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(54) ELONGATED ANTENNA

(57) An elongated shape antenna has a base material, a feeder element and a non-driven element. The base material has an elongated shape, and has different permittivity at its outer circumferential part and its center part. The feeder element contacts at least the outer circumferential part of the first base material, and is arranged along the shape of the outer circumferential part. The non-driven element is arranged adjacent to the feeder elements. Thus, the feeder element is arranged outside the center part of the base material. When the feeder element is arranged a long the outer circumferential part of the base material of the elongated shape, the feeding point and the tip part of the feeder elements are positioned close to each other, and the electromagnetic coupling possibly occur between them. However, since the center part of the base material is preferably hollowed and its permittivity is smaller than that of the outer circumferential part, such electromagnetic coupling can be suppressed.

FIG. 1A

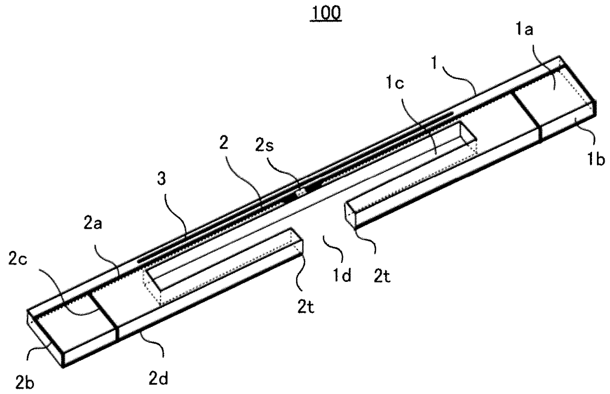

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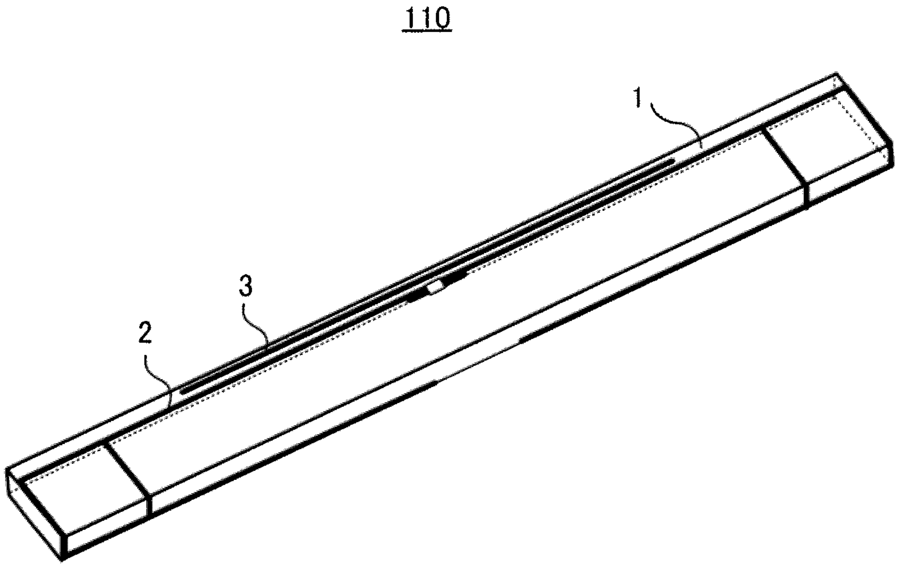
FIG. 1B



Description

TECHNICAL FIELD

[0001] The present invention relates to a small antenna.

BACKGROUND TECHNIQUE

[0002] At present, as an antenna for receiving the terrestrial digital broadcasting on a vehicle, a film antenna is generally used.

[0003] However, it is quite difficult to change the film antenna once it is stuck. Therefore, the user or the operator of the car goods shop needs excessive caution in the sticking work. In addition, the working time becomes long. Thus, the film antenna is not easy to handle.

[0004] further, the film antenna once peeled off is hardly reused and is therefore scrapped. In view of the protection of the environment, it is not preferable nature that it must be scrapped if sticking it is failed.

[0005] Examples of small antenna used for a mobile phone and the like are disclosed in Patent References 1 and 2.

[0006]

Patent Reference 1:
Japanese Patent Application Laid-open under No. 2002-217628
Patent Reference 2:
Japanese Patent Application Laid-open under No. 2005-303637

DISCLOSURE OF INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0007] The above is one of the problem to be solved by the present invention. It is an object of the present invention to provide a non-film type small antenna which is small enough not to be conspicuous when attached on a vehicle and which has a broad receiving band covering the frequency band of the terrestrial digital broadcasting.

MEANS FOR SOLVING THE PROBLEM

[0008] The elongated shape antenna according to the invention of claim 1 includes: a first base material which has an elongated shape and which has different permittivity at its outer circumferential part and its center part; a feeder element which contacts at least a part of the outer circumferential part of the first base material and which is arranged along the shape of the outer circumferential part; and a non-driven element which is arranged adjacent to the feeder element.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

FIGS. 1A and 1B are perspective views of antennas of a first embodiment and a comparative example.
FIGS. 2A and 2B show impedance characteristics of the antennas of the first embodiment and the comparative example.
FIGS. 3A and 3B show VSWR characteristics of the antennas of the first embodiment and the comparative example.
FIGS. 4A to 4C are perspective views of the antennas of modified examples of the first embodiment.
FIG. 5 is a perspective view of the antenna of a modified example of the first embodiment.
FIGS. 6A to 6C are perspective views of the antennas of a second embodiment and the comparative example.
FIGS. 7A and 7B show impedance characteristics of the antennas of the second embodiment and the comparative example.
FIGS. 8A and 8B show VSWR characteristics of the antennas of the second embodiment and the comparative example.
FIGS. 9A and 9B are perspective views of an antenna of a third embodiment.
FIGS. 10A and 10B show impedance characteristics of the antennas of the third embodiment and the second embodiment.
FIGS. 11A and 11B show VSWR characteristics of the antennas of the third embodiment and the second embodiment.
FIGS. 12A and 12B are perspective views of an antenna of a modified example of the third embodiment.
FIGS. 13A to 13C examples of the shape of dielectric base in the third embodiment.

DESCRIPTON OF REFERENCE NUMBERS

[0010]

1, 11, 24 Base Material
2, 12, 22 Feeder Element
3, 13, 23 Non-driven Element
7 Resin Case
8 Dielectric Material
21 Base Plate
27, 28 Amplifier Circuit
100, 200, 300 Antenna

MOST PREFERRED FORM TO EXERCISE THE INVENTION

[0011] According to one preferred aspect of the invention, an elongated shape antenna includes: a first base material which has an elongated shape and which has different permittivity at its outer circumferential part and its center part; a feeder element which contacts at least a part of the outer circumferential part of the first base material and which is arranged along the shape of the outer circumferential part; and a non-driven element which is arranged adjacent to the feeder element.

[0012] In the above antenna, the first base material is formed by dielectric such as ceramic, and has different permittivity at its outer circumferential part and its center part. The feeder element contacts at least a part of the outer circumferential part and is arranged along the shape of the outer circumferential part. The non-driven element is arranged adjacent to the feeder element. The feeder element is arranged on the circumferential part of the basematerial, i.e., outside of the center part of the base material. When the feeder element is arranged along the circumferential part of the material of the elongated shape, the feeding point and the tip parts of the feeder element approach and the electromagnetic coupling possibly occur between them. However, in the above antenna, the center part of the base material, intervening between the feeding point and the feeder element has permittivity different from the permittivity of the outer circumferential part, and therefore such electromagnetic coupling can be suppressed.

[0013] Preferably, the permittivity of the center part of the base material is smaller than the permittivity of the outer circumferential part. In a preferred example, the center part of the first base material is hollowed. Therefore, since air intervenes in the center part, the electromagnetic coupling between the feeding point and the tip parts of the feeder element can be suppressed. In a preferred example, the first base material has a slot-shaped plane shape in which only the center part is hollowed. In another preferred example, the first base material has a C-shaped plane shape in which a part of the outer circumferential part positioned at a center in a longitudinal direction of the first base material is cut.

[0014] In one mode of the above elongated shape antenna, a width of a part of the feeder element in contact with the outer circumferential part in a lateral direction of the first material is larger than a width of a part of the feeder element in contact with the outer circumferential part in a longitudinal direction of the first base material. When the plural parts constituting the feeder element are formed to have dif ferent widths, the impedance characteristic can be adjusted to be a desired characteristic.

[0015] In another mode of the above elongated shape antenna, a part of the feeder element in contact with the outer circumferential part in the lateral direction of the first base material is branched into plural parts. By appropriately setting the interval between the branched parts of the feeder element, the impedance characteristic can be adjusted to be a desired characteristic.

[0016] Still another mode of the above elongate shape antenna further includes a second base material having permittivity lower than the permittivity of the outer circumferential part of the first material, and the feeder element and the non-driven element are formed on the second base material. In this mode, the feeder element and the non-driven element are formed on the second base material, and the base material of dielectric is arranged on them. The manufacturing cost increases when the feeder element and the non-driven element are formed on the base material of dielectric. By forming the feeder element and the non-driven element on the second base material, the manufacturing cost can be reduced.

[0017] In still another mode of the above elongated shape antenna, a feeding point of the feeder element and two ends of the feeder elements are arranged to confront each other near a center position in the longitudinal direction of the first base material. In this case, the electromagnetic coupling easily occurs particularly between the feeding point and two ends of the feeder element. However, since the permittivity of the center part of the base material is different from that of the outer circumferential part, such coupling can be effectively suppressed.

[0018] In a preferred example of the above elongated shape antenna, the feeder element is in contact with the first base material at the area other than two ends of the feeder element and the feeding point.

[0019] In a preferred example, the above elongated shape antenna is enclosed by a resin case. By this, corrosion of the conductor part of the feeder element and the non-driven element can be prevented.

[0020] In another preferred example, the above elongated shape antenna is arranged adjacent to dielectric having an area broader than the area of the first base material. Thus, the resonance frequency of the antenna can be lowered, and the antenna can be downsized by that amount.

EMBODIMENT

[0021] Preferred embodiments of the present invention will be described below with reference to the attached drawings.

[1st Embodiment]

[0022] FIG. 1A is a perspective view of an antenna according so the first embodiment. The antenna 100 includes a base material 1 of an elongated shape, a feeder element 2 and a non-driven element 3. The size, such as the length and the width of the feeder element 2 and the non-driven element 3 as well as the length, the width and the thickness of the base material 1, is determined to satisfactorily receive the terrestrial digital broadcasting.

[0023] The base material 1 has an elongated shape (plate-shape, stick-shape), and is formed by a dielectric such as ceramic. In this embodiment, the permittivity of the base material 1 is approximately 20, the length of the base material 1 is approximately 100 to 150, and the thickness of the base material 1 is approximately 3 to 5 mm.

[0024] The center part of the base material 1 is hollowed in the rectangular shape to form the hollowed part 1c. The substantial center of the base material 1 in the longitudinal direction is cut out to form the space 1d. As a result, the base material 1 has a C-shaped plane shape. In this embodiment, the hollowed part 1 corresponds to "the center part" of the base material in the present invention, and the part of the base material 1 at the outer circumference of the hollowed part 1c corresponds to "the outer circumferential part" of the base material.

[0025] The feeder element 2 is an element electrically driven from outside, and is formed by bending a linear element plural times and arranging it along the outer circumferential part of the base material 1. The feeder element 2 has a feeding point 2s at the center in the longitudinal direction of the base material 1. The signal received by the antenna 100 is outputted from the feeding point 2s. The feeder element 2 has linear parts 2a, 2b, 2c and 2d. The linear parts 2a extend, on the upper surface 1a of the base material 1, from the feeding point 2s to both ends in the longitudinal direction of the base material 1. The linear parts 2b extend along both ends of the base material 1 in the lateral direction of the base material 1, and further extend on the lateral surface 1b of the base material 1 two the bottom surface side. The linear parts 2c are provided inside of the ends of the base materials 1 in the longitudinal direction and substantially in parallel with the linear part 2b. The linear parts 2d extends on the lateral surface 1b of the base material 1 along the bottom surface to the center of the base material 1. In this way, the feeder element 2 is arranged to enclose the hollowed part 1c. Two tip parts 2t of the feeder element 2 are arranged to confront the feeding point 2s, over the hollowed part 1c, in the vicinity of the center of the base material 1 in its longitudinal direction.

[0026] While the linear parts 2b and 2c of the feeder element 2 are formed in the branched manner between the linear parts 2a and 2d, by adjusting the interval between the linear parts 2b and 2c, it is possible to obtain the same effect as the case of increasing the width of a single linear part.

[0027] The non-driven element 3 is a linear element and is provided on the upper surface 1a of the base material 1. The non-driven element 3 is arranged near the linear part 2a of the feeder element 2 substantially in parallel with the linear part 2a. Thenon-driven element 3 has a role of creating the antenna characteristic of two resonance state and broadening the frequency band capable of transmitting and receiving, when it is arranged near the feeder element 2.

[0028] The antenna 100 of the embodiment is formed by the feeder element 2 electrically driven from outside and the non-driven element 3 arranged near the feeder element 2. By appropriately adjusting the total length of the feeder element 2 and the non-driven element 3, two resonance characteristic is created within the desired operation frequency band. The pattern of the feeder element 2 is formed by bending a linear element plural times in accordance with the shape of the base material 1. By this, the length of the feeder element 2 in the longitudinal direction can be short, and the whole antenna 100 can be small.

[0029] In the case that the feeder element 2 is arranged on the elongated base material 1 in accordance with the outer circumferential shape of the base material 1 like this embodiment, since the feeding point 2s and the tip parts 2t of the feeder element 2 are positioned close to each other, there is such a problem that the electromagnetic coupling occurs between the feeding point 2s and the tip parts 2t, thereby deteriorating the characteristic of the antenna. Therefore, in the present invention, in order to suppress the electromagnetic coupling between the feeding point 2s and the tip parts 2t of the feeder element 2, the center part of the elongated-shaped base material 1 is hollowed to provide the hollowed part 1c. Since air intervenes between the feeding point 2s and the tip parts 2t of the feeder element 2, their electromagnetic coupling can be weakened. As a result, the deterioration of the characteristics at the intermediate area of two resonances can be suppressed, and the antenna having a stable characteristic can be realized.

[0030] This point will be described below in comparison with a comparative example. FIG. 1B is a perspective view of an antenna 110 according to a comparative example. The antenna 110 of the comparative example has the same configuration as the antenna 100, except that the hollowed part 1c is not provided.

[0031] FIG. 2A shows the impedance characteristic of the antenna 100 of the first embodiment of the invention, and FIG. 2B shows the impedance characteristic of the antenna 110 of the comparative example. The horizontal axis shows the frequency, and the vertical axis shows the impedance. In FIGS. 2A and 2B, the graph Re shows the real component of the impedance, and the graph Im shows the imaginary component of the impedance. As is understood by comparing FIGS. 2A and 2B, the maximum value of the real component Re is smaller and the variation of the imaginary component is smaller in the antenna 100. Namely, the antenna 100 of the first embodiment has smaller variation of the impedance characteristic and is stable.

[0032] FIG. 3A shows the VSWR (Voltage Standing Wave Ratio) of the antenna 100 of the first embodiment, and FIG. 3B shows the VSWR of the antenna 110 of the comparative example. Since the antenna 100 of the first embodiment has smaller variation of impedance characteristic, the variation of the VSWR in a desired frequency band becomes smaller. Particularly, it is understood that the deterioration of the characteristic between two resonance points is suppressed. By this, the received electric power does not have a large difference even if the signal receiving frequency band varies, and there is such an advantage that the signal receiving level becomes flat.

[0033] While the antenna 100 shown in FIG. 1A has the C-shaped plane shape, it can be formed to have a slot-like plane shape by providing the base material 1 with only the hollowed part 1c like the antenna 100a shown in FIG. 4A. Also in this case, the hollowed part 1c has an effect of suppressing the electromagnetic coupling between the feeding point 2s and the tip parts 2t of the feeder element 2.

[0034] Like the antenna 100b shown in FIG. 4B, the non-driven element 3 may be provided inside of the feeder element 2, i.e., on the side of the hollowed part 1c. While FIG. 4B shows the example of the slot-shaped antenna, the non-driven element 3 may be provided inside of the feeder element 2 in the C-shaped antenna 100 shown in FIG. 1A.

[0035] As shown in FIG. 4C, when the antenna 100 is enclosed by a resin case 7, it is possible prevent that the user directly touch the conductor part constituting the element. Thus, corrosion of the element by rust can be prevented. The antennas 100a, 100b may be enclosed by the resin case in the same manner.

[0036] In addition, as shown in FIG. 5, when the antenna 100 is arranged close to a dielectric material 8 having relatively large area than the size of the antenna 100, the resonance frequency can be lowered in comparison with the case in which the antenna 100 is mounted by itself (i.e., the case in which the antenna 100 is covered by air). By this, the antenna can be further downsized. The same is true of the antennas 100a, 100b. At this time, the antenna may be enclosed by the resin case 7, but it is not indispensable. As the dielectric material 8, the front glass or the dashboard of the vehicle can used in case of the antenna to be mounted on vehicle.

[2nd Embodiment]

[0037] FIG. 6A is a perspective view of the antenna according to the second embodiment. The antenna 200 includes a base material 11 of an elongated shape, a feeder element 12 and a non-driven element 13. The size, such as the length and the width of the feeder element 12 and the non-driven element 13 as well as the length, the width and the thickness of the base material 11, is determined to satisfactorily receive the terrestrial digital broadcasting.

[0038] The base material 11 has an elongated shape, and is formed by a dielectric such as ceramic. In this embodiment, the permittivity of the base material 11 is approximately 20, the length of the base material 11 is approximately 100 to 150, and the thickness of the base material 11 is approximately 3 to 5 mm.

[0039] The center of the base material 11 is hollowed in the rectangular shape to form the hollowed part 11c. As a result, the basematerial 11 has a slot-like plane shape. In this embodiment, the hollowed part 11c corresponds to "the center part" of the base material in the present invention, and the part of the base material 11 at the outer circumference of the hollowed part 11c corresponds to "the outer circumferential part" of the base material.

[0040] The feeder element 12 is formed by bending a linear element plural times and arranging it along the outer circumferential part of the base material 11. The feeder element 12 has a feeding point 12s at the center of the base material 11 in the longitudinal direction. The feeder element 12 has linear parts 12a, 12b, 12c and 12d provided on the upper surface 11a of the base material 11. The linear parts 12a extend from the feeding point 12s to the vicinity of both ends of the hollowed part 11c in the longitudinal direction of the base material 11. The linear parts 12b extend along the outer circumference of the base material 11 to the ends of the base material 11 in the longitudinal direction thereof. The linear parts 12c extend in the lateral direction of the base material 11 at both ends of the base material 11 in the longitudinal direction. The linear parts 12d extend from the end of the base material 11 to the center thereof in the longitudinal direction. In this way, the feeder element 12 is arranged to enclose the hollowed part 11c. In the second embodiment, in comparison with the first embodiment, since the feeder element 12 is formed only on the upper surface 11a of the base material 11 and is not formed on the lateral surfaces, forming the feeder element 12 is easy and the manufacturing cost can be reduced.

[0041] The non-driven element 13 is a linear element and is provided on the upper surface 11a of the base material 1. The non-driven element 13 is arranged near the linear part 12a of the feeder element 12 substantially in parallel with the linear part 12a. The non-driven element 3 has a role of creating the antenna characteristic of two resonance state and broadening the frequency band capable of transmitting and receiving, when it is arranged near the feeder element 2.

[0042] Also in the second embodiment, in order to suppress the electromagnetic coupling between the feeding point 12s and the tip parts 12t of the feeder element 12, the center part of the elongated-shaped base material 11 is hollowed to provide the hollowed part 11c. Since air intervenes between the feeding point 12s and the tip parts 12t of the feeder element 12, their electromagnetic coupling can be weakened. As a result, the deterioration of the characteristics at the intermediate area of two resonances can be suppressed, and the antenna having a stable characteristic can be realized.

[0043] This point will be described below in comparison with a comparative example. As shown in FIG. 6C, the antenna 210 of the comparative example has the same configuration as the antenna 200, except that the hollowed part 11c is not provided. It is noted that the following characteristics are obtained in the case that the antennas 200 and 210 are enclosed by the resin case 7 and are further arranged close to the dielectric material 8 having relatively broad area as shown in FIG. 5.

[0044] FIG. 7A shows the impedance characteristic of the antenna 200 of the second embodiment of the invention, and FIG. 7B shows the impedance characteristic of the antenna 210 of the comparative example. The horizontal axis shows the frequency, and the vertical axis shows the impedance. In FIGS. 7A and 7B, the graph

Re shows the real component of the impedance, and the graph Im shows the imaginary component of the impedance. As is understood by comparing FIGS. 7A and 7B, the maximum value of the real component Re is smaller and the variation of the imaginary component is smaller in the antenna 200. Namely, the antenna 200 of the second embodiment has smaller variation of the impedance characteristic and is stable.

[0045] FIG. 8A shows the VSWR of the antenna 200 of the second embodiment, and FIG. 8B shows the VSWR of the antenna 210 of the comparative example. Since the antenna 200 of the second embodiment has smaller variation of impedance characteristic, the variation of the VSWR in a desired frequency band becomes smaller. Particularly, it is understood that the deterioration of the characteristic between two resonance points is suppressed. By this, the received electric power does not have a large difference even if the signal receiving frequency band varies, and there is such an advantage that the signal receiving level becomes flat.

[0046] Further, in the second embodiment, as shown in FIG. 6A, by making the widths of the linear parts 12a to 12d constituting the feeder element 12 different from each other, the deterioration of the characteristic between two resonance points is suppressed.

[0047] Also in the second embodiment, similarly to the antenna 100b shown in FIG. 4B, the non-driven element 13 may be provided inside of the feeder element 12, i.e., on the side of the hollowed part 11c. While the antenna 200 is an example of the slot-shaped antenna, the base material 11 may be formed to have the C-shaped plane shape like the antenna 100 shown in FIG. 1.

[0048] As shown in FIG. 6B, when the antenna 200 is enclosed by the resin caste 7, it is possible prevent that the user directly touch the conductor part constituting the element. Thus, corrosion of the element by rust can be prevented.

[0049] In addition, like the example shown in FIG. 5, when the antenna 200 is arranged close to the dielectric material 8 having relatively large area than the size of the antenna 200, the resonance frequency can be lowered in comparison with the case in which the antenna 200 is mounted by itself. By this, the antenna can be further downsized. At this time, the antenna may be enclosed by the resin case 7, but it is not indispensable.

[3rd Embodiment]

[0050] FIG. 9A is a perspective view of the antenna according to the third embodiment, and FIG. 9B is an exploded perspective view thereof. The antenna 300 includes a base plate 21 of an elongated shape, a feeder element 22, a non-driven element 23 and a base material 24 of an elongated shape. The external size of the base plate 21 and the base material 24 are substantially identical. The size, such as the length and the width of the feeder element 22 and the non-driven element 23 as well as the length, the width and the thickness of the base plate 21 and the base material 24, is determined to satisfactorily receive the terrestrial digital broadcasting.

[0051] The base plate 21 is a base plate of low permittivity, and one example is a FR4 printed wiring board used for the pattern wiring of an electronic circuit. As shown in FIG. 9B, the feeder element 22 and the non-driven element 23 are formed on the base plate 21. No hollowed part is formed on the base plate 21.

[0052] The feeder element 22 is formed by bending a linear element plural times and arranging it along the outer circumferential part of the base plate 21. The feeder element 22 has a feeding point 22s at the center of the base plate 21 in the longitudinal direction. The feeder element 22 has linear parts 22a, 22b and 22c provided on the upper surface of the base plate 21. The linear parts 22a extend from the feeding point 22s to both ends of the base plate 21 in the longitudinal direction of the plate 21. The linear parts 22b extend in the lateral direction of the base plate 21 at the ends of the base plate 21 along the outer circumference of the base plate 21. The linear part 22c extends from both ends in the longitudinal direction of the base plate 21 toward the center thereof.

[0053] The non-driven element 23 is a linear element and is provided on the upper surface of the base plate 21. The non-driven element 23 is arranged near the linear part 22a of the feeder element 22 substantially in parallel with the linear part 22a.

[0054] The base material 24 has an elongate shape, and is formed by a dielectric such as alumina. The base material 24 is arranged on the surface of the base plate 21 on which the feeder element 22 and the non-driven element 23 are formed, and functions as a dielectric cover. The permittivity of the base material 24 is larger than the permittivity of the base plate 21. For example, the relative permittivity of the base plate 21 using the FR4 printed wiring board is approximately 4 to 5, whereas the relative permittivity of the base material 24 is approximately 8 to 10. Also, in this embodiment, the length of the base plate 21 and the base material 24 is approximately 100 to 150 mm, the thickness of the base plate 21 is approximately 1 mm, and the thickness of the base material 24 is approximately 2 mm.

[0055] The center of the base material 24 is hollowed in the rectangular shape to form the hollowed part 24c. As a result, the base material 24 has a slot-like plane shape. In this embodiment, the hollowed part 24c corresponds to "the center part" of the base material, and the part of the material 24 at the outer circumference of the hollowed part 24c corresponds to "the outer circumferential part".

[0056] In this embodiment, the patterns of the feeder element 22 and the non-driven element 23 formed, not on the base material 24 of dielectric, but on the base plate 21 such as a high frequency circuit board of low cost, and the dielectric base material 24 formed with element is arranged on the base plate 21. Since forming the element on the base plate 21 requires lower cost than forming the element on the dielectric base material, the manufacturing cost of the antenna can be reduced.

[0057] Also in the third embodiment, in order to suppress the electromagnetic coupling between the feeding point 22s and the tip parts 22t of the feeder element 22, the center part of the elongated-shaped base material 24 is hollowed to provide the hollowed part 24c. By this, the electromagnetic coupling between the feeding point 22s and the tip parts 22t of the feeder element 22 can be weakened. As a result, the deterioration of the characteristics at the intermediate area of two resonances can be suppressed, and the antenna having a stable characteristic can be realized. In comparison with the first and the second embodiments, since no hollowed part is formed on the base material 21, the base material 21 exists between the feeding point 22s and the tip parts 22t of the feeder element 22. However, since the permittivity of the base plate 21 is sufficiently lower than the permittivity of the base material 24, it is possible to obtain the effect of suppressing the electromagnetic coupling between the feeding point 22s and the tip parts 22t of the feeder element 22 even if the base plate 21 exists.

[0058] The relative permittivity of the FR4 printed circuit board used as the base plate 21 is approximately 4.5, and the electromagnetic coupling may occur if the received signal frequency is a high frequency of approximately several GHz. However, this embodiment intends the reception of the terrestrial digital broadcasting, and the electromagnetic coupling hardly occurs for the signal in the frequency range of the terrestrial digital broadcasting in the case of the relative permittivity of this base plate 21. Therefore, it is not necessary to form the hollowed part on the base plate 21.

[0059] The characteristic of the antenna according to the third embodiment will be described below. It is noted that the following characteristics are obtained in the case that the antenna 300 is enclosed by the resin case 7 and is further arranged close to the dielectric material 8 having relatively broad area as shown in FIG. 5.

[0060] FIG. 10A shows the impedance characteristic of the antenna 300 of the third embodiment of the invention. As a reference, FIG. 10B shows the impedance characteristic of the antenna of the second embodiment of the present invention. The horizontal axis shows the frequency, and the vertical axis shows the impedance. In FIGS. 10A and 10B, the graph Re shows the real component of the impedance, and the graph Im shows the imaginary component of the impedance. As shown in FIGS. 10A and 10B, the maximum value of the real component Re is smaller and the variation of the imaginary component is smaller in the antenna 300.

[0061] FIG. 11A shows the VSWR of the antenna 300 of the third embodiment. As a reference, FIG. 10B shows the VSWR of the antenna 200 of the second embodiment. Both show the stable characteristic having two resonances within the frequency range of the terrestrial digital broadcasting.

[0062] In the third embodiment, as shown in FIGS. 9A and 9B, by making the widths of the linear parts 22a to 22c constituting the feeder element 22 different from each other, the deterioration of the characteristic between two resonance points is suppressed.

[0063] In the third embodiment, similarly to the antenna 100b shown in FIG. 4B, the non-driven element 23 may be provided inside of the feeder element 22, i.e., on the side of the hollowed part 24c. While the antenna 300 is an example of the slot-shaped antenna, the base material 24 may be formed as the C-shaped plane shape like the antenna 100 shown in FIG. 1.

[0064] As shown in FIG. 6B, when the antenna 300 is enclosed by the resin case 7, it is possible prevent that the user directly touch the conductor part constituting the element. Thus, corrosion of the element by rust can be prevented.

[0065] In addition, like the example shown in FIG. 5, when the antenna 300 is arranged close to a dielectric material 8 having relatively large area than the size of the antenna 300, the resonance frequency can be lowered in comparison with the case in which the antenna is mounted by itself (i.e., the case in which the antenna is covered by air). By this, the antenna can be further downsized. At this time, the antenna may be enclosed by the resin case 7, but it is not indispensable.

[0066] Further, in the third embodiment, as shown in FIG. 12A, an amplifier circuit 27 may be mounted inside the hollowed part 24c of the base material 24. By this, the entire thickness of the antenna 300 including the amplifier circuit 27 can be thin. In the example of FIG. 12A, the signal received by the elements 22 and 23 of the antenna 300 and outputted by the feeding point 22s is amplified by the amplifier circuit 27 to be supplied to the external circuit via the cable 27a.

[0067] Further, in another example, as shown in FIG. 12B, an amplifier circuit 28 may be formed on the base plate 21. Namely, the feeder element 22, the non-driven element 23 and the amplifier circuit 28 are formed on the base plate 21, and then the base material 24 of dielectric is mounted on the base plate 21. By this, the electronic parts included in the amplifier circuit 28 are placed inside the hollowed part 24c of the base material 24, and hence the thickness of the antenna 300 itself, including the amplifier circuit 28, can be thin.

[0068] FIGS. 13A to 13C show modified examples of the dielectric base material 24. It is sufficient that the base material 24 covers the position, on the pattern of the feeder element 22 formed on the base plate 21, where the wavelength shrinkage effect can be effectively obtained. The position where the wavelength shrinkage effect can be effectively obtained is the part where the electromagnetic coupling between the patterns is strong, and such a part should be covered. This position is determined by a simulation or an experiment. For example, the vicinity of the ends of the feeder element and the vicinity of the feeding point are not necessarily needed to be covered. Therefore, other than the slot-shape shown in FIG. 12B, the base material 24 may be the C-shape shown in FIG. 13A, the recess-shape shown in

FIG. 13B and the divided-recess-shape shown in FIG. 13C.

[Modified Example]

[0069] In the above-described embodiments, the dielectric base materials 1, 11 and 24 have the rectangular plane shape, but the present invention is not limited to this example. The base material may have an ellipse plane shape or a diamond plane shape if it has an elongated shape in which the length in one direction is sufficiently longer than the length in the perpendicular direction.

[0070] In the above-described embodiments, the inside of the hollowed part 1c, 11c, 24c of the base materials 1, 11, 24 is a space in which air exists. Instead, inside the hollowed parts 1c, 11c, 24c, a dielectric having the permittivity sufficiently lower than the permittivity of the base materials 1, 11, 24 may be arranged.

[0071] In the above-described embodiment, all part of the feeder elements 2, 12, 22 contacts the dielectric base materials 1, 11, 24. However, this is not indispensable. It is sufficient that the dielectric base material covers the part on the feeder element where the wavelength shrinkage effect is obtained. Therefore, a part of the feeder element may be arranged in a manner out of contact with the dielectric base material.

[0072] In the above embodiments, the feeder elements 2, 12, 22 has the linear shape, but the present invention is not limited to this example. For example, the feeder element may have a zigzag shape or a meander shape.

[0073] In the above embodiments, the dielectric base materials 1, 11, 24 has the rectangular parallelopiped shape. However, the present invention in not limited to this. The base material may have an ellipse plane shape or a diamond plane shape. In that case, the feeder element may be arranged along its circumference of the shape, and may be arranged in a rectangular shape.

INDUSTRIAL APPLICABILITY

[0074] This invention can be used for a signal receiving antenna for the terrestrial digital broadcasting to be loaded on a vehicle. Also, this invention can be used for a signal receiving antenna for the terrestrial digital broadcasting to be installed on a small portable equipment such as a portable TV and a portable game machine.

Claims

1. An elongated shape antenna comprising:

   a first material which has an elongated shape and which has different permittivity at its outer circumferential part and its center part;
   a feeder element which contacts at least a part of the outer circumferential part of the first base material and which is arranged along the shape of the outer circumferential part; and
   a non-driven element which is arranged adjacent to the feeder element.

2. The elongated shape antenna according to claim 1, wherein the center part of the first base material is hollowed.

3. The elongated shape antenna according to claim 2, wherein the first base material has a C-shaped plane shape in which a part of the outer circumferential part positioned at a center in a longitudinal direction of the first base material is cut.

4. The elongated shape antenna according to any one of claims 1 to 3, wherein a width of a part of the feeder element in contact with the outer circumferential part in a lateral direction of the first material is larger than a width of a part of the feeder element in contact with the outer circumferential part in a longitudinal direction of the first base material.

5. The elongated shape antenna according to any one of claims 1 to 4, wherein a part of the feeder element in contact with the outer circumferential part in the lateral direction of the first base material is branched into plural parts.

6. The elongate shape antenna according to any one of claims 1 to 5, further comprises a second base material having permittivity lower than the permittivity of the outer circumferential part of the first material,
   wherein the feeder element and the non-driven element are formed on the second base material.

7. The elongated shape antenna according to any one of claim 1 to 6, wherein a feeding point of the feeder element and two ends of the feeder elements are arranged to confront each other near a center position in the longitudinal direction of the second base material.

8. The elongated shape antenna according to any one of claims 1 to 7, wherein the feeder element is in contact with the first base material at the area other than two ends of the feeder element and the feeding point.

9. The elongated shape antenna according to any one of claims 1 to 8, which is enclosed by a resin case.

10. The elongated shape antenna according to any one of claims 1 to 9, which is arranged adjacent to a dielectric having an area broader than the area of the first base material.

FIG. 1A

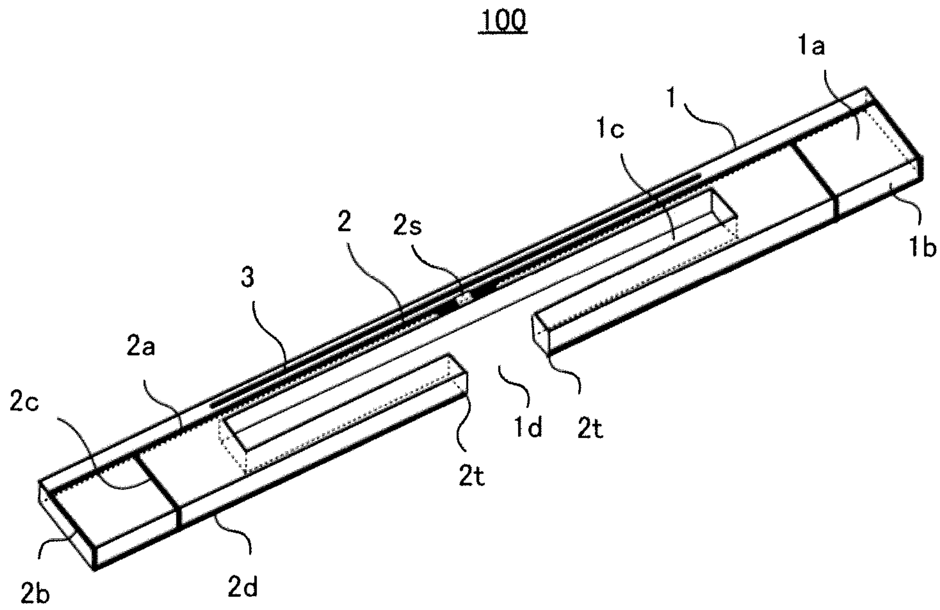


FIG. 1B

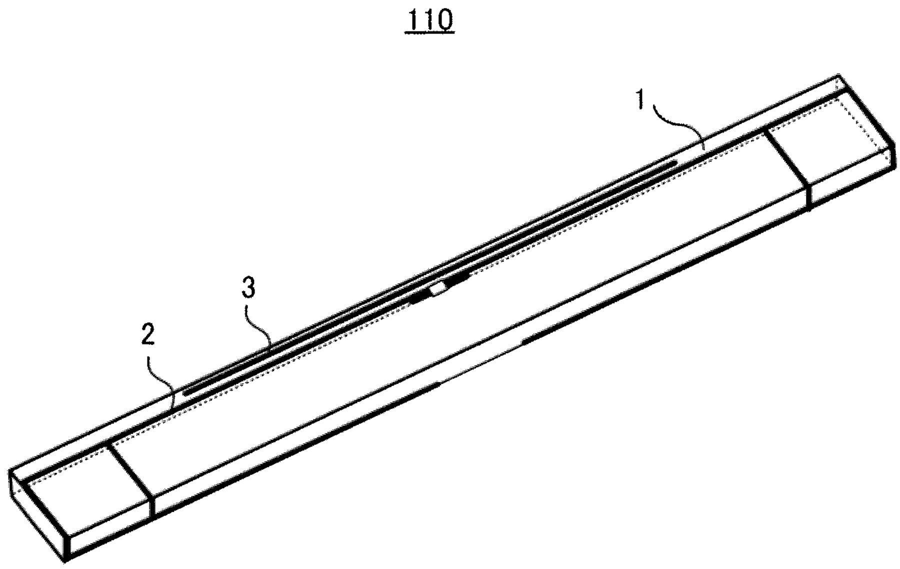


FIG. 2A

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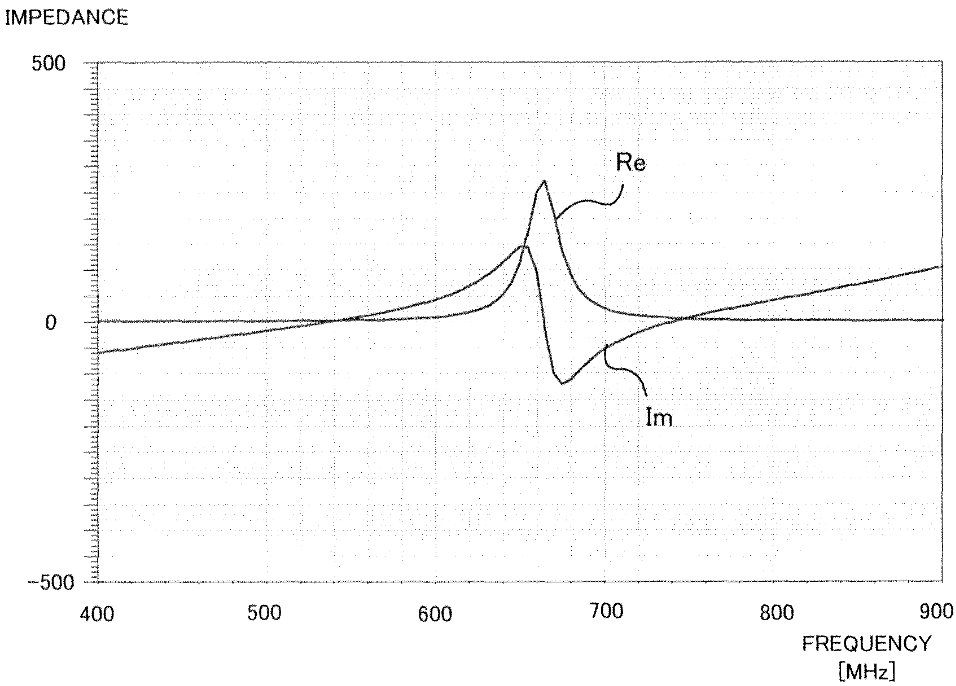


FIG. 2B

<COMPARATIVE EXAMPLE>

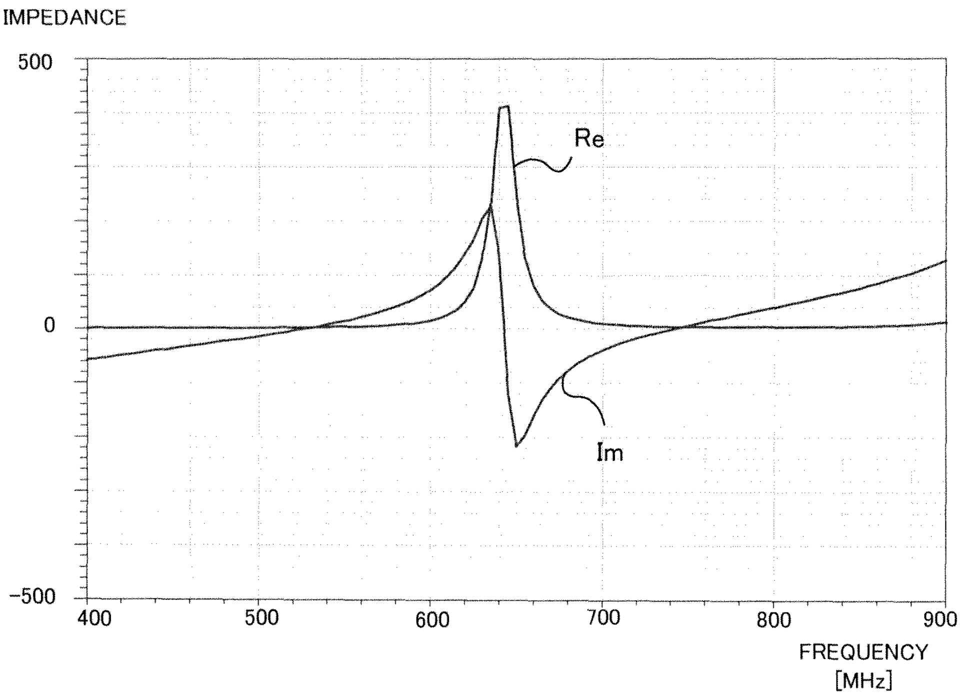
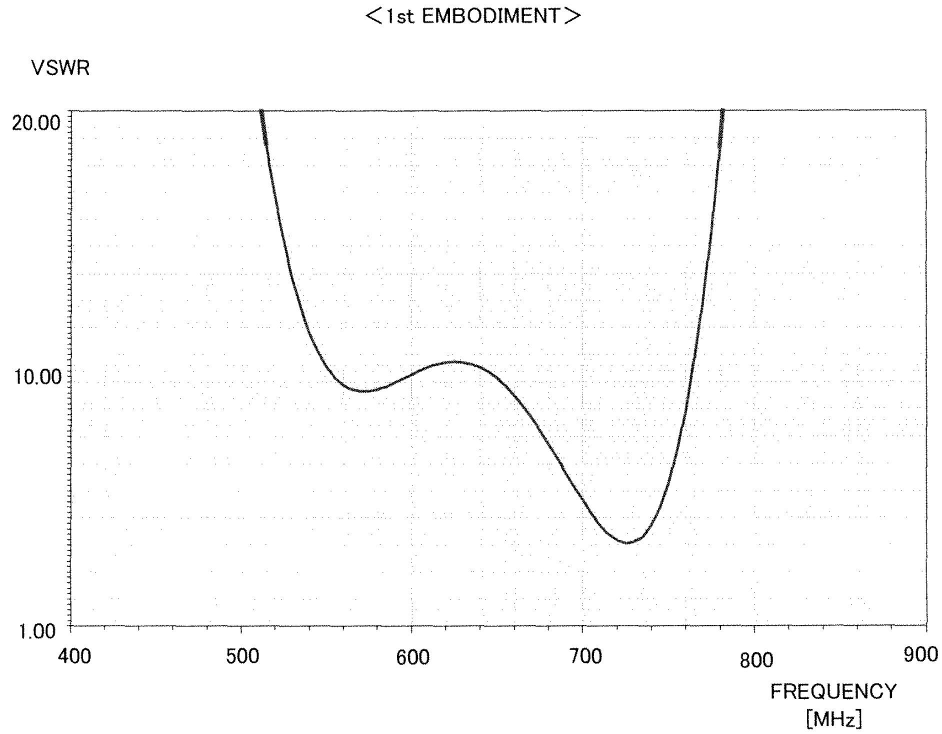


FIG. 3A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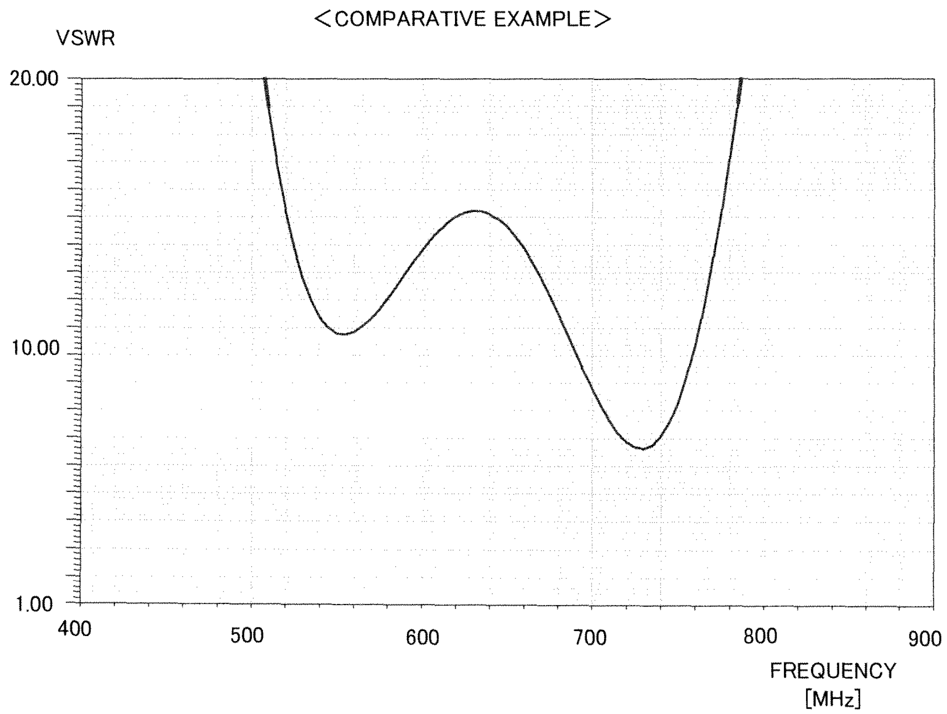
800
900
FREQUENCY
[MHz]

FIG. 3B


<COMPARATIVE EXAMPLE>
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400
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600
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FREQUENCY
[MHz]

FIG. 4A

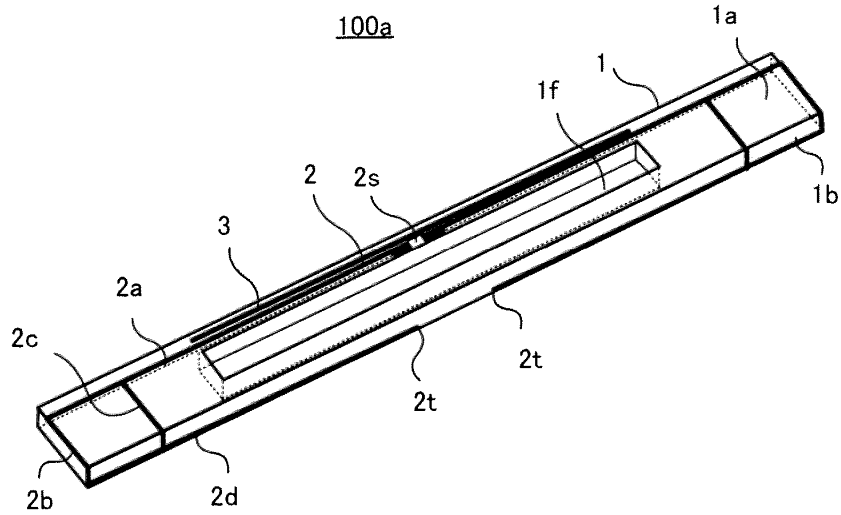


FIG. 4B

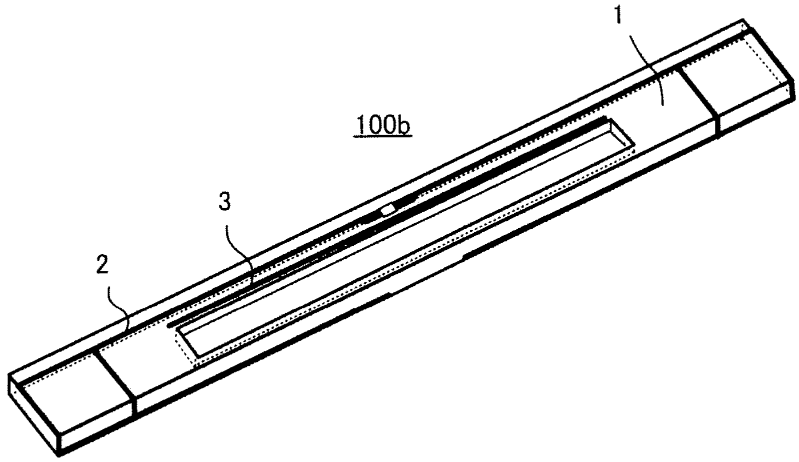


FIG. 4C

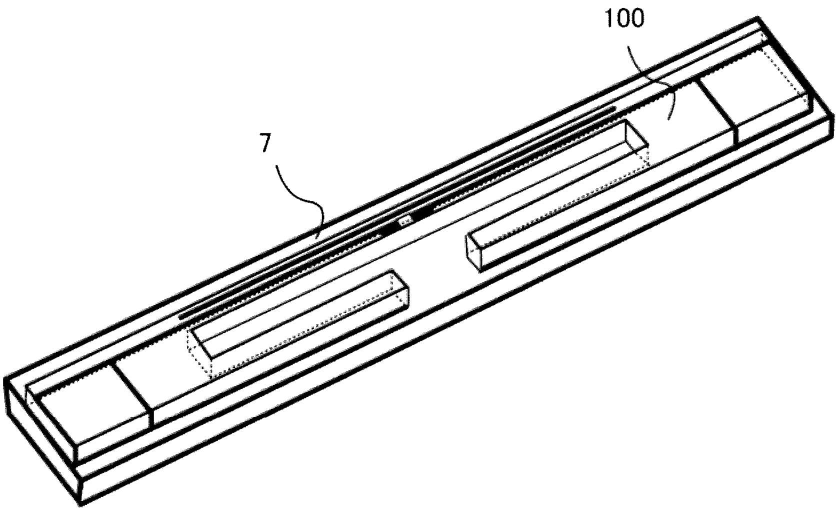


FIG. 5

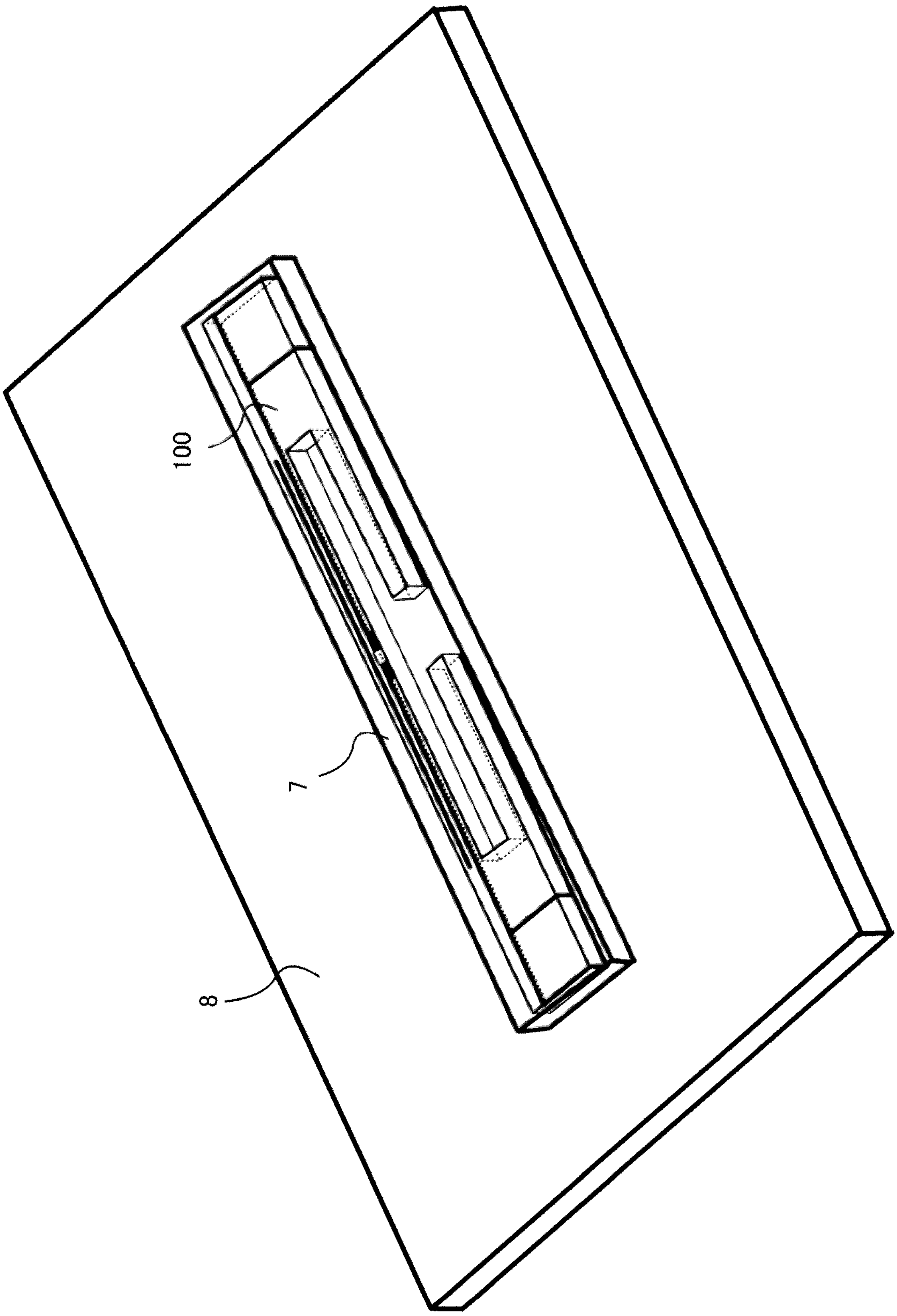


FIG. 6A

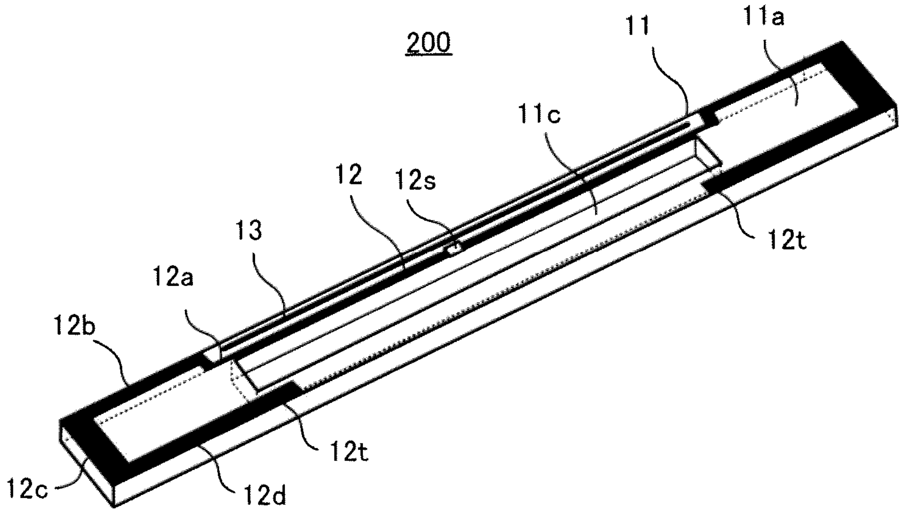


FIG. 6B

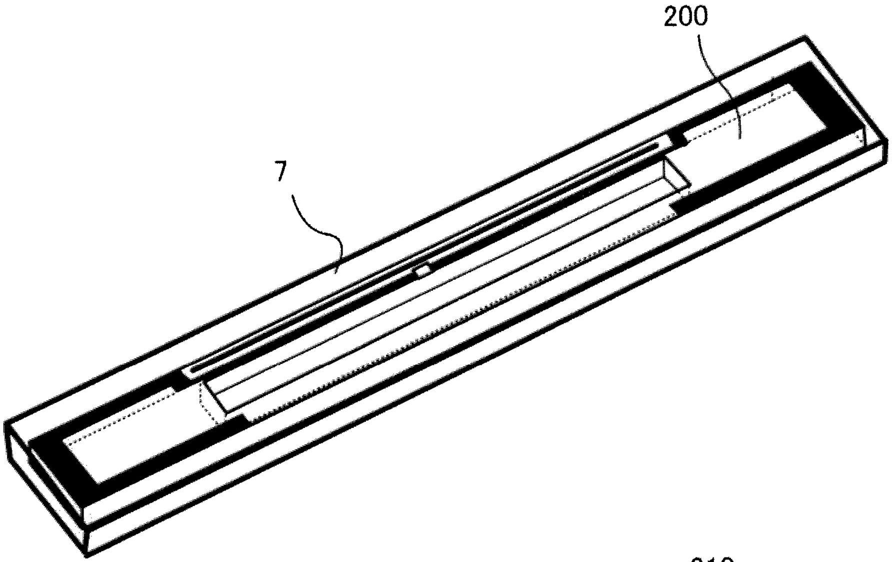


FIG. 6C

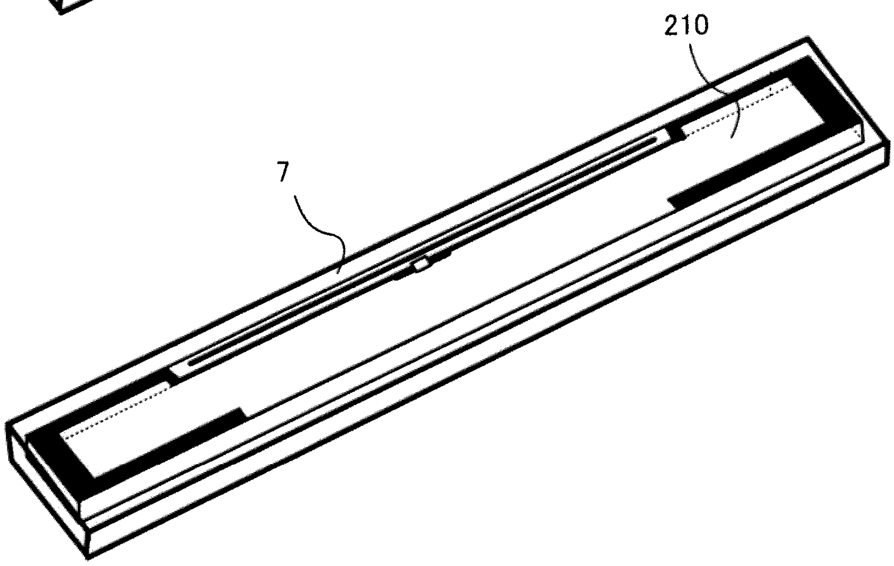
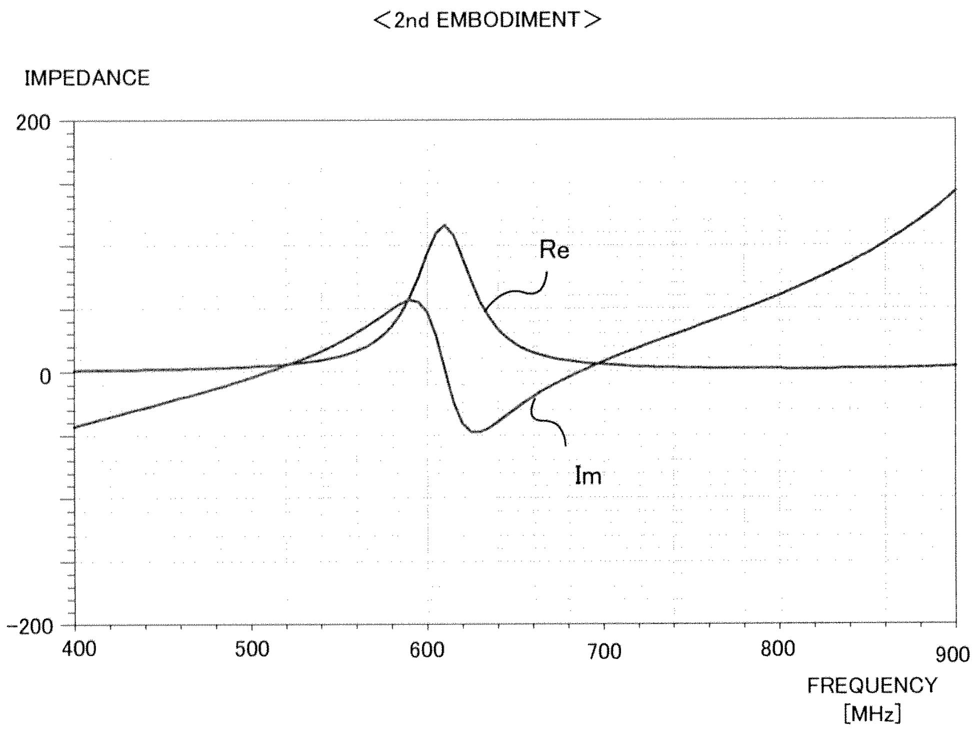


FIG. 7A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800
900
Re
Im
FREQUENCY
[MHz]

FIG. 7B

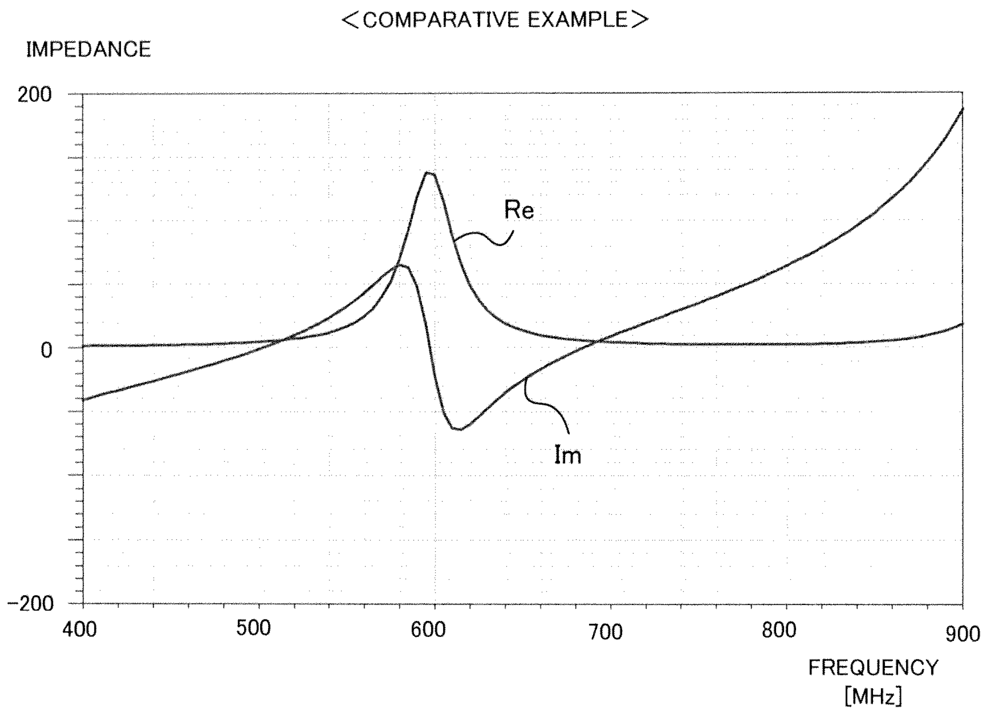
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FIG. 8A

<2nd EMBODIMENT>

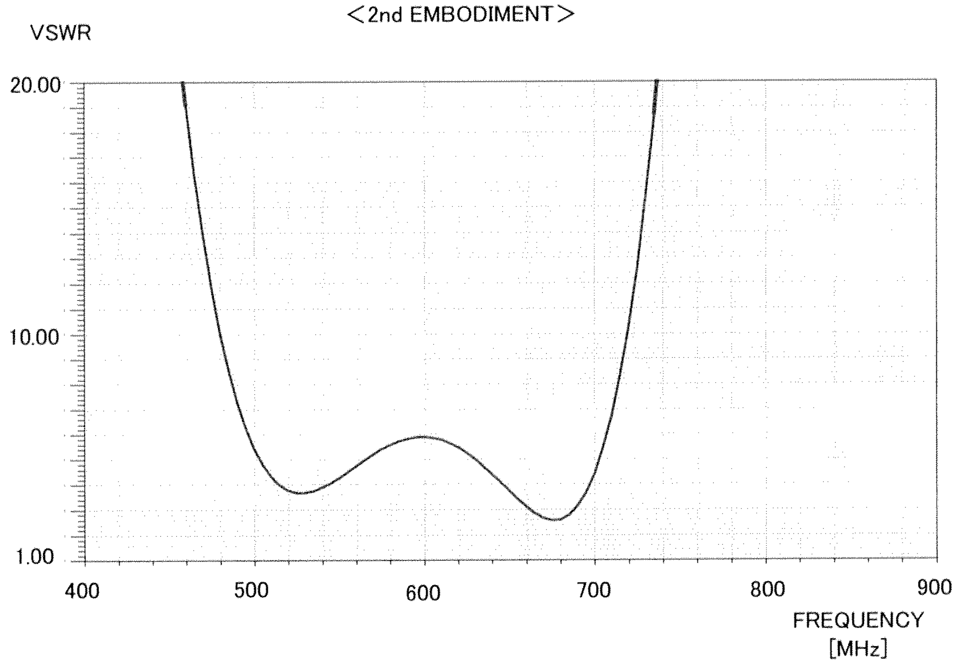

FIG. 8B

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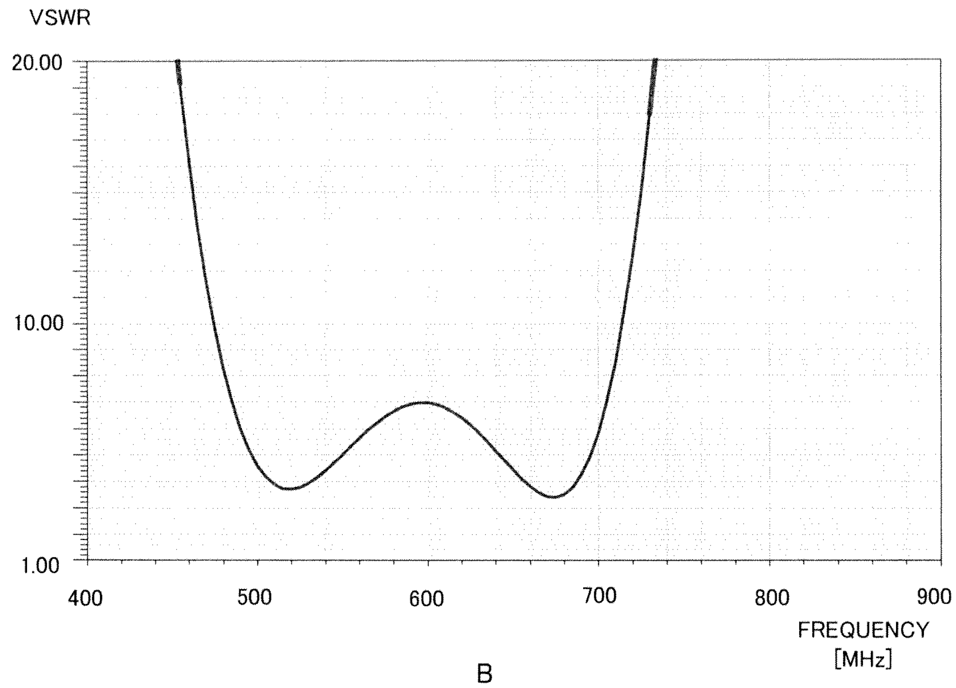

B

FIG. 9A

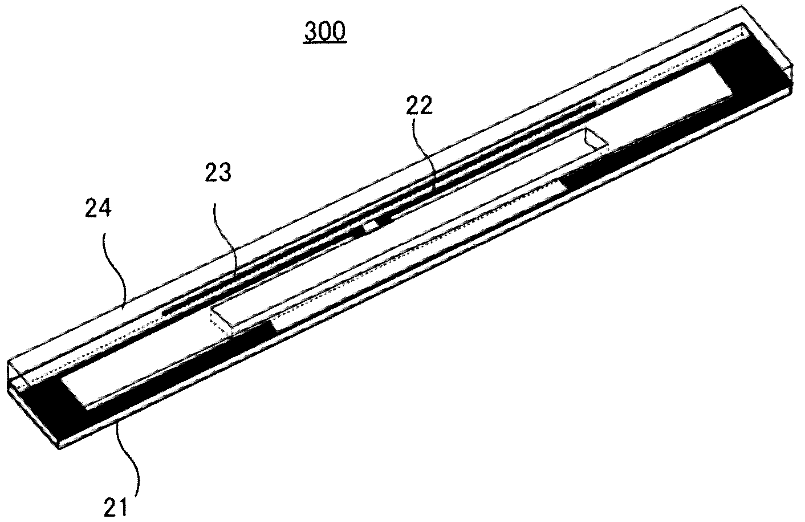

FIG. 9B

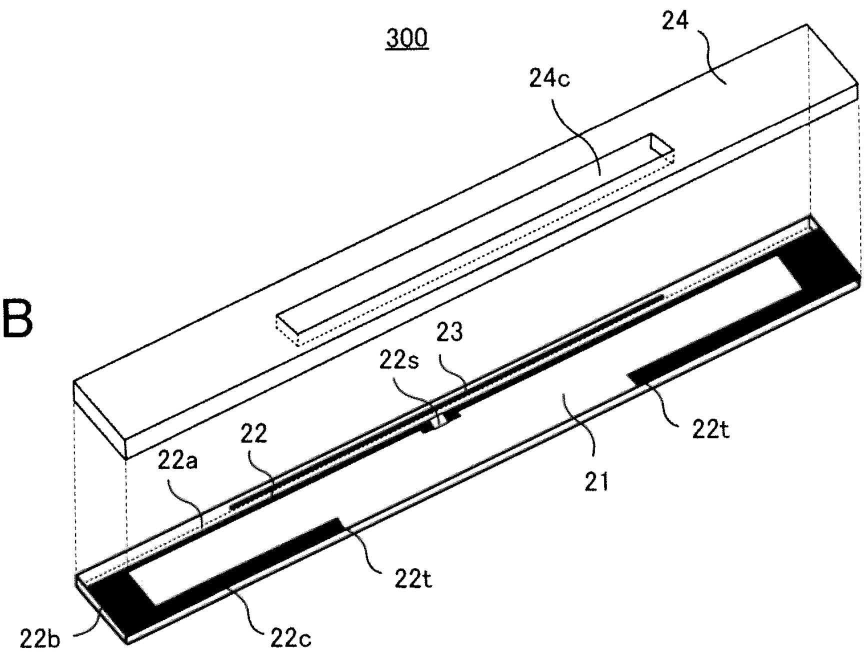

FIG. 10A

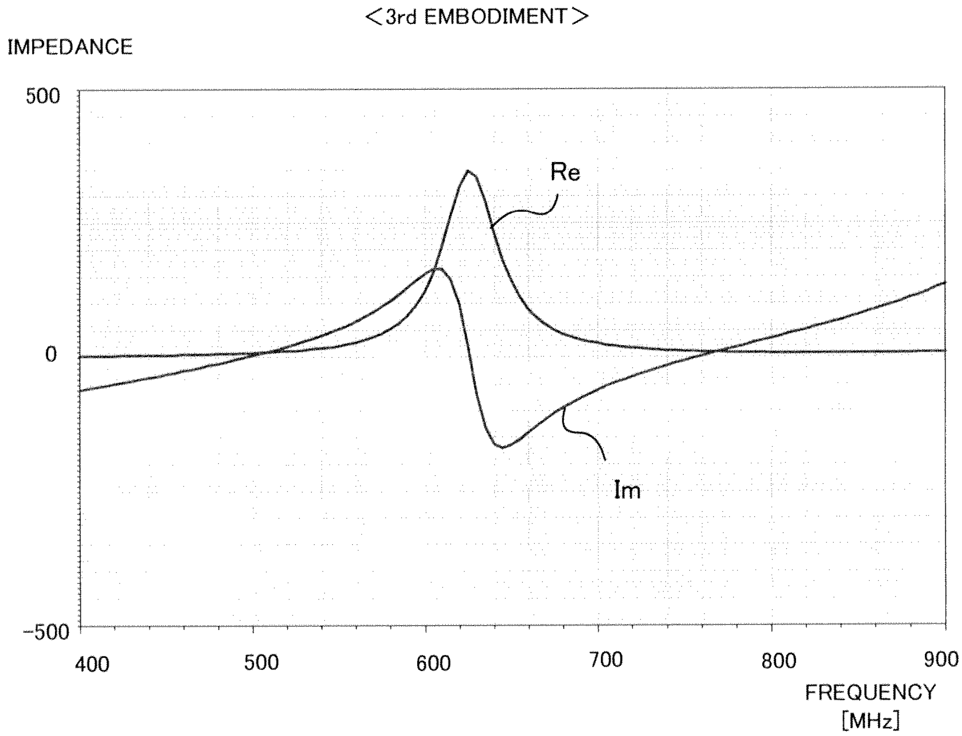

FIG. 10B

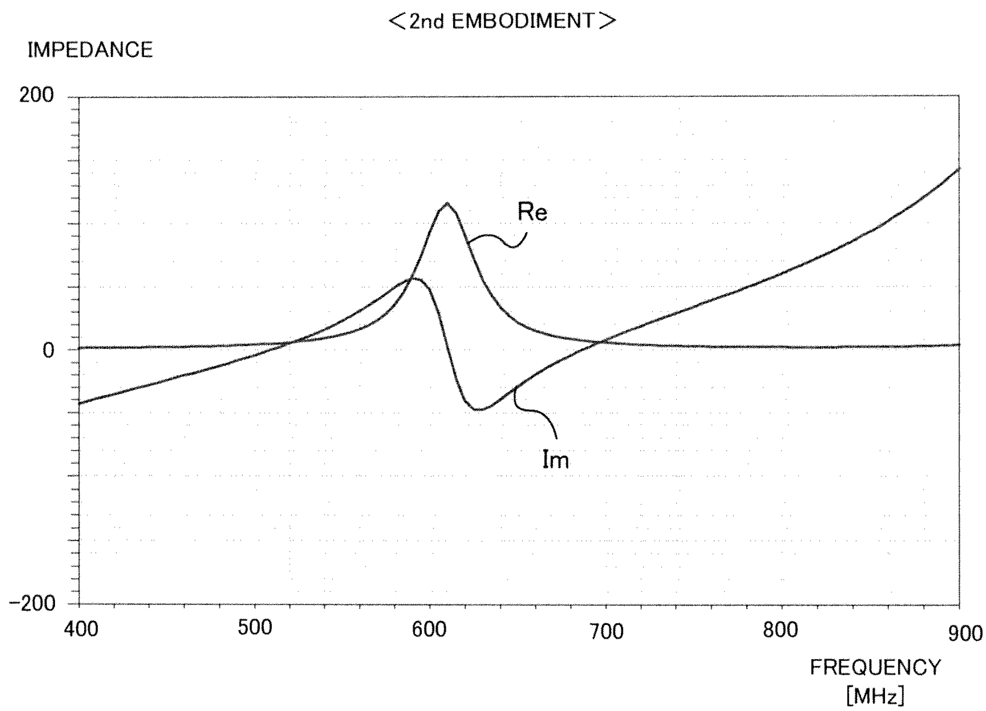

FIG. 11A

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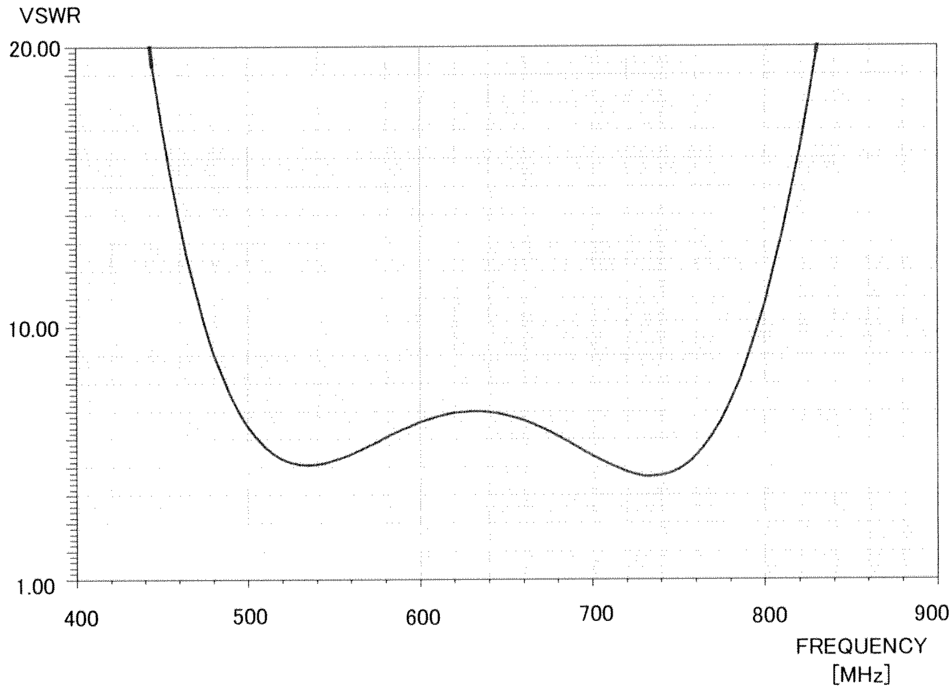

FIG. 11B

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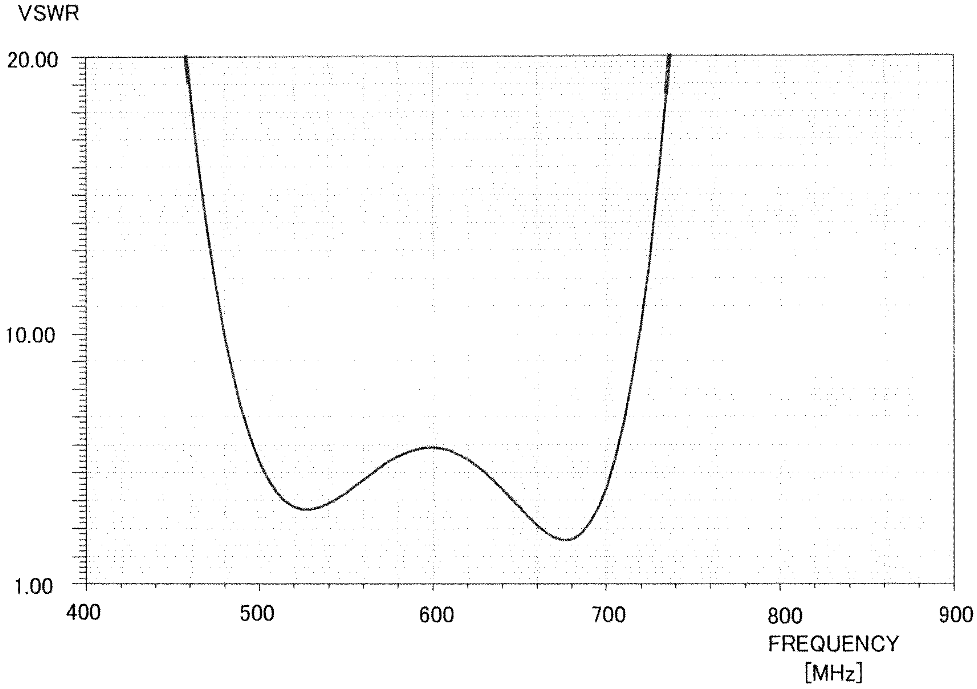


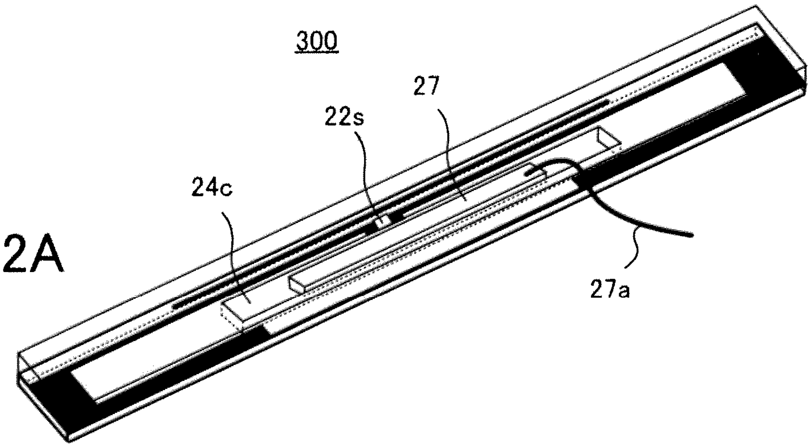


FIG. 12A

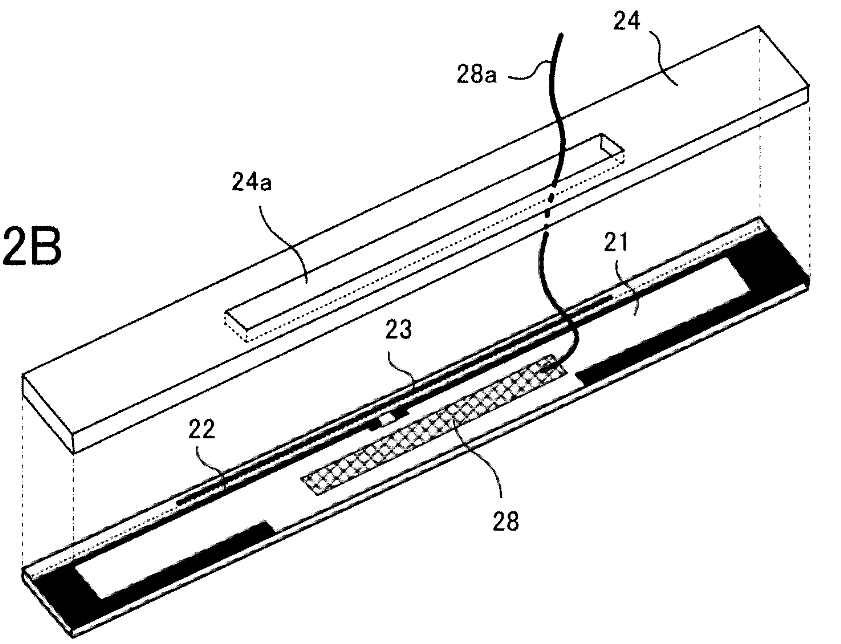


FIG. 12B

FIG. 13A

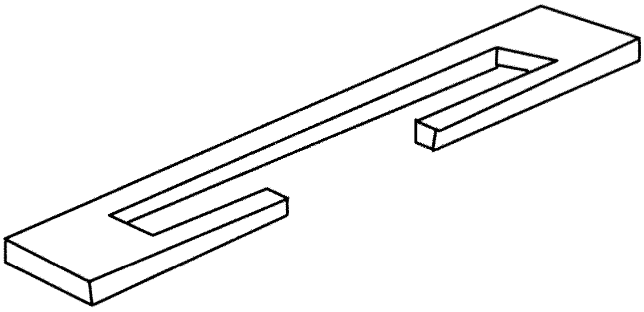


FIG. 13B

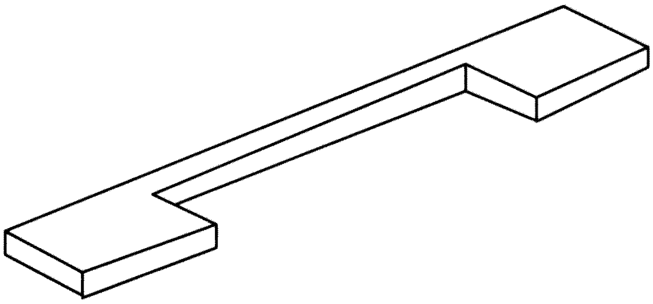
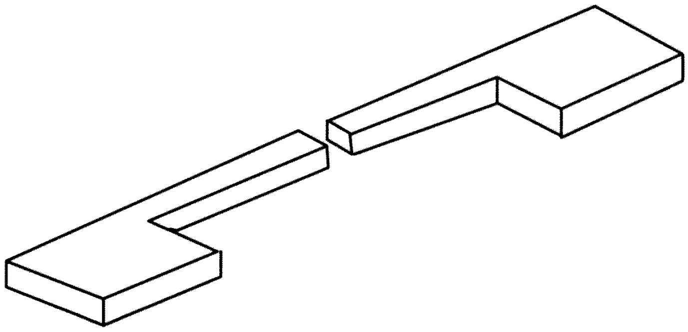


FIG. 13C



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/065546

A. CLASSIFICATION OF SUBJECT MATTER
H01Q9/26(2006.01)i, *H01Q1/38*(2006.01)i, *H01Q1/40*(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)
H01Q9/26, H01Q1/38, H01Q1/40

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	1996-2008
Kokai Jitsuyo Shinan Koho	1971-2008	Toroku Jitsuyo Shinan Koho	1994-2008

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	WO 01/018909 A1 (Murata Mfg. Co., Ltd.), 15 March, 2001 (15.03.01), Full text; all drawings & JP 3596526 B2 & US 6501425 B1 & EP 1139490 A1 & CA 2426497 A1 & CA 2341736 A1 & CN 1321347 A & DE 60033275 T2	1-10
A	JP 2004-032776 A (Harris Corp.), 29 January, 2004 (29.01.04), Full text; all drawings & US 2004/0001027 A1 & EP 1376759 A2 & CA 2431185 A1 & DE 60311360 T2 & CA 2431185 A1 & AU 2003204642 B2	1-10

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

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
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"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	Date of mailing of the international search report
27 November, 2008 (27.11.08)	09 December, 2008 (09.12.08)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/065546

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 07-038325 A (Hitachi Cable, Ltd.), 07 February, 1995 (07.02.95), Full text; all drawings (Family: none)	1-10
A	JP 60-129708 U (Nippon Antenna Co., Ltd.), 30 August, 1985 (30.08.85), Full text; all drawings (Family: none)	1-10
A	JP 50-025785 B1 (Sony Corp.), 26 August, 1975 (26.08.75), Full text; all drawings (Family: none)	1-10

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2002217628 A **[0006]**
- JP 2005303637 A **[0006]**