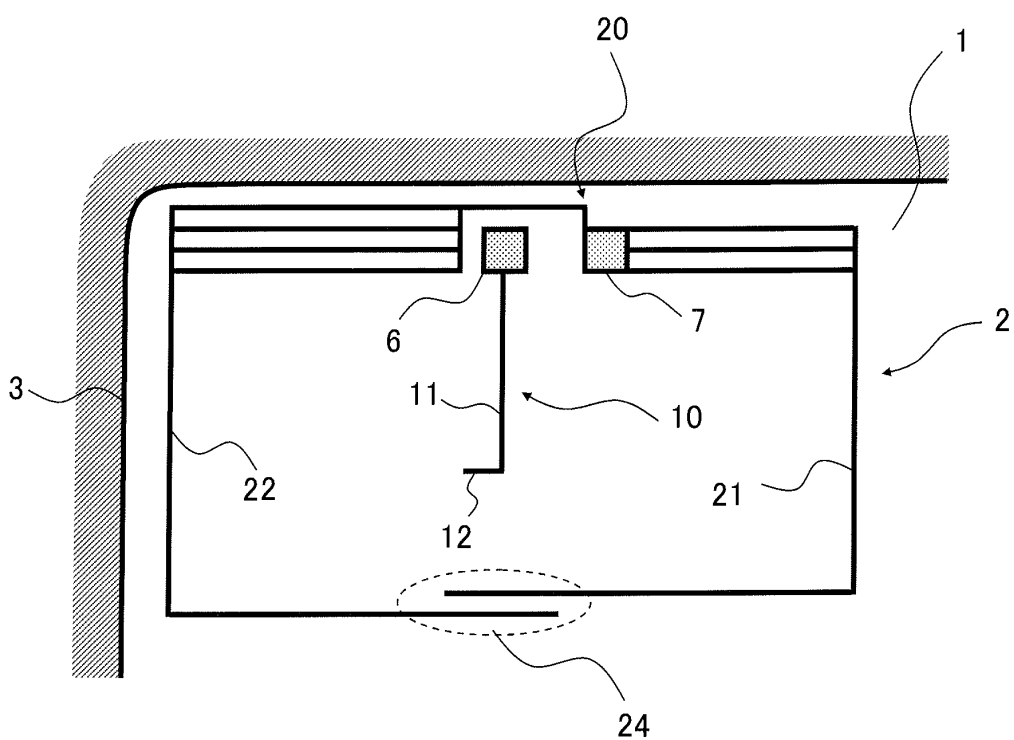


Fig. 2

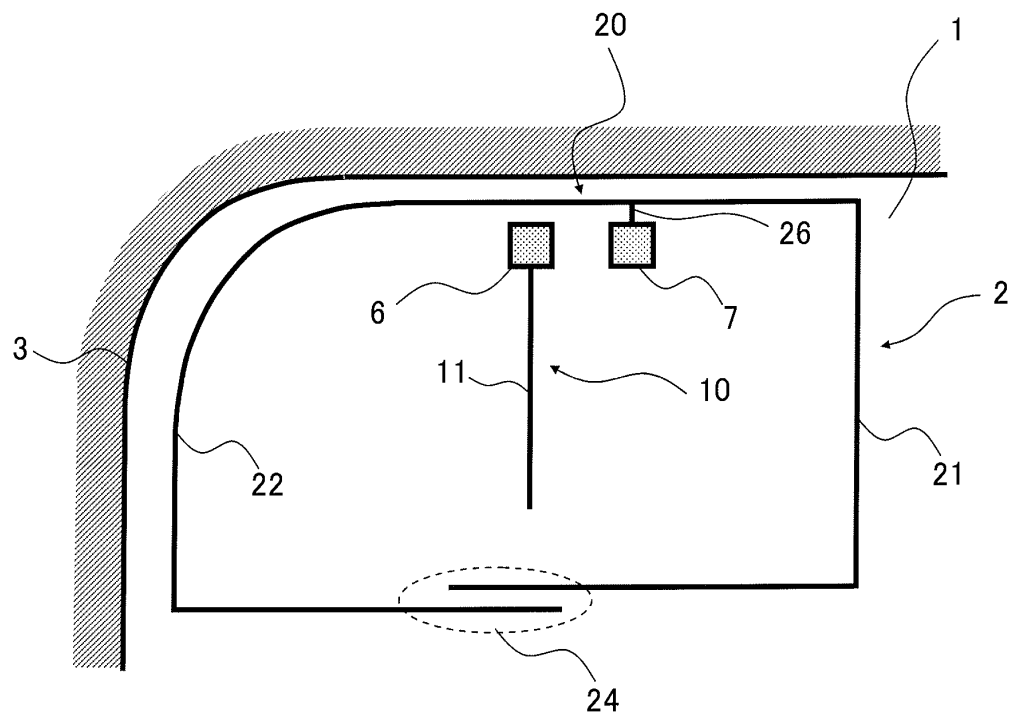


Fig. 3

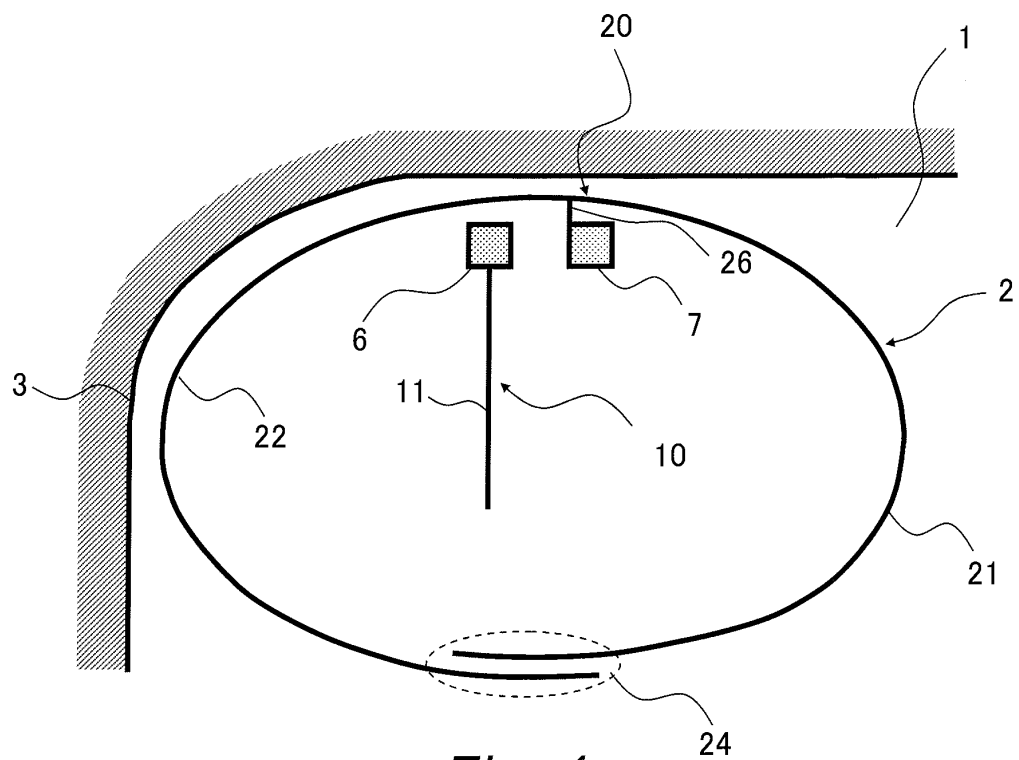


Fig. 4

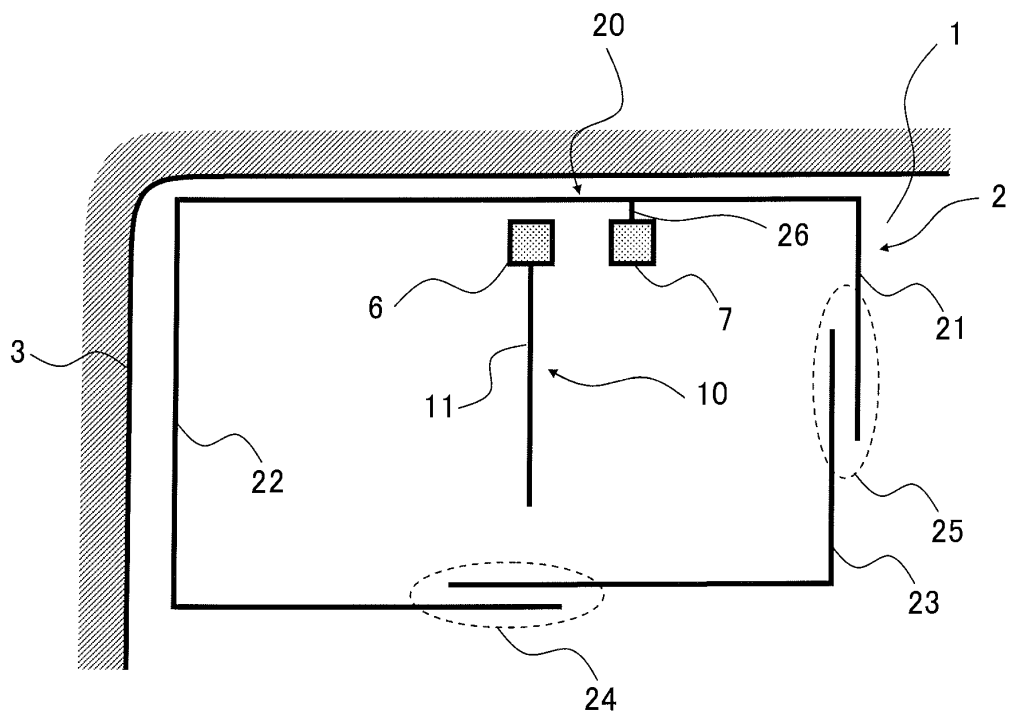


Fig. 5

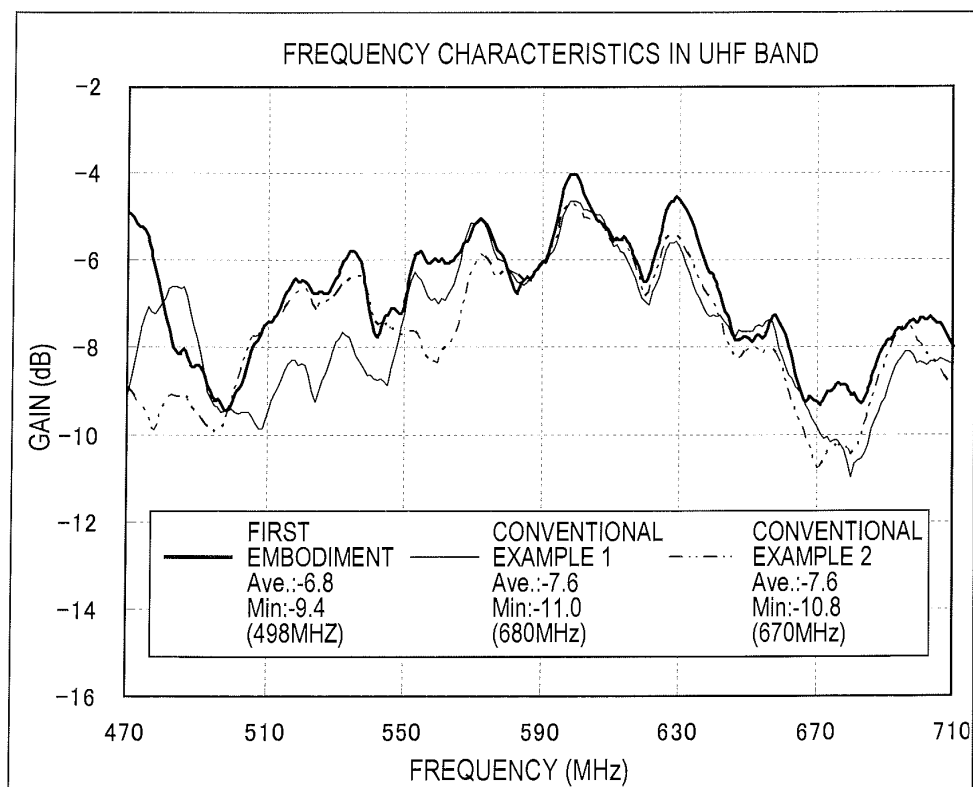


Fig. 6

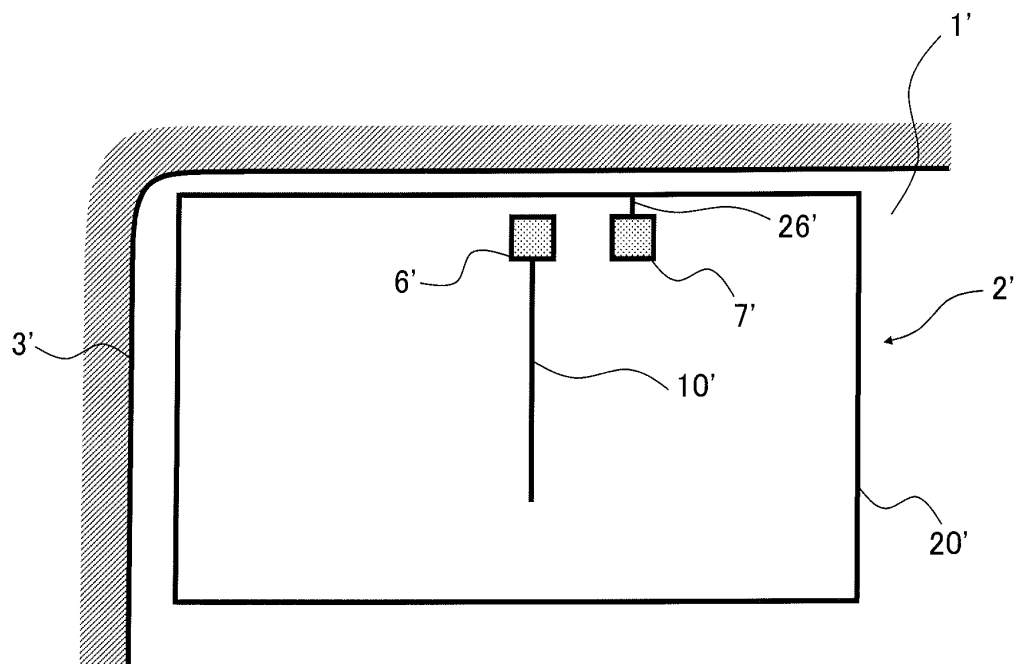


Fig. 7

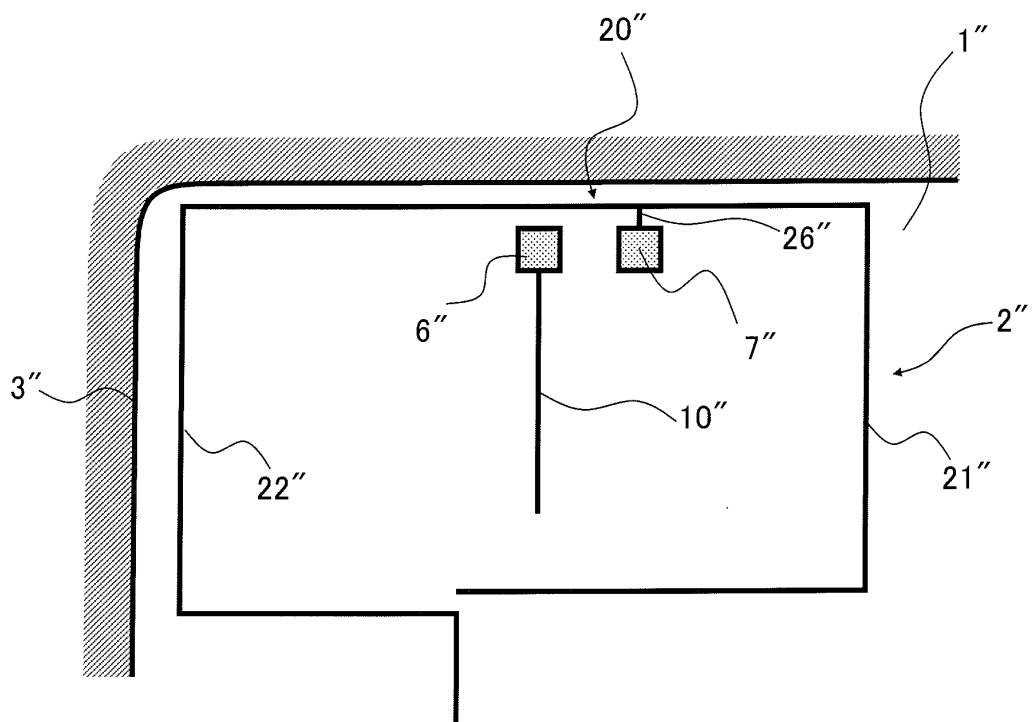


Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/064293

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	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

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 2005-229140 A (Central Glass Co., Ltd.), 25 August 2005 (25.08.2005), entire text; all drawings & US 2006/0176227 A1 & EP 1605543 A1 & WO 2004/084343 A1 & KR 10-2005-0111380 A & CN 1762069 A	1-10
A	JP 2010-114782 A (Asahi Glass Co., Ltd.), 20 May 2010 (20.05.2010), entire text; all drawings & CN 101740853 A	1-10

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

* Special categories of cited documents:

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

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search
13 September, 2011 (13.09.11)Date of mailing of the international search report
20 September, 2011 (20.09.11)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/064293

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 6-53723 A (Pilkington PLC.), 25 February 1994 (25.02.1994), entire text; all drawings & US 5418543 A & GB 9209332 D & GB 2266627 A & GB 9209332 D0 & EP 568284 A1 & DE 69307766 T & DE 69307766 D & AU 3713993 A & ES 2099907 T & ZA 9302949 A & AT 148586 T	1-10
A	JP 8-298406 A (Asahi Glass Co., Ltd.), 12 November 1996 (12.11.1996), entire text; all drawings (Family: none)	1-10
A	JP 2003-46312 A (Peter Joseph Vernon), 14 February 2003 (14.02.2003), entire text; all drawings & US 2002/0018020 A1 & US 6252550 B1 & EP 903805 A2 & DE 69816922 D & DE 69816922 T & NZ 519721 A & AU 4888402 A & CN 1393957 A & ZA 200205065 A & AT 246847 T	1-10
A	JP 2004-88748 A (Asahi Glass Co., Ltd.), 18 March 2004 (18.03.2004), entire text; all drawings & US 2004/0008144 A1	1-10

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2005229140 A [0005] [0007] [0069]
- JP 2005159657 A [0006] [0007]
- JP 2010165701 A [0081]