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(72) Inventors:
• **Mizoguchi, Satoshi**
Minato-ku, Tokyo 105-8001 (JP)
• **Amano, Takashi**
Minato-ku, Tokyo 105-8001 (JP)

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(74) Representative: **HOFFMANN - EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(71) Applicant: **Kabushiki Kaisha Toshiba**
Minato-ku, Tokyo 105 (JP)

(54) **Wireless communication apparatus including antenna**

(57) A wireless communication apparatus which has a casing (1) having thickness and a first surface perpendicular to a direction of the thickness, the wireless communication apparatus characterized in that comprises a dipole antenna (3) including a first base portion, and an opposed element (4) formed of a conductor ma-

terial and including a second base portion, the dipole antenna (3) and the opposed element (4) being disposed within the casing (1) such that the dipole antenna (3) and the opposed element (4) extend in an imaginary plane that is substantially parallel to the first surface, and the first base portion and the second base portion are opposed to each other.

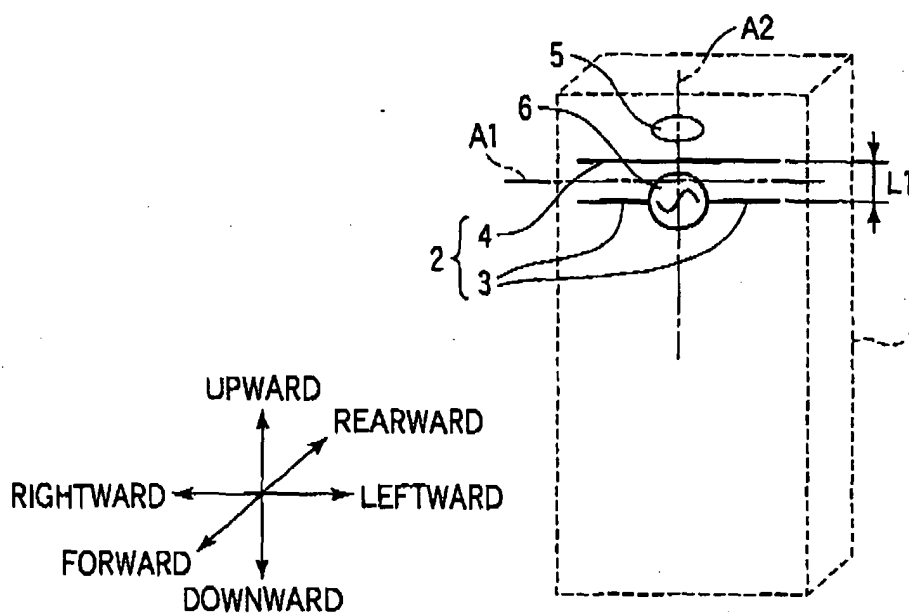


FIG. 3

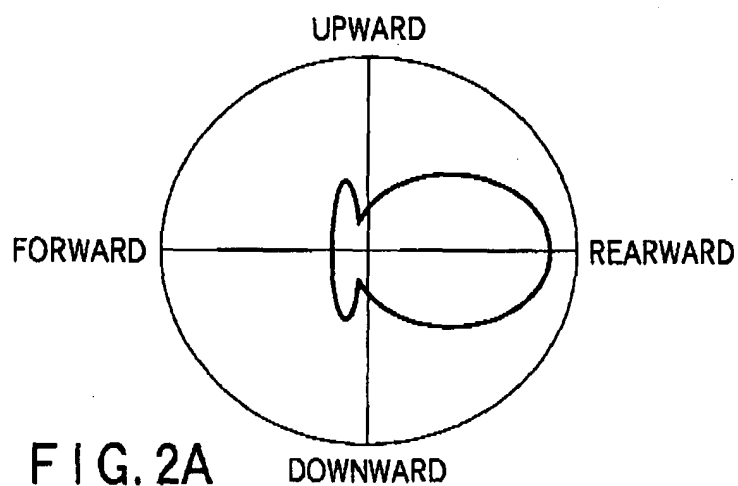


FIG. 2A

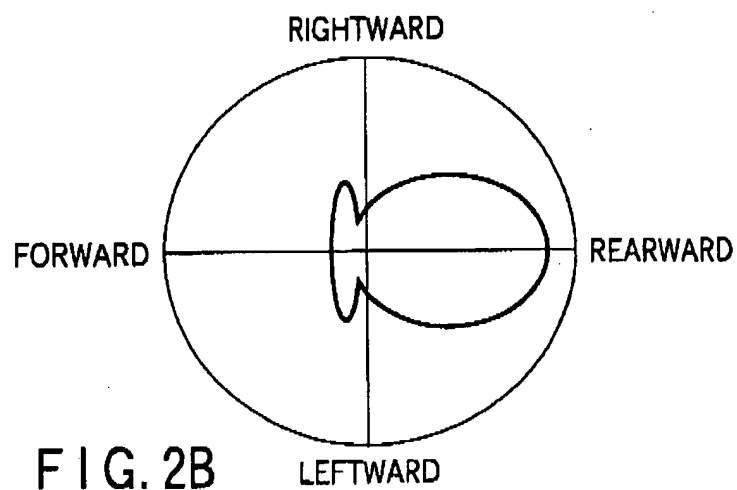


FIG. 2B

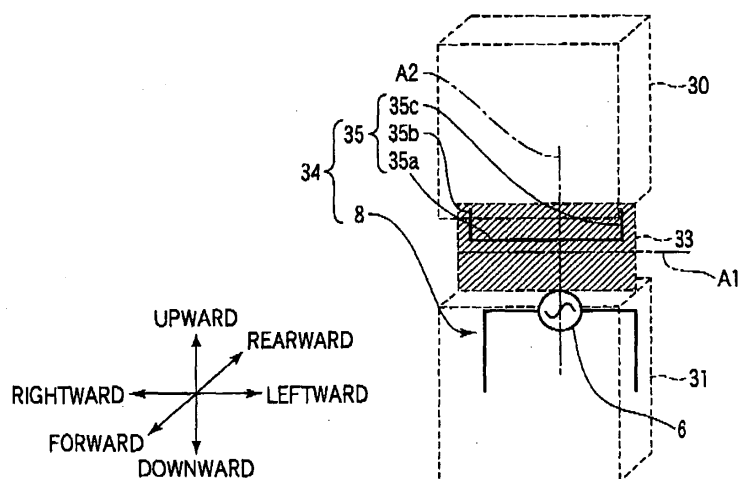


FIG. 29

Description

[0001] The present invention relates to a wireless communication apparatus including an antenna.

[0002] A mobile telephone apparatus, when used for talking, is positioned near the head of the user. If a radiation pattern of an antenna built in the mobile telephone apparatus has such a pattern as to have a peak toward the vicinity of the user's head, the radiation characteristics of the antenna would greatly be affected and varied, for example, by the presence of the user's head that is present near the mobile telephone apparatus.

[0003] Jpn. Pat. Appln. KOKAI Publication No. 2002-9534 (Document 1) and Jpn. Pat. Appln. KOKAI Publication No. 2001-339215 (Document 2) disclose prior-art techniques for overcoming this drawback.

[0004] FIG. 1 is a perspective view showing the structure of a mobile telephone apparatus disclosed in Document 1.

[0005] This mobile telephone apparatus has an antenna 2 that is built in a casing 1. The antenna 2 is configured such that a dipole antenna 3 and an opposed element 4 are arranged to be substantially parallel to each other. The direction of arrangement of the dipole antenna 3 and opposed element 4 is substantially perpendicular to the front surface of the casing 1 (the surface on which a receiver 5 is disposed). The distance between the opposed element 4 and the front surface of the casing 1 is greater than that between the dipole antenna 3 and the front surface of casing 1. Power is fed to the dipole antenna 3 from power feed means 6. Thereby, the dipole antenna 3 functions as a dipole antenna. The opposed element 4 is a parasitic element.

[0006] FIG. 2A and FIG. 2B show radiation patterns of the antenna 2 shown in FIG. 1.

[0007] As shown in FIG. 2A and FIG. 2B, by virtue of a coupling function between the dipole antenna 3 and opposed element 4, the antenna 2 has such a directivity as to have a peak in a direction from the dipole antenna 3 toward the opposed element 4. In other words, the antenna 2 has characteristics of directivity toward the rear side of the casing 1. Therefore, the effect of the human body, which is present near the front surface of the casing 1, can be reduced.

[0008] Document 2, on the other hand, discloses an antenna comprising a pair of a dipole antenna and a parasitic element and another pair of a dipole antenna and a parasitic element. The two pairs are arranged such that the parasitic elements are sandwiched between the dipole antennas, or vice versa. By feeding power to the dipole antennas in opposite phases, the amount of current on the PCB-GND flowing in the casing of the wireless apparatus is reduced and degradation in characteristics due to the effect of the human body is alleviated.

[0009] In the antenna disclosed in Document 1, however, the distance between the dipole antenna 3 and opposed element 4 needs to be sufficiently reduced in order to obtain the radiation pattern characteristics shown

in FIG. 2A and FIG. 2B, while maintaining impedance matching between the power feed circuit and the antenna. The following document teaches that this distance needs to be 9/100 of wavelength or more: Tay, Balzano, Kuster, "Dipole configurations with strongly improved radiation efficiency for hand-held transceivers", IEEE Trans. On Antennas and Propagation, Vol. 46, June 1998, pp. 798-806. This distance is 13.5 mm even where the frequency is 2 GHz. The distance becomes greater in a lower frequency band. Consequently, it becomes necessary to increase the width of the casing 1 in the front-and-rear direction, i.e. the thickness of the casing 1.

[0010] In the invention of Document 2, the two pairs of dipole antennas and parasitic elements are provided, and power needs to be fed to both the dipole antennas in the two pairs. In terms of circuitry scale and mounting of components, this invention is not suited to miniaturization.

[0011] Japanese Patent No. 3356363 (Document 3) and Jpn. Pat. Appln. KOKAI Publication No. 2002-344222 (Document 4) disclose techniques for broadening frequency characteristics.

[0012] However, the techniques disclosed in Document 3 and Document 4 are unable to prevent variation in antenna radiation characteristics due to the effect of the presence of the head, etc.

[0013] The object of the present invention is to provide a mobile phone apparatus including an antenna that is capable of suppressing radiation in a specific direction and can efficiently be included in a thin shaped casing.

[0014] According to first aspect of the present invention, there is provided a wireless communication apparatus that performs wireless communication, the apparatus having a casing with a first surface, an external dimension of the casing in a direction perpendicular to the first surface being less than an external dimension of the casing in another direction, the wireless communication apparatus characterized in that comprising: a dipole antenna including a first base portion; and an opposed element formed of a conductor material and including a second base portion, the dipole antenna and the opposed element being disposed within the casing such that the dipole antenna and the opposed element extend in an imaginary plane that is substantially parallel to the first surface, and the first base portion and the second base portion are opposed to each other.

[0015] According to second aspect of the present invention, there is provided a wireless communication apparatus that performs wireless communication, the apparatus having a first casing and a second casing that are coupled to each other, the first casing having a first surface and such a shape that an external dimension of the first casing in a direction perpendicular to the first surface is less than an external dimension of the first casing in another direction, and the second casing having a second surface and such a shape that an external dimension of the second casing in a direction perpendicular

ular to the second surface is less than an external direction of the second casing in another direction, the wireless communication apparatus being characterized by comprising: a dipole antenna including a first base portion, the dipole antenna being disposed within the first casing such that the dipole antenna extends in an imaginary plane that is substantially parallel to the first surface and the second surface; and an opposed element formed of a conductor material and including a second base portion, the opposed element being disposed within the second casing such that the opposed element extends in the imaginary plane and the second base portion is opposed to the first base portion.

[0016] According to third aspect of the present invention, there is provided a wireless communication apparatus that performs wireless communication, the apparatus having a first casing and a second casing that are coupled to each other, and a flexible board that electrically connects the first casing and the second casing, the first casing having a first surface and such a shape that an external dimension of the first casing in a direction perpendicular to the first surface is less than an external direction of the first casing in another direction, the wireless communication apparatus being characterized by comprising: a dipole antenna including a first base portion, the dipole antenna being disposed within the first casing such that the dipole antenna extends in an imaginary plane that is substantially parallel to the first surface; and an opposed element formed of a conductor material and including a second base portion, the opposed element being disposed on the flexible board such that the second base portion is opposed to the first base portion.

[0017] This summary of the invention does not necessarily describe all necessary features so that the invention may also be a sub-combination of these described features.

[0018] The invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a perspective view showing the structure of a mobile telephone apparatus disclosed in Jpn. Pat. Appln. KOKAI Publication No. 2002-9534;

FIGS. 2A and 2B illustrate radiation patterns of the antenna shown in FIG. 1;

FIG. 3 shows the structure of a mobile telephone apparatus according to a first embodiment of the present invention;

FIG. 4 illustrates a state in which electric current occurs in the antenna shown in FIG. 3;

FIG. 5 illustrates a radiation pattern of the antenna shown in FIG. 3;

FIG. 6 shows a relationship between a distance, on the one hand, which lies between the dipole antenna and opposed element shown in FIG. 3, and a difference, on the other hand, between a maximum value and a minimum value in the antenna radiation

pattern;

FIG. 7 shows the structure of a mobile telephone apparatus according to a second embodiment of the present invention;

FIG. 8 illustrates a radiation pattern of the antenna shown in FIG. 7;

FIG. 9 shows the structure of a mobile telephone apparatus according to a third embodiment of the present invention;

FIG. 10 illustrates a state in which electric current occurs in the antenna shown in FIG. 9;

FIG. 11 illustrates a radiation pattern of the antenna shown in FIG. 9;

FIG. 12 shows the structure of a mobile telephone apparatus according to a fourth embodiment of the present invention;

FIG. 13 illustrates a state in which electric current occurs in the antenna shown in FIG. 12;

FIG. 14 shows the structure of a mobile telephone apparatus according to a fifth embodiment of the present invention;

FIG. 15 shows the structure of an antenna included in a mobile telephone apparatus according to a sixth embodiment of the present invention;

FIG. 16 shows the structure of an antenna included in a mobile telephone apparatus according to a seventh embodiment of the present invention;

FIG. 17 shows the structure of an antenna included in a mobile telephone apparatus according to an eighth embodiment of the present invention;

FIG. 18 shows the structure of an antenna included in a mobile telephone apparatus according to a ninth embodiment of the present invention;

FIG. 19 shows a variation of the antenna included in the mobile telephone apparatus according to the ninth embodiment of the present invention;

FIGS. 20A and 20B illustrate distributions of current in the antennas shown in FIG. 19 and FIG. 12;

FIG. 21 shows a radiation pattern of the antenna shown in FIG. 19;

FIG. 22 shows a variation in VSWR characteristics due to the presence/absence of short-circuit elements shown in FIG. 19;

FIG. 23 is a Smith chart indicating a difference in characteristics due to the presence/absence of the short-circuit elements shown in FIG. 19;

FIG. 24 shows the structure of an antenna included in a mobile telephone apparatus according to a tenth embodiment of the present invention;

FIG. 25 shows the structure of an antenna included in a mobile telephone apparatus according to an eleventh embodiment of the present invention;

FIG. 26 shows the structure of a mobile telephone apparatus according to a twelfth embodiment of the present invention;

FIG. 27 shows the structure of a mobile telephone apparatus according to a 13th embodiment of the present invention;

FIG. 28 shows the structure of a mobile telephone apparatus according to a 14th embodiment of the present invention;

FIG. 29 shows the structure of a mobile telephone apparatus according to a 15th embodiment of the present invention;

FIG. 30 illustrates a variation in VSWR characteristics when the state of the mobile telephone apparatus is varied, in a case where the mobile telephone apparatus shown in FIG. 27 is equipped with the antenna shown in FIG. 19;

FIG. 31 illustrates a variation in VSWR characteristics in the open state and closed state of the casing in the case where the mobile telephone apparatus shown in FIG. 27 is equipped with the antenna shown in FIG. 19;

FIG. 32 shows the structure of a mobile telephone apparatus according to a 16th embodiment of the present invention;

FIG. 33 illustrates a state in which electric current occurs in the antenna shown in FIG. 32;

FIG. 34 illustrates a radiation pattern of the antenna shown in FIG. 32;

FIG. 35 illustrates VSWR characteristics of the antenna shown in FIG. 32;

FIG. 36 shows the structure of a mobile telephone apparatus according to a 17th embodiment of the present invention;

FIG. 37 shows the structure of a mobile telephone apparatus according to a 18th embodiment of the present invention;

FIG. 38 shows the structure of an antenna included in a mobile telephone apparatus according to a 19th embodiment of the present invention;

FIG. 39 shows the structure of an antenna included in a mobile telephone apparatus according to a 20th embodiment of the present invention;

FIG. 40 shows the structure of an antenna included in a mobile telephone apparatus according to a 21st embodiment of the present invention;

FIG. 41 shows the structure of an antenna included in a mobile telephone apparatus according to a 22nd embodiment of the present invention;

FIG. 42 shows the structure of an antenna included in a mobile telephone apparatus according to a 23rd embodiment of the present invention;

FIG. 43 shows the structure of an antenna included in a mobile telephone apparatus according to a 24th embodiment of the present invention;

FIG. 44 shows the structure of an antenna included in a mobile telephone apparatus according to a 25th embodiment of the present invention;

FIG. 45 shows the structure of an antenna included in a mobile telephone apparatus according to a 26th embodiment of the present invention;

FIG. 46 illustrates VSWR characteristics in a case where the antenna shown in FIG. 45 is accommodated in the upper casing shown in FIG. 27;

FIGS. 47A to 47F show radiation patterns of the antenna shown in FIG. 45;

FIG. 48 shows the structure of an antenna included in a mobile telephone apparatus according to a 27th embodiment of the present invention; and

FIG. 49 shows a variation of the antenna included in the mobile telephone apparatus according to the 27th embodiment of the present invention.

10 (First Embodiment)

[0019] A mobile telephone apparatus according to a first embodiment of the present invention will now be described with reference to FIG. 3 through FIG. 6.

15 [0020] As is shown in FIG. 3, the mobile telephone apparatus according to the first embodiment has an antenna 2 built in a casing 1. The antenna 2 includes a dipole antenna 3 and an opposed element 4. Each of the dipole antenna 3 and opposed element 4 is formed of a conductor material in a straight shape. The length of the dipole antenna 3 is equal to a half wavelength. Power feed means 6 feeds power to a substantially middle point of the dipole antenna 3 in a balanced-feed fashion. Specifically, the dipole antenna 3, as a single element, functions as a half-wave dipole antenna. The dipole antenna 3 and opposed element 4 are arranged with a predetermined distance L1. Each of the dipole antenna 3 and opposed element 4 is disposed in a right-and-left direction. The distance L1 is 1/4 wavelength ($\lambda/4$) or less. The dipole antenna 3 and opposed element 4 are in line-symmetry with respect to an opposed axis A1. The opposed axis A1 is parallel to the dipole antenna 3 and opposed element 4 and is located at a middle point between the dipole antenna 3 and opposed element 4. The dipole antenna 3 and opposed element 4 are in line-symmetry with respect to a symmetric axis A2. The symmetric axis A2 intersects the dipole antenna 3 at right angles at a midpoint in the longitudinal direction of the dipole antenna 3. The dipole antenna 3 and opposed element 4 are arranged such that an imaginary plane in which the dipole antenna 3 and opposed element 4 are positioned is parallel to the front surface of the casing 1 (the surface on which the receiver 5 is disposed).

45 [0021] In FIG. 3, an imaginary plane is shown as being superposed on the front surface of the casing 1. This is for easy understanding of the relationships between the imaginary plane and the front surface of the casing 1. It should be noted that the imaginary plane may be arranged at any position such as a position in front of the casing 1 or a position behind the casing 1. The same is applied to the analogous Figures described later.

50 [0022] In the descriptions above and below, the technical terms "opposed axis", "symmetric axis" and "imaginary plane" are used to explain geometrical concepts and do not designate physical objects that are structural elements of the mobile wireless communication terminal.

[0023] If power is supplied from the power feed means 6 to the dipole antenna 3, a drive current vector V occurs in the dipole antenna 3, as shown in FIG. 4. On the other hand, an induction current vector V_i , which is induced by the drive current vector V and has a phase opposite to the phase of the drive current vector V , is caused in the opposed element 4. The antenna 2 emits radiation by the drive current vector V and induction current vector V_i .

[0024] When the radiation pattern of the antenna 2 is viewed from the left side of the casing 1, it looks like a simple figure eight, which is substantially symmetric with respect to the front-and-rear axis, as shown in FIG. 5. The reason for this is that the current vectors V and V_i have opposite phases and thus the energy radiated from the dipole antenna 3 and the energy radiated from the opposed element 4 cancel each other in the vicinity of the center in the front-and-rear direction.

[0025] As is illustrated in FIG. 6, as the distance $L1$ between the dipole antenna 3 and opposed element 4 decreases, the ratio between the maximum value and minimum value of a relative power gain relating to horizontally polarized waves, as viewed from the left side or right side of the casing 1, becomes higher. In other words, as the distance $L1$ between the dipole antenna 3 and opposed element 4 decreases, the electromagnetic field radiated in the forward or rearward direction of the casing 1 is more suppressed. On the other hand, as the distance $L1$ is decreased, the antenna 2 is reduced in size.

[0026] According to the first embodiment, by decreasing the distance $L1$ between the dipole antenna 3 and opposed element 4, the electromagnetic field radiated in the forward direction can be more suppressed and the antenna 2 can be reduced in size. The external shape of the antenna 2 is thin shape along the front surface of the casing 1. Hence, in the case where the casing 1 is formed to have a thin shape with an external dimension in the front-and-rear direction that is less than an external dimension in another direction, as shown in FIG. 3, the antenna 2 can efficiently be contained within the casing 1. Therefore, it is possible to obtain a mobile phone apparatus which has a small size and can decrease degradation in communication performance due to the close positional relationship between the human body and the front surface of the casing 1. In addition, where the casing 1 is formed to have such a thin shape, a circuit board, etc. are, in many cases, disposed in parallel to the antenna 2. In such a case, radiation directed to the circuit board, etc. may considerably be lost due to attenuation by the circuit board, etc. According to the first embodiment, however, an electromagnetic field that is radiated toward the rear side where the circuit board, etc. are disposed is suppressed, and thus the loss due to the circuit board, etc. can be suppressed.

[0027] The opposed element 4 may be inclined relative to the dipole antenna 3. The imaginary plane in which the dipole antenna 3 and opposed element 4 are

positioned may be inclined relative to the front surface of the casing 1. The dipole antenna 3 and opposed element 4 may not be in line-symmetry with respect to the opposed axis $A1$. The dipole antenna 3 and opposed element 4 may not be in line-symmetry with respect to the symmetric axis $A2$. The length of the dipole antenna 3 may be an odd-number of times of a half wavelength. It should be noted, however, that as the degree of parallelism or symmetry becomes lower, the symmetric property of the radiation pattern is degraded. Thus, in the case where a regular radiation pattern is required, it is desirable to maximize the degree of parallelism or symmetry.

[0028] Unless the degree of parallelism or symmetry is considerably lowered, the characteristics of the radiation pattern are maintained. It is also possible to adjust the directivity by varying the degree of parallelism or symmetry. In general terms, it is preferable for the use of the mobile telephone apparatus to obtain a relatively high radiation intensity in the direction of the angle of elevation of the casing 1. The degree of parallelism or symmetry can be adjusted so as to obtain such a radiation pattern.

[0029] The length of the dipole antenna 3 may be an odd-number of times of a half length. Theoretically, the optimal length of the dipole antenna 3 is an odd-number of times of a half length. However, because of the frequency to be used or constraints on mounting, the optimal length of the dipole antenna 3 is slightly different from an odd-number of times of a half length.

[0030] The distance $L1$ between the dipole antenna 3 and opposed element 4 may be made greater than $\lambda/4$.

[0031] The dipole antenna 3 and opposed element 4 may be inclined relative to the lateral direction.

(Second Embodiment)

[0032] A mobile telephone apparatus according to a second embodiment of the present invention will now be described with reference to FIG. 7 and FIG. 8. In FIGS. 7 and 8, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted.

[0033] As is shown in FIG. 7, the mobile telephone apparatus according to the second embodiment includes an antenna 2 having the same structure as the antenna of the first embodiment. In the second embodiment, however, the dipole antenna 3 and opposed element 4 are arranged so as to extend in the up-and-down direction.

[0034] In the second embodiment, the same advantages as with the first embodiment can be obtained.

[0035] If the "up-and-down" direction in FIG. 3 coincides with the vertical direction, the dipole antenna 3 and opposed element 4 in the first embodiment are horizontally situated. Thus, as shown in FIG. 5, the radiation electromagnetic field is mainly composed of a horizon-

tally polarized wave component, and a vertically polarized wave component is relatively small. On the other hand, according to the mobile telephone apparatus of the second embodiment, when the radiation pattern of the antenna 2 is viewed from the upper side of the casing 1, it looks like a simple figure eight, which is substantially symmetric with respect to the front-and-rear axis, as shown in FIG. 8. Since the drive current vector V and induction current vector V_i are substantially vertical, the vertically polarized wave component can be made greater than the horizontally polarized wave component.

[0036] The structure of the second embodiment can similarly be modified like the first embodiment. In the second embodiment, however, if the practicability of the mobile telephone apparatus is taken into account, it is desirable to maintain the symmetric property of the radiation pattern.

(Third Embodiment)

[0037] A mobile telephone apparatus according to a third embodiment of the present invention will now be described with reference to FIG. 9 through FIG. 11. In FIGS. 9 and 10, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted.

[0038] As is shown in FIG. 9, the mobile telephone apparatus according to the third embodiment has an antenna 7 built in the casing 1. The antenna 7 includes a dipole antenna 8 and an opposed element 4. In the antenna 7, the dipole antenna 8 is substituted for the dipole antenna 3 of the antenna 2.

[0039] The dipole antenna 8 is configured such that both end portions of the conductor of the dipole antenna 3 are bent at right angles. A middle portion of the dipole antenna 8 is referred to as a base portion 8a. The portions bent perpendicular to the base portion 8a are referred to as bent portions 8b and 8c. The length of the dipole antenna 8 is equal to a half wavelength. The power feed means 6 feeds power to a substantially middle point of the dipole antenna 8. Specifically, the dipole antenna 8, as a single element, functions as a half-wave dipole antenna. The dipole antenna 8 and opposed element 4 are disposed such that the base portion 8a and opposed element 4 have the same positional relationship as the dipole antenna 3 and opposed element 4 in the first embodiment. The dipole antenna 8 is disposed such that its bent portions 8b and 8c are situated away from the opposed element 4. The dipole antenna 8 and opposed element 4 are arranged such that the imaginary plane in which these elements are positioned is parallel to the front surface of the casing 1.

[0040] When power is fed to the dipole antenna 8 from the power feed means 6, a drive current vector V_a occurs in the base portion 8a, a drive current vector V_b occurs in the bent portion 8b and a drive current vector

V_c occurs in the bent portion 8c, as shown in FIG. 10. An induction current vector V_i , which is induced by the drive current vector V_a and has a phase opposite to the phase of the drive current vector V_a , is caused in the opposed element 4.

[0041] The antenna 7 emits electromagnetic field radiation, which is similar with the first embodiment, by the drive current vector V_a and induction current vector V_i . On the other hand, as shown in FIG. 10, the drive current vectors V_b and V_c occur in the up-and-down direction and have mutually opposite phases. Accordingly, the functions of the drive current vectors V_b and V_c are substantially equivalent to those of the drive current vectors V and V_i in the second embodiment. The radiation pattern of the antenna 7, when viewed from the upper side of the casing 1, it looks like a simple figure eight, which is substantially symmetric with respect to the front-and-rear axis, as shown in FIG. 11. If the "up-and-down" direction in FIG. 9 is the vertical direction, the drive current vectors V_b and V_c are substantially vertical, so the vertically polarized wave component becomes greater than the horizontally polarized wave component.

[0042] Therefore, in the third embodiment, the same advantages as with the first embodiment can be obtained. According to the third embodiment, the horizontally polarized wave component is mainly radiated by the functions of the drive current vector V_a and induction current vector V_i , and the vertically polarized wave component is mainly radiated by the functions of the drive current vectors V_b and V_c . Hence, both polarized wave components can sufficiently be radiated. Which of the horizontally and vertically polarized wave components is dominant is determined by the ratio in length between the base portion 8a and the bent portion 8b, 8c of the dipole antenna 8.

[0043] The structure of the third embodiment may be modified as in the first embodiment.

(Fourth Embodiment)

[0044] A mobile telephone apparatus according to a fourth embodiment of the present invention will now be described with reference to FIG. 12 and FIG. 13. In FIGS. 12 and 13, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted.

[0045] As is shown in FIG. 12, the mobile telephone apparatus according to the fourth embodiment has an antenna 9 accommodated in the casing 1. The antenna 9 includes a dipole antenna 8 and an opposed element 10. In the antenna 9, the opposed element 10 is substituted for the opposed element 4 of the antenna 7.

[0046] The opposed element 10 is configured such that both end portions of the conductor of the opposed element 4 are bent at right angles. A middle portion of the opposed element 10 is referred to as a base portion 10a. The portions bent perpendicular to the base portion

10a are referred to as bent portions 10b and 10c. The dipole antenna 8 and opposed element 10 are disposed such that the base portion 8a and the base portion 10a have the same positional relationship as the dipole antenna 3 and opposed element 4 in the first embodiment. The dipole antenna 8 and opposed element 10 are disposed such that the bent portions 8b and 8c and the bent portions 10b and 10c are situated away from each other. The dipole antenna 8 and opposed element 10 are arranged such that the imaginary plane in which these elements are positioned is parallel to the front surface of the casing 1.

[0047] When power is fed to the dipole antenna 8 from the power feed means 6, a drive current vector Va occurs in the base portion 8a, a drive current vector Vb occurs in the bent portion 8b and a drive current vector Vc occurs in the bent portion 8c, as shown in FIG. 13. An induction current vector Via, which is induced by the drive current vector Va and has a phase opposite to the phase of the drive current vector Va, is caused in the base portion 10a of the opposed element 10. With the occurrence of the induction current vector Via, an induction current vector Vib occurs in the bent portion 10b and an induction current vector Vic occurs in the bent portion 10c.

[0048] The antenna 9 emits electromagnetic field radiation, which is similar with the first embodiment, by the functions of the drive current vector Va and induction current vector Via. On the other hand, as shown in FIG. 11, the drive current vectors Vb and Vc and induction current vectors Vib and Vic occur in the up-and-down direction. The drive current vector Vb and induction current vector Vib have the same direction, and the drive current vector Vc and induction current vector Vic have the same direction. The drive current vector Vb and induction current vector Vib have opposite phases, and the drive current vector Vc and induction current vector Vic have opposite phases. Accordingly, by the functions of the drive current vector Vb and induction current vector Vib and the drive current vector Vc and induction current vector Vic, the radiation pattern of the antenna 9, when viewed from the upper side of the casing 1, it looks like a simple figure eight, which is substantially symmetric with respect to the front-and-rear axis. If the "up-and-down" direction in FIG. 12 is the vertical direction, the drive current vectors Vb and Vc and the induction current vectors Vib and Vic are substantially vertical, so the vertically polarized wave component becomes greater than the horizontally polarized wave component.

[0049] Therefore, in the fourth embodiment, the same advantages as with the first embodiment can be obtained. According to the fourth embodiment, the horizontally polarized wave component is mainly radiated by the functions of the drive current vector Va and induction current vector Via, and the vertically polarized wave component is mainly radiated by the functions of the drive current vectors Vb and Vc and the induction current vectors Vib and Vic. Hence, both polarized wave

components can sufficiently be radiated.

[0050] The structure of the fourth embodiment can also be modified like the first embodiment.

5 (Fifth Embodiment)

[0051] A mobile telephone apparatus according to a fifth embodiment of the present invention will now be described with reference to FIG. 14. In FIG. 14, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted.

[0052] As is shown in FIG. 7, the mobile telephone apparatus according to the fifth embodiment has an antenna 9 having the same structure as the antenna 9 of the first embodiment. In the fifth embodiment, however, the base portions 8a and 10a are disposed in the up-and-down direction.

[0053] Thus, in the fifth embodiment, the same advantages as with the first embodiment can be obtained. According to the fifth embodiment, the vertically polarized wave component is mainly radiated by the functions of the drive current vector Va and induction current vector Vi, and the horizontally polarized wave component is mainly radiated by the functions of the drive current vectors Vb and Vc and the induction current vectors Vib and Vic. Hence, both polarized wave components can sufficiently be radiated.

[0054] The structure of the fifth embodiment can also be modified like the first embodiment. It is desirable, however, that the base portions 8a and 10a be disposed in line-symmetry with respect to the opposed axis A1 in order to maintain the symmetric property of the vertically polarized wave component in the left-and-right axial direction.

35 (Sixth Embodiment)

[0055] A mobile telephone apparatus according to a sixth embodiment of the present invention will now be described with reference to FIG. 15. In FIG. 15, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted. FIG. 15 shows only the structure of an antenna 11 built in the mobile telephone apparatus according to the sixth embodiment.

[0056] The mobile telephone apparatus according to the sixth embodiment is based on the mobile telephone apparatus according to the fourth embodiment, and it includes the antenna 11 which is obtained by modifying the antenna 9. The antenna 11 includes a dipole antenna 12 and the opposed element 10. Specifically, the antenna 11 includes the dipole antenna 12 in place of the dipole antenna 8 of the antenna 9.

[0057] The dipole antenna 12, like the dipole antenna 8, is formed of a conductor material so as to have a base portion 12a and bent portions 12b and 12c. The bent

portions 12b and 12c, however, are opened outward, while being line-symmetric with respect to the symmetric axis A2.

[0058] Even with this configuration, the radiation pattern mainly comprising the vertically polarized wave component can be kept symmetric with respect to the front-and-rear axis. On the other hand, the dipole antenna 12 and opposed element 10 are not in line-symmetry with respect to the opposed axis A1. Consequently, the radiation pattern mainly comprising the horizontally polarized wave component is not symmetric with respect to the up-and-down axial direction. It should be noted, however, that the feature that there is no radiation directivity toward the front or the rear remains unchanged. As a result, the same advantages as with the first embodiment can be obtained.

[0059] Moreover, the radiation directivity of the horizontally polarized wave component in the up-and-down axial direction can be optimized by properly determining the angle of the bent portion 12b, 12c.

[0060] The structure of the sixth embodiment may be modified as in the first embodiment.

(Seventh Embodiment)

[0061] A mobile telephone apparatus according to a seventh embodiment of the present invention will now be described with reference to FIG. 16. In FIG. 16, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted. FIG. 16 shows only the structure of an antenna 13 built in the mobile telephone apparatus according to the seventh embodiment.

[0062] The mobile telephone apparatus according to the seventh embodiment is based on the mobile telephone apparatus according to the fourth embodiment, and it includes the antenna 13 which is obtained by modifying the antenna 9. The antenna 11 includes a dipole antenna 14 and an opposed element 15.

[0063] The dipole antenna 14, like the dipole antenna 8, is formed of a conductor material so as to have a base portion 14a and bent portions 14b and 14c. The base portion 14a, however, has such a bent shape that the base portion 14a gradually approaches the opposed element 15 from its middle point toward its both ends. The base portion 14a is line-symmetric with respect to the symmetric axis A2. The bent portions 14b and 14c are opened outward, while being line-symmetric with respect to the symmetric axis A2.

[0064] The opposed element 15, like the opposed element 10, is formed so as to have a base portion 15a and bent portions 15b and 15c. The base portion 15a, however, has such a bent shape that the base portion 15a gradually approaches the dipole antenna 14 from its middle point toward its both ends. The base portion 14a and base portion 15a are line-symmetric with respect to the opposed axis A1.

[0065] With this configuration, the same advantages as with the sixth embodiment can be obtained by the same functions as with the sixth embodiment.

[0066] The structure of the seventh embodiment may be modified as in the first embodiment.

(Eighth Embodiment)

[0067] A mobile telephone apparatus according to an eighth embodiment of the present invention will now be described with reference to FIG. 17. In FIG. 17, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted. FIG. 17 shows only the structure of an antenna 16 that is built in the mobile telephone apparatus according to the eighth embodiment.

[0068] The mobile telephone apparatus according to the eighth embodiment is based on the mobile telephone apparatus according to the fourth embodiment, and it includes the antenna 16 which is obtained by modifying the antenna 9. The antenna 16 includes a dipole antenna 17 and an opposed element 18.

[0069] The dipole antenna 17 is formed by adding a shorting element 17a of a conductor material to the dipole antenna 8. The shorting element 17a short-circuits the bent portions 8b and 8c.

[0070] The opposed element 18 is formed by adding a shorting element 18a of a conductor material to the opposed element 10. The shorting element 18a short-circuits the bent portions 10b and 10c.

[0071] The antenna 16 has an impedance that varies depending on the distance between the base portion 8a and shorting element 17a and the distance between the base portion 10a and shorting element 18a. By properly determining these distances, impedance matching can be effected between the power feed means 6 and antenna 16.

[0072] The structure of the eighth embodiment may be modified as in the first embodiment.

(Ninth Embodiment)

[0073] A mobile telephone apparatus according to a ninth embodiment of the present invention will now be described with reference to FIG. 18 through FIG. 23. In FIGS. 18 and 19, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted. FIG. 18 and FIG. 19 show only the structure of an antenna 19, 22 built in the mobile telephone apparatus according to the ninth embodiment.

[0074] The mobile telephone apparatus according to the ninth embodiment is based on the mobile telephone apparatus according to the fourth embodiment, and it includes the antenna 19 which is obtained by modifying the antenna 9. The antenna 19 is formed by adding shorting elements 20 and 21 of conductor material to

the antenna 9. The shorting elements 20 and 21 short-circuit the dipole antenna 8 and opposed element 10.

[0075] The antenna 22 shown in FIG. 19 is a variation of the antenna 19. The antenna 22 includes shorting elements 23 and 24 formed of conductor material in the same shape as the dipole antenna 8 and opposed element 10. The shorting element 23 short-circuits the bent portions 8b and 10b, and the shorting element 24 short-circuits the bent portions 8c and 10c. In FIG. 19, reference numeral 25 denotes a board accommodated in the casing 1 along with the antenna 22.

[0076] The antenna 22 has a current distribution as shown in FIG. 20A. On the other hand, the antenna 9 has a current distribution as shown in FIG. 20B. The degrees of current balance in FIGS. 20A and 20B are 95% and 81%, respectively. That is, the current distribution in the antenna 22 has a higher degree of current balance than the current distribution in the antenna 9. Thus, as shown in FIG. 21, a null appears clearly in the radiation pattern of the antenna 22, as viewed from the upper side of the casing 1. In FIG. 21, the forward direction corresponds to the direction of 0 degree (i.e. the right-hand direction of the horizontal axis). According to the radiation pattern shown in FIG. 21, it is understood that a null of the vertically polarized wave component indicated by the solid line is formed in good condition in the forward direction.

[0077] On the other hand, as shown in FIGS. 22 and 23, the addition of the shorting elements 23 and 24 increases the impedance. Thus, even if the PCB-GND provided at the board 25 is situated close to the antenna 22, the impedance matching can be achieved.

[0078] The shape of the shorting elements and the locations of connection of the shorting elements to the dipole antenna 8 and opposed element 10 can freely be chosen. It is desirable, however, to maintain the symmetry with respect to the symmetric axis A2.

[0079] The structure of the ninth embodiment may be modified as in the first embodiment.

(Tenth Embodiment)

[0080] A mobile telephone apparatus according to a tenth embodiment of the present invention will now be described with reference to FIG. 24. In FIG. 24, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted.

[0081] The mobile telephone apparatus according to the tenth embodiment is based on the mobile telephone apparatus according to the fourth embodiment. In the tenth embodiment, the mode of power feed is altered. Specifically, power feed means 26 is added. The power feed means 26 feeds power to the opposed element 10 with a phase that is opposite to the phase of the power feed means 6.

[0082] With this structure, an induction current vector induced by the dipole antenna 8 and a drive current vec-

tor fed from the power feed means 26 are added in the reverse phase in the opposed element 10. Therefore, the same advantages as with the fourth embodiment can be obtained, and the radiation intensity can be increased.

[0083] This mode of power feed is also applicable to a configuration that is based on embodiments other than the fourth embodiment of the present invention.

10 (Eleventh Embodiment)

[0084] A mobile telephone apparatus according to an eleventh embodiment of the present invention will now be described with reference to FIG. 25. In FIG. 25, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted.

[0085] The mobile telephone apparatus according to the eleventh embodiment is based on the mobile telephone apparatus according to the fourth embodiment. In the eleventh embodiment, the mode of power feed is altered. Specifically, the position of the power feed means 6 is displaced from the middle point of the base portion 8a.

25 **[0086]** With this structure, too, the drive current vector V_b in the bent portion 8b and the drive current vector V_c in the bent portion 8c can maintain the relationship of opposite phases, as far as the dipole antenna 8 is configured to have a proper length based on an odd-number of times of $\lambda/2$. Therefore, the same advantages as with the fourth embodiment can be achieved.

[0087] This mode of power feed is also applicable to a configuration that is based on embodiments other than the fourth embodiment of the present invention.

35 **[0088]** The structure of the eleventh embodiment may be modified as in the first embodiment.

(Twelfth Embodiment)

40 **[0089]** A mobile telephone apparatus according to a twelfth embodiment of the present invention will now be described with reference to FIG. 26. In FIG. 26, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted.

[0090] The mobile telephone apparatus according to the twelfth embodiment is based on the mobile telephone apparatus according to the fourth embodiment, and it includes the antenna 27 which is obtained by modifying the antenna 9. The antenna 27 includes a dipole antenna 28 and the opposed element 10. Specifically, the antenna 27 includes the dipole antenna 28 in place of the dipole antenna 8 of the antenna 9.

50 **[0091]** The dipole antenna 28 is formed as a conductor pattern on a board 29 that is built in the casing 1. The dipole antenna 28 includes a base portion 28a and bent portions 28b and 28c. The shape and the position of the dipole antenna 28 are the same as those of the dipole

antenna 8.

[0092] With this structure, when the board 29 is fabricated, the dipole antenna 28 can be formed at the same time. If the board 29 is mounted in the casing 1, the dipole antenna 28 can also be mounted. In addition, if the opposed element 10 is disposed in the casing 1, the antenna 27 can be formed. Thus, the mobile telephone apparatus according to the twelfth embodiment can efficiently be manufactured.

[0093] This mode of mounting is also applicable to a configuration that is based on embodiments other than the fourth embodiment of the present invention.

[0094] The structure of the twelfth embodiment may be modified as in the first embodiment.

(13th Embodiment)

[0095] A mobile telephone apparatus according to a 13th embodiment of the present invention will now be described with reference to FIG. 27. In FIG. 27, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted.

[0096] The mobile telephone apparatus according to the 13th embodiment includes an upper casing 30 and a lower casing 31 that are configured to be foldable by means of a hinge (not shown). Electric circuits accommodated in the upper casing 30 and lower casing 31 are electrically connected by means of a connection member 32 such as a flexible board.

[0097] The upper casing 30 contains the antenna 9. The antenna 9 is configured such that the imaginary plane in which the dipole antenna 8 and opposed element 10 are positioned is parallel to the front surface of the upper casing 30.

[0098] With the structure of the 13th embodiment, the same advantages as with the fourth embodiment can be obtained.

[0099] This mode of mounting is also applicable to a configuration that is based on embodiments other than the fourth embodiment of the present invention.

[0100] The structure of the 13th embodiment may be modified as in the first embodiment.

(14th Embodiment)

[0101] A mobile telephone apparatus according to a 14th embodiment of the present invention will now be described with reference to FIG. 28. In FIG. 28, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted.

[0102] The mobile telephone apparatus according to the 14th embodiment includes an upper casing 30 and a lower casing 31, like the 13th embodiment. The dipole antenna 8 is accommodated in the lower casing 31 such that the imaginary plane in which the base element 8a and bent elements 8b and 8c are positioned is parallel

to the front surface of the lower casing 31. The opposed element 10 is accommodated in the upper casing 30 such that the imaginary plane in which the base element 10a and bent elements 10b and 10c are positioned is parallel to the front surface of the upper casing 30.

[0103] With the structure of the 14th embodiment, the same advantages as with the fourth embodiment can be obtained.

[0104] This mode of mounting is also applicable to the case of using antennas according to embodiments other than the fourth embodiment of the present invention.

[0105] The structure of the 14th embodiment may be modified as in the first embodiment.

15 (15th Embodiment)

[0106] A mobile telephone apparatus according to a 15th embodiment of the present invention will now be described with reference to FIG. 29. In FIG. 29, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted.

[0107] The mobile telephone apparatus according to the 15th embodiment includes the upper casing 30 and lower casing 31, like the 13th embodiment. Electric circuits accommodated in the upper casing 30 and lower casing 31 are electrically connected by means of a connection member 33 such as a flexible board.

[0108] The mobile telephone apparatus according to the 15th embodiment includes an antenna 34 that is formed by modifying the antenna 9 of the fourth embodiment. The antenna 34 includes the dipole antenna 8 and an opposed element 35. Specifically, the antenna 34 includes the opposed element 35 that is substituted for the opposed element 10 of the antenna 9.

[0109] The opposed element 35 is formed as a conductor pattern on the connection member 33. The opposed element 35 includes a base portion 35a and bent portions 35b and 35c. The opposed element 35 has the same shape as the opposed element 10. The imaginary plane in which the base portion 35a and bent portions 35b and 35c of the opposed element 35 are positioned is parallel to the front surface of the upper casing 30 in the state in which the upper casing 30 and lower casing 31 are opened, as shown in FIG. 29.

[0110] With the structure of the 15th embodiment, the same advantages as with the fourth embodiment can be obtained. In addition, according to the 15th embodiment, it should suffice if only the dipole antenna 8 is accommodated in the casing. Thus, the size of the casing can further be reduced.

[0111] The structure of the 15th embodiment may be modified as in the first embodiment.

[0112] Besides, in the 15th embodiment, the dipole antenna 8 may be accommodated in the upper casing 30. It is possible that the dipole antenna is formed of a conductor pattern on the connection member and the opposed element 35 is accommodated in the upper cas-

ing 30 or lower casing 31. Both the dipole antenna and opposed element may be formed of conductor patterns on the connection member.

[0113] The antenna in each of the first to 15th embodiments is basically composed of a balanced-type dipole antenna, and an opposed element is additionally provided. Thus, a current decreases, which flows, according to radiation from the antenna, on the board accommodated in the casing along with the antenna. As a result, a variation in voltage standing-wave ratio (VSWR), which depends on the change of the condition of use, decreases. In short, such an advantage can be obtained that the variation in input impedance due to the change of the state of use is small and an increase of mismatching loss will hardly occur.

[0114] Assume that the antenna 9 of the mobile wireless communication terminal shown in FIG. 27 is replaced with the antenna 22 shown in FIG. 19. FIG. 30 and FIG. 31 show experimental values of VSWR relating to this mobile wireless communication terminal.

[0115] As is understood from FIG. 30, the VSWR characteristics do not greatly vary between the following states: a state (Free) in which the mobile wireless communication terminal is disposed in a free space, a state (Hand) in which the lower casing 31 is held by the hand, and a state (Head) in which the lower casing 31 is held by the hand and the upper casing 30 is positioned close to the head. As is understood from FIG. 31, the VSWR characteristics do not greatly vary between the following states: a state (OPEN) in which the upper casing 30 and lower casing 31 are opened and a state (CLOSE) in which the upper casing 30 and lower casing 31 are closed.

(16th Embodiment)

[0116] A mobile telephone apparatus according to a 16th embodiment of the present invention will now be described with reference to FIG. 32 through FIG. 35. In FIG. 32 and FIG. 33, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted.

[0117] As is shown in FIG. 32, the mobile telephone apparatus according to the 16th embodiment includes an antenna 36 built in the casing 1. The antenna 36 includes the dipole antenna 3, the opposed element 4, and parasitic elements 37 and 38. Specifically, the antenna 36 is formed by adding parasitic elements 37 and 38 to the antenna 2 of the first embodiment.

[0118] The parasitic elements 37 and 38 are formed of conductor material in a straight shape. The length of each parasitic element 37, 38 differs from that of the dipole antenna 3. In FIG. 32, each parasitic element 37, 38 is shorter than the dipole antenna 3. The parasitic elements 37 and 38 are disposed in the imaginary plane in which the dipole antenna 3 and opposed element 4 are positioned. The parasitic element 37 is spaced apart

from the dipole antenna 3 by a predetermined distance L2 and is parallel to the dipole antenna 3. The parasitic element 38 is spaced apart from the opposed element 4 by a predetermined distance L3 and is parallel to the opposed element 4. The distance L2, L3 is $\lambda/4$ or less. In other words, the parasitic element 38, opposed element 4, dipole antenna 3 and parasitic element 37 are arranged in the named order in the up-and-down direction of the casing 1 at intervals of $\lambda/4$ or less. The parasitic elements 37 and 38 are configured to be in line-symmetry with respect to the symmetric axis A2.

[0119] When power is fed from the power feed means 6 to the dipole antenna 3, a drive current vector V occurs in the dipole antenna 3, as shown in FIG. 33. An induction current vector Vi1, which is induced by the drive current vector V and has a phase opposite to the phase of the drive current vector V, is caused in the opposed element 4. An induction current vector Vi2, which is induced by the drive current vector V and has a phase opposite to the phase of the drive current vector V, is caused in the parasitic element 37. An induction current vector Vi3, which is induced by the induction current vector Vi1 and has the same phase as the drive current vector V, is caused in the parasitic element 38. The antenna 36 emits radiation by the drive current vector V and induction current vectors Vi1, Vi2 and Vi3.

[0120] When the radiation pattern of the antenna 36 is viewed from the left side of the casing 1, it looks like a simple figure eight, which is substantially symmetric with respect to the front-and-rear axis, as shown in FIG. 34. The reason for this is that the current vectors v and Vi1 have opposite phases and thus the energy radiated from the dipole antenna 3 and the energy radiated from the opposed element 4 cancel each other in the vicinity of the center in the front-and-rear direction. Since the dipole antenna 3 and opposed element 4 are disposed in the right-and-left direction of the casing 1, the horizontally polarized wave component is dominant, relative to the vertically polarized wave component. Since the dipole antenna 3 and opposed element 4 are configured to be in line-symmetry with respect to the symmetric axis A2, the radiation pattern (not shown) as viewed from the front side of the casing 1 is symmetric in the right-and-left direction.

[0121] A VSWR with reference to the power feed means 6, which relates to only the functions of the dipole antenna 3 and opposed element 4, has characteristics as shown by a broken line in FIG. 35. In short, single-peak frequency characteristics with a first resonance point are obtained. The frequency at the first resonance point is determined by the length of the dipole antenna 3.

[0122] On the other hand, since the induction current vectors V12 and V13 have opposite phases, the radiation pattern formed by these vectors has the same shape as shown in FIG. 34. A VSWR, which relates to only the functions of the parasitic elements 37 and 38, also has single-peak frequency characteristics. However, since the parasitic element 37, 38 has a length dif-

ferent from the length of the dipole antenna 6, a second resonance point with a frequency different from the frequency of the first resonance point occurs depending on the functions of the parasitic elements 37 and 38. If the parasitic element 37, 38 is shorter than the dipole antenna 6, as shown in FIG. 32, the second resonance point has a higher frequency than the first resonance point. The VSWR of the antenna 36 has frequency characteristics that are obtained by compounding these two characteristics. That is, double-peak frequency characteristics are obtained as shown by a solid line in FIG. 35.

[0123] One of the resonance points in the frequency characteristics shown by the solid line in FIG. 35 is obtained from the first resonance point, but these points do not coincide, as shown in FIG. 35, because of the effect of the functions of the parasitic elements 37 and 38. Note that for the purpose of easier understanding, FIG. 35 shows the displacement in a larger scale than the actual one.

[0124] As is understood from FIG. 35, the antenna 36 has a broader frequency band than the antenna 2 of the first embodiment which comprises only the dipole antenna 3 and opposed element 4.

[0125] In the 16th embodiment, the addition of the parasitic elements 37 and 38 makes the size of the antenna 36 larger than the antenna 2. However, since the parasitic elements 37 and 38 are disposed in the same imaginary plane as the dipole antenna 3 and opposed element 4, the antenna 36, like the antenna 2, has a thin external shape along the front surface of the casing 1. Hence, when the casing 1 is formed to have a thin shape with a small thickness in the front-and-rear direction, the antenna 36 can efficiently be accommodated in the casing 1. Therefore, it is possible to obtain a mobile telephone apparatus which has a small size and can decrease degradation in communication performance due to the close positional relationship between the human body and the front surface of the casing 1.

[0126] The structure of the 16th embodiment may be modified as in the first embodiment. In the 16th embodiment, the parasitic elements 37 and 38 may be inclined relative to the dipole antenna 3 and opposed element 4. The parasitic elements 37 and 38 may not be in line-symmetry with respect to the symmetric axis A2. It should be noted, however, that as the degree of parallelism or symmetry becomes lower, the symmetric property of the radiation pattern is degraded. Thus, in the case where a regular radiation pattern is required, it is desirable to maximize the degree of parallelism or symmetry.

[0127] The parasitic element 37, 38 may be longer than the dipole antenna 3. In this case, the second resonance point has a lower frequency than the first resonance point.

[0128] The distance L2, L3 may be greater than $\lambda/4$.

[0129] The direction of the dipole antenna 3 and opposed element 4 may be inclined relative to the right-and-left direction.

[0130] The antenna 36 may be contained in the upper casing 30 or the lower casing 31.

(17th Embodiment)

[0131] A mobile telephone apparatus according to a 17th embodiment of the present invention will now be described with reference to FIG. 36. In FIG. 36, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted.

[0132] As is shown in FIG. 36, the mobile telephone apparatus according to the 17th embodiment includes an antenna 39 that is built in the casing 1. The antenna 39 includes the dipole antenna 8, opposed element 10, and parasitic elements 37 and 38. Specifically, the antenna 39 is formed by adding parasitic elements 37 and 38 to the antenna 9 of the fourth embodiment.

[0133] The parasitic element 37, 38 is shorter than the base portion 8a. The parasitic element 37 is disposed such that the relationship between the base portion 8a and parasitic element 37 coincides with the relationship between the dipole antenna 3 and parasitic element 37 in the 16th embodiment. The parasitic element 38 is disposed such that the relationship between the base portion 10a and parasitic element 38 coincides with the relationship between the opposed element 10 and parasitic element 38 in the 16th embodiment.

[0134] When power is fed to the dipole antenna 8 from the power feed means 6, the antenna 39 emits radiation, similarly with the fourth embodiment, by the functions of the drive current vector occurring in the dipole antenna 8 and the induction current vector occurring in the opposed element 10. On the other hand, the antenna 39 emits radiation, similarly with the 16th embodiment, by the functions of the induction current vectors occurring in the parasitic elements 37 and 38. In addition, since the parasitic element 37, 38 is shorter than the dipole antenna 8, the VSWR of the antenna 39 has double-peak frequency characteristics for the same reason as has been stated in connection with the 16th embodiment.

[0135] Thus, with the 17th embodiment, it is possible to obtain a mobile telephone apparatus which has a small size and can decrease degradation in communication performance due to the close positional relationship between the human body and the front surface of the casing 1. Furthermore, according to the 17th embodiment, both the horizontally polarized wave component and vertically polarized wave component can fully be radiated, and a broad frequency band is realized.

[0136] The structure of the 17th embodiment may be modified as in the first embodiment or the 16th embodiment.

[0137] The antenna 39 may be contained in the upper casing 30 or the lower casing 31.

(18th Embodiment)

[0138] A mobile telephone apparatus according to an 18th embodiment of the present invention will now be described with reference to FIG. 37. In FIG. 37, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted.

[0139] As is shown in FIG. 37, the mobile telephone apparatus according to the 18th embodiment includes an antenna 40 that is built in the casing 1. The antenna 40 includes the dipole antenna 8, opposed element 10, and parasitic elements 37 and 38. Specifically, the antenna 40 is formed by adding parasitic elements 37 and 38 to the antenna 9 of the fourth embodiment.

[0140] The parasitic element 37, 38 is shorter than the dipole antenna 8. The parasitic elements 37 and 38 are arranged to sandwich the dipole antenna 8 and opposed element 10. The parasitic element 37 is disposed in parallel to the bent portions 8b and 10b. The parasitic element 38 is disposed in parallel to the bent portions 8c and 10c. The parasitic elements 37 and 38 are disposed in the imaginary plane in which the dipole antenna 8 and opposed element 10 are positioned.

[0141] When power is fed to the dipole antenna 8 from the power feed means 6, the antenna 40 emits radiation, similarly with the fourth embodiment, by the functions of the drive current vector occurring in the dipole antenna 8 and the induction current vector occurring in the opposed element 10. On the other hand, the antenna 40 emits radiation, similarly with the 16th embodiment, by the functions of the induction current vectors occurring in the parasitic elements 37 and 38. In addition, since the parasitic element 37, 38 is shorter than the dipole antenna 8, the VSWR of the antenna 40 has double-peak frequency characteristics for the same reason as has been stated in connection with the 16th embodiment.

[0142] In the 18th embodiment, however, the direction of the parasitic elements 37 and 38 is rotated by 90° relative to the direction of the parasitic elements 37 and 38 in the 16th or 17th embodiment. That is, the parasitic elements 37 and 38 are disposed in the up-and-down direction. Thus, the second resonance point appears conspicuously in the vertically polarized wave component in the 18th embodiment, while it appears conspicuously in the horizontally polarized wave component in the 16th or 17th embodiment.

[0143] Thus, with the 18th embodiment, it is possible to obtain a mobile telephone apparatus which has a small size and can decrease degradation in communication performance due to the close positional relationship between the human body and the front surface of the casing 1. Furthermore, according to the 18th embodiment, both the horizontally polarized wave component and vertically polarized wave component can fully be radiated, and a broad frequency band is realized.

[0144] The structure of the 18th embodiment may be

modified as in the first embodiment or the 16th embodiment.

[0145] The antenna 40 may be contained in the upper casing 30 or the lower casing 31.

(19th Embodiment)

[0146] A mobile telephone apparatus according to a 19th embodiment of the present invention will now be described with reference to FIG. 38. In FIG. 38, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted. FIG. 38 shows only the structure of an antenna 41 built in the mobile telephone apparatus according to the 19th embodiment.

[0147] The mobile telephone apparatus according to the 19th embodiment is based on the mobile telephone apparatus according to the fourth embodiment, and it includes the antenna 41 which is obtained by modifying the antenna 9. The antenna 41 includes the dipole antenna 8, opposed element 10, and parasitic elements 42 and 43. Specifically, the antenna 41 is formed by adding the parasitic elements 42 and 43 to the antenna 9.

[0148] The parasitic element 42, like the dipole antenna 8, is formed of a conductor material so as to have a base portion 42a and bent portions 42b and 42c. The base portion 42a and bent portions 42b and 42c are shorter than the base portion 8a and bent portions 8b and 8c, respectively. The parasitic element 42 is disposed inside the dipole antenna 8 such that the base portion 42a and bent portions 42b and 42c are parallel to the base portion 8a and bent portions 8b and 8c, respectively.

[0149] The parasitic element 43, like the opposed element 10, is formed of a conductor material so as to have a base portion 43a and bent portions 43b and 43c. The base portion 43a and bent portions 43b and 43c are shorter than the base portion 10a and bent portions 10b and 10c, respectively. The parasitic element 43 is disposed inside the opposed element 10 such that the base portion 43a and bent portions 43b and 43c are situated parallel to the base portion 10a and bent portions 10b and 10c, respectively.

[0150] The parasitic elements 42 and 43 are disposed in the imaginary plane in which the dipole antenna 8 and opposed element 10 are positioned. The parasitic elements 42 and 43 are in line-symmetry with respect to the symmetric axis A2.

[0151] When power is fed to the dipole antenna 8 from the power feed means 6, the antenna 41 emits radiation, similarly with the fourth embodiment, by the functions of the drive current vector occurring in the dipole antenna 8 and the induction current vector occurring in the opposed element 10. On the other hand, since the induction current vectors occurring in the parasitic elements 42 and 43 have opposite phases, the antenna 41 emits radiation by functions similar to the functions of the drive

current vector occurring in the dipole antenna 8 and the induction current vector occurring in the opposed element 10. In addition, since the parasitic element 42, 43 is shorter than the dipole antenna 8, the VSWR of the antenna 41 has double-peak frequency characteristics for the same reason as has been stated in connection with the 16th embodiment.

[0152] In the 19th embodiment, the base portion 42a of parasitic element 42 is perpendicular to the bent portions 42b and 42c, and the base portion 43a of parasitic element 43 is perpendicular to the bent portions 43b and 43c. Thus, the second resonance point appears conspicuously in each of the vertically polarized wave component and horizontally polarized wave component.

[0153] Thus, with the 19th embodiment, it is possible to obtain a mobile telephone apparatus which has a small size and can decrease degradation in communication performance due to the close positional relationship between the human body and the front surface of the casing 1. Furthermore, according to the 19th embodiment, the vertically polarized wave component can fully be radiated, and a broad frequency band is realized.

[0154] The structure of the 19th embodiment may be modified as in the first embodiment or the 16th embodiment.

[0155] The antenna 41 may be contained in the upper casing 30 or the lower casing 31.

(20th Embodiment)

[0156] A mobile telephone apparatus according to a 20th embodiment of the present invention will now be described with reference to FIG. 39. In FIG. 39, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted. FIG. 39 shows only the structure of an antenna 44 that is built in the mobile telephone apparatus according to the 20th embodiment.

[0157] As is shown in FIG. 39, the mobile telephone apparatus according to the 20th embodiment includes the antenna 44 built in the casing 1. The antenna 44 includes the dipole antenna 8, opposed element 10, and parasitic elements 37 and 38.

[0158] Specifically, the antenna 44 includes the same elements as those of the antenna 39 of the 17th embodiment. The parasitic elements 37 and 38 are disposed along the base portions 8a and 10a in an imaginary plane that is different from the imaginary plane in which the dipole antenna 8 and opposed element 10 are positioned. Each of the parasitic elements 37 and 38 is line-symmetric with respect to a symmetric axis A3. The symmetric axis A3 is parallel to the symmetric axis A2 with a distance of $\lambda/4$ or less in the forward direction. In the description below, the imaginary planes in which the symmetric axes A2 and A3 are positioned are referred to as a first imaginary plane and a second imaginary

plane, respectively.

[0159] When power is fed to the dipole antenna 8 from the power feed means 6, the antenna 44 emits radiation similarly with the 17th embodiment.

[0160] In the 20th embodiment, the dipole antenna 8 and opposed element 10 are disposed in the first imaginary plane, and the parasitic elements 37 and 38 are disposed in the second imaginary plane, the first and second imaginary planes being arranged in the front-and-rear direction. Consequently, the thickness of the antenna 44 in the front-and-rear direction becomes larger than that of the antenna 39 of the 17th embodiment. However, since the distance between the first and second imaginary planes can be set at $\lambda/4$ or less, the thickness of the casing 1 in the front-and-rear direction is not greatly increased. Conversely, since the inside areas of the dipole antenna 8 and opposed element 10 can effectively be used for disposing other components, the thickness of the casing 1 may possibly be reduced by devising arrangement of other components.

[0161] Thus, with the 20th embodiment, it is possible to obtain a mobile telephone apparatus which has a small size and can decrease degradation in communication performance due to the close positional relationship between the human body and the front surface of the casing 1. Furthermore, according to the 20th embodiment, both the horizontally polarized wave component and vertically polarized wave component can fully be radiated, and a broad frequency band is realized.

[0162] The structure of the 20th embodiment may be modified as in the first embodiment or the 16th embodiment.

[0163] In the 20th embodiment, the first imaginary plane and the second imaginary plane may be reversely positioned in the front-and-rear direction.

[0164] Besides, in the 20th embodiment, the second imaginary plane may be inclined relative to the first imaginary plane. It should be noted, however, that as the degree of parallelism between the first and second imaginary planes becomes lower, the symmetric property of the radiation pattern is degraded. Thus, in the case where a regular radiation pattern is required, it is desirable to maximize the degree of parallelism between the first and second imaginary planes.

[0165] The antenna 44 may be contained in the upper casing 30 or the lower casing 31.

(21st Embodiment)

[0166] A mobile telephone apparatus according to a 21st embodiment of the present invention will now be described with reference to FIG. 40. In FIG. 40, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted. FIG. 40 shows only the structure of an antenna 45 that is built in the mobile telephone apparatus according to the 21st embodiment.

[0167] As is shown in FIG. 40, the mobile telephone apparatus according to the 21st embodiment includes the antenna 45 built in the casing 1. The antenna 45 includes the dipole antenna 8, opposed element 10, and parasitic elements 37 and 38.

[0168] Specifically, the antenna 45 includes the same elements as those of the antenna 40 of the 18th embodiment. The parasitic elements 37 and 38 are disposed along the bent portions 8b and 10b and the bent portions 8c and 10c, respectively. The parasitic elements 37 and 38 are line-symmetric with respect to the symmetric axis A3.

[0169] When power is fed to the dipole antenna 8 from the power feed means 6, the antenna 45 emits radiation similarly with the 18th embodiment.

[0170] In the 21st embodiment, the thickness of the antenna 45 in the front-and-rear direction and the thickness of the casing 1 in the front-and-rear direction are the same as those in the 20th embodiment.

[0171] With the 21st embodiment, it is possible to obtain a mobile telephone apparatus which has a small size and can decrease degradation in communication performance due to the close positional relationship between the human body and the front surface of the casing 1. Furthermore, according to the 21st embodiment, both the horizontally polarized wave component and vertically polarized wave component can fully be radiated, and a broad frequency band is realized.

[0172] The structure of the 21st embodiment may be modified as in the first embodiment, the 16th embodiment or the 20th embodiment.

[0173] The antenna 45 may be contained in the upper casing 30 or the lower casing 31.

(22nd Embodiment)

[0174] A mobile telephone apparatus according to a 22nd embodiment of the present invention will now be described with reference to FIG. 41. In FIG. 41, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted. FIG. 41 shows only the structure of an antenna 46 that is built in the mobile telephone apparatus according to the 22nd embodiment.

[0175] As is shown in FIG. 41, the mobile telephone apparatus according to the 22nd embodiment includes the antenna 46 built in the casing 1. The antenna 46 includes the dipole antenna 8, opposed element 10, and parasitic elements 42 and 43.

[0176] Specifically, the antenna 46 includes the same elements as those of the antenna 41 of the 19th embodiment. The parasitic elements 42 and 43 are disposed in the second imaginary plane. The parasitic elements 42 and 43 are line-symmetric with respect to the symmetric axis A3.

[0177] When power is fed to the dipole antenna 8 from the power feed means 6, the antenna 46 emits radiation

similarly with the 19th embodiment.

[0178] In the 22nd embodiment, the thickness of the antenna 46 in the front-and-rear direction and the thickness of the casing 1 in the front-and-rear direction are the same as those in the 20th embodiment.

[0179] With the 22nd embodiment, it is possible to obtain a mobile telephone apparatus which has a small size and can decrease degradation in communication performance due to the close positional relationship between the human body and the front surface of the casing 1. Furthermore, according to the 22nd embodiment, both the horizontally polarized wave component and vertically polarized wave component can fully be radiated, and a broad frequency band is realized.

[0180] The structure of the 22nd embodiment may be modified as in the first embodiment, the 16th embodiment or the 20th embodiment.

[0181] The antenna 46 may be contained in the upper casing 30 or the lower casing 31.

(23rd Embodiment)

[0182] A mobile telephone apparatus according to a 23rd embodiment of the present invention will now be described with reference to FIG. 42. In FIG. 42, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted. FIG. 42 shows only the structure of an antenna 47 that is built in the mobile telephone apparatus according to the 23rd embodiment.

[0183] As is shown in FIG. 42, the mobile telephone apparatus according to the 23rd embodiment includes the antenna 47 built in the casing 1. The antenna 47 includes a dipole antenna 48, an opposed element 49, and parasitic elements 50 and 51.

[0184] The dipole antenna 48, opposed element 49 and parasitic elements 50 and 51 are all formed of flat-plate conductor materials. The dipole antenna 48 is formed to have a base portion 48a and bent portions 48b and 48c. The bent portions 48b and 48c are bent from both ends of the base portion 48a at right angles and extend in the same direction. A major surface of the base portion 48a faces in the front-and-rear direction. Major surfaces of the bent portions 48b and 48c face in the right-and-left direction. Like the dipole antenna 48, the opposed element 49 is configured to have a base portion 49a and bent portions 49b and 49c, the parasitic element 50 is configured to have a base portion 50a and bent portions 50b and 50c, and the parasitic element 51 is configured to have a base portion 51a and bent portions 51b and 51c.

[0185] The dipole antenna 48, opposed element 49 and parasitic elements 50 and 51 are disposed with the same positional relationship as the dipole antenna 8, opposed element 10 and parasitic elements 42 and 43 in the 19th embodiment. However, the base portions 48a, 49a, 50a and 51a are disposed in the same imaginary

plane, and the bent portions 48b, 48c, 49b, 49c, 50b, 50c, 51b and 51c are disposed in the same direction.

[0186] When power is fed to the dipole antenna 48 from the power feed means 6, the antenna 47 emits radiation similarly with the 19th embodiment.

[0187] In the 23rd embodiment, the bent portions 48b, 48c, 49b, 49c, 50b, 50c, 51b and 51c are projected rearward, relative to the base portions 48a, 49a, 50a and 51a. Consequently, the thickness of the antenna 47 in the front-and-rear direction is larger than that of the antenna 41 of the 19th embodiment. However, the antenna 47 can efficiently be accommodated in the casing 1 by arranging the bent portions 48b, 48c, 49b, 49c, 50b, 50c, 51b and 51c along the side faces of the casing 1. Thereby, the effective mounting area for disposing other components such as a display can be increased.

[0188] Thus, with the 23rd embodiment, it is possible to obtain a mobile telephone apparatus which has a small size and can decrease degradation in communication performance due to the close positional relationship between the human body and the front surface of the casing 1. Furthermore, according to the 23rd embodiment, both the horizontally polarized wave component and vertically polarized wave component can fully be radiated, and a broad frequency band is realized.

[0189] The structure of the 23rd embodiment may be modified as in the first embodiment or the 16th embodiment.

[0190] In the 23rd embodiment, the bent portions 48b, 48c, 49b, 49c, 50b, 50c, 51b and 51c may be projected forward, relative to the base portions 48a, 49a, 50a and 51a. In addition, the major surfaces of the base portions 48a, 49a, 50a and 51a may not be at right angles with the major surfaces of the bent portions 48b, 48c, 49b, 49c, 50b, 50c, 51b and 51c.

[0191] The antenna 47 may be contained in the upper casing 30 or the lower casing 31.

(24th Embodiment)

[0192] A mobile telephone apparatus according to a 24th embodiment of the present invention will now be described with reference to FIG. 43. In FIG. 43, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted. FIG. 43 shows only the structure of an antenna 52 that is built in the mobile telephone apparatus according to the 24th embodiment.

[0193] As is shown in FIG. 43, the mobile telephone apparatus according to the 24th embodiment includes the antenna 52 built in the casing 1. The antenna 52 includes a dipole antenna 53, an opposed element 54, and parasitic elements 55 and 56.

[0194] The dipole antenna 53, opposed element 54 and parasitic elements 55 and 56 are all formed of flat-plate conductor materials. The dipole antenna 53 is formed to have a base portion 53a and bent portions

53b and 53c. The bent portions 53b and 53c are bent from both ends of the base portion 53a at right angles and extend in the same direction. A major surface of the base portion 53a faces in the up-and-down direction.

Major surfaces of the bent portions 53b and 53c face in the right-and-left direction. Like the dipole antenna 53, the opposed element 54 is configured to have a base portion 54a and bent portions 54b and 54c, the parasitic element 55 is configured to have a base portion 55a and bent portions 55b and 55c, and the parasitic element 56 is configured to have a base portion 56a and bent portions 56b and 56c.

[0195] The dipole antenna 53, opposed element 54 and parasitic elements 55 and 56 are disposed with the same positional relationship as the dipole antenna 8, opposed element 10 and parasitic elements 42 and 43 in the 19th embodiment.

[0196] When power is fed to the dipole antenna 53 from the power feed means 6, the antenna 52 emits radiation similarly with the 19th embodiment.

[0197] In the 24th embodiment, the dipole antenna 53, opposed element 54 and parasitic elements 55 and 56 have thickness in the front-and-rear direction. Consequently, the thickness of the antenna 52 in the front-and-rear direction is larger than that of the antenna 41 of the 19th embodiment. However, the antenna 52 can efficiently be accommodated in the casing 1 by arranging the bent portions 53b, 53c, 54b, 54c, 55b, 55c, 56b and 56c along the side faces of the casing 1. Thereby, the effective mounting area for disposing other components such as a display can be increased.

[0198] Thus, with the 24th embodiment, it is possible to obtain a mobile telephone apparatus which has a small size and can decrease degradation in communication performance due to the close positional relationship between the human body and the front surface of the casing 1. Furthermore, according to the 24th embodiment, both the horizontally polarized wave component and vertically polarized wave component can fully be radiated, and a broad frequency band is realized.

[0199] The structure of the 24th embodiment may be modified as in the first embodiment or the 16th embodiment.

[0200] The antenna 52 may be contained in the upper casing 30 or the lower casing 31.

(25th Embodiment)

[0201] A mobile telephone apparatus according to a 25th embodiment of the present invention will now be described with reference to FIG. 44. In FIG. 44, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted. FIG. 44 shows only the structure of an antenna 57 that is built in the mobile telephone apparatus according to the 25th embodiment.

[0202] As shown in FIG. 44, the mobile telephone ap-

paratus according to the 25th embodiment includes the antenna 57 built in the casing 1. The antenna 57 includes the dipole antenna 8, opposed element 10, and parasitic elements 58 and 59. Specifically, the antenna 57 is formed by adding the parasitic elements 58 and 59 to the antenna 9 of the fourth embodiment.

[0203] The parasitic element 58 is formed of a conductor material so as to have a base portion 58a, a pair of first bent portions 58b and 58c, and a pair of second bent portions 58d and 58e. The base portion 58a is longer than the base portion 8a. The first bent portions 58b and 58c are bent from both ends of the base portion 58a at right angles and extend in the same direction. The first bent portions 58b and 58c have the same length. The second bent portions 58d and 58e are bent at right angles from the ends of the first bent portions 58b and 58c and extend toward each other. The parasitic element 59, like the parasitic element 58, is formed to have a base portion 59a, a pair of first bent portions 59b and 59c, and a pair of second bent portions 59d and 59e.

[0204] The parasitic elements 58 and 59 are arranged along the opposed axis A2. An imaginary plane in which all portions of the parasitic element 58 are positioned and an imaginary plane in which all portions of the parasitic element 59 are positioned are opposed to each other. These two imaginary planes are perpendicular to the imaginary plane in which the dipole antenna 8 and opposed element 10 are positioned. In addition, the bent portions 8b, 8c, 10b and 10c pass through these two imaginary planes. The parasitic element 58 is line-symmetric with respect to a symmetric axis M1, and the parasitic element 59 is line-symmetric with respect to a symmetric axis M2. The symmetric axes M1 and M2 intersect at right angles with the symmetric axis A2 and extend in the front-and-rear direction.

[0205] When power is fed to the dipole antenna 8 from the power feed means 6, the antenna 57 emits radiation similarly with the 17th embodiment.

[0206] In the 25th embodiment, the parasitic elements 58 and 59 have thickness in the front-and-rear direction. Consequently, the thickness of the antenna 57 in the front-and-rear direction is larger than that of the antenna 39 of the 17th embodiment. However, the antenna 57 can efficiently be accommodated in the casing 1 by arranging the bent portions 58b, 58c, 58d, 58e, 59b, 59c, 59d and 59e along the side faces of the casing 1. Thereby, the effective mounting area for mounting other components such as a display can be increased.

[0207] Thus, with the 25th embodiment, it is possible to obtain a mobile telephone apparatus which has a small size and can decrease degradation in communication performance due to the close positional relationship between the human body and the front surface of the casing 1. Furthermore, according to the 25th embodiment, both the horizontally polarized wave component and vertically polarized wave component can fully be radiated, and a broad frequency band is realized.

[0208] The structure of the 25th embodiment may be

modified as in the first embodiment or the 16th embodiment.

[0209] The antenna 57 may be contained in the upper casing 30 or the lower casing 31.

(26th Embodiment)

[0210] A mobile telephone apparatus according to a 26th embodiment of the present invention will now be described with reference to FIG. 45. In FIG. 45, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted. FIG. 45 shows only the structure of an antenna 60 that is built in the mobile telephone apparatus according to the 26th embodiment.

[0211] As shown in FIG. 45, the mobile telephone apparatus according to the 26th embodiment includes the antenna 60 built in the casing 1. The antenna 60 includes the dipole antenna 8, opposed element 10, shorting elements 23 and 24, and parasitic elements 42 and 43. Specifically, the antenna 60 is formed by adding the parasitic elements 42 and 43 to the antenna 22 of the ninth embodiment.

[0212] The parasitic element 42 is disposed inside the dipole antenna 8 such that the base portion 42a and bent portions 42b and 42c are parallel to the base portion 8a and bent portions 8b and 8c, respectively. The parasitic element 43 is disposed inside the opposed element 10 such that the base portion 43a and bent portions 43b and 43c are parallel to the base portion 10a and bent portions 10b and 10c, respectively.

[0213] The parasitic elements 42 and 43 are disposed in the imaginary plane in which the dipole antenna 8 and opposed element 10 are positioned. The parasitic elements 42 and 43 are in line-symmetry with respect to the symmetric axis A2.

[0214] When power is fed to the dipole antenna 8 from the power feed means 6, the antenna 60 emits radiation, similarly with the 19th embodiment. In addition, by the functions of the shorting elements 23 and 24, the same advantages as with the ninth embodiment can be obtained.

[0215] Thus, with the 26th embodiment, it is possible to obtain a mobile telephone apparatus which has a small size and can decrease degradation in communication performance due to the close positional relationship between the human body and the front surface of the casing 1. Furthermore, according to the 26th embodiment, both the horizontally polarized wave component and vertically polarized wave component can fully be radiated, and a broad frequency band is realized.

[0216] The structure of the 26th embodiment may be modified as in the first embodiment or the 16th embodiment.

[0217] The antenna 60 may be contained in the upper casing 30 or the lower casing 31.

[0218] The VSWR in the case where the antenna 60

is contained in the upper casing 30 was measured. FIG. 46 shows the measurement result in which two resonance points are obtained. In FIG. 46, "Open" indicates a measurement result in the state in which the upper casing 30 and lower casing 31 are opened, and "Close" indicates a measurement result in the state in which the upper casing 30 and lower casing 31 are closed.

[0219] A radiation pattern of the antenna 60 relating to 1920 MHz, which is a frequency near one of the resonance points shown in FIG. 46, was simulated and radiation patterns as shown in FIGS. 47A, 47B and 47C were obtained. In addition, a radiation pattern of the antenna 60 relating to 2170 MHz, which is a frequency near the other resonance point shown in FIG. 46, was simulated and radiation patterns as shown in FIGS. 47D, 47E and 47F were obtained. The radiation patterns in FIGS. 47A and 47D were obtained with reference to the up-and-down axis. The radiation patterns in FIGS. 47B and 47E were obtained with reference to the front-and-rear axis. The radiation patterns in FIGS. 47C and 47F were obtained with reference to the right-and-left axis. In these examples, it is assumed that the antenna 60 is designed such that the vertically polarized wave component is dominant.

[0220] As is shown in these Figures, a null of a radiation pattern is created in the forward direction in each of the cases of 1920 MHz and 2170 MHz. Therefore, a decrease in radiation efficiency due to the effect of the human body can be avoided.

(27th Embodiment)

[0221] A mobile telephone apparatus according to a 27th embodiment of the present invention will now be described with reference to FIG. 48 and FIG. 49. In FIGS. 48 and 49, the structural elements common to those shown in the preceding Figures are denoted by like reference numerals, and a detailed description thereof is omitted. FIG. 48 and FIG. 49 show only the structure of an antenna 61, 66 built in the mobile telephone apparatus according to the 27th embodiment.

[0222] As is shown in FIG. 48, the wireless communication apparatus according to the 27th embodiment includes an antenna 61. The antenna 61 includes a dipole antenna 62, an opposed element 63 and shorting elements 64 and 65.

[0223] The dipole antenna 62 is formed of a conductor material so as to have a base portion 62a and bent portions 62b and 62c. The bent portions 62b and 62c are bent from both ends of the base portion 62a at right angles and extend in the same direction. The bent portions 62b and 62c are further bent at right angles so as to extend toward each other. Then, the bent portions 62b and 62c are folded so as to extend away from each other. Finally, distal end portions of the bent portions 62b and 62c are bent at right angles so as to approach the base portion 62a. The opposed element 63, like the dipole antenna 62, is formed to have a base portion 63a

and bent portions 63b and 63c.

[0224] The dipole antenna 62 and opposed element 63 are disposed such that the base portion 62a and base portion 63a have the same positional relationship as the dipole antenna 3 and opposed element 4 in the first embodiment. The dipole antenna 62 and opposed element 63 are disposed such that the bent portions 62b and 62c are situated away from the bent portions 63b and 63c. The dipole antenna 62 and opposed element 63 are arranged such that the imaginary plane in which the base portions 62a and 63a are positioned is parallel to the front surface of the casing 1.

[0225] The shorting element 64 is formed of a conductor material so as to have a pair of parallel portions 64a and 64b and a portion 64c that linearly connects both ends of the portions 64a and 64b. The distance between the portions 64a and 64b is equal to the distance between the base portions 62a and 63a. Like the shorting element 64, the shorting element 65 is formed of conductor material so as to have portions 65a, 65b and 65c. The shorting elements 64 and 65 are connected to the base portions 62a and 63a so as to project rearward, relative to the base portions 62a and 63a.

[0226] The antenna 66 shown in FIG. 49 is a variation of the antenna 61. The antenna 66 includes the dipole antenna 62, opposed element 63 and shorting elements 67 and 68. Specifically, the antenna 66 includes the shorting elements 67 and 68 in place of the shorting elements 64 and 65 of the antenna 61.

[0227] The shorting elements 67 and 68, like the shorting elements 64 and 65, are connected to the base portions 62a and 63a so as to project rearward, relative to the base portions 62a and 63a. However, the shorting elements 67 and 68 are formed so as to protrude upward and downward.

[0228] With the configuration of the 27th embodiment, the line lengths of the bent portions 62b, 62c, 63b and 63c are increased and these portions are disposed along the periphery of the board 25, as shown in FIGS. 48 and 49. Thereby, these portions can efficiently be accommodated in the casing 1.

[0229] In addition, the shorting elements 64 and 65 and the shorting elements 67 and 68 are disposed along the periphery of the board 25, as shown in FIGS. 48 and 49. Thereby, these shorting elements can efficiently be accommodated in the casing 1. The shorting element 67, 68 can have a greater line length than the shorting element 20, 21, 23, 24, 64, 65.

[0230] Thus, with the 27th embodiment, it is possible to obtain a mobile telephone apparatus which has a small size and can decrease degradation in communication performance due to the close positional relationship between the human body and the front surface of the casing 1. Furthermore, according to the 27th embodiment, both the horizontally polarized wave component and vertically polarized wave component can fully be radiated, and a broad frequency band is realized.

[0231] The structure of the 27th embodiment may be

modified as in the first embodiment or the 16th embodiment.

[0232] The antenna 61, 66 may be contained in the upper casing 30 or the lower casing 31.

Claims

1. A wireless communication apparatus which has a casing (1) having a thickness and a first surface perpendicular to a direction of the thickness, the wireless communication apparatus **characterized in that** comprising:

a dipole antenna (3, 8, 14, 48, 53, 62) including a first base portion (8a, 14a, 48a, 53a, 62a); and
an opposed element (4, 10, 15, 49, 54, 63) formed of a conductor material and including a second base portion (10a, 15a, 49a, 54a, 63a), the dipole antenna (3, 8, 14, 48, 53, 62) and the opposed element (4, 10, 15, 49, 54, 63) being disposed within the casing (1) such that the dipole antenna (3, 8, 14, 48, 53, 62) and the opposed element (4, 10, 15, 49, 54, 63) extend in an imaginary plane that is substantially parallel to the first surface, and the first base portion (8a, 14a, 48a, 53a, 62a) and the second base portion (10a, 15a, 49a, 54a, 63a) are opposed to each other.

2. A wireless communication apparatus which has a first casing (30) and a second casing (31) that are coupled to each other, the first casing (30) having a first thickness and a first surface perpendicular to a direction of the thickness, and the second casing (31) having a second thickness and a second surface perpendicular to a direction of the thickness, the wireless communication apparatus being **characterized by** comprising:

a dipole antenna (3, 8, 14, 48, 53, 62) including a first base portion (8a, 14a, 48a, 53a, 62a), the dipole antenna (3, 8, 14, 48, 53, 62) being disposed within the first casing (30) such that the dipole antenna (3, 8, 14, 48, 53, 62) extends in an imaginary plane that is substantially parallel to the first surface and the second surface; and
an opposed element (4, 10, 15, 49, 54, 63) formed of a conductor material and including a second base portion (10a, 15a, 49a, 54a, 63a), the opposed element (4, 10, 15, 49, 54, 63) being disposed within the second casing (31) such that the opposed element (4, 10, 15, 49, 54, 63) extends in the imaginary plane and the second base portion (10a, 15a, 49a, 54a, 63a) is opposed to the first base portion (8a, 14a, 48a, 53a, 62a).

3. A wireless communication apparatus which has a first casing (30) and a second casing (31) that are coupled to each other, and a flexible board (33) that electrically connects the first casing (30) and the second casing (31), the first casing (30) having a thickness and a first surface perpendicular to a direction of the thickness, the wireless communication apparatus being **characterized by** comprising:

a dipole antenna (3, 8, 14, 48, 53, 62) including a first base portion (8a, 14a, 48a, 53a, 62a), the dipole antenna (3, 8, 14, 48, 53, 62) being disposed within the first casing (30) such that the dipole antenna (3, 8, 14, 48, 53, 62) extends in an imaginary plane that is substantially parallel to the first surface; and
an opposed element (4, 10, 15, 35, 49, 54, 63) formed of a conductor material and including a second base portion (10a, 15a, 35a, 49a, 54a, 63a), the opposed element (4, 10, 15, 35, 49, 54, 63) being disposed on the flexible board (33) such that the second base portion (10a, 15a, 35a, 49a, 54a, 63a) is opposed to the first base portion (8a, 14a, 48a, 53a, 62a).

4. The wireless communication apparatus according to any one of claims 1 to 3, **characterized in that** the dipole antenna (8, 14, 48, 53, 62) further includes a pair of first bent portions (8b, 8c, 14b, 14c, 48b, 48c, 53b, 53c, 62b, 62c) that extend in the same direction from both ends of the first base portion (8a, 14a, 48a, 53a, 62a).

5. The wireless communication apparatus according to claim 4, **characterized in that** the opposed element (4, 10, 15, 49, 54, 63) further includes a pair of second bent portions (10b, 10c, 15b, 15c, 49b, 49c, 54b, 54c, 63b, 63c) that extend from both ends of the second base portion (10a, 15a, 49a, 54a, 63a) in a direction opposite to the direction in which the first bent portions (8b, 8c, 14b, 14c, 48b, 48c, 53b, 53c, 62b, 62c) extend.

6. The wireless communication apparatus according to claim 5, **characterized by** further comprising:

a first short element (17a) that short-circuits the pair of the first bent portions (8b, 8c); and
a second short element (18a) that short-circuits the pair of the second bent portions (10b, 10c).

7. The wireless communication apparatus according to claim 5, **characterized by** further comprising a pair of short elements (20, 21, 23, 24, 64, 67) that short-circuit the dipole antenna (8, 62) and the opposed element (10, 63).

8. The wireless communication apparatus according

to any one of claims 1 to 3, **characterized in that** the first base portion (8a, 14a, 48a, 53a, 62a) and the second base portion (10a, 15a, 49a, 54a, 63a) are substantially in line-symmetry with respect to an imaginary opposed axis (A1) that is located at a middle point between the first base portion (8a, 14a, 48a, 53a, 62a) and the second base portion (10a, 15a, 49a, 54a, 63a).

9. The wireless communication apparatus according to any one of claims 1 to 3, **characterized in that** each of the dipole antenna (3, 8, 14, 48, 53, 62) and the opposed element (4, 10, 15, 49, 54, 63) is in line-symmetry with respect to an imaginary symmetric axis (A2) that extends in a direction of arrangement of the first base portion (8a, 14a, 48a, 53a, 62a) and the second base portion (10a, 15a, 49a, 54a, 63a) and passes through a middle point of the first base portion (8a, 14a, 48a, 53a, 62a).

10. The wireless communication apparatus according to any one of claims 1 to 3, **characterized in that** a first parasitic element (37, 42, 50, 55, 58) formed of a conductor material and including a third base portion (37a, 42a, 50a, 55a, 58a) is disposed such that the third base portion (37a, 42a, 50a, 55a, 58a) is opposed to the first base portion (8a, 14a, 48a, 53a, 62a), and
a second parasitic element (38, 43, 51, 56, 59) formed of a conductor material and including a fourth base portion (38a, 43a, 51a, 56a, 59a) is disposed such that the fourth base portion (38a, 43a, 51a, 56a, 59a) is opposed to the second base portion (10a, 15a, 49a, 54a, 63a).

11. The wireless communication apparatus according to claim 10, **characterized in that** the first parasitic element (37, 42, 50, 55, 58) further includes a pair of third bent portions (42b, 42c, 50b, 50c, 55b, 55c, 58b, 58c) that extend in the same direction from both ends of the third base portion (37a, 42a, 50a, 55a, 58a).

12. The wireless communication apparatus according to claim 11, **characterized in that** the second parasitic element (38, 43, 51, 56, 59) further includes a pair of fourth bent portions (43a, 43b, 51a, 51b, 56a, 56b, 59a, 59b) that extend from both ends of the fourth base portion (38a, 43a, 51a, 56a, 59a) in a direction opposite to the direction in which the third bent portions (42b, 42c, 50b, 50c, 55b, 55c, 58b, 58c) extend.

13. The wireless communication apparatus according to claim 4, **characterized in that** a first parasitic element (37) formed of a conductor material and including a third base portion is disposed such that the third base portion is opposed to one of the pair

of the first bent portions (8b, 8c), and

a second parasitic element (38) formed of a conductor material and including a fourth base portion is disposed such that the fourth base portion is opposed to the other of the pair of the first bent portions (8b, 8c).

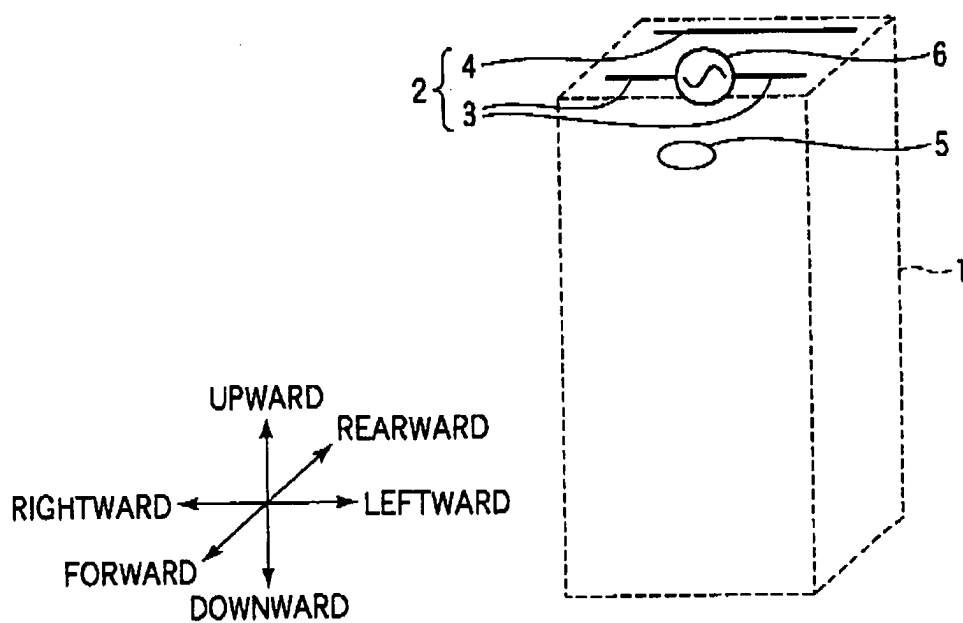


FIG. 1

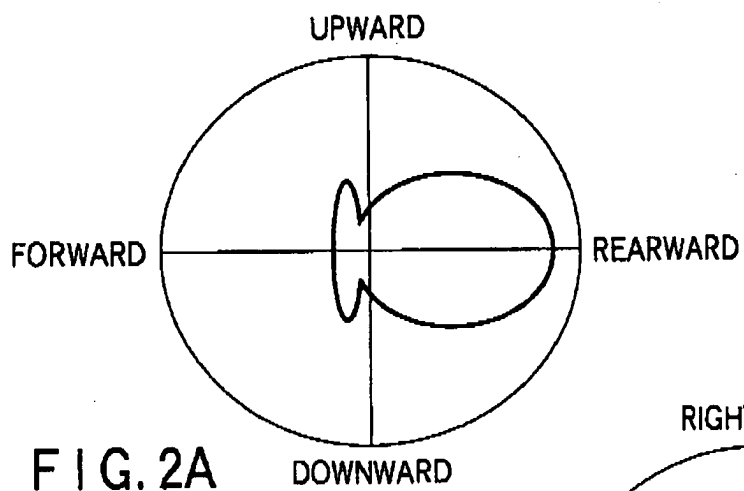


FIG. 2A

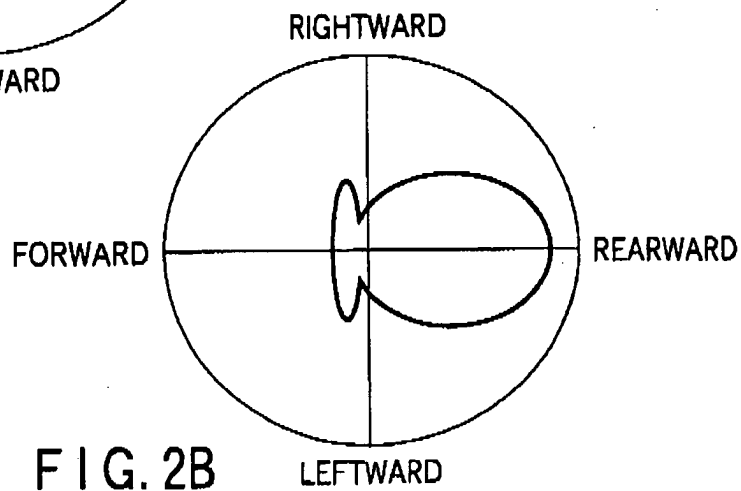


FIG. 2B

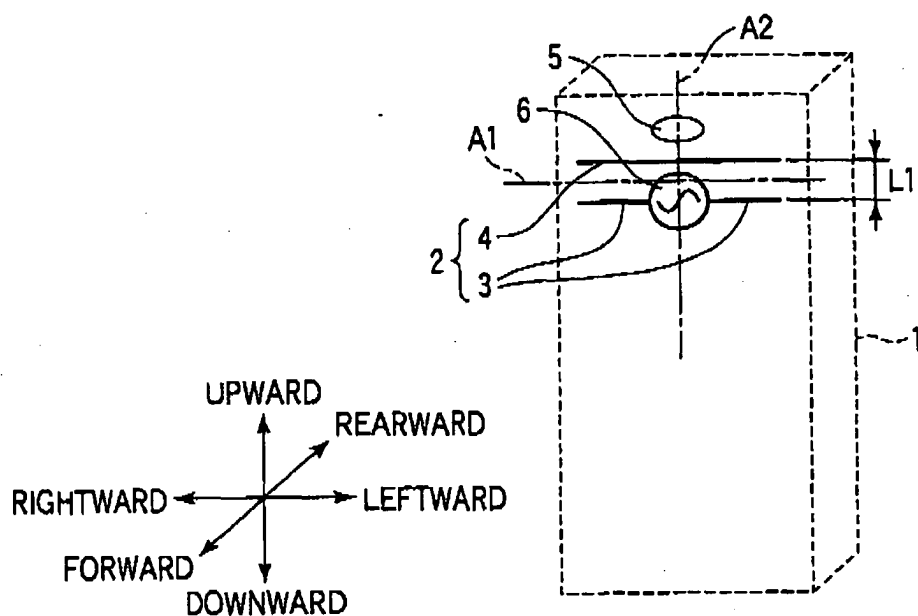


FIG. 3

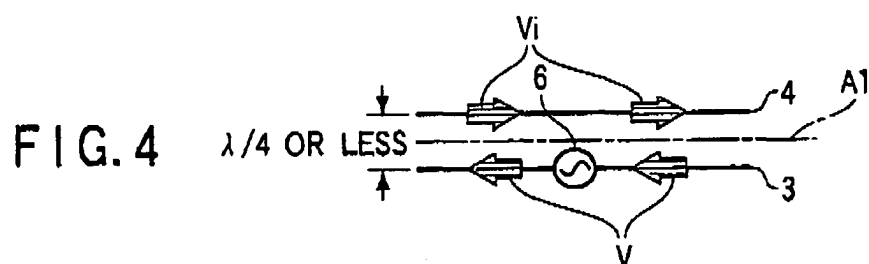


FIG. 4

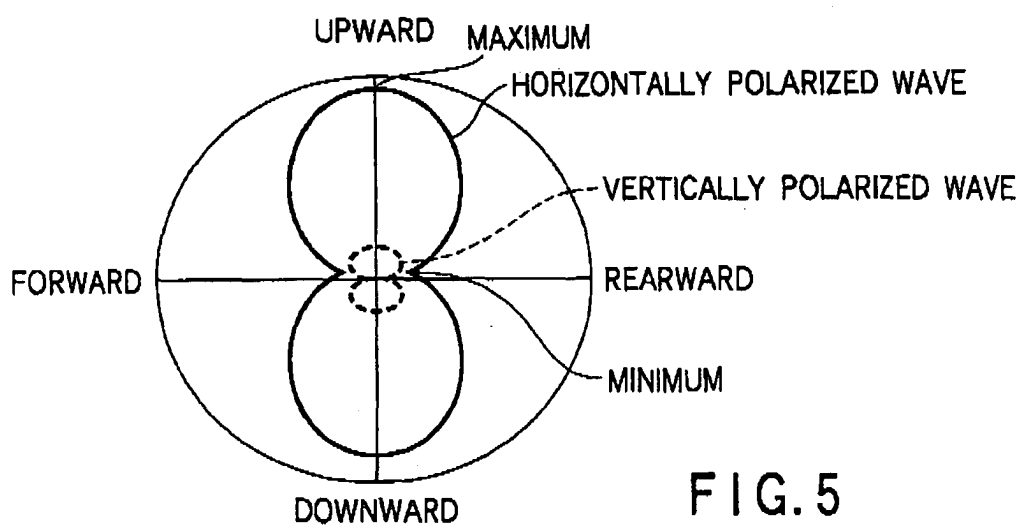
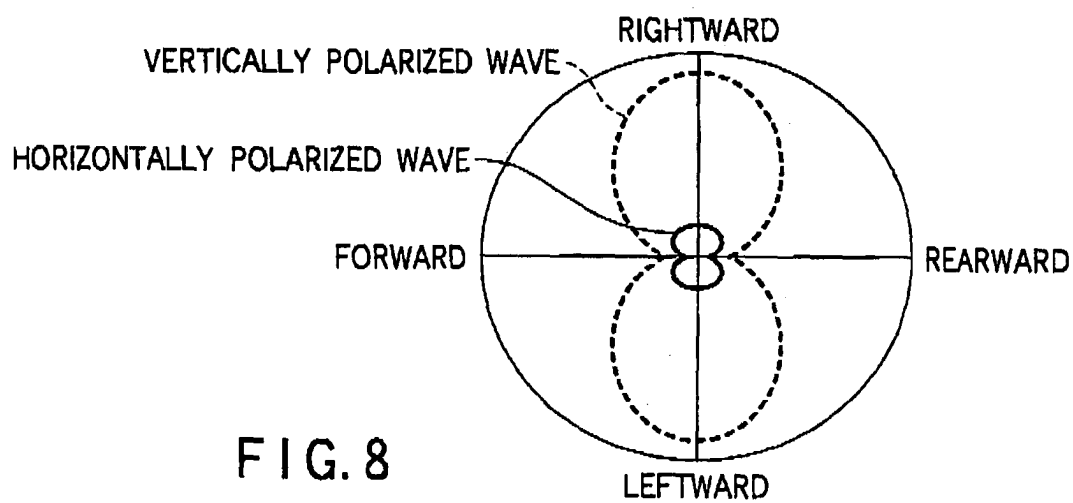
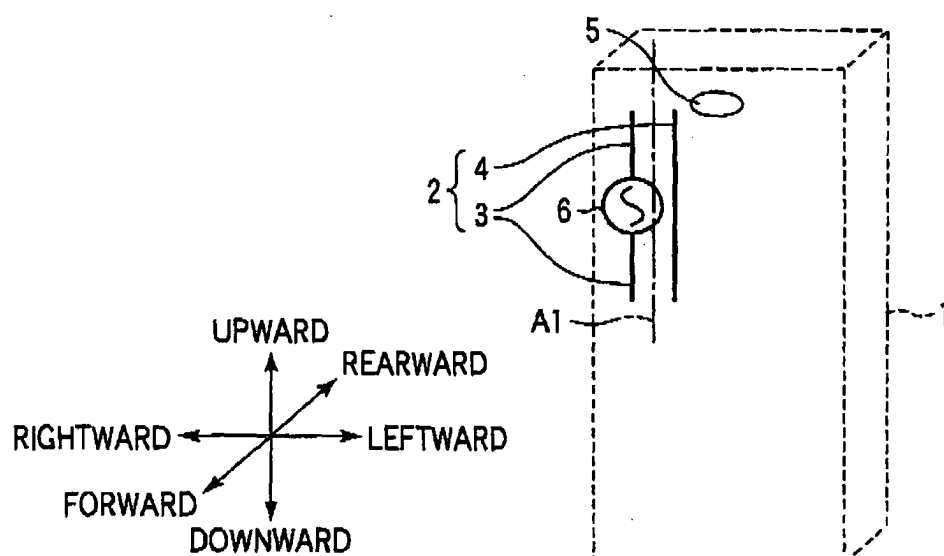
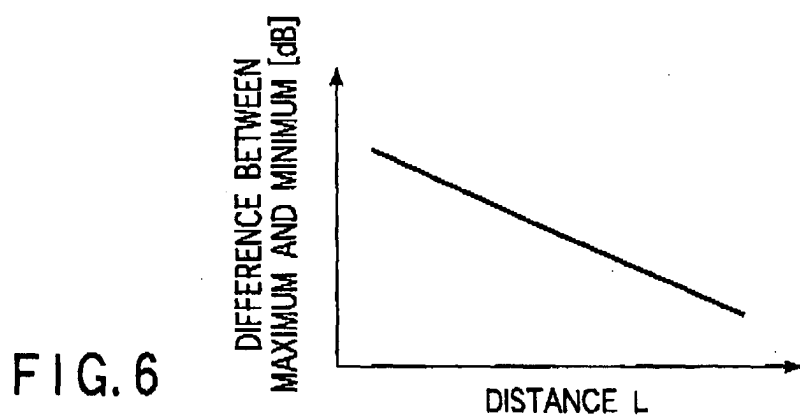


FIG. 5



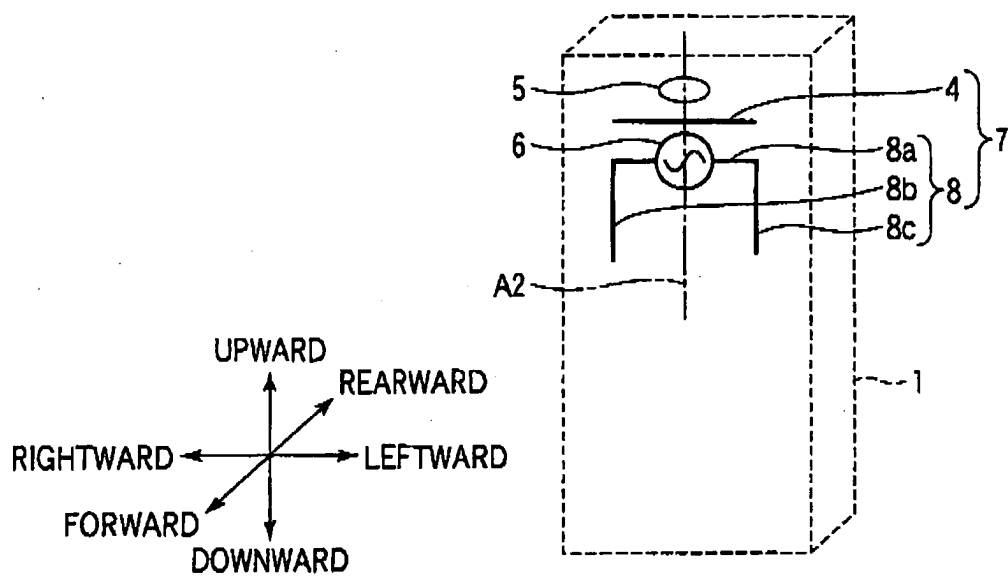


FIG. 9

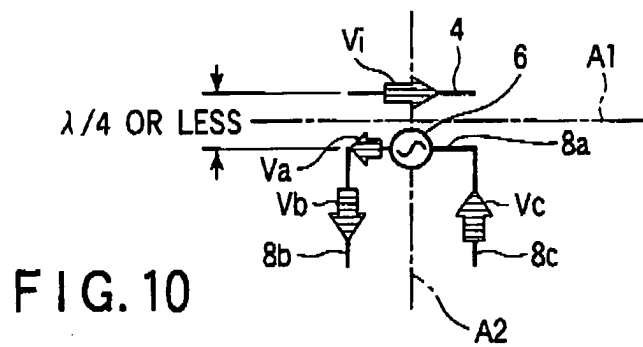


FIG. 10

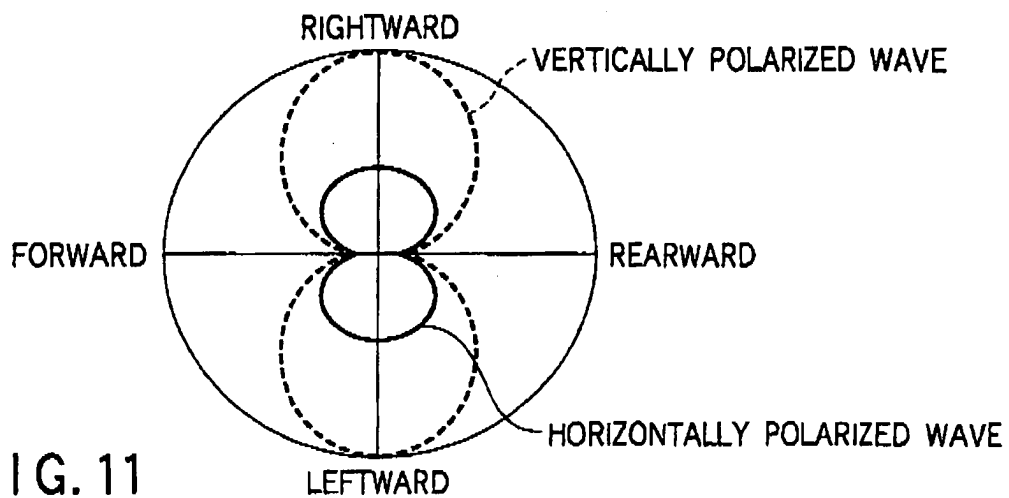
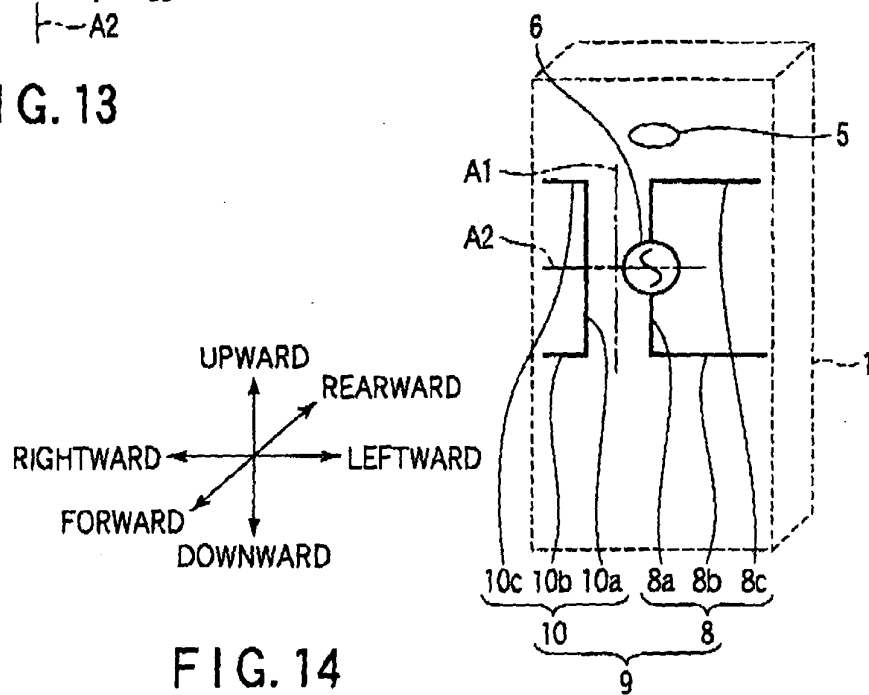
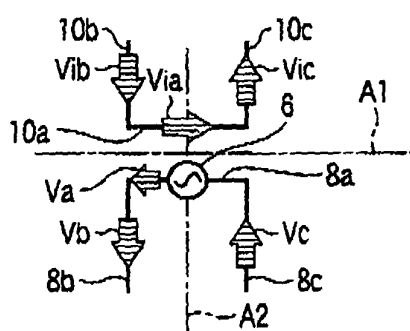
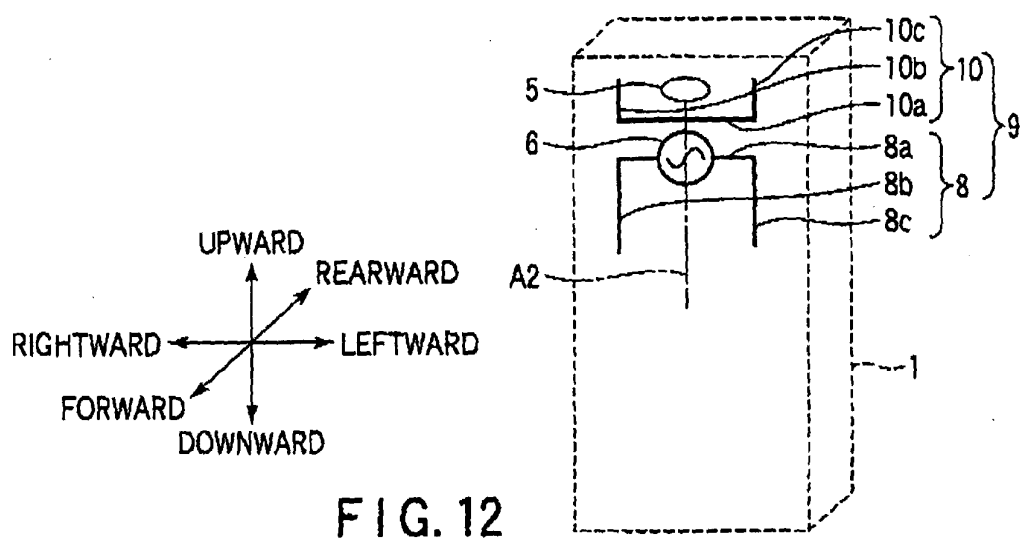


FIG. 11



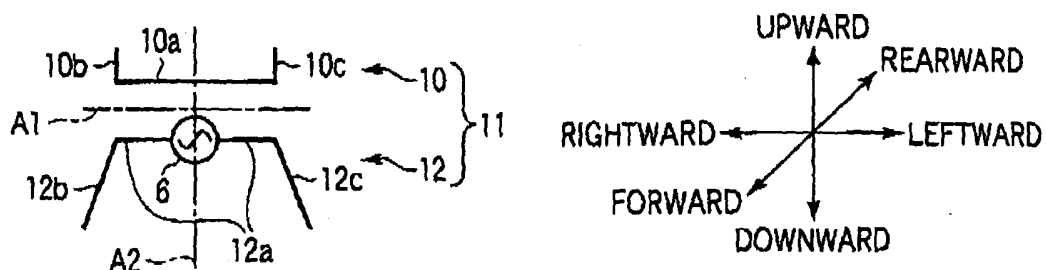


FIG. 15

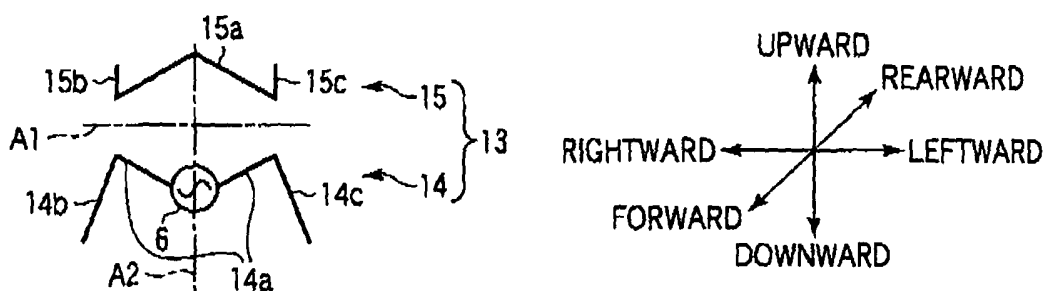


FIG. 16

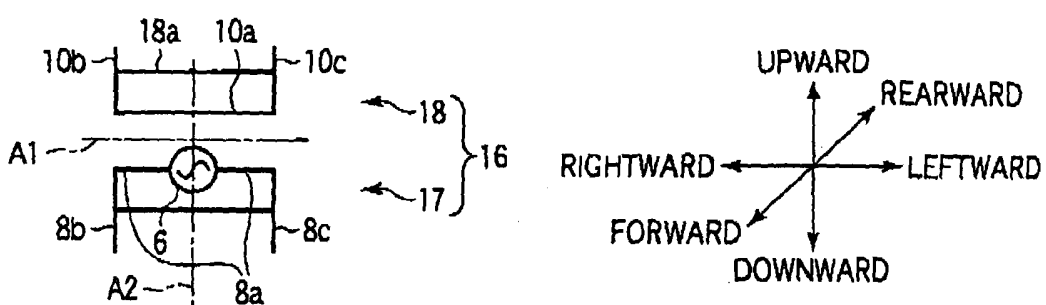


FIG. 17

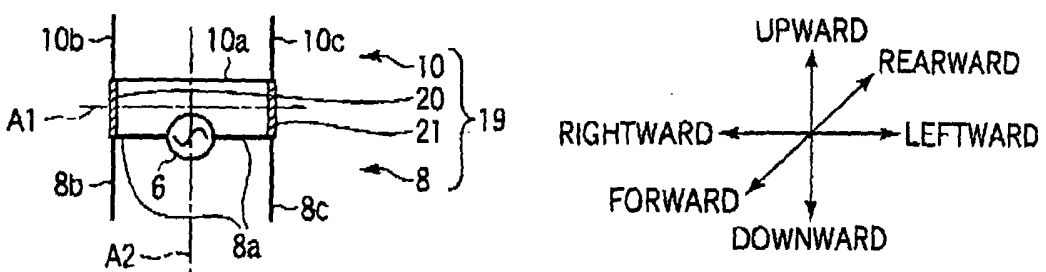
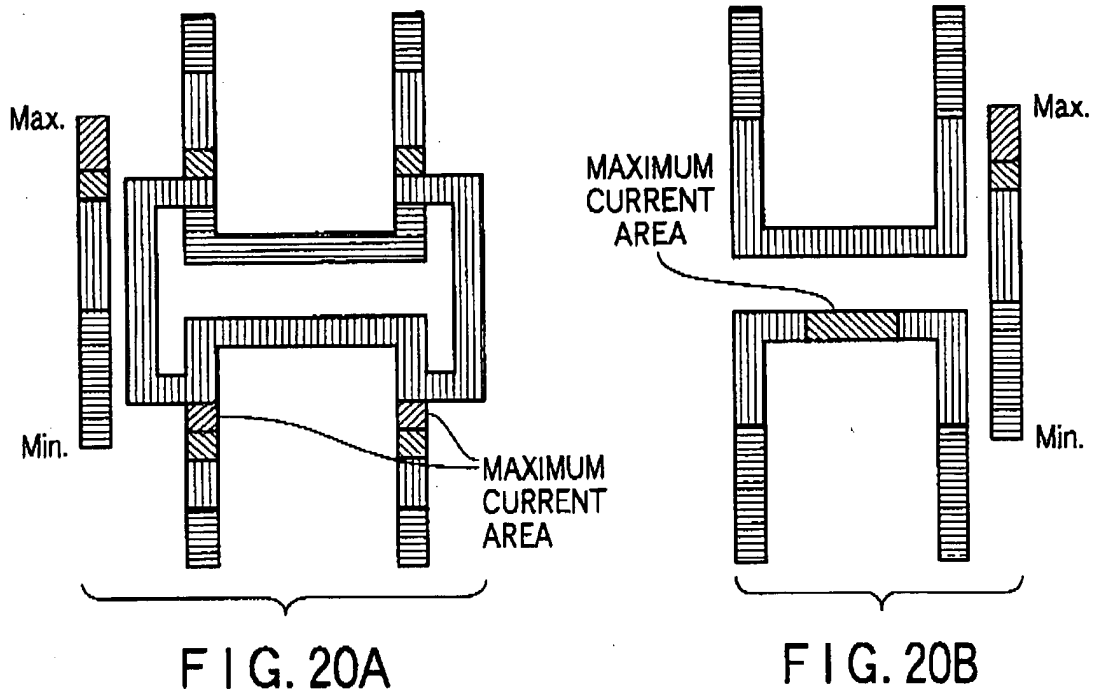
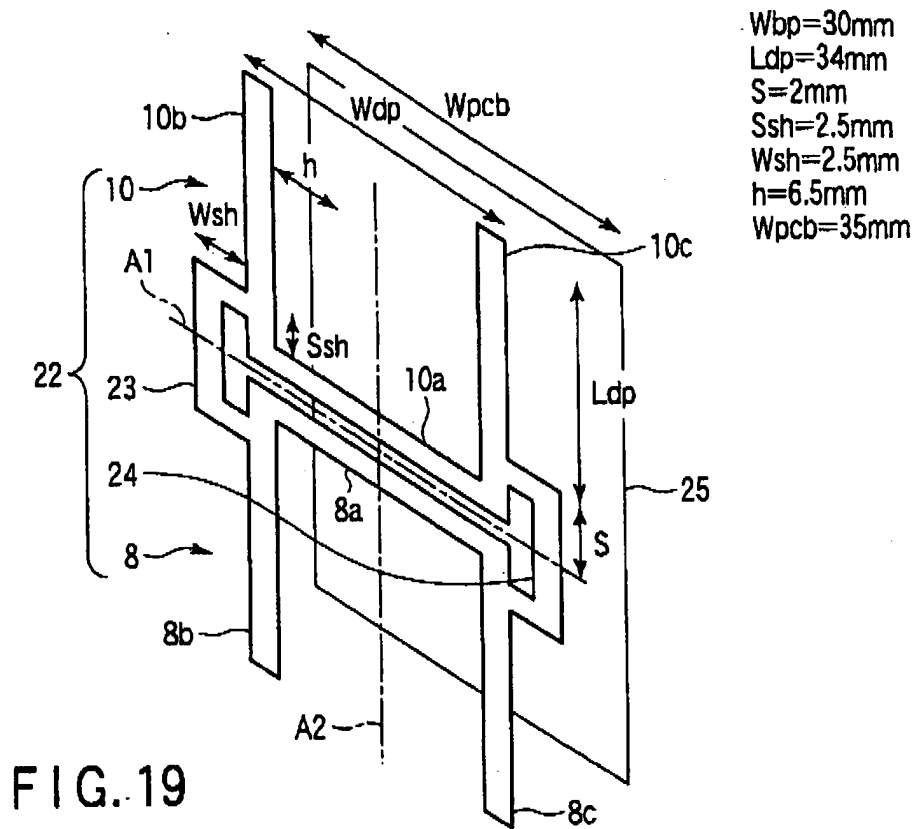
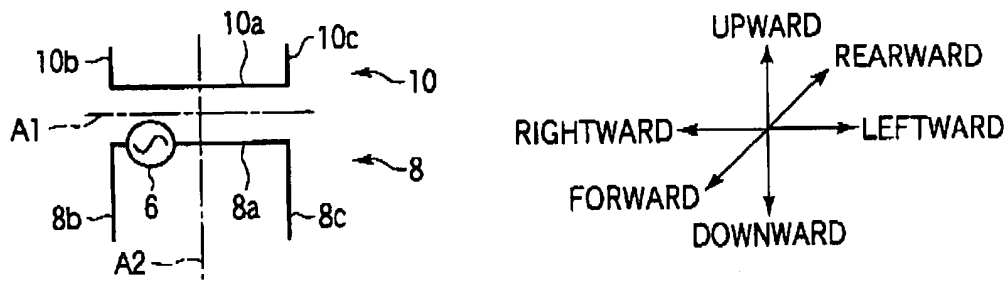
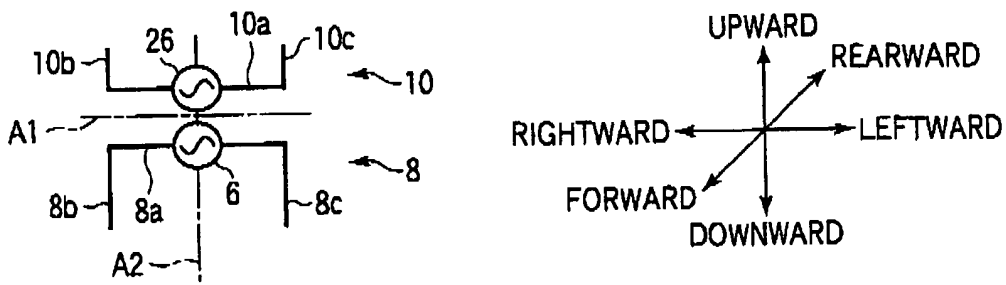
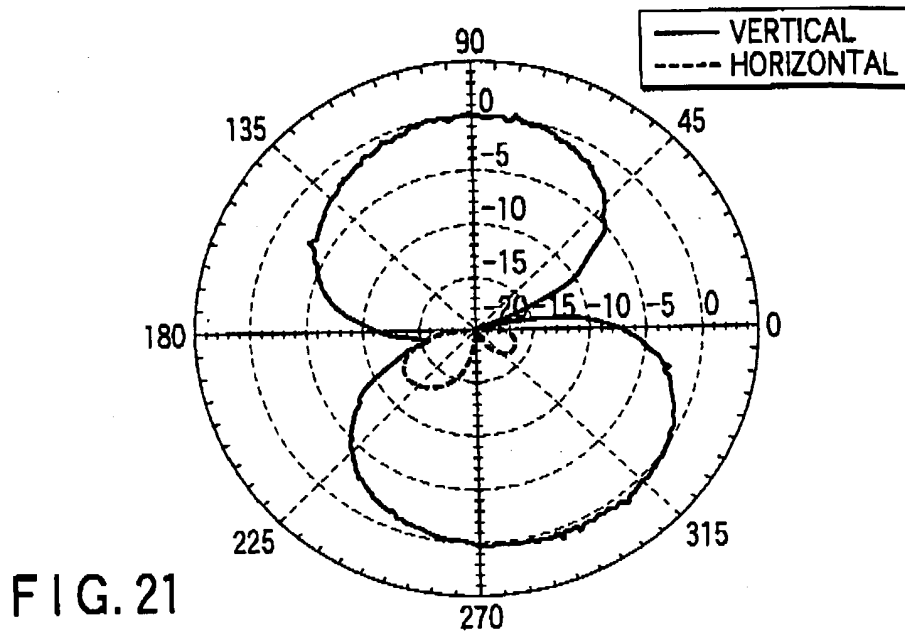


FIG. 18





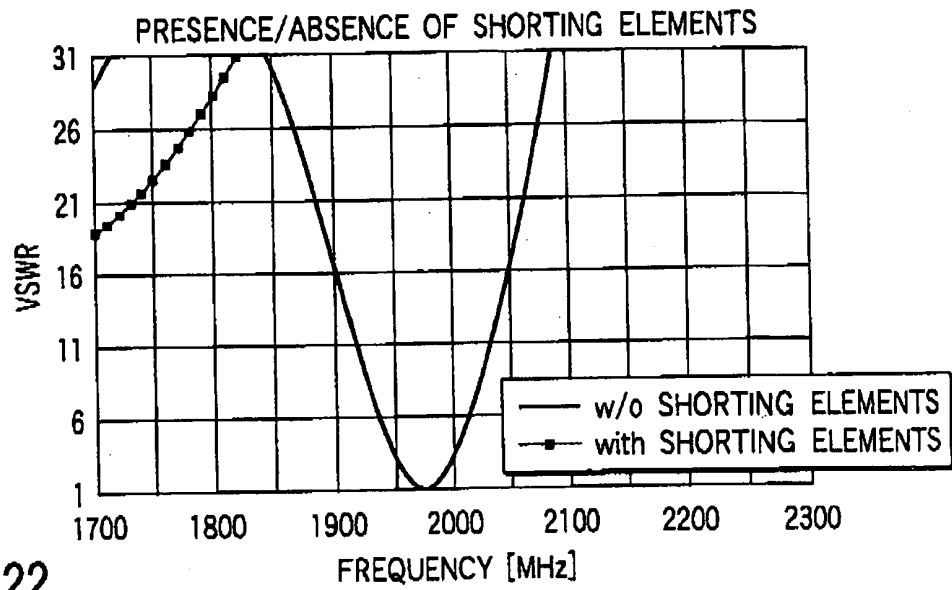


FIG. 22

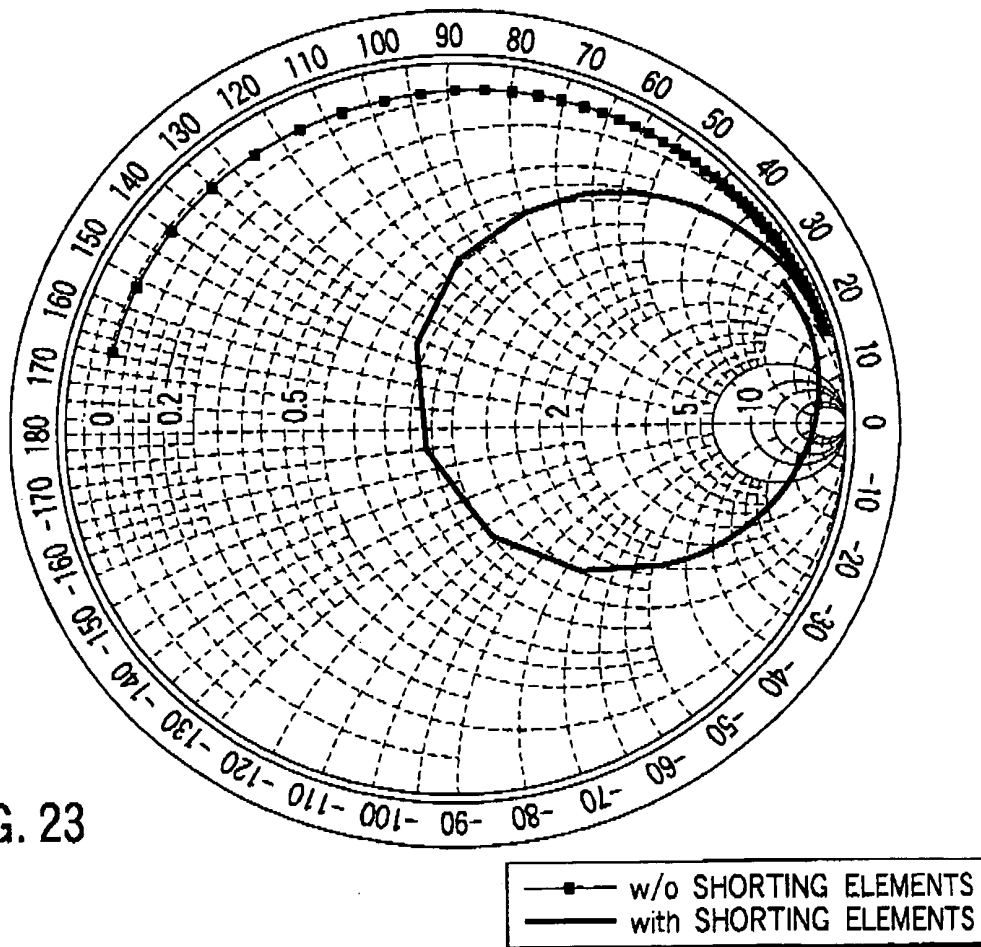


FIG. 23

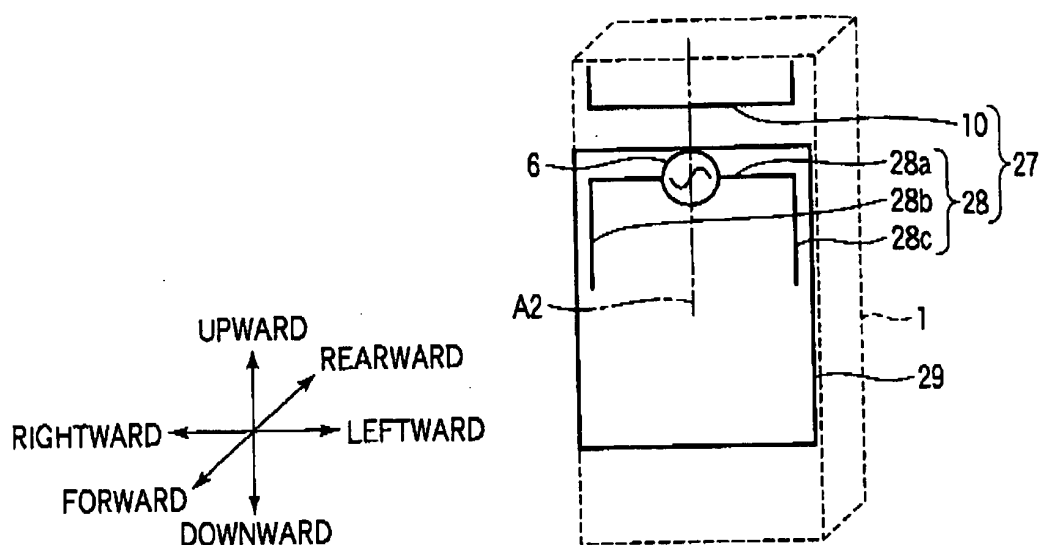


FIG. 26

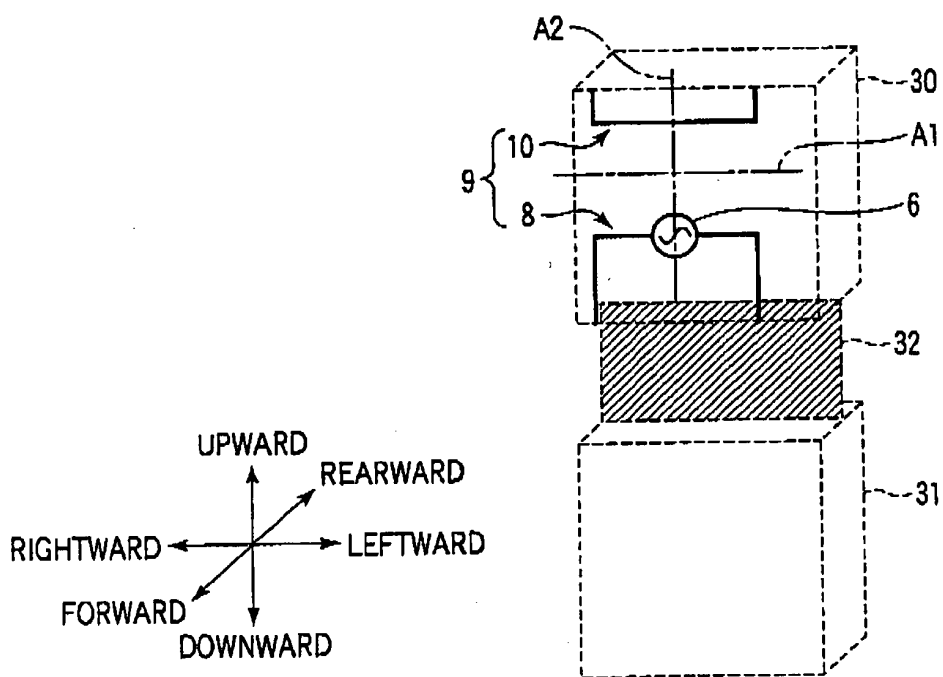


FIG. 27

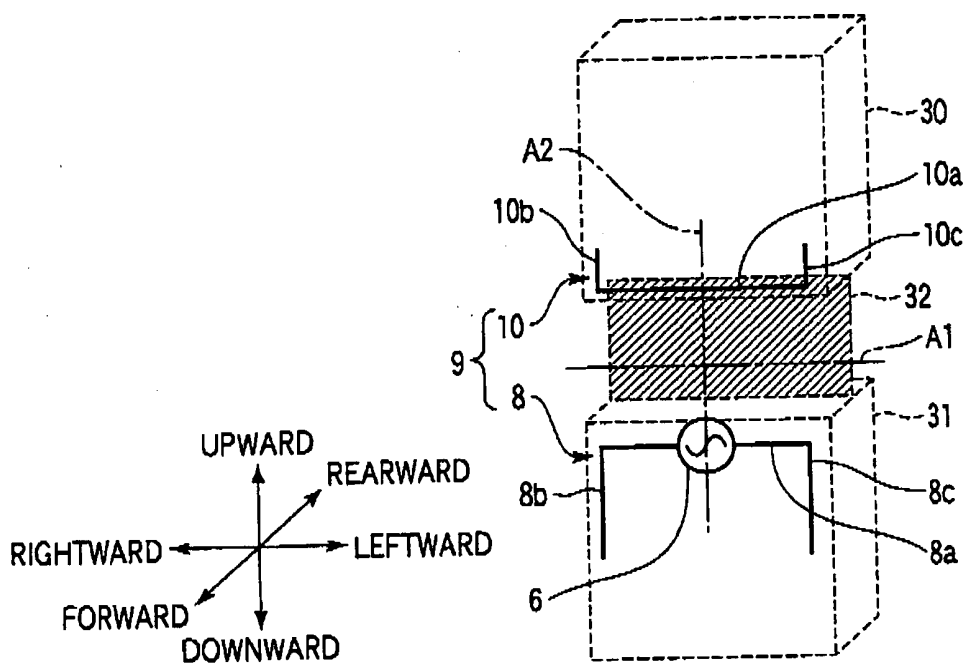


FIG. 28

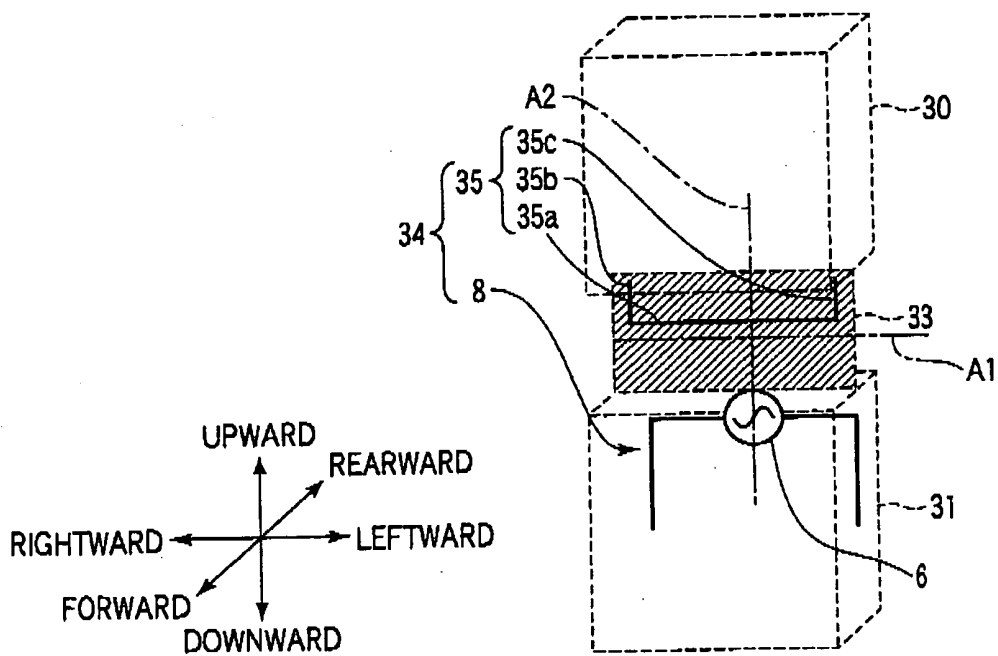
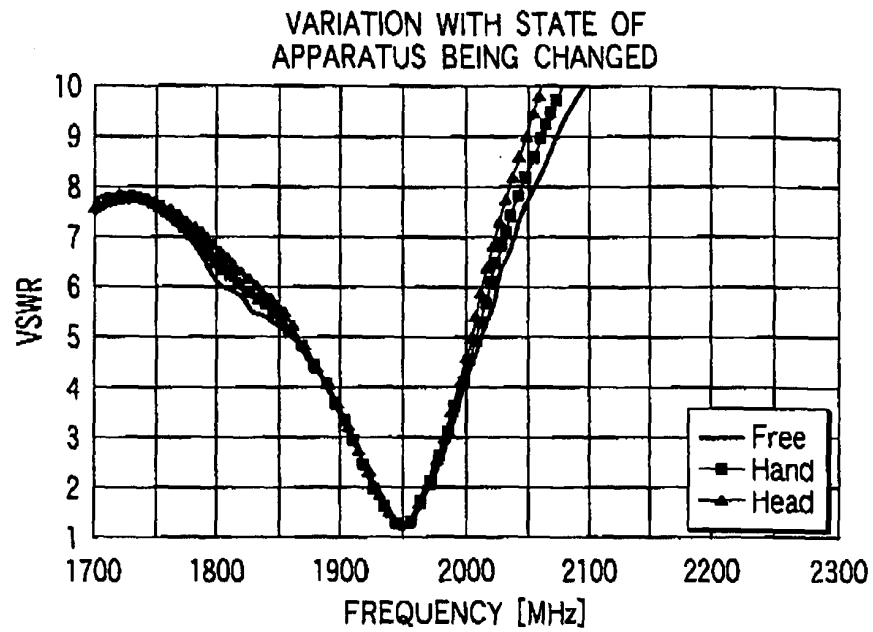
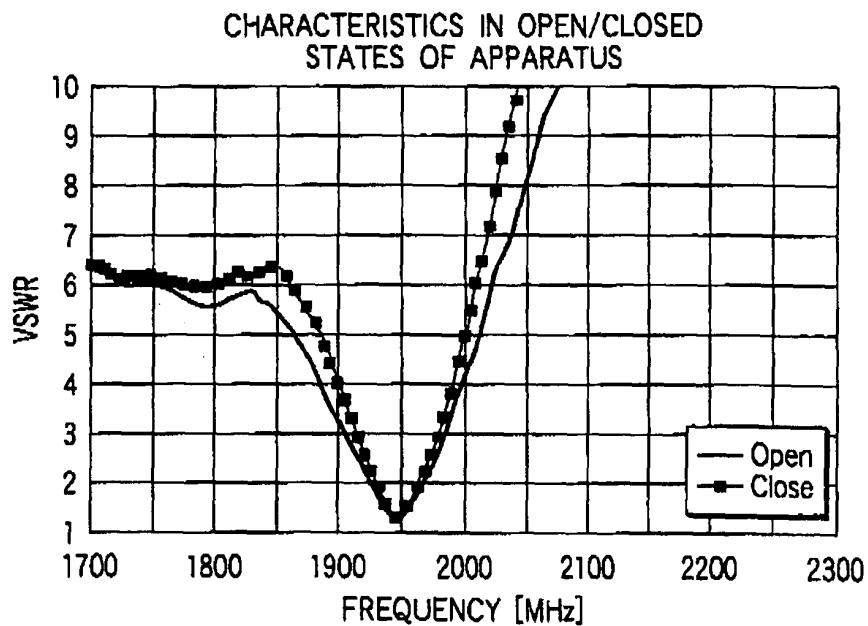


FIG. 29



Free: STATE OF APPARATUS IN FREE SPACE
 Hand: STATE OF APPARATUS WITH LOWER CASING HELD BY HAND
 Head: STATE OF APPARATUS HELD BY HAND NEAR HEAD
 (NORMAL TALKING STATE)

FIG. 30



OPEN: STATE IN WHICH CASING IS OPENED
 CLOSE: STATE IN WHICH CASING IS CLOSED

FIG. 31

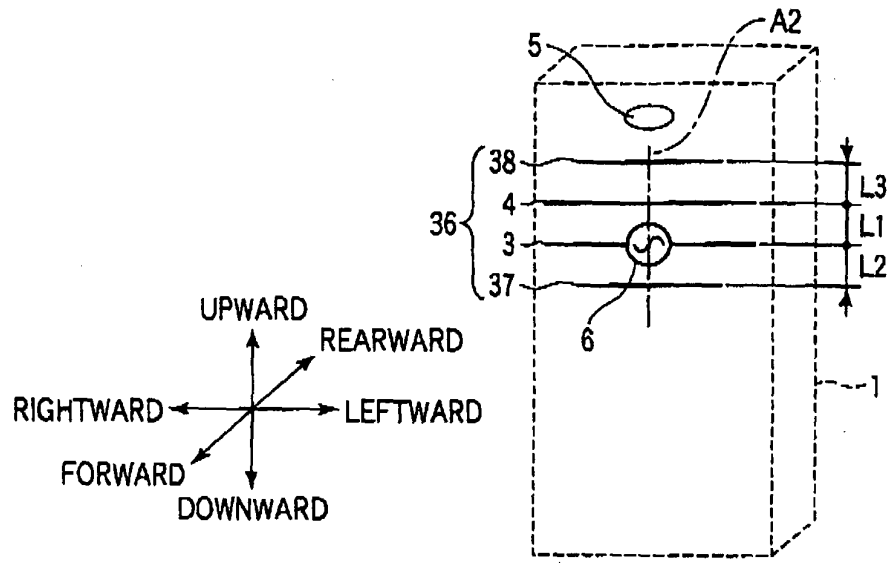


FIG. 32

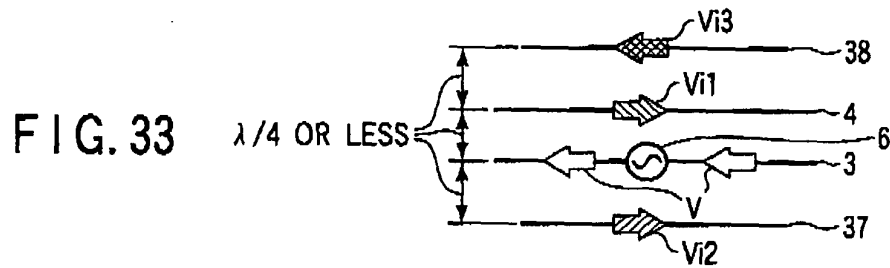


FIG. 33

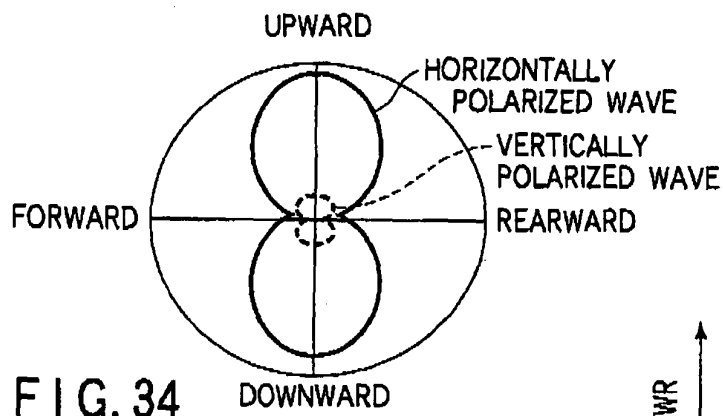


FIG. 34

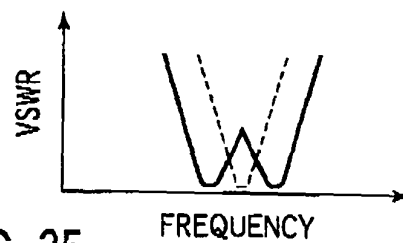


FIG. 35

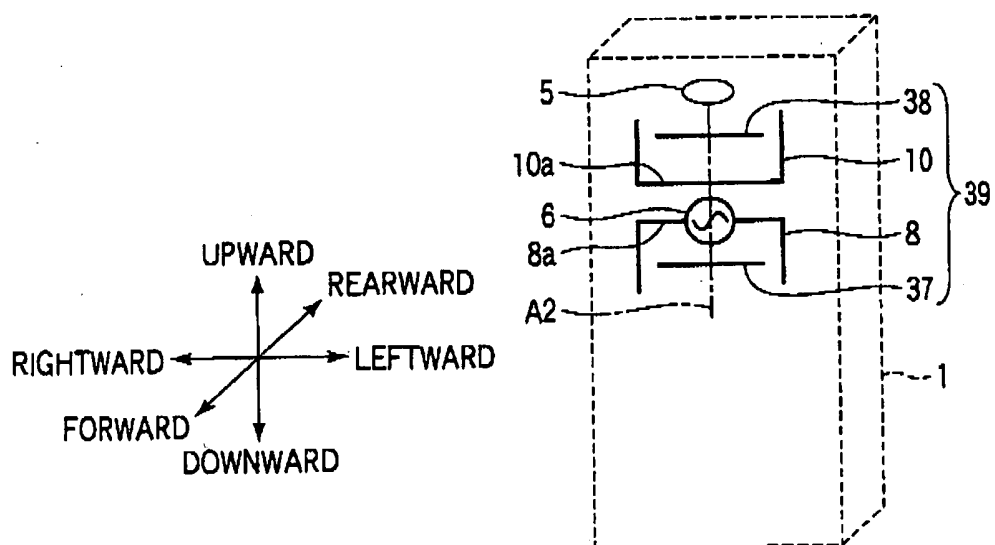


FIG. 36

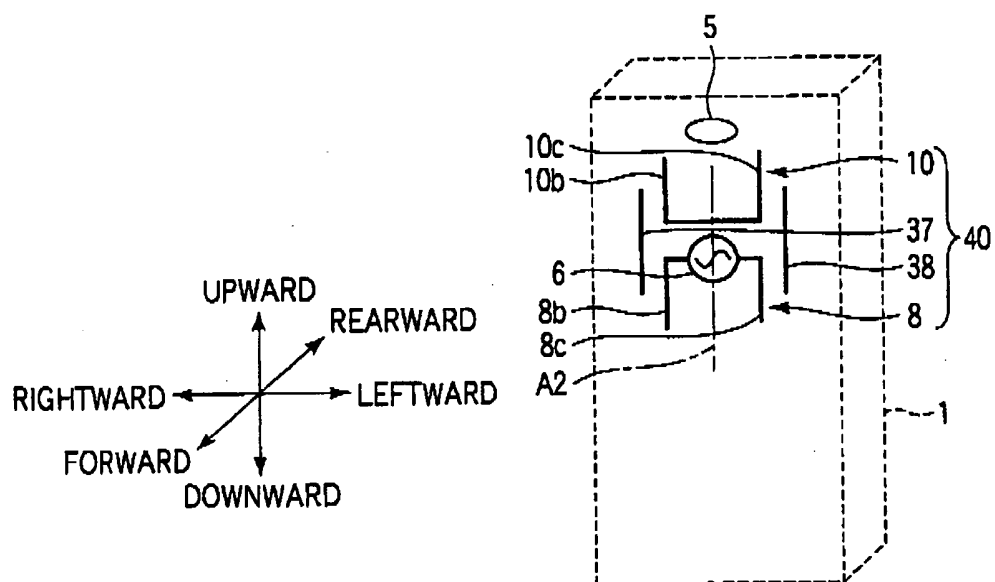
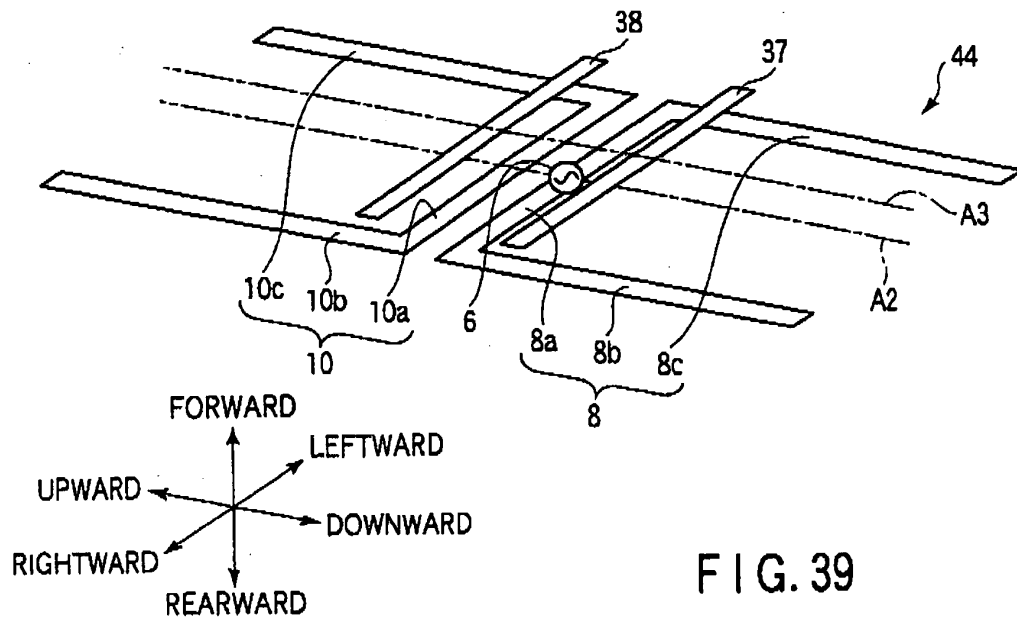
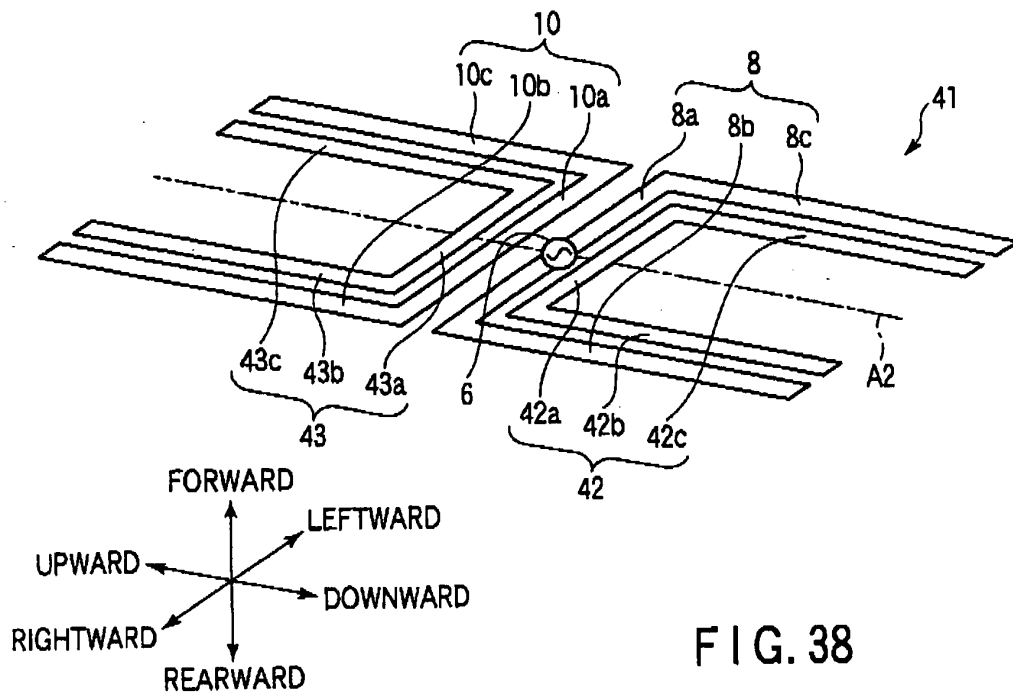
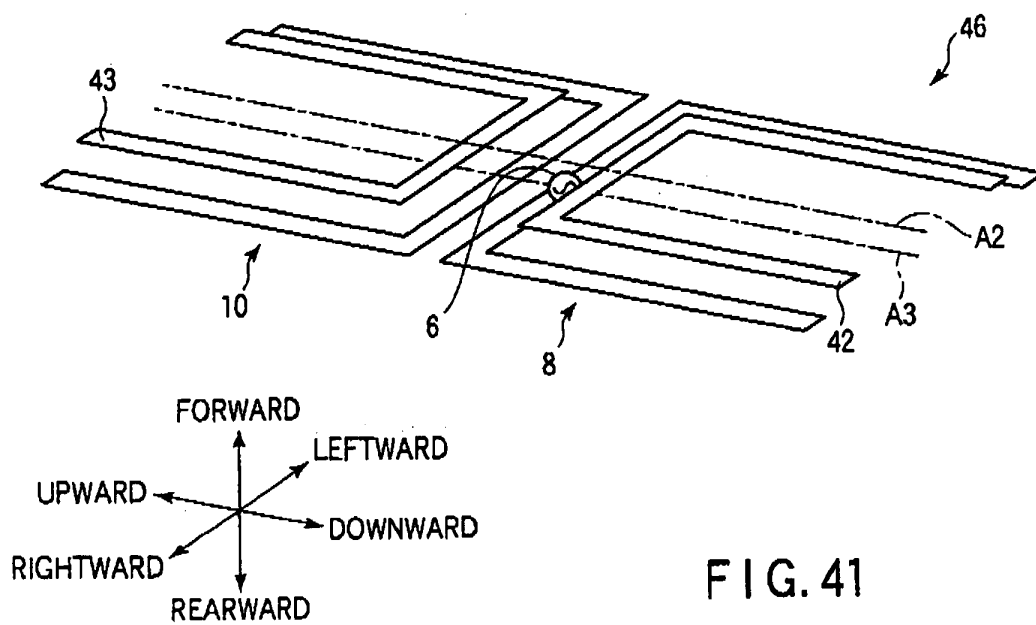
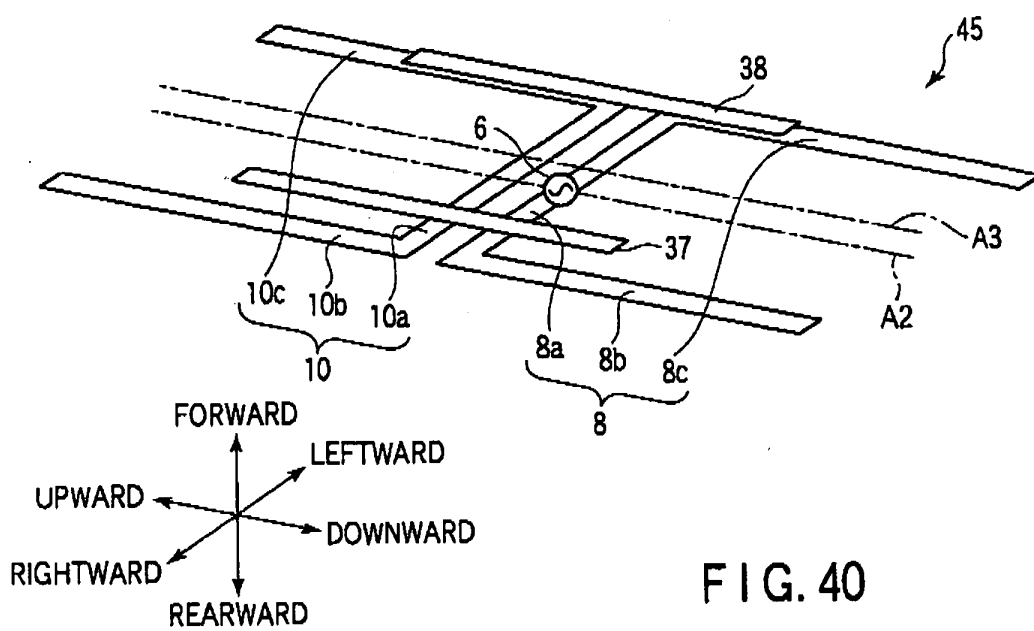
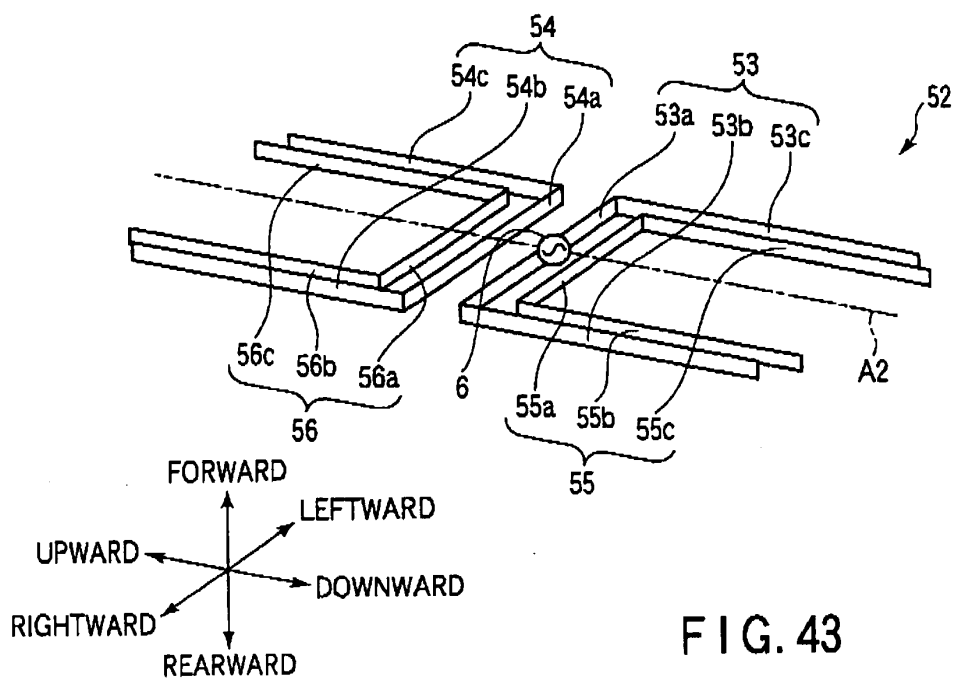
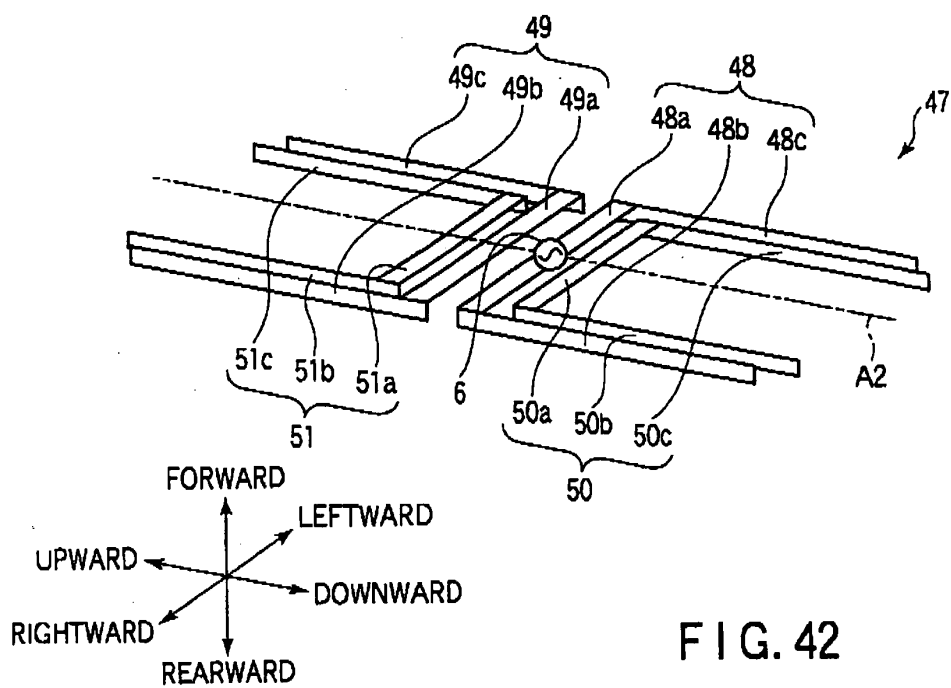
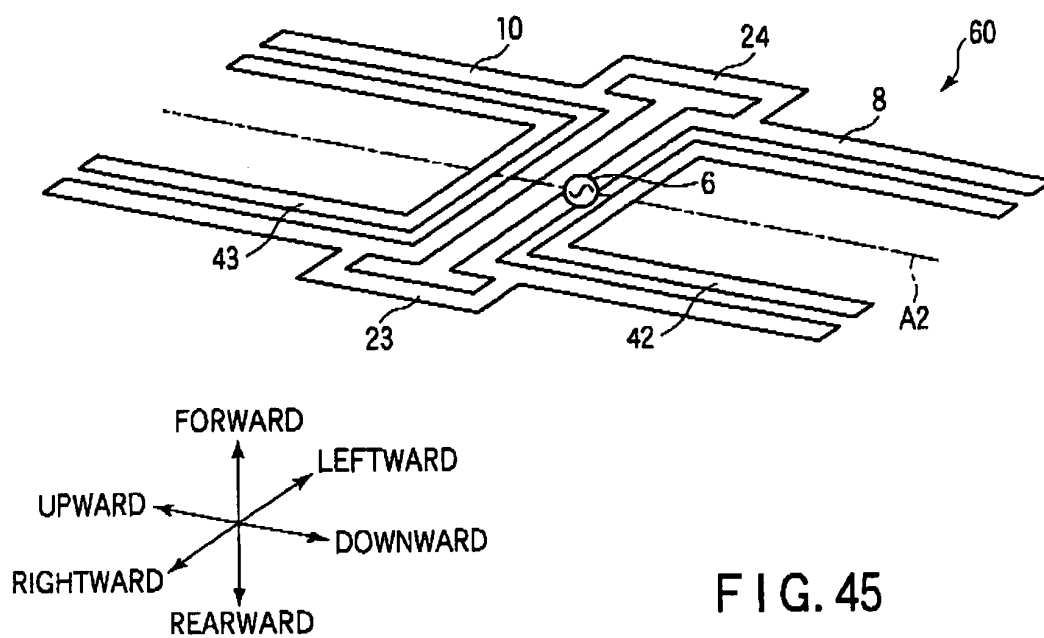
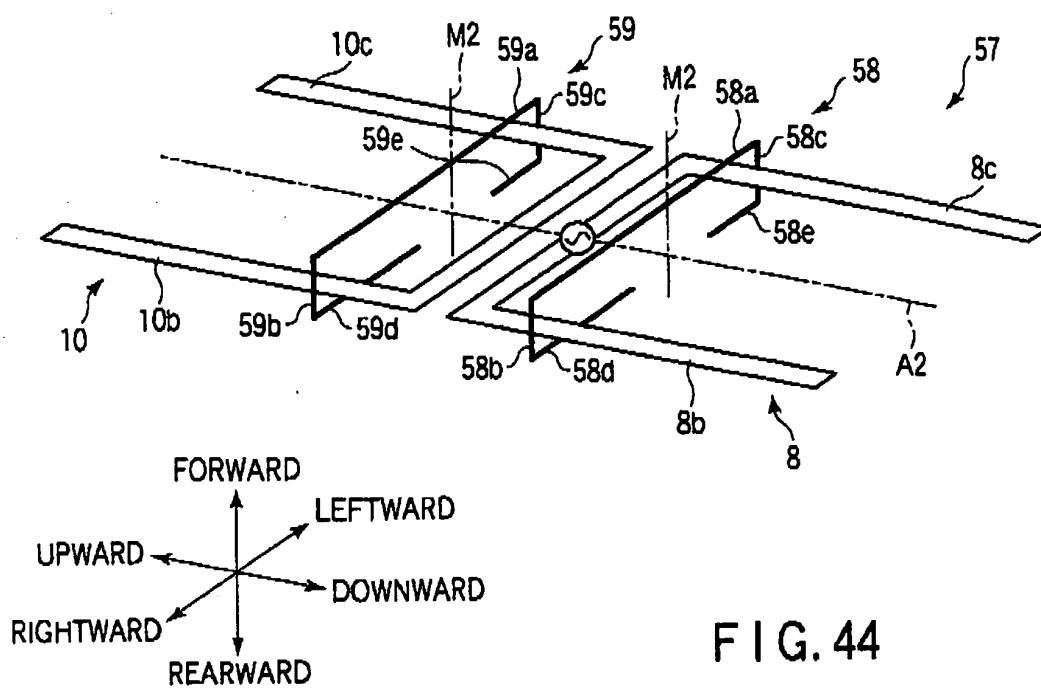


FIG. 37









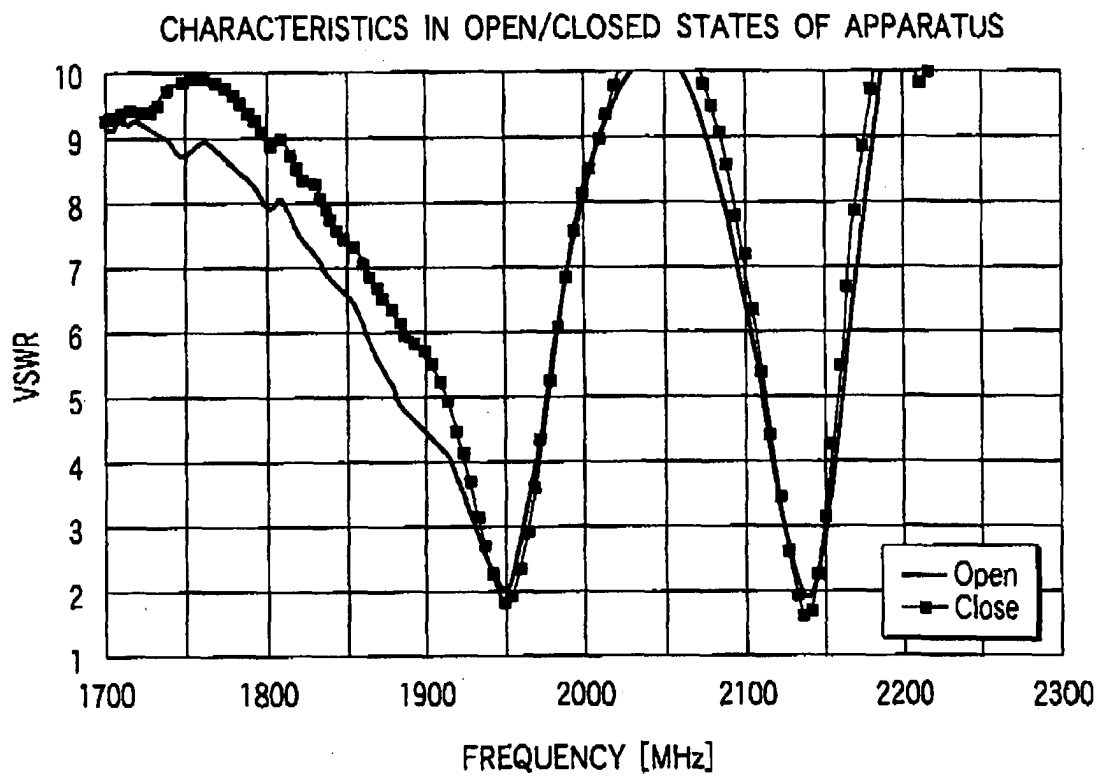


FIG. 46

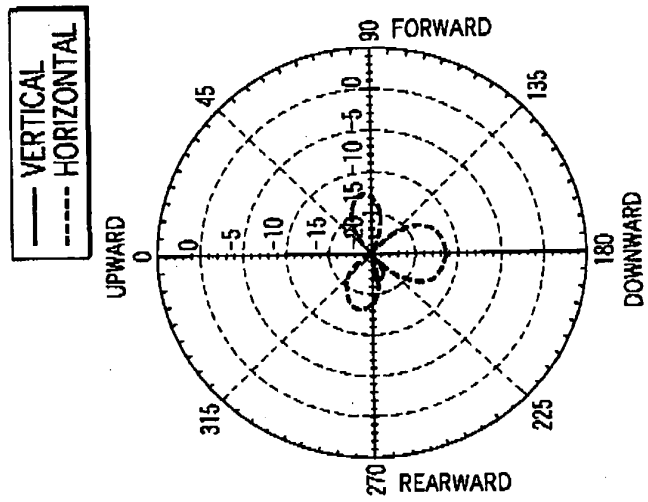


FIG. 47C

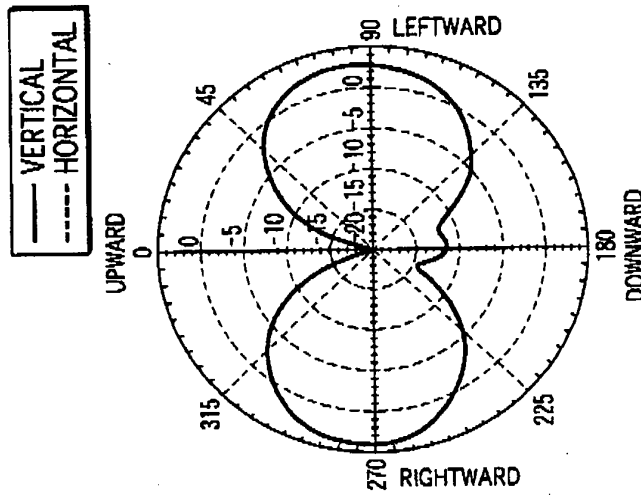


FIG. 47B

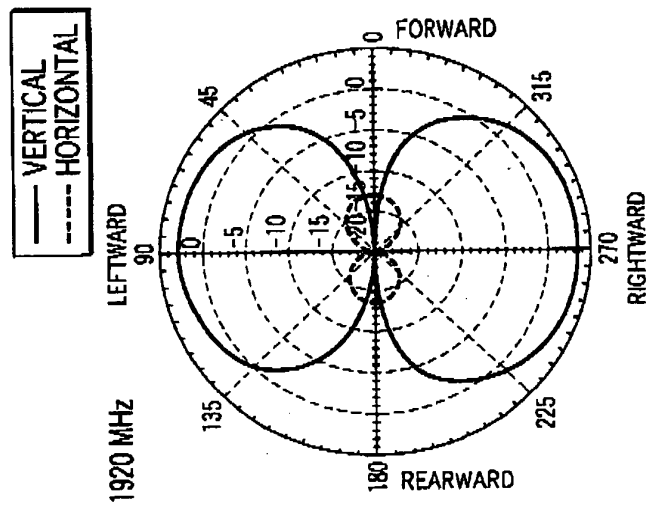


FIG. 47A

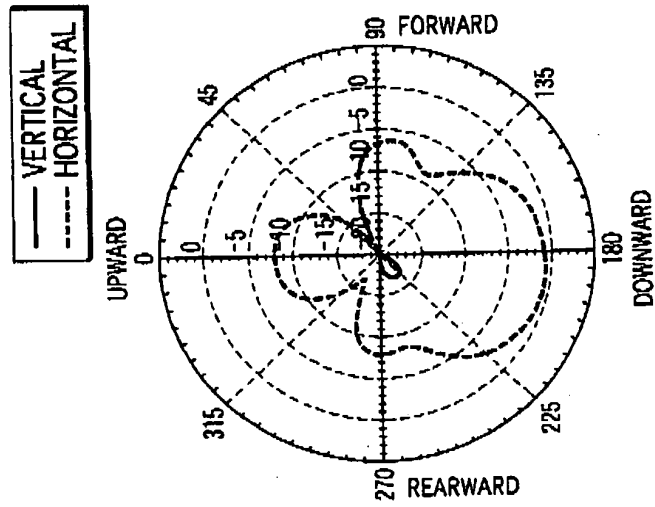


FIG. 47D

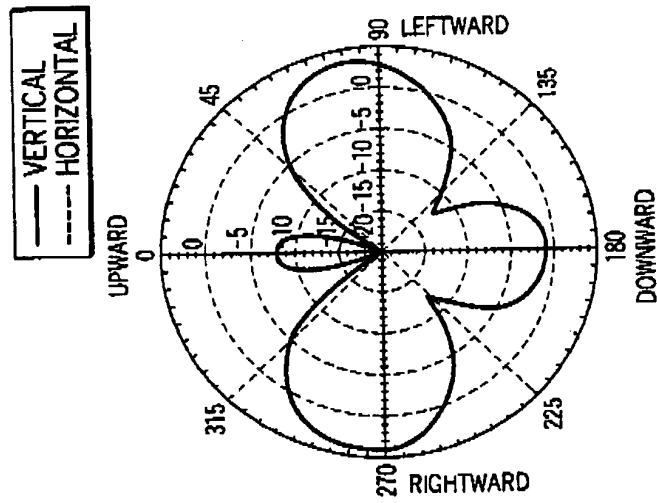


FIG. 47E

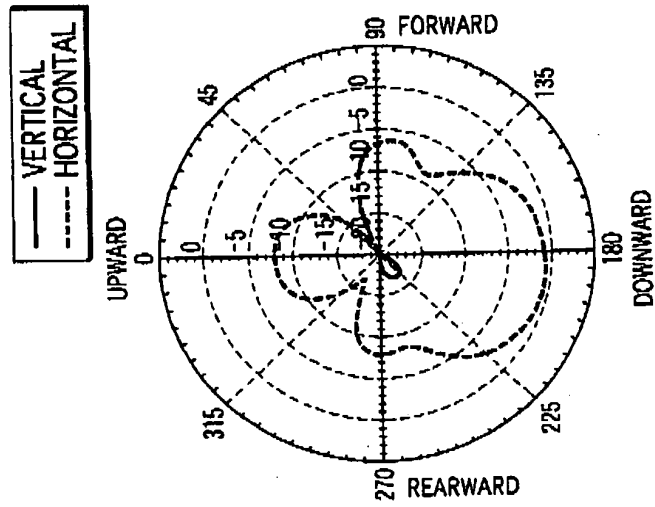


FIG. 47F

