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feeding part and the independent conductor are provided with a window glass for the vehicle; and at least one pair of adjacent liner conductors, out of the plurality of liner conductors, has an open end opened toward the antenna conductor between leading ends opposing the antenna conductor of the adjacent liner conductors.

Description

BACKGROUND

1. Field of the Invention

[0001] The present invention relates to a glass antenna for a vehicle whose antenna conductor and feeding part are provided in/on a window glass for a vehicle. Also, the present invention relates to a window glass for a vehicle, including the glass antenna.

2. Description of the Related Art

[0002] As related arts, glass antennas for a vehicle capable of receiving digital audio broadcasting (DAB) described in, for example, JP-A-H10-327009 and JP-A-2000-307321 are known. The DAB is composed of two different frequency bands, that is, Band III of 174 through 240 MHz and L band of 1452 through 1492 MHz.

[0003] It is not easy to design and fabricate a glass antenna for a vehicle, whose antenna conductor provided in/on a window glass for a vehicle, has sufficient receiving performance applicable to a desired band. In particular, for coping with a dual frequency band as the DAB, the desired bands are away from each other, and therefore, it is difficult to design and fabricate a glass antenna for a vehicle, having sufficient receiving performance applicable to the both bands.

SUMMARY

[0004] An object of the invention is providing a glass antenna for a vehicle, which achieves a receiving characteristic applicable to desired bands, and a window glass for a vehicle, including the glass antenna.

[0005] In order to achieve the object, according to an aspect of the invention, there is provided a glass antenna for a vehicle, including: an antenna conductor; a feeding part; and an independent conductor, spaced from the antenna conductor, and including a plurality of liner conductors extending along a reference direction, wherein: the antenna conductor, the feeding part and the independent conductor are provided with a window glass for the vehicle; and at least one pair of adjacent liner conductors, out of the plurality of liner conductors, has an open end opened toward the antenna conductor between leading ends opposing the antenna conductor of the adjacent liner conductors.

[0006] Furthermore, the present invention provides a window glass for a vehicle, including the glass antenna of the invention.

[0007] According to the present invention, a receiving characteristic applicable to desired bands may be attained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawing which is given by way of illustration only, and thus is not limitative of the present invention and wherein:

FIG. 1 is a diagram illustrating a pattern including an AM glass antenna 20A.

FIG. 2 is a diagram illustrating a pattern including an AM glass antenna 20B, that is, a basic pattern of an AM glass antenna.

FIG. 3 is a diagram illustrating a pattern including an AM glass antenna 20C.

FIG. 4 is a diagram illustrating actually measured data of average values of antenna gain of a glass antenna 100 attained with various patterns of an AM glass antenna.

FIG. 5 is a diagram illustrating actually measured data of average values of antenna gain of the glass antenna 100 employing the pattern of FIG. 1 attained with a minimum distance w_{10} varied.

FIG. 6 is a diagram illustrating actually measured data of average values of antenna gain of the glass antenna 100 employing the pattern of FIG. 3 attained with the minimum distance w_{10} varied.

FIG. 7 is a diagram illustrating actually measured data of average values of antenna gain of the glass antenna 100 attained with a length H_b of a right short-circuit line 29 varied.

FIG. 8 is a diagram illustrating actually measured data of average values of antenna gain of the glass antenna 100 attained with the length H_b and the position of the right short-circuit line 29 varied.

FIG. 9 is a diagram illustrating a pattern of a glass antenna 500 and an AM glass antenna.

FIGS. 10A, 10B, 10C and 10D are diagrams illustrating other patterns of the glass antenna 500 and the AM glass antenna.

FIG. 11 is a diagram illustrating actually measured data of average values of antenna gain of the glass antenna 500 attained with various patterns of the AM glass antenna.

FIG. 12 is a diagram illustrating a pattern in which an uppermost liner conductor 21 overlaps an antenna element 4.

FIG. 13 is a diagram illustrating actually measured data of average values of antenna gain of the glass antenna 500 attained with a distance w_{18} varied.

FIG. 14 is a diagram illustrating a pattern of a glass antenna 600 and an AM glass antenna.

FIG. 15 is a diagram illustrating actually measured data of average values of antenna gain of the glass antenna 600 attained with a short-circuit portion varied.

FIG. 16 is a diagram illustrating a pattern in which the glass antenna 600 is wholly surrounded.

FIG. 17 is a diagram illustrating actually measured data of average values of antenna gain of the glass antenna 600 attained with or without an AM glass antenna provided.

FIG. 18 is a plan view of the glass antenna 100.

FIG. 19 is a plan view of the glass antenna 500.

FIG. 20 is a plan view of the glass antenna 600.

DETAILED DESCRIPTION OF THE INVENTION

[0009] Embodiments for carrying out the invention will be described with reference to the accompanying drawings. It is noted that a direction mentioned with reference to a drawing used for explaining an embodiment means a direction on the drawing unless otherwise mentioned. Also, such a drawing is a view seen from the inside (or the outside) of a vehicle with a window glass fixed on the vehicle, and a lateral direction in the drawing corresponds to the horizontal direction. Furthermore, when a window glass to be described is, for example, a backlite fixed on a rear part of a vehicle, a lateral direction in the drawing corresponds to the vehicle width direction. Incidentally, the present invention is not limited to a backlite but is applicable to a windscreen fixed on a front part of a vehicle or a side window fixed on a side part of a vehicle.

[0010] FIG. 1 (taken from the inside or the outside of a vehicle) illustrates a right upper area of a backlite 12 including a glass antenna of this invention. In the backlite 12, an antenna conductor 100, a plurality of heater lines and a plurality of bus bars (merely one of which is illustrated in FIG. 1) for supplying power to the plural heater lines are provided, and the plural heater lines and the plural bus bars together form a defogger 30.

[0011] The antenna conductor 100 will be described with reference to FIG. 18. FIG. 18 is a plan view of the glass antenna 100 for receiving waves of a first broadcasting frequency band and a second broadcasting frequency band higher than the first broadcasting frequency band. The glass antenna 100 includes an antenna conductor and a feeding part provided in/on the window glass 12. The window glass antenna 100 has a structure including, as the antenna conductor, a loop element 5 formed in the shape of a loop; an L-shaped element composed of a first antenna element of an antenna element 1 extending from a first point 5a disposed on the loop element 5 in a first direction substantially perpendicular to the horizontal direction and a second antenna element of an antenna element 2 extending in a second direction substantially perpendicular to the first direction from a first end point 1g corresponding to the end of extension in the first direction of the antenna element 1; and a connection element 6 extending from a second point 5b disposed on the loop element 5 in a third direction corresponding to a direction away from the L-shaped element (that is, a direction opposite by 180 degrees to the first direction in FIG. 18) to be connected to a feeding part 18 at a connection point 6a. It is noted that the L-shape herein includes a shape laterally symmetrical to the shape of

L, and a corner of the L-shape may be bent with a curvature. Furthermore, an end point may be an end of the extension of the antenna element or a conductor portion disposed before and in the vicinity of the end.

[0012] The glass antenna 100 is a monopole antenna, and a received signal obtained by the antenna conductor may be taken out from a positive side (a hot side) of the feeding part 18, and the thus obtained received signal is transmitted to a receiver (not shown). In providing the glass antenna as a monopole antenna, a vehicle body opening on which the window glass 12 is mounted or a portion in the vicinity of the body opening is preferably usable as ground (because what is called body earth can be thus attained). In the exemplary case of FIG. 18, the glass antenna 100 is disposed in the vicinity of an upper flange 15e of the body opening.

[0013] FIG. 18 illustrates the feeding part 18 formed in a rectangular shape. The connection point 6a connected to the connection element 6 is disposed on the lower side of the feeding part 18. Although the connection point 6a is disposed at the center of the lower side of the feeding part 18 in FIG. 18, it may be disposed in an arbitrary position on the lower side or disposed on the point of intersection of the lower side with the right or left side. The connection element 6 extends between the feeding part 18 and the loop element 5 so as to connect the feeding part 18 and the loop element 5 to each other.

[0014] The loop element 5 is an antenna conductor formed in the shape of a loop. The shape of a loop is not limited to the shape formed with a line having a constant line width but a part of the line may have a larger width as far as the line forms a loop. The shape of the loop element may be a circular shape, such as a circle, an approximate circle, an ellipse or an approximate ellipse, or a rectangular or polygonal shape, such as a square, an approximate square, a rectangle, an approximate rectangle, a parallelogram, an approximate parallelogram, a rhombus or an approximate rhombus. The loop element 5 is in the shape of a square in FIG. 18. The connection point 5a connected to the antenna element 1 and the connection point 5b connected to the connection element 6 are disposed on the conductor portion of the loop element 5. The connection point 5a is disposed on one side (i.e., a lower side in the illustrated case) of a virtual line extending in the horizontal direction through the center of gravity of the loop element 5 while the connection point 5b is disposed on the other side (i.e., an upper side in the illustrated case). The connection points 5a and 5b of FIG. 18 are disposed on a straight line parallel to the first direction. Although the connection point 5b is disposed at the center of the upper side of the loop element 5 in FIG. 18, it may be disposed in an arbitrary position on the upper side or disposed on the point of intersection of the upper side with the left or right side of the loop element 5.

[0015] Furthermore, the connection point 5b connected to the connection element 6 may be disposed in an arbitrary position on the right or left side of the loop ele-

ment 5.

[0016] The antenna element 1 may extend from the connection point 5a in the downward direction (i.e., in the first direction) to the end point 1g. Although the connection point 5a is disposed at the center of the lower side of the loop element 5 in FIG. 18, it may be disposed in an arbitrary position on the lower side or disposed on the point of interconnection of the lower side with the left or right side of the loop element 5.

[0017] The antenna element 2 may extend from the end point 1g in the leftward direction (i.e., in the second direction) to an end point 2g. Alternatively, it may extend rightward (namely, in a direction opposite to the second direction by 180 degrees). The extending direction of the antenna element 2 (namely, the second direction) is preferably parallel or substantially parallel to the horizontal direction with the window glass 12 mounted on the body opening because the antenna gain may be thus improved as compared with the case where the direction is not parallel.

[0018] In FIG. 1, a reference numeral 30a denotes an uppermost heater line and a reference numeral 30b denotes a bus bar. Also, a reference numeral 20A denotes an example of the glass antenna for receiving AM broadcasting disposed in a vacant area above the defogger 30.

[0019] In the window glass 12, an independent conductor not DC connected to but disposed in the vicinity of the antenna conductor 100 (that is, the AM glass antenna 20A in the exemplary case of FIG. 1) is preferably provided in a vacant area disposed on a side of the antenna element 2 closer to the periphery of the window glass from the viewpoint of improvement of antenna gain in the L band. The independent conductor preferably includes a plurality of liner conductors extending in parallel to a reference direction (corresponding to the second direction in FIG. 1) and electrically connected to a second feeding part (not shown in FIG. 1 but is provided in, for example, a left end portion of the AM glass antenna 20A) different from the feeding part 18, and thus, the independent conductor may be used for receiving the frequency band of AM broadcasting.

[0020] The independent conductor 20A includes a plurality of liner conductors 21 through 26 extending in parallel to the reference direction. In this invention, at least one pair of adjacent liner conductors out of the plural liner conductors preferably has an open end opened toward the antenna conductor 100 between a leading end opposing the antenna conductor 100 of one liner conductor and the other liner conductor of the pair, and thus, antenna gain in the band III may be improved. Furthermore, the sum in length along a vertical direction substantially perpendicular to the reference direction of vertical spaces sandwiched between adjacent liner conductors (hereinafter referred to as vertical or first direction components) corresponding to open ends is preferably 30% or more of the sum in length along the vertical direction of vertical components sandwiched between leading ends opposing the antenna conductor of the uppermost liner con-

ductor and the lowermost liner conductor out of the plural liner conductors because thus, the antenna gain in the band III may be improved. More preferably, the sum in length of the vertical components corresponding to open ends is 60% or more of the sum in length of all vertical components.

[0021] In the exemplary case of FIG. 1, out of the plural liner conductors, all of liner conductors having leading ends opposing the antenna conductor are not DC connected in a direction parallel to the vertical direction, namely, all of them have open ends as illustrated in FIG. 1, which is preferable from the viewpoint of the improvement of the antenna gain. Each open end is a portion opened toward the antenna conductor along the vehicle width direction and is provided between the leading ends opposing the antenna conductor of one of adjacent liner conductors and the other liner conductor.

[0022] In the plural liner conductors, liner conductors adjacent to each other may have a short-circuit portion connected through a short-circuit line extending from the leading end opposing the antenna conductor of at least one of the adjacent liner conductors.

[0023] In forming such a short-circuit portion, assuming that there are a desired first broadcasting frequency band and a desired second broadcasting frequency band higher than the first broadcasting frequency band, that the wavelength in the air of a center frequency of the first broadcasting frequency band is indicated by λ_{01} , that the shortening coefficient of wavelength by glass is indicated by k (whereas $k = 0.64$) and that $\lambda_{g1} = \lambda_{01} \cdot k$, a length in the vertical direction substantially perpendicular to the reference direction of a vertical component corresponding to a short-circuit line connected to a leading end of a liner conductor disposed closest to the periphery of the window glass out of all the leading ends of the plural liner conductors opposing the antenna conductor is preferably $0.027 \cdot \lambda_{g1}$ or less because the antenna gain in the first broadcasting frequency band such as the band III may be thus improved. More preferably, the length is $0.022 \cdot \lambda_{g1}$ or less.

[0024] When, for example, the band III (of 174 through 240 MHz) is used as the first broadcasting frequency band, the center frequency is 207 MHz and the wavelength λ_{g1} at 207 MHz is 927.5 mm, and when the L band (of 1452 through 1492 MHz) is used as the second broadcasting frequency band, the center frequency is 1472 MHz and the wavelength λ_{g2} at 1472 MHz is 130.4 mm. Accordingly, specifically, the length in the first direction of a first direction component corresponding to a short-circuit line connected to a leading end closest to the periphery of the window glass out of all the leading ends opposing the antenna conductor of the plural liner conductors is preferably 25 mm or less and more preferably 20 mm or less from the viewpoint of the improvement of the antenna gain in the band III.

[0025] Furthermore, assuming that there are a desired first broadcasting frequency band and a desired second broadcasting frequency band higher than the first broad-

casting frequency band, that the wavelength in the air of a center frequency of the second broadcasting frequency band is indicated by λ_{02} , that the shortening coefficient of wavelength by glass is indicated by k (whereas $k = 0.64$) and that $\lambda_{g2} = \lambda_{02} \cdot k$, the minimum distance in the reference direction between the antenna conductor and the independent conductor on the same horizontal plane is preferably $0.008 \cdot \lambda_{g2}$ through $0.39 \cdot \lambda_{g2}$ and more preferably $0.08 \cdot \lambda_{g2}$ through $0.23 \cdot \lambda_{g2}$ from the viewpoint of the improvement of the antenna gain of the antenna conductor.

[0026] Accordingly, specifically, the minimum distance in the second direction between the antenna conductor and the independent conductor on the same horizontal plane is preferably 1 mm through 50 mm and more preferably 1 mm through 30 mm from the viewpoint of the improvement of the antenna gain of the antenna conductor.

[0027] Furthermore, in the exemplary case of FIG. 1, the glass antenna is preferably provided so that the antenna element 2 extends in a vacant area disposed between the independent conductor and the heater line 30a from the viewpoint of the improvement of the antenna gain.

[0028] Next, another embodiment of the invention will be described. As an antenna pattern for attaining high antenna gain in both the first broadcasting frequency band and the second broadcasting frequency band, an antenna pattern additionally including an independent conductor 20D in a shape closely surrounding an antenna conductor 500 illustrated in FIG. 19 may be employed. In this embodiment, the independent conductor 20D may be provided closely merely to a second direction side of the antenna conductor 500 or merely to a fourth direction side of the antenna conductor 500.

[0029] At this point, the antenna conductor 500 will be described with reference to FIG. 19. FIG. 19 is a plan view of the dual-band glass antenna 500, that is, an antenna conductor for receiving waves of a first broadcasting frequency band and a second broadcasting frequency band higher than the first broadcasting frequency band. The glass antenna 500 includes an antenna conductor and a feeding part provided in the window glass 12. The glass antenna 500 has a structure including, as the antenna conductor, a first antenna element of an antenna element 1 extending from the feeding part 18 in a first direction substantially perpendicular to the horizontal direction; a second antenna element of an antenna element 2 extending in a second direction substantially perpendicular to the first direction (namely, in the horizontal direction) from an end point 1g corresponding to the end of the extension in the first direction of the antenna element 1; a third antenna element of an antenna element 3 extending in a third direction, that is, the opposite direction to the first direction (namely, a direction parallel to and opposite to the first direction, i.e., the upward direction opposite to the first direction by 180 degrees, in FIG. 19) from an end point 2g corresponding to the end

of the extension in the second direction of the antenna element 2; and a fourth antenna element of an antenna element 4 extending in the second direction from an end point 3g corresponding to the end of the extension in the third direction of the antenna element 3 to an end point 4g. It is noted that each corner of the antenna conductor may be bent with a curvature. Also, the end point may be an end of extension of an antenna element or a conductor portion disposed before and in the vicinity of the end.

[0030] The antenna element 1 may extend from a connection point 1s in the downward direction (i.e., the first direction) to the end point 1g.

[0031] The antenna element 2 may extend from the end point 1g in the leftward direction (i.e., the second direction) to the end point 2g. Alternatively, the antenna element 2 may extend in the rightward direction (namely, a direction opposite to the second direction by 180 degrees). The extending direction of the antenna element 2 (namely, the second direction) is preferably parallel or substantially parallel to the horizontal direction with the window glass 12 mounted on a body opening because the antenna gain may be thus improved as compared with the case where the direction is not parallel.

[0032] The antenna element 3 may extend from the end point 2g in the upward direction (i.e., the third direction) to the end point 3g.

[0033] The antenna element 4 may extend from the end point 3g in the leftward direction (i.e., the second direction) to the end point 4g. When the antenna element 2 extends in the rightward direction, the antenna element 4 may extend in the rightward direction in the same manner as the antenna element 2.

[0034] In FIG. 9, the independent conductor 20D corresponds to a parasitic conductor for the antenna conductor 500. The independent conductor 20D may be, for example, an AM glass antenna for receiving AM broadcasting disposed in a vacant area above the defogger 30.

[0035] Specifically, the independent conductor 20D (that is, the AM antenna in the exemplary case of FIG. 9) not DC connected to but disposed close to the antenna conductor 500 is provided in a vacant area of the window glass 12, and the independent conductor 20D is preferably provided in a vacant area disposed on the second direction side of the antenna element 3 and in a vacant area disposed on the fourth direction side of the antenna element 1 because the antenna gain in the band III and the L band may be thus improved.

[0036] The independent conductor 20D preferably includes a plurality of liner conductors extending in parallel to the reference direction (that is, the second direction in the exemplary case of FIG. 9) and electrically connected to a second feeding part (not shown in FIG. 9 and corresponding to, for example, a feeding part for an AM antenna) different from the feeding part 18, and thus, the independent conductor 20D may be used for receiving waves of the frequency band of the AM broadcasting.

[0037] In FIG. 9, the antenna pattern of the independ-

ent conductor 20D provided as the AM antenna surrounds the first direction side, the second direction side and the fourth direction side of the antenna conductor 500 as a whole. In other words, the antenna conductor 500 is disposed in a vacant area 13 whose first direction side, second direction side and fourth direction side are surrounded with the pattern of the AM antenna.

[0038] The independent conductor 20D includes a first liner conductor group composed of a plurality of liner conductors 21 through 26 disposed in the vacant area on the second direction side of the antenna element 3 and a second liner conductor group composed of a plurality of liner conductors 51 through 55 and 26 disposed in the vacant area on the fourth direction side of the antenna element 1. The liner conductor 26 runs through a vacant area disposed between the antenna element 2 and the defogger 30 so as to be provided in both the vacant area on the second direction side and the vacant area on the fourth direction side. The vacant area 13 where the antenna conductor 500 is provided is surrounded with the first liner conductor group and the second liner conductor group. Also, reference numerals 21g through 25 g respectively denote leading ends (end points) opposing the antenna conductor 500 corresponding to ends of extension in the fourth direction of the liner conductors 21 through 25. Reference numerals 51g through 55g respectively denote leading ends (end points) opposing the antenna conductor 500 corresponding to ends of extension in the second direction of the liner conductors 51 through 55.

[0039] Also in this embodiment, in the same manner as in the aforementioned embodiment, at least one pair of adjacent liner conductors out of the plural liner conductors preferably has an open end opened toward the antenna conductor 500 between the leading end opposing the antenna conductor 500 of one liner conductor of the pair and the other liner conductor, and thus, antenna gain in the band III may be improved. Furthermore, the sum in length along a vertical direction substantially perpendicular to the reference direction of vertical components corresponding to open ends is preferably 30% or more of the sum in length along the vertical direction of vertical components sandwiched between the leading ends opposing the antenna conductor of the uppermost liner conductor and the lowermost liner conductor because thus, the antenna gain in the band III may be improved. More preferably, the sum in length of the vertical components corresponding to open ends is 60% or more of the sum in length of all vertical components.

[0040] All liner conductors having leading ends opposing the antenna conductor out of the plural liner conductors are preferably opened (as open ends) toward a direction parallel to the vertical direction from the viewpoint of the improvement of the antenna gain. For example, in FIG. 9, one open end opened toward the antenna conductor is formed between the leading end 21g and the leading end 22g. Also, one open end opened toward the antenna conductor is formed between the leading end

55g and the liner conductor 26.

[0041] Moreover, the plural liner conductors included in the independent conductor 20D may have at least one short-circuit portion formed by connecting a leading end opposing the antenna conductor 500 of one liner conductor of an adjacent pair out of the plural liner conductors to the other liner conductor of the pair through a short-circuit line. For example, in Fig. 9, one short-circuit portion is formed by connecting the leading end 21g and the leading end 22g to each other through a short-circuit line extending in a direction parallel to the first direction. Also, one short-circuit portion is formed by connecting the leading end 55g and the liner conductor 26 to each other through a short-circuit line.

[0042] In forming such a short-circuit portion, assuming that there are a desired first broadcasting frequency band and a desired second broadcasting frequency band higher than the first broadcasting frequency band, that the wavelength in the air of a center frequency of the first broadcasting frequency band is indicated by λ_{01} , that the shortening coefficient of wavelength by glass is indicated by k (whereas $k = 0.64$) and that $\lambda_{g1} = \lambda_{01} \cdot k$, a length in the first direction of a first direction component corresponding to a short-circuit line connected to a leading end closest to the periphery of the window glass out of all leading ends opposing the antenna conductor of the plural liner conductors is preferably $0.027 \cdot \lambda_{g1}$ or less, and thus, the antenna gain in the first broadcasting frequency band such as the band III may be improved. The length is more preferably $0.022 \cdot \lambda_{g1}$ or less. Specifically, a length in the first direction of a first direction component corresponding to a short-circuit line connected to a leading end closest to the periphery of the window glass out of all leading ends opposing the antenna conductor of the plural liner conductors is preferably 25 mm or less and more preferably 20 mm or less from the viewpoint of the improvement of the antenna gain in the band III.

[0043] Furthermore, in this embodiment, assuming that there are a desired first broadcasting frequency band and a desired second broadcasting frequency band higher than the first broadcasting frequency band, that the wavelength in the air of a center frequency of the first broadcasting frequency band is indicated by λ_{01} , that the shortening coefficient of wavelength by glass is indicated by k (whereas $k = 0.64$) and that $\lambda_{g1} = \lambda_{01} \cdot k$, as the positional relationship between an antenna element closest to the periphery of the window glass out of all antenna elements included in the antenna conductor and extending in the direction parallel to the second direction and a closest liner conductor, out of plural liner conductors included in the independent conductor, positioned closer to the periphery of the window glass than the closest antenna element, the closest antenna element preferably overlaps the closest liner conductor, when the closest liner conductor is projected in the first direction, by a length of $0.043 \cdot \lambda_{g1}$ or less and more preferably $0.011 \cdot \lambda_{g1}$ or less because thus, the antenna gain in the first broadcasting frequency band such as the band III may be im-

proved. Specifically, the overlap length is preferably 40 mm or less and more preferably 10 mm or less, and still more preferably they do not overlap at all from the viewpoint of the improvement of the antenna gain in the band III.

[0044] Alternatively, the antenna conductor of this embodiment may be formed, as the antenna pattern for attaining high antenna gain in both the first broadcasting frequency band and the second broadcasting frequency band, in an antenna pattern as illustrated in FIG. 20, in which the antenna element of FIG. 19 is further folded.

[0045] FIG. 20 is a plan view of a dual-band glass antenna 600 corresponding to an antenna conductor for receiving waves of a first broadcasting frequency band and a second broadcasting frequency band higher than the first broadcasting frequency band. Like reference numerals are used to refer to like elements used in the structure of FIG. 19 and the description is omitted. The glass antenna 600 has a structure including, as the antenna conductor, antenna elements 1, 2, 3 and 4; a fifth antenna element of an antenna element 5 extending in the third direction from the end point 4g corresponding to the end of the extension in the second direction of the antenna element 4; and a sixth antenna element of an antenna element 6 extending in the fourth direction, that is, a direction opposite to the second direction (i.e., a direction parallel to and opposite to the second direction, namely, the rightward direction opposite to the second direction by 180 degrees, in FIG. 20) from an end point 5g corresponding to the end of extension in the third direction of the antenna element 5 to an end point 6g. The antenna element 6 extends to the end point 6g in a portion spaced from the feeding part 18 and the antenna element 1 so as not to cross the feeding part 18 and the antenna element 1.

[0046] The feeding part 18 of this invention is electrically connected to a feeder line connected to a receiver. When an AV line is used as the feeder line, the feeding part 18 is connected to an amplifier provided on the vehicle for attaining body earth through ground of the amplifier. At this point, when a connector for electrically connecting the AV line to the feeding part 18 is mounted on the feeding part 18, the AV line is easily attached to the feeding part 18.

[0047] When the window glass 12 is provided with an earth part (not shown), the feeding part 18 is electrically connected to an internal conductor of a coaxial cable, and an external conductor of the coaxial cable is electrically connected to the earth part. When connectors for electrically connecting the coaxial cable to the feeding part 18 and the earth part are mounted on the feeding part 18, the coaxial cable can be easily attached to the feeding part 18 and the earth part.

[0048] When the connector mounted on the feeding part 18 includes an amplifier circuit for amplifying a received signal taken out from the feeding part 18, ground of the amplifier circuit may be electrically connected to a ground portion such as the external conductor of the co-

axial cable with the input side of the amplifier circuit electrically connected to the feeding part 18 and with the output side of the amplifier circuit connected to the internal conductor of the coaxial cable.

[0049] The shape of the feeding part 18 may be determined in accordance with the shape of a leading end of the feeder line directly attached to the feeding part 18 or the shape of a connection member used for connecting the feeder line to the feeding part 18 (for example, in accordance with the shape of a mounting surface or a contact terminal of a connector). A rectangular or polygonal shape such as a square, an approximate square, a rectangle or an approximate rectangle is preferred from the viewpoint of implementation. The feeding part 18 may be in a circular shape such as a circle, an approximate circle, an ellipse or an approximate ellipse.

[0050] The aforementioned glass antenna is not provided with an auxiliary antenna conductor, which does not limit the invention. An auxiliary antenna element in a substantially T-shape, a substantially L-shape or a loop shape may be added through or not through a connection conductor to an antenna element for impedance matching, phase adjustment, directivity adjustment or the like.

[0051] Furthermore, a glass antenna may be obtained by forming a conductive layer including an antenna conductor in or on a synthetic resin film and attaching the synthetic resin film having the conductive layer onto the interior or exterior surface of a window glass plate for a vehicle. Alternatively, a glass antenna may be obtained by attaching a flexible circuit board on which an antenna conductor has been formed onto the interior or exterior surface of a window glass plate for a vehicle.

[0052] An angle at which the window glass plate is mounted on a vehicle is preferably 15 through 90 degrees and more preferably 30 through 90 degrees against the horizontal direction.

[0053] An antenna conductor is formed by printing a paste including a conductive metal, such as a silver paste, onto the interior surface of a window glass plate and baking the printed paste. The method for forming an antenna conductor is not limited to this. Instead, a line or a foil of a conductive substance such as copper may be formed on the interior or exterior surface of a window glass plate, may be adhered onto a window glass with an adhesive or the like, or may be formed within a window glass. The feeding part 18 may be similarly formed.

[0054] Furthermore, with a masking film formed on a window glass, a part or the whole of an antenna conductor may be formed on the masking film. An example of the masking film is a ceramic film such as a black ceramic film. In this case, when seen from the outside of the vehicle, the portion of the antenna conductor formed on the masking film is invisible from the outside of the vehicle due to the masking film, resulting in obtaining a window glass with superior design. In employing the structure illustrated in any of the drawings, when at least a part of the feeding part and the antenna conductor is formed on a masking film, a portion including thin lines alone is vis-

ible from the outside of the vehicle, and hence, the resultant window glass is preferred from the viewpoint of design.

[Example 1]

[0055] A pattern in which the antenna element 2 of the glass antenna 500 illustrated in FIG. 19 is extended in a vacant area disposed between an AM glass antenna and a defogger is provided on an actual backlite, so as to fabricate a vehicle high frequency glass antenna.

[0056] FIG. 2 is a diagram illustrating a pattern including an AM glass antenna 20B, that is, a basic shape of the AM glass antenna. The basic dimensions of respective portions of the AM glass antenna 20B are as follows:

w1: 375 mm
w2: 335 mm
w3 through w7: 20 mm
w8: 40 mm
w9: 20 mm
w10: 10 mm
w11: 1070 mm
w12: 150 mm

The dimension w1 corresponds to a distance along the vehicle width direction between a middle short-circuit line 28, which short-circuits a plurality of liner conductors 21 through 26 in substantially central positions thereof, and a left short-circuit line 27, which short-circuits left leading ends of the plural liner conductors 21 through 26. The dimension w2 corresponds to a distance along the vehicle width direction between the middle short-circuit line 28 and a right short-circuit line 29, which short-circuits right leading ends of the plural liner conductors 21 through 26. Each of the dimensions w3 through w7 corresponds to a distance between adjacent liner conductors. The dimension w8 corresponds to a distance between the liner conductor 26 disposed in the lowermost position out of all the liner conductors of the AM glass antenna 20B and the heater line 30a disposed in the uppermost position out of all heater lines provided between bus bars 30b and 30c of the defogger 30. The dimension w9 corresponds to a distance between the liner conductor 26 and the antenna element 2. The dimension w10 corresponds to the minimum distance along the vehicle width direction between the glass antenna 100 and the AM glass antenna 20B (which corresponds to a distance between the right short-circuit line 29 and a left side part 5e of the loop element 5 in FIG. 2). The dimension w11 corresponds to a length of the heater line 30a. The dimension w12 corresponds to a distance between an upper flange 15a of the body opening and the heater line 30a. It is noted that the conductor width of the respective antenna elements and the short-circuit lines of the AM glass antenna 20B is 0.8 mm.

[0057] Furthermore, vehicle high frequency glass antennas respectively employing, as the pattern shape of

the AM glass antenna according to this invention, the pattern of the AM glass antenna 20A illustrated in FIG. 1 and the pattern of an AM glass antenna 20C illustrated in FIG. 3 are fabricated.

[0058] In the AM glass antenna 20A, the right leading ends of the liner conductors 21 through 26 are not connected to one another (namely, the right short-circuit line 29 of FIG. 2 is not formed), and hence, open ends 41 through 45 opened toward the glass antenna 100 in the vehicle width direction are formed. In the pattern of FIG. 1, the dimensions and the pattern formed on the left-hand side are the same as those illustrated in FIG. 2 although omitted.

[0059] In the AM glass antenna 20C, two open ends 42 and 44 opened toward the glass antenna 100 along the vehicle width direction are formed. Specifically, a short-circuit portion 29b for short-circuiting the liner conductors 22 and 23 and a short-circuit portion 29d for short-circuiting the liner conductors 24 and 25 are formed in the AM glass antenna 20C in positions shifted from its right end toward its center along the vehicle width direction, so as to form a meander pattern at the right end of the AM glass antenna 20C. In FIG. 3, the dimensions and the pattern formed on the left-hand side are the same as those illustrated in FIG. 2 although omitted. In the pattern of FIG. 3, the sum of vertical lengths of right short-circuit lines 29a, 29c and 29e connecting the right leading ends corresponds to 60% ($= (3/5 \times 100 [\%])$) of a vertical space length between the right leading end of the uppermost liner conductor 21 and the right leading end of the lowermost liner conductor 26 (in other words, the total length of the right short-circuit line 29 of FIG. 2). Incidentally, it corresponds to 0% in the pattern of FIG. 1. In the case of FIG. 1, the sum of the vertical lengths of the open ends corresponds to 40% of the vertical length between the right leading end of the uppermost liner conductor 21 and the right leading end of the lowermost liner conductor 26.

[0060] Next, in each of the vehicle high frequency glass antennas fabricated by providing the patterns of FIGS. 1, 2 and 3 different from one another in the pattern of the AM glass antenna respectively on actual backlites, antenna gain attained all around the vehicle is measured so as to calculate average antenna gain.

[0061] In this case, the dimensions of the respective portions of the glass antenna 100 illustrated in FIG. 18 are as follows:

x1: 78 mm
x2: 164 mm
x6: 2 mm
Lx: 35 mm
Ly: 35 mm

It is noted that the conductor width of each antenna element of the glass antenna 100 is 0.8 mm.

[0062] The antenna gain is measured by radiating, with radio waves, a vehicle on which the window glass is

mounted at 15 degrees against the horizontal direction with the vehicle rotated by 360 degrees per angle of 2 degrees. The radio waves are vertical polarization and varied in the frequency by 10 MHz in each of the ranges of the band III and the L band. The measurement is performed with the wave angle between the position for emitting the waves and the antenna conductor set to the horizontal direction (namely, with the wave angle set to 0 degree assuming that a plane parallel to the ground surface is regarded as 0 degree and that a direction toward the vertex is regarded as 90 degrees). The antenna gain is expressed with that of a half-wave dipole antenna as a reference (in both the band III and the L band) and is standardized with the gain of a half-wave dipole antenna regarded as 0 dB.

[0063] FIG. 4 illustrates actually measured data of average values of the antenna gain of the glass antenna 100 in employing the respective patterns of the AM glass antenna. In FIG. 4, "Open" corresponds to data obtained by employing the pattern of FIG. 1, "Short" corresponds to data obtained by employing the pattern of FIG. 2, "Meander" corresponds to data obtained by employing the pattern of FIG. 3, and "Without-AM" corresponds to data obtained without providing the AM glass antenna. As illustrated in FIG. 4, when the AM glass antenna corresponding to the parasitic conductor for the glass antenna 100 is provided in the position on the upper side of the antenna element 2 and on the left side of the antenna element 1, the antenna gain in the L band is improved with the antenna gain in the band III kept high. Among these patterns, the pattern in which at least a part of the right short-circuit line at the right end of the AM glass antenna is opened (namely, the pattern of FIG. 3) is preferred, and the pattern in which all the right leading ends have open ends (namely, the pattern of FIG. 1) is more preferred from the viewpoint of the improvement of the antenna gain of the glass antenna 100.

[Example 2]

[0064] Subsequently, with respect to the patterns of FIGS. 1 and 3 with which preferable results are attained in Example 1, the antenna gain of the glass antenna 100 attained all around the vehicle is measured for calculating average antenna gain with the minimum distance w_{10} (see FIG. 2) between the AM glass antenna and the glass antenna 100 varied. At this point, the average antenna gain is calculated with the antenna gain attained without providing the AM glass antenna used as a reference and with the antenna gain of "Without-AM" regarded as 0 dB.

[0065] FIG. 5 illustrates actually measured data of average values of the antenna gain of the glass antenna 100 employing the pattern of FIG. 1 with the minimum distance w_{10} varied. FIG. 6 illustrates actually measured data of average values of the antenna gain of the glass antenna 100 employing the pattern of FIG. 3 with the minimum distance w_{10} varied. In FIGS. 5 and 6, the antenna gain indicated by the ordinate corresponds to an

average value of the antenna gain attained at every 10 MHz in the frequency band of 170 through 240 MHz corresponding to the band III and an average value of the antenna gain attained at every 10 MHz in the frequency band of 1450 through 1490 MHz corresponding to the L band.

[0066] As illustrated in FIGS. 5 and 6, the antenna gain is increased as the minimum distance w_{10} is increased no matter whether the pattern of FIG. 1 is employed or the pattern of FIG. 3 is employed. In particular, when the pattern of FIG. 3 is employed, the antenna gain in the L band is remarkably increased as the minimum distance w_{10} is increased as illustrated in FIG. 6. Accordingly, when the AM glass antenna is provided, high antenna gain may be attained by setting the minimum distance along the vehicle width direction between the AM glass antenna and the glass antenna 100 to 10 mm or more (and more preferably, 20 mm or more).

[Example 3]

[0067] Next, the antenna gain the glass antenna 100 attained all around the vehicle is measured with a length H_b of the right short-circuit line 29 of the AM glass antenna 20B of FIG. 2 varied, so as to calculate average antenna gain in the same manner as in Example 2. In this case, without varying the positions and the lengths of the liner conductors 21 through 26, the width of an opening provided at the right end of the AM glass antenna 20B is gradually increased from the upper side (namely, the right short-circuit line 29 is gradually eliminated from the upper side), and thus, the length H_b of the right short-circuit line 29 is varied.

[0068] FIG. 7 illustrates actually measured data of average values of the antenna gain of the glass antenna 100 with the length H_b of the right short-circuit line 29 varied. It is noted that the antenna gain indicated by the ordinate of FIG. 7 corresponds to an average value of the antenna gain attained at every 10 MHz in the frequency band of 170 through 240 MHz corresponding to the band III or an average value of the antenna gain attained at every 10 MHz in the frequency band of 1450 through 1490 MHz corresponding to the L band. Furthermore, when the length H_b is 100 mm, the resultant pattern corresponds to the pattern of the AM glass antenna 20B illustrated in FIG. 2, and when the length H_b is 0 mm, the resultant pattern corresponds to the pattern of the AM glass antenna 20A illustrated in FIG. 1.

[0069] As illustrated in FIG. 7, as the length H_b is reduced by gradually eliminating the right short-circuit line 29 from the upper side, the antenna gain in the band III is improved with the antenna gain in the L band kept high. Accordingly, when the AM glass antenna is provided, high antenna gain may be attained by setting the total length H_b along the first direction of the short-circuit line connecting the leading ends of the liner conductors 21 through 26 to 70% or less of a total vertical length H of vertical components sandwiched between the right lead-

ing end of the uppermost liner conductor 21 and the right leading end of the lowermost linear component 26. In other words, high antenna gain may be attained by setting the total width of open ends provided at the right end of the AM glass antenna 20B to 30% or more (and more preferably 60% or more) of the total length H of the vertical components sandwiched between the right leading end of the uppermost liner conductor 21 and the right leading end of the lowermost liner conductor 26.

[0070] FIG. 8 illustrates actually measured data of average values of the antenna gain of the glass antenna 100 attained all around the vehicle with the length Hb and the position of the right short-circuit line 29 varied. The antenna gain is calculated by the same method as in Example 2. In this drawing, "20 mm short-circuited from upper end" corresponds to data obtained when merely the liner conductor 21 and the liner conductor 22 close to the upper flange 15a of the body opening are short-circuited through the right short-circuit line 29 and the liner conductors 22 through 26 have open ends. Also, "20 mm opened from upper end" corresponds to data obtained when merely the liner conductor 21 and the liner conductor 22 close to the upper flange 15a of the body opening have an open end and the liner conductors 22 through 26 are mutually short-circuited through the right short-circuit line 29.

[0071] As illustrated in FIG. 8, when the liner conductor 21 close to the upper flange 15a of the body opening is connected to the right short-circuit line 29, the antenna gain in the band III is degraded even if the liner conductors 22 through 26 have open ends. On the other hand, when the liner conductors 21 and 22 have an open end, the antenna gain in the band III is improved even if the liner conductors 22 through 26 are connected to the right short-circuit line 29. In other words, when the liner conductor 21 close to the upper flange 15a of the body opening is connected to the right short-circuit line 29, the length of the right short-circuit line 29 is preferably short.

[0072] Accordingly, assuming that there are a desired first broadcasting frequency band and a desired second broadcasting frequency band higher than the first broadcasting frequency band, that the wavelength in the air of a center frequency of the second broadcasting frequency band is indicated by λ_{02} , that the shortening coefficient of wavelength by glass is indicated by k (whereas $k = 0.64$) and that $\lambda_{g2} = \lambda_{02} \cdot k$, the total length along the first direction of first direction components corresponding to a short-circuit line connected to the liner conductor 21 close to the upper flange 15a of the body opening is preferably 0 through $0.19 \cdot \lambda_{g2}$ and more preferably 0 through $0.15 \cdot \lambda_{g2}$ on the basis of the data of FIG. 8 from the viewpoint of the improvement of the antenna gain. Specifically, the length of the short-circuit line is preferably 0 mm through 25 mm and more preferably 0 mm through 20 mm from the viewpoint of the improvement of the antenna gain.

[Example 4]

[0073] Next, a vehicle high frequency glass antenna is fabricated by providing a pattern including the glass antenna 500 of FIG. 19 surrounded with the independent conductor 20D on an actual backlite, and the antenna gain of the glass antenna 500 attained all around the vehicle is measured so as to calculate average antenna gain with short-circuit portions of the independent conductor 20D varied. The basic dimensions of the respective portions of the independent conductor 20D of FIG. 9 are as follows:

w1: 375 mm
w2: 200 mm
w3 through w7: 20 mm
w8: 20 mm
w9: 10 mm
w10: 10 mm
w11: 1070 mm
w12: 150 mm
w13: 130 mm
w14: 30 mm
w15: 175 mm
w16: 10 mm
w17: 10 mm

The dimension w1 corresponds to a distance along the vehicle width direction between the middle short-circuit line 28, which short-circuits the plural liner conductors 21 through 26 in substantially central positions thereof, and the left short-circuit line 27, which short-circuits the left leading ends of the plural liner conductors 21 through 26 (i.e., leading ends on the opposite side to the glass antenna 500). The dimension w2 corresponds to a distance along the vehicle width direction between the middle short-circuit line 28 and the leading end 21g (or 22g) of the liner conductor 21 (or 22). Each of the dimensions w3 through w7 corresponds to a distance between adjacent liner conductors (which also corresponds to a distance between adjacent liner conductors 51 through 55 and 26). The dimension w8 corresponds to a distance between the liner conductor 26 disposed in the lowermost position out of all the liner conductors of the independent conductor 20D and the heater line 30a disposed in the uppermost position out of all the heater lines provided between the bus bars 30b and 30c of the defogger 30. The dimension w9 corresponds to a distance between the liner conductor 26 and the antenna element 2. The dimension w10 corresponds to the minimum distance along the vehicle width direction between the antenna element 4 of the glass antenna 500 and the liner conductor 21 of the independent conductor 20D (which corresponds to a distance between the leading end 21g (or 22g) and the end point 4g in FIG. 9). The dimension w11 corresponds to a length of the heater line 30a. The dimension w12 corresponds to a distance between the upper flange 15a of the body opening and the heater line

30a. The dimension w13 corresponds to a distance between the leading end 21g or 22g and the leading end 23g, 24g or 25g. The dimension w14 corresponds to a distance between any of the leading ends 23g through 25g and any of the leading ends 51g through 55g. The dimension w15 corresponds to a distance between the right short-circuit line 29 short-circuiting the right leading ends of the plural liner conductors 51 through 55 and 26 and any of the leading ends 51g through 55g. The dimension w16 corresponds to a distance between any of the leading ends 23g through 25g and the antenna element 3. The dimension w17 corresponds to a distance between any of the leading ends 51g through 55g and the antenna element 1. It is noted that the conductor width of the antenna elements and the short-circuit lines of the AM glass antenna 20D is 0.8 mm.

[0074] Furthermore, as alternative patterns of the independent conductor, each of patterns of the AM glass antennas 20E through 20H illustrated in FIGS. 10A through 10D is provided around the pattern of the glass antenna 500, and vehicle high frequency glass antennas respectively employing these patterns are fabricated. In each pattern illustrated in FIGS. 10A through 10D, although the reference numerals, the dimensions and the pattern formed on the left-hand side are partly omitted, the omitted portions are the same as those illustrated in FIG. 9.

[0075] With respect to the vehicle high frequency glass antennas employing the five kinds of patterns of the AM glass antennas illustrated in FIGS. 9 and 10A through 10D, the antenna gain of each antenna attained all around the vehicle is measured, so as to calculate average antenna gain. The antenna gain is measured in the same manner as in Example 1.

[0076] At this point, the dimensions of the respective portions of the glass antenna 500 of FIG. 19 are as follows:

- x1: 107 mm
- x2: 10 mm
- x3: 70 mm
- x4: 130 mm

It is noted that the conductor width of the antenna elements of the glass antenna 500 is 0.8 mm.

[0077] FIG. 11 illustrates actually measured data of average values of the antenna gain of the glass antenna 500 attained by employing the respective patterns of the independent conductor. In this drawing, "0" corresponds to data obtained by employing the pattern of FIG. 9 in which all the leading ends opposing the glass antenna 500 of the liner conductors are not DC short-circuited along the direction parallel to the first direction and have open ends opened toward the glass antenna along the vehicle width direction. Also, "20" corresponds to data obtained by employing the pattern of FIG. 10D in which a short-circuit portion is formed by connecting the leading end 21g (or 51g) closest to the upper flange 15a of the

body opening to the liner conductor 22 (or 52) and open ends are formed between the liner conductors 22 and 26 and the liner conductors 52 and 26. Furthermore, "40" corresponds to data obtained by employing the pattern of FIG. 10C in which a short-circuit portion is formed by connecting the leading end 21g (or 51g) closest to the upper flange 15a of the body opening to the liner conductors 22 and 23 (or 52 and 53) and open ends are formed between the liner conductors 23 and 26 and the liner conductors 53 and 26. Also, "80" corresponds to data obtained by employing the pattern of FIG. 10B in which an open end is formed between the liner conductor 21 (or 51) having the leading end 21g (or 51g) closest to the upper flange 15a of the body opening and the liner conductor 22 (or 52) and short-circuit portions are formed between the liner conductors 22 and 26 and the liner conductors 52 and 26. Also, "100" corresponds to data obtained by employing the pattern of FIG. 10A in which all the leading ends opposing the glass antenna 500 of the liner conductors are DC short-circuited in the direction parallel to the first direction so as to form short-circuit portions at all the leading ends without forming any open end.

[0078] In the pattern of FIG. 10A, the sum in length of first direction components closed by short-circuit lines (namely, short-circuit portions) corresponds to 100% of the total length of all first direction components formed between adjacent liner conductors out of the plural liner conductors. In the pattern of FIG. 10B, the sum in length of short-circuit portions corresponds to 80%, in the pattern of FIG. 10C, it corresponds to 40%, and in the pattern of FIG. 10D, it corresponds to 20%.

[0079] As illustrated in FIG. 11, when the liner conductor 21 (or 51) close to the upper flange 15a of the body opening is connected to a short-circuit line (as in the case of "20" of FIG. 11), the antenna gain in the band III is degraded as compared with the case where all the leading ends have open ends (as in the case of "0" in FIG. 11) even though the open ends are formed between the liner conductors 22 through 26 (or 52 through 26). On the other hand, when an open end is formed between the liner conductor 21 (or 51) and the liner conductor 22 (or 52), the antenna gain in the band III is improved even though the liner conductors 22 through 26 (or 52 through 56) are connected to a short-circuit line (as in the case of "80" of FIG. 11). In other words, when the leading end 21g (or 51g) of the liner conductor 21 (or 51) close to the upper flange 15a of the body opening is connected to a short-circuit line, the short-circuit line is preferably short.

[0080] Accordingly, assuming that there are a desired first broadcasting frequency band and a desired second broadcasting frequency band higher than the first broadcasting frequency band, that the wavelength in the air of a center frequency of the first broadcasting frequency band is indicated by λ_{01} , that the shortening coefficient of wavelength by glass is indicated by k (whereas $k = 0.64$) and that $\lambda_{g1} = \lambda_{01} \cdot k$, the total length of first direction components corresponding to a short-circuit line con-

nected to the leading end 21g (or 51g) closest to a periphery 12a of the vehicle glass window 12 is preferably $0.027 \cdot \lambda_{g1}$ or less and more preferably $0.022 \cdot \lambda_{g1}$ or less from the viewpoint of the improvement of the antenna gain in the band III. Specifically, the total length is preferably 25 mm or less and more preferably 20 mm or less.

[Example 5]

[0081] Next, with respect to the pattern of FIG. 9 with which a preferable result is attained in Example 4, the antenna gain of the glass antenna 500 attained all around the vehicle is measured so as to calculate average antenna gain with an overlap length w18 in the vertical direction between the uppermost liner conductor 21 and the antenna element 4 varied.

[0082] FIG. 13 illustrates actually measured data of average values of antenna gain of the glass antenna 500 with the length w18 varied. It is noted that the antenna gain indicated by the ordinate corresponds to an average value of the antenna gain attained at every 10 MHz in the frequency band of 170 through 240 MHz corresponding to the band III or an average value of antenna gain attained at every 10 MHz in the frequency band of 1450 through 1490 MHz corresponding to the L band.

[0083] As illustrated in FIG. 13, as the overlap length w18 is shorter, the antenna gain is increased. In particular, the antenna gain in the band III is improved by setting the overlap length w18 to 40 mm or less and more preferably to 10 mm or less. Furthermore, the overlap length w18 is preferably less than 0 mm, namely, they do not preferably overlap, from the viewpoint of the improvement of the antenna gain in the band III.

[Example 6]

[0084] Next, vehicle high frequency glass antennas are fabricated by respectively employing a pattern in which the glass antenna 600 of FIG. 20 is surrounded with an independent conductor 20I and a pattern in which the glass antenna 600 is not provided with an independent conductor, and the antenna gain of the glass antenna 600 attained all around the vehicle is measured so as to calculate average antenna gain with a short-circuit portion of the independent conductor 20I varied. The antenna gain is measured in the same manner as in Example 1.

[0085] The dimensions of respective portions of the glass antenna 600 employing the pattern of FIG. 20 not provided with the independent conductor 20I are as follows:

x1: 107 mm
x2: 20 mm
x3: 70 mm
x4: 50 mm
x5: 20 mm
x6: 50 mm

It is noted that the conductor width of the respective antenna elements of the glass antenna 600 is 0.8 mm.

[0086] FIG. 14 is a diagram illustrating the pattern including the independent conductor 20I. The basic dimensions of respective portions of the independent conductor 20I are as follows:

w2: 270 mm
w13: 50 mm
w14: 40 mm

The other dimensions are the same as those of FIG. 9.

[0087] FIG. 15 illustrates actually measured data of average values of the antenna gain of the glass antennas 600 with the pattern of the independent conductor varied. In this drawing, "Open" corresponds to data obtained by employing the pattern of FIG. 14 in which all leading ends of the liner conductors opposing the pattern of the glass antenna 600 are not DC short-circuited in the direction parallel to the first direction but have open ends opened toward the glass antenna 600 in the vehicle width direction. Also, "Short" corresponds to data obtained by employing a pattern in which all leading ends of the liner conductors opposing the pattern of the glass antenna 600 are DC short-circuited in the direction parallel to the first direction without forming any open end in the pattern of FIG. 14. Also, "Without-AM" corresponds to data obtained by employing the pattern of FIG. 20 without providing the independent conductor.

[0088] As illustrated in FIG. 15, with the glass antenna 600 not provided with the independent conductor regarded as a reference, when the independent conductor is provided on the left-hand side of the antenna element 3 and on the right-hand side of the antenna element 1, the antenna gain in the band III and the L band may not be improved depending upon the pattern of the independent conductor. In Example 6, when all the leading ends of the independent conductor are short-circuited, the antenna gain is degraded as compared with the case where the independent conductor is not provided, but when all the leading ends of the independent conductor are opened, the antenna gain in the band III and the L band is preferably improved to the equivalent level to that attained without providing the independent conductor.

[Example 7]

[0089] Alternatively, an antenna conductor may be surrounded with an independent conductor as illustrated in FIG. 16. In this case, a liner conductor 21 of an independent conductor 20J extends to a vacant area above the antenna element 6.

[0090] The dimensions of respective portions of the glass antenna 600 employing the pattern of FIG. 20 not provided with the independent conductor 20J are as follows:

x1: 107 mm

x2: 10 mm
 x3: 60 mm
 x4: 65 mm
 x5: 10 mm
 x6: 65 mm

It is noted that the conductor width of the respective antenna elements of the glass antenna 600 is 0.8 mm.

[0091] The basic dimensions of respective portions of the independent conductor 20J of FIG. 16 are as follows:

w13: 65 mm
 w14: 30 mm

The other dimensions are the same as those of Example 6.

[0092] FIG. 17 illustrates actually measured data of average values of antenna gain of the glass antenna 600 attained without providing it with the independent conductor and attained by surrounding it with the independent conductor. In this drawing, "Open" corresponds to data obtained by employing the pattern of FIG. 16 in which all leading ends of the liner conductors opposing the pattern of the glass antenna 600 are not DC short-circuited in the direction parallel to the first direction and have open ends opened toward the glass antenna 600 in the vehicle width direction. Also, "Without-AM" corresponds to data obtained by employing the pattern of FIG. 20 not provided with the AM glass antenna.

[0093] As illustrated in FIG. 17, when all the leading ends opposing the antenna conductor 600 are formed as open ends, the antenna gain in both the band III and the L band is improved as compared with the case where the independent conductor is not provided.

Claims

1. A glass antenna for a vehicle, comprising:

an antenna conductor;
 a feeding part; and
 an independent conductor, spaced from the antenna conductor, and including a plurality of liner conductors extending along a reference direction, wherein:

the antenna conductor, the feeding part and the independent conductor are provided with a window glass for the vehicle; and
 at least one pair of adjacent liner conductors, out of the plurality of liner conductors, has an open end opened toward the antenna conductor between leading ends opposing the antenna conductor of the adjacent liner conductors.

2. The glass antenna according to claim 1, wherein

in a case that a first broadcasting frequency band and a second broadcasting frequency band higher than the first broadcasting frequency band are provided, that a wavelength in the air of a center frequency of the second broadcasting frequency band is indicated by λ_{02} , that the shortening coefficient of wavelength by glass is indicated by k (whereas $k = 0.64$) and that $\lambda_{g2} = \lambda_{02} \cdot k$, a minimum length on the same horizontal plane along the reference direction of a component disposed between the antenna conductor and the independent conductor is $0.008 \cdot \lambda_{g2}$ through $0.39 \cdot \lambda_{g2}$.

3. The glass antenna according to claim 1 or 2, wherein the minimum length on the same horizontal plane along the reference direction of the component disposed between the antenna conductor and the independent conductor is 1 mm through 50 mm.

4. The glass antenna according any of claims 1 through 3, wherein a summation of the distance of the open end with respect to the vertical direction substantially perpendicular to the reference direction is 30% or more compared with a distance between highest and lowest levels of the leading edges of the plurality of liner conductors at the side of the antenna conductor.

5. The glass antenna according to any of claims 1 through 4, wherein in a case that adjacent liner conductors out of the plurality of liner conductors have a short-circuit portion connected through a short-circuit line starting from a leading end opposing the antenna conductor of at least one of the adjacent liner conductors, that a first broadcasting frequency band and a second broadcasting frequency band higher than the first broadcasting frequency band are provided, that the wavelength in the air of a center frequency of the first broadcasting frequency band is indicated by λ_{01} , that the shortening coefficient of wavelength by glass is indicated by k (whereas $k = 0.64$) and that $\lambda_{g1} = \lambda_{01} \cdot k$, a length of vertical components arranged substantially perpendicular to the reference direction, the length being corresponding to a short-circuit line connected to a leading end closest to a periphery edge of the window glass out of all leading ends of the plural liner conductors opposing the antenna conductor, is $0.027 \cdot \lambda_{g1}$ or less.

6. The glass antenna according to any of claims 1 through 5, wherein in a case that adjacent liner conductors out of the plurality of liner conductors have a short-circuit portion connected through a short-circuit line starting from a leading end opposing the antenna conductor of at least one of the adjacent liner conductors, the length of vertical components arranged substantially

perpendicular to the reference direction, the length being corresponding to the short-circuit line connected to the leading end closest to the periphery edge of the window glass out of all leading ends of the plural liner conductors opposing the antenna conductor, is 25 mm or less. 5

7. The glass antenna according to any of claims 1 through 6, wherein 10
in a case that a first broadcasting frequency band and a second broadcasting frequency band higher than the first broadcasting frequency band are provided, that the wavelength in the air of a center frequency of the first broadcasting frequency band is indicated by λ_{01} , that the shortening coefficient of wavelength by glass is indicated by k (whereas $k = 0.64$) and that $\lambda_{g1} = \lambda_{01} \cdot k$, a closest antenna element closest to the periphery edge of the window glass out of antenna elements of the antenna conductor extending in the direction parallel to the reference direction and a closest liner conductor closer to the periphery edge of the window glass than the closest antenna element out of the plurality of liner conductors overlap each other by a length of $0.043 \cdot \lambda_{g1}$ or less when the closest liner conductor is projected in the direction substantially perpendicular to the reference direction. 15 20 25
8. The glass antenna according to any of claims 1 through 6, wherein 30
a closest antenna element closest to the periphery edge of the window glass out of the antenna elements of the antenna conductor extending in the direction parallel to the reference direction and the closest liner conductor closer to the periphery edge of the window glass than the closest antenna element out of the plurality of liner conductors overlap each other by a length of 40 mm or less when the closest liner conductor is projected in the direction substantially perpendicular to the reference direction. 35 40
9. The glass antenna according to any of claims 1 through 8, wherein 45
the reference direction is a horizontal or a substantially horizontal direction when the independent conductor is provided in the window glass.
10. A window glass for a vehicle, comprising 50
the glass antenna of any of claims 1 through 9.

55

FIG. 1

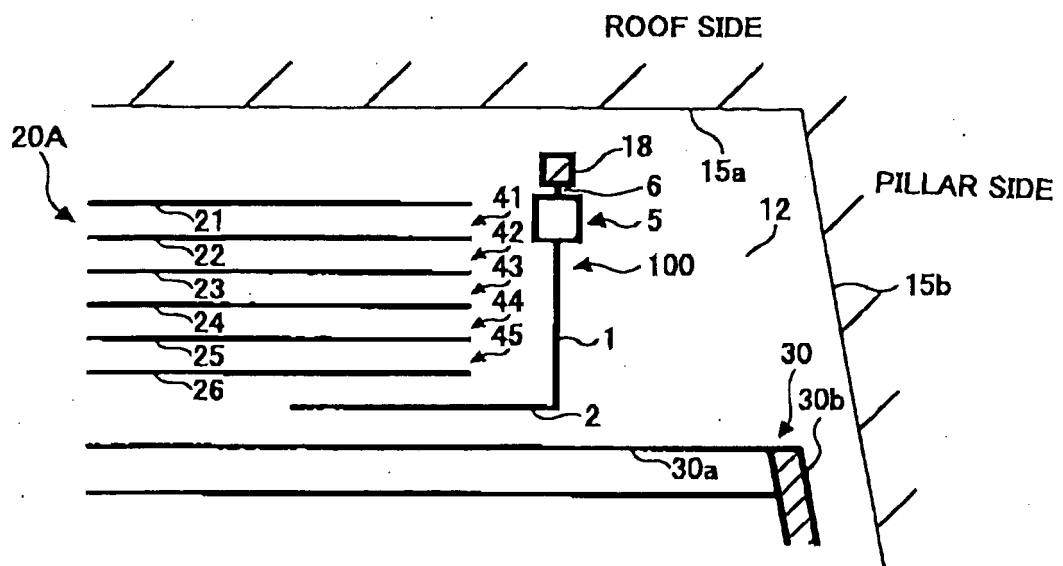


FIG. 2

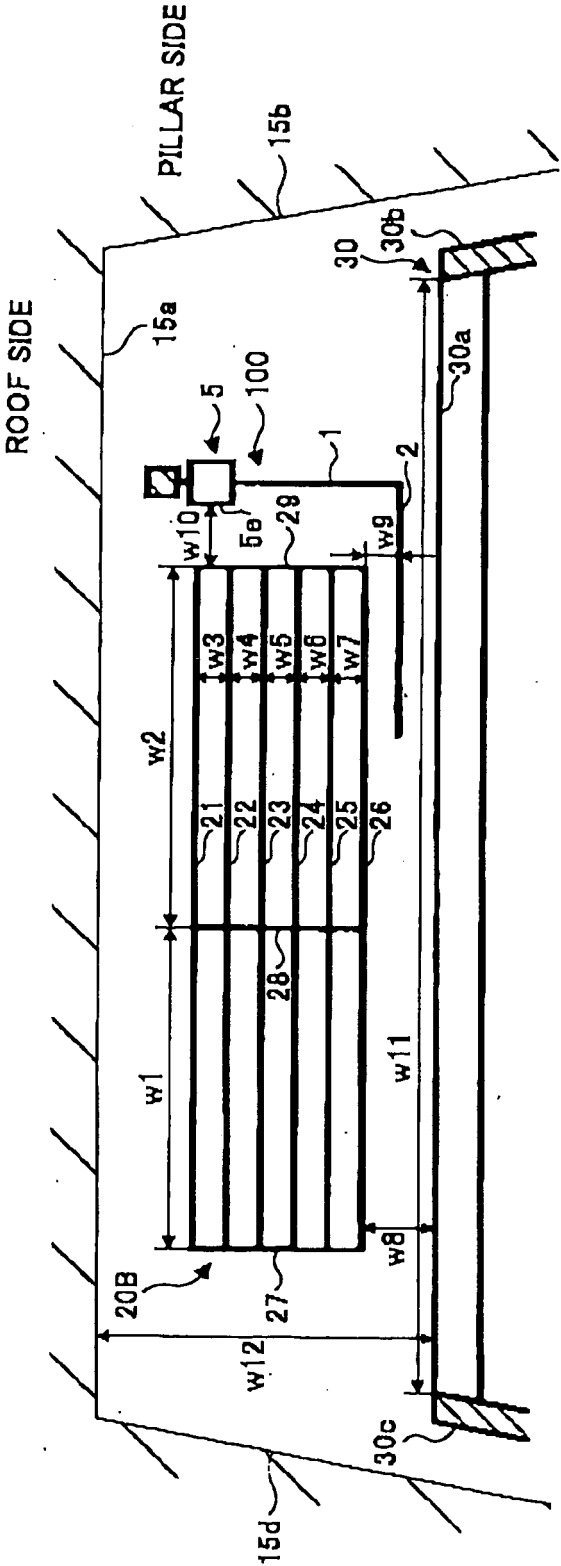


FIG. 3

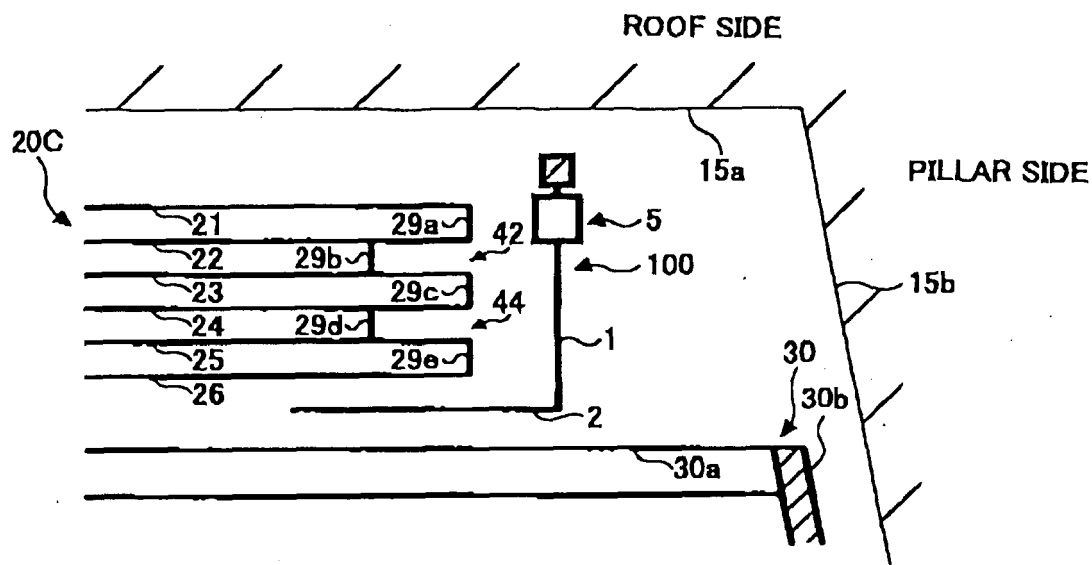


FIG. 4

	BAND III	L BAND
Open	-7.90	-9.81
Short	-9.91	-9.84
Meander	-8.60	-10.24
Without-AM	-8.87	-11.00

FIG. 5

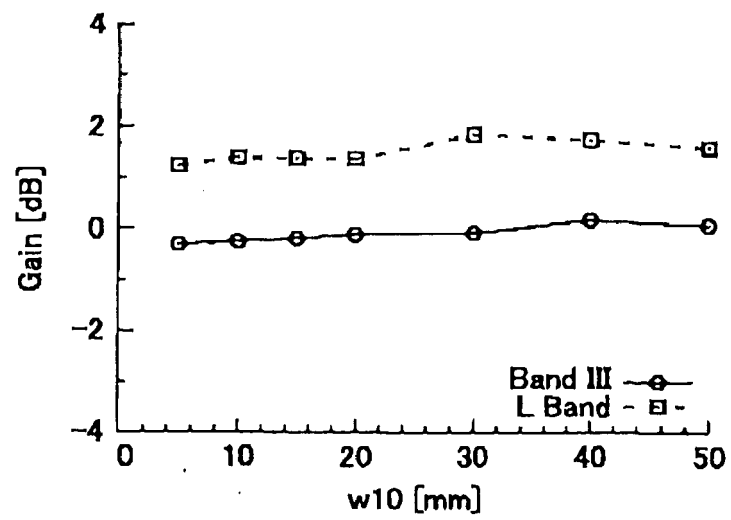


FIG. 6

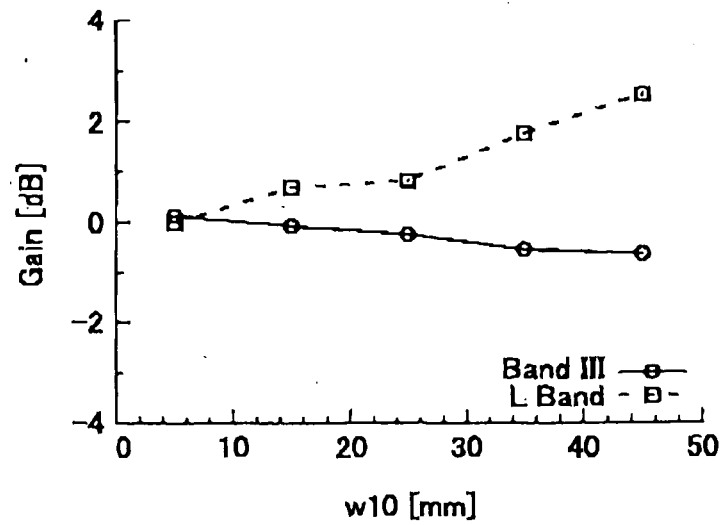


FIG. 7

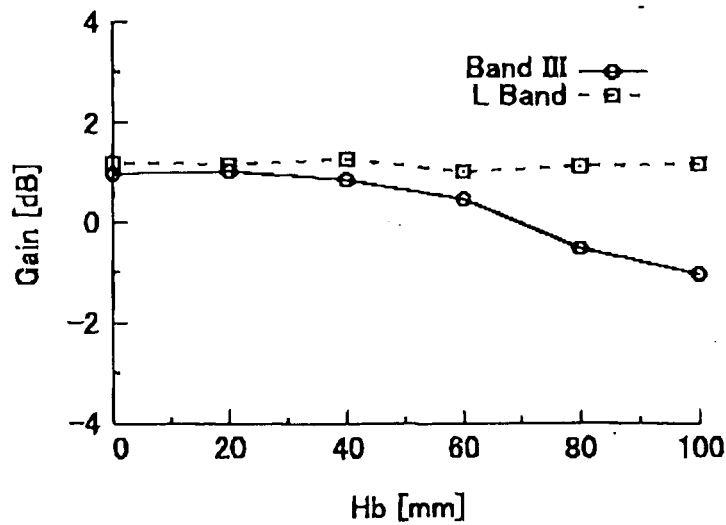


FIG. 8

	BAND III	L BAND
20 mm short-circuited from upper end	-3.18	0.82
20 mm opened from upper end	-0.51	1.12

FIG. 9

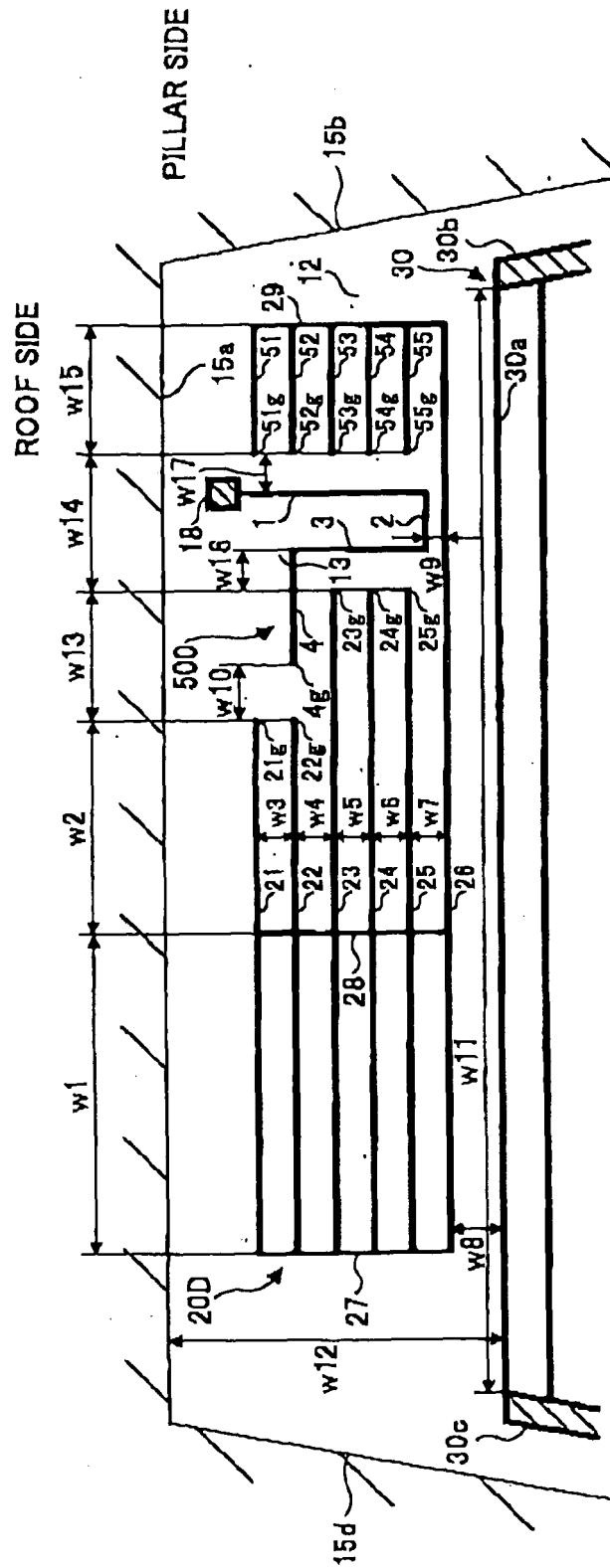


FIG. 10A

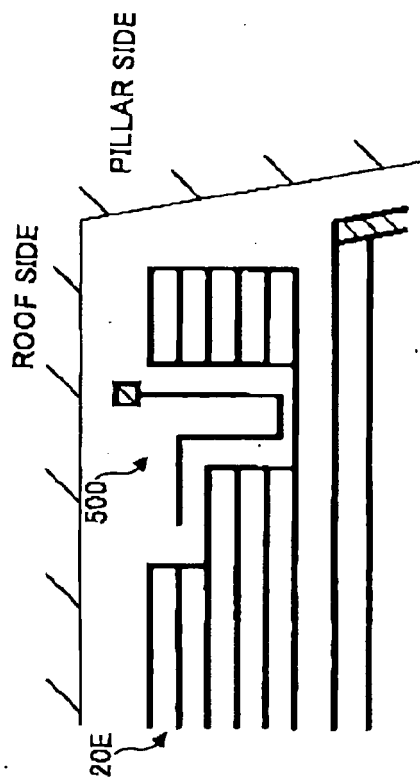


FIG. 10B

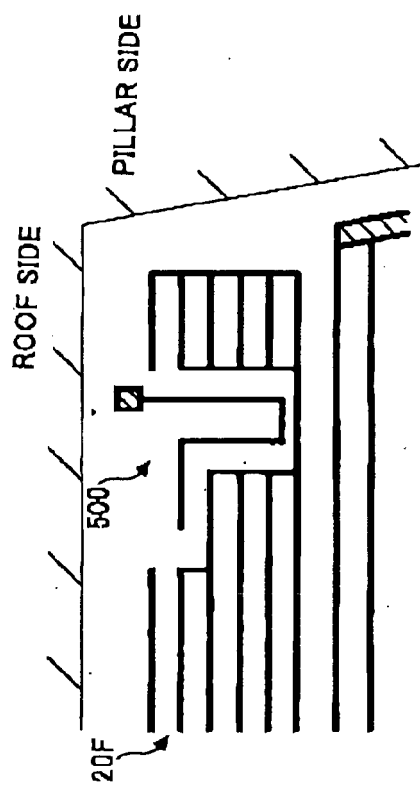


FIG. 10C

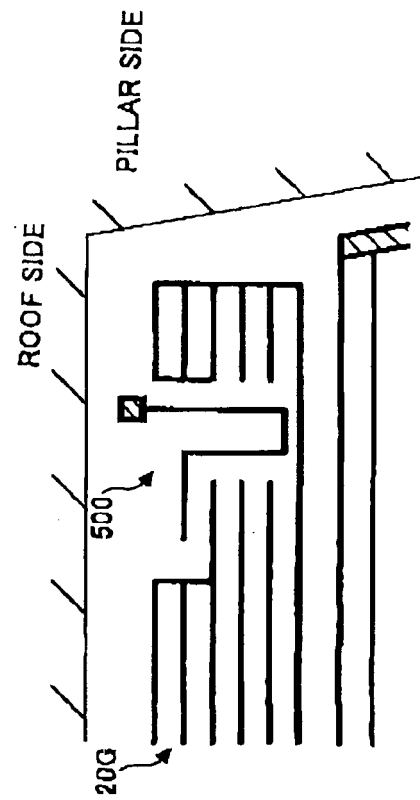


FIG. 10D

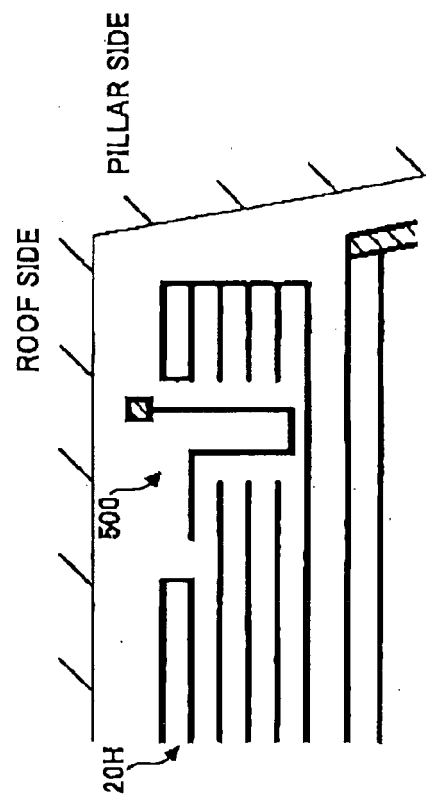


FIG. 11

	BAND III	L BAND
0	1.12	0.49
20	0.58	-0.33
40	-2.40	0.29
80	1.08	0.27
100	-2.14	-0.44

FIG. 12

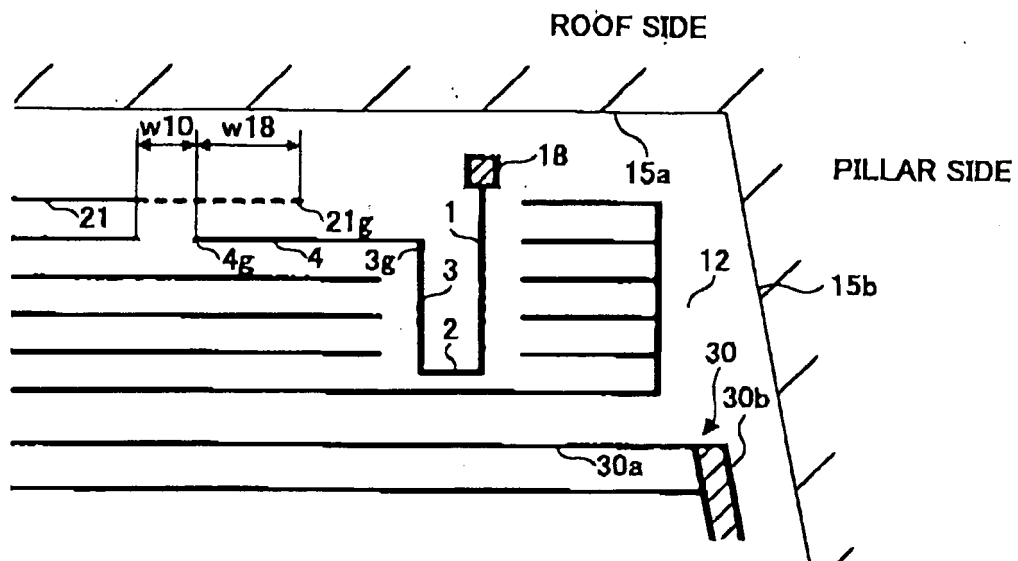


FIG. 13

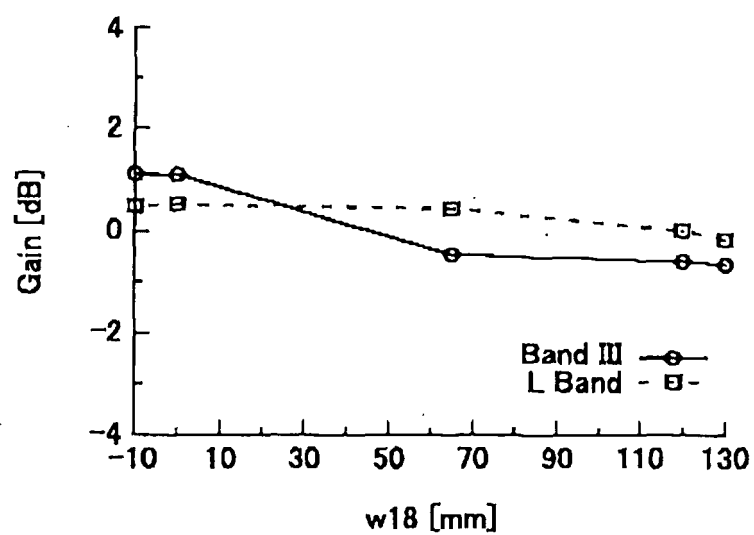


FIG. 14

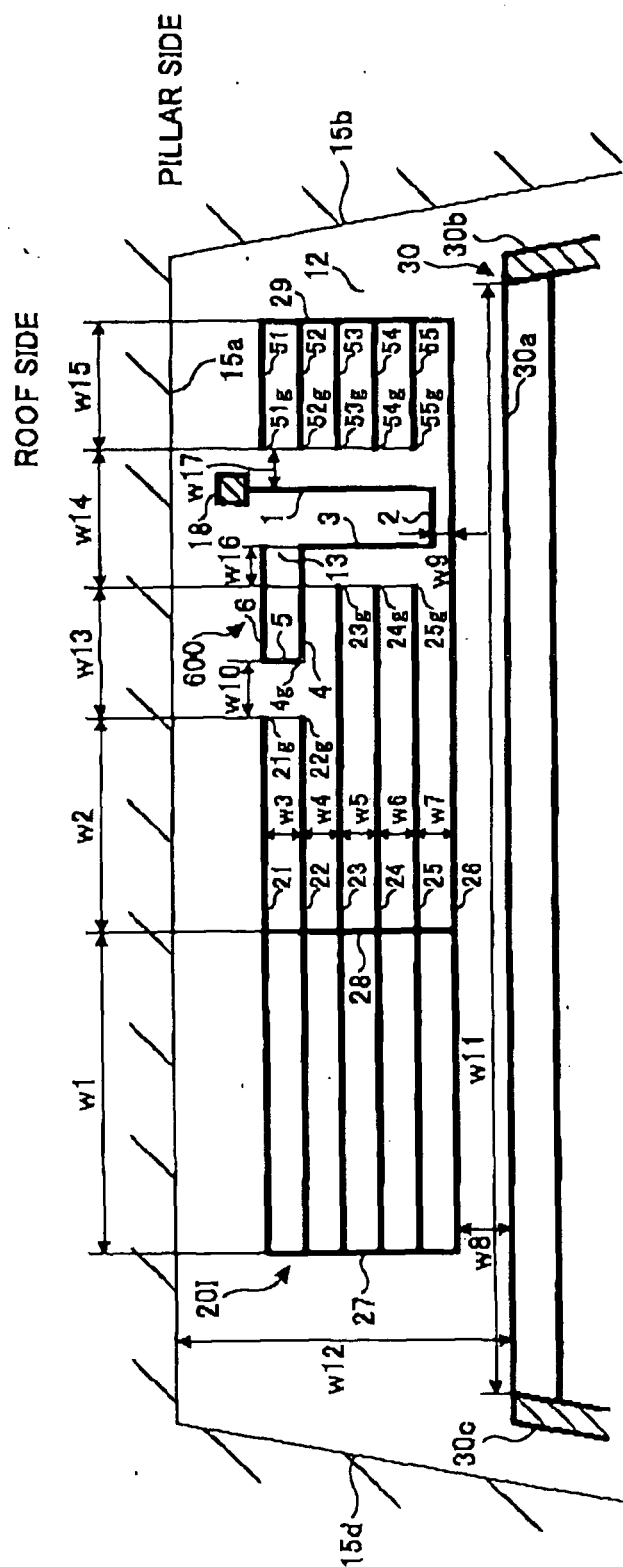


FIG. 15

	BAND III	L BAND
Open	-10.97	-8.71
Short	-11.85	-10.66
Without-AM	-10.55	-8.90

FIG. 16

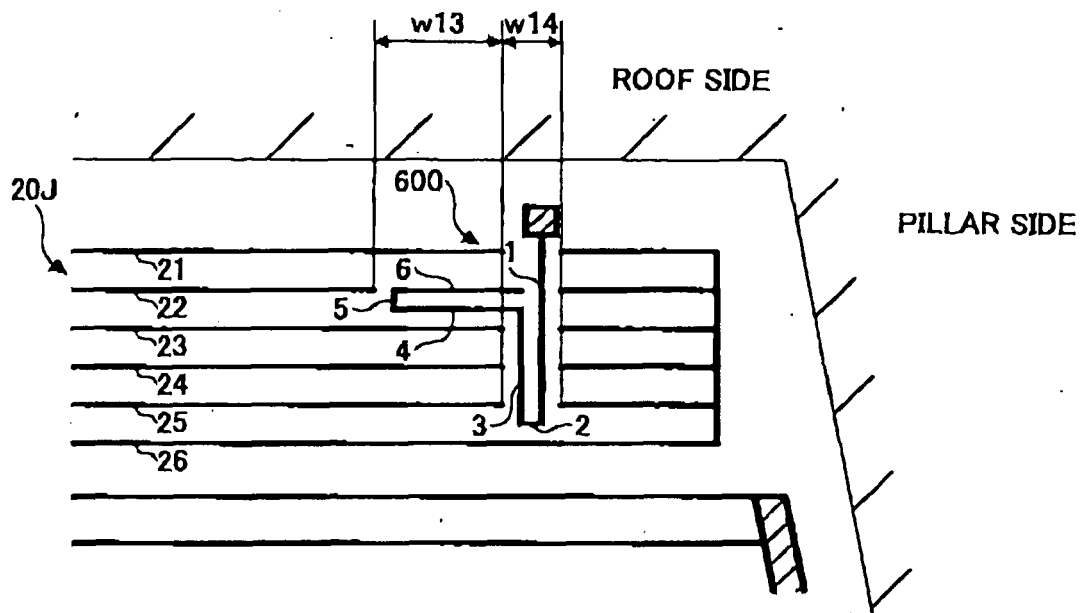


FIG. 17

	BAND III	L BAND
Open	-9.29	-9.80
Without-AM	-11.22	-10.45

FIG. 18

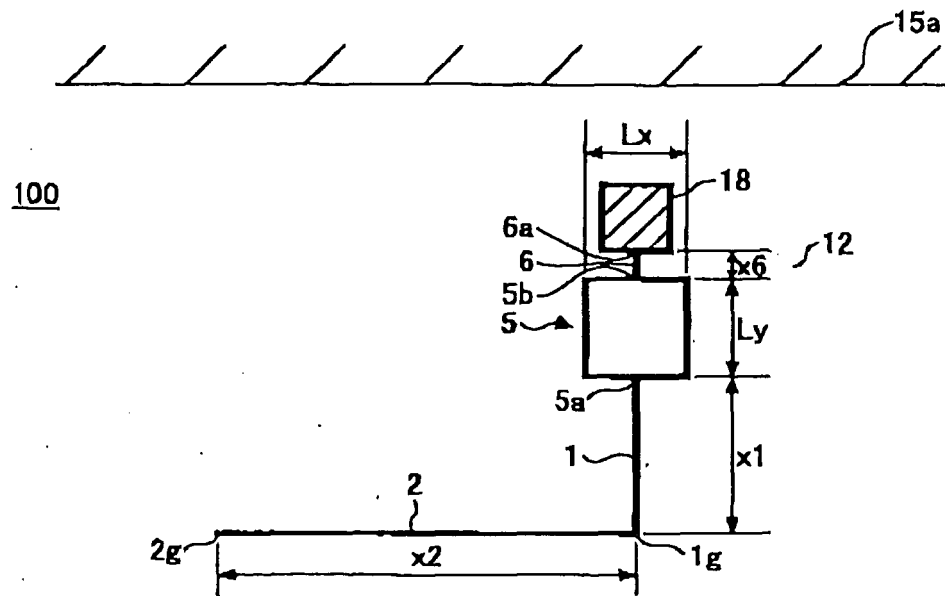


FIG. 19

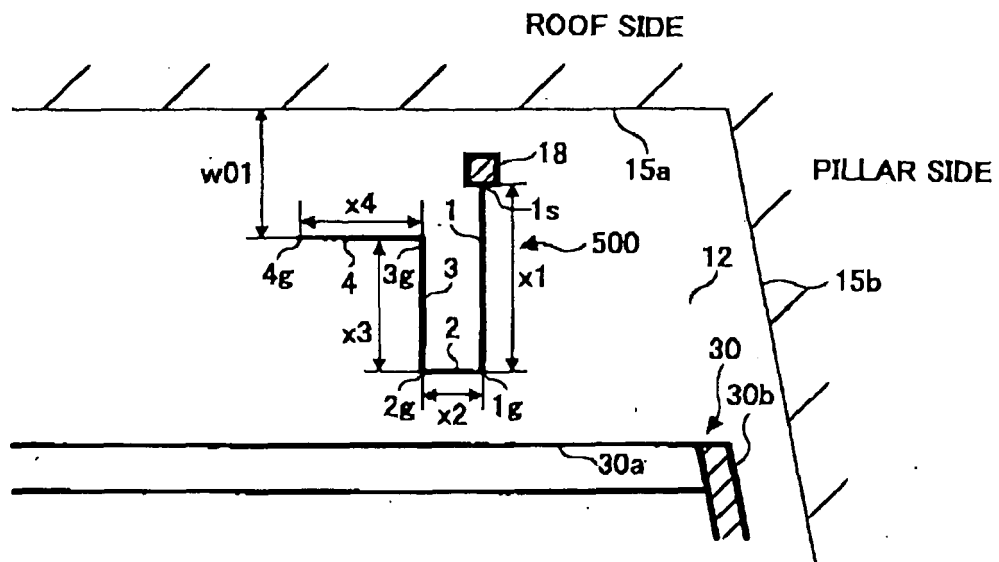
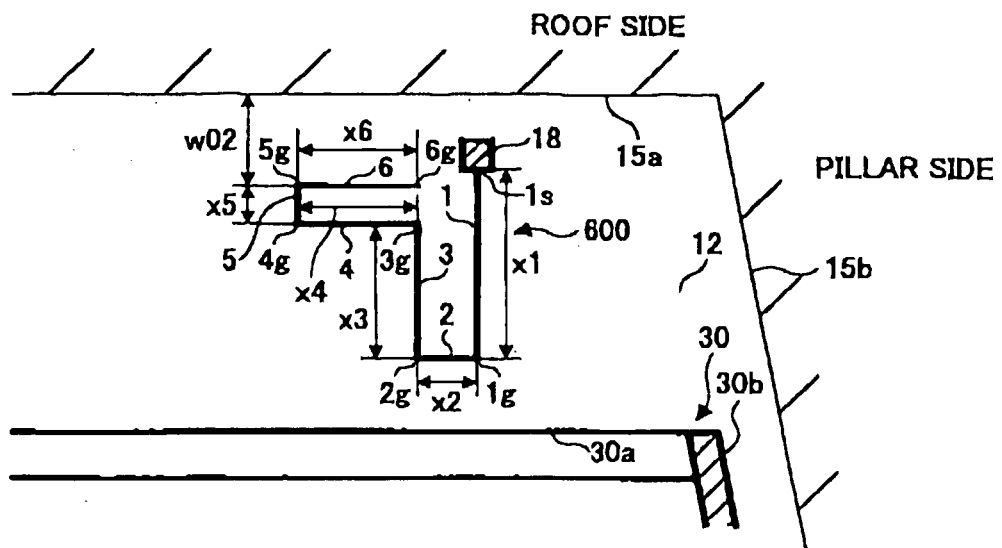


FIG. 20





EUROPEAN SEARCH REPORT

Application Number
EP 09 01 4495

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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			H01Q
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 24 February 2010	Examiner Moumen, Abderrahim
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