(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 555 716 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 158(3) EPC

(43) Date of publication:
20.07.2005 Bulletin 2005/29

(21) Application number: **04773360.5**

(22) Date of filing: **15.09.2004**

(51) Int Cl.[7]: **H01Q 1/24**

(86) International application number:
PCT/JP2004/013878

(87) International publication number:
WO 2005/029638 (31.03.2005 Gazette 2005/13)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL HR LT LV MK

(30) Priority: **18.09.2003 JP 2003326689**

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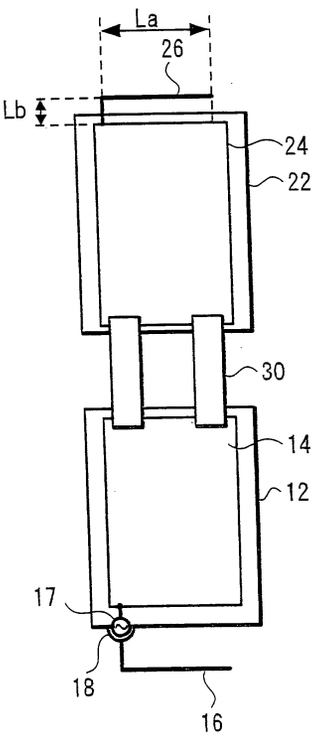
(54) MOBILE COMMUNICATION TERMINAL

(57) In order for antenna characteristics of a combination of an antenna and a passive element to avoid the influence of the length of a circuit board in which the antenna and the passive element are disposed, a mobile communication terminal capable of being folded includes a first casing and a second casing, in which a power feeding antenna 16 is provided in a first circuit board included in the first casing and a passive antenna 26 is provided in a second circuit board included in the second casing.

Further, a switch is provided between the second circuit board and the passive antenna 26 and, the passive antenna is connected only when the terminal is in a predetermined state.

FIG. 2



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Description

TECHNICAL FIELD

[0001] The present invention relates to a mobile communication terminal, particularly to a mobile communication terminal in which an antenna is installed.

BACKGROUND ART

[0002] As a kind of mobile communication terminal, there is a mobile phone unit of a folding type in which a casing can be folded. The mobile phone unit of a folding type has an antenna. When the mobile phone unit of such folding type is folded, an unfavorable effect may be given to characteristics of the antenna.

[0003] Therefore, as shown in Patent document 1, technology of disposing a dipole antenna in one part of a casing and disposing a conductor in the other part of the casing is proposed. When such a mobile phone unit is folded, one part of the casing faces the other part of the casing and the dipole antenna faces the conductor as well. Hence, characteristics of the antenna become stabilized, because the conductor functions as a passive element, which is described in Published Japanese Patent Application No. H10-84406 issued by the Japan Patent Office.

[0004] However, in the case where a dipole antenna and a conductor (passive element) are combined as described above, characteristics of the antenna when a mobile phone unit of the folding type is opened may become deteriorated depending on the length of a circuit board in which the dipole antenna and the conductor are disposed.

[0005] Therefore, the present invention is to provide the combination of an antenna and a passive element in which characteristics of the antenna are not easily subject to the influence of the length of a circuit board where the antenna and the passive element are disposed.

DISCLOSURE OF THE INVENTION

[0006] A first aspect of the present invention is a mobile communication terminal including a first casing having a feeding antenna to which power is supplied and a second casing connected to the first casing, in which the second casing has a passive antenna to which power is not supplied and which resonates at approximately the lower limit communication frequency in a communication frequency band used for communication.

[0007] A second aspect of the present invention is the mobile communication terminal according to the first aspect of the present invention, in which an electrical length of the passive antenna is a quarter of a wavelength of a radio wave corresponding to the lower limit communication frequency.

[0008] A third aspect of the present invention is the mobile communication terminal according to the first aspect of the present invention, in which the first casing and the second casing can be folded to be opposed to each other.

[0009] A fourth aspect of the present invention is the mobile communication terminal according to the third aspect of the present invention, in which the power feeding antenna and the passive antenna are electromagnetically coupled when folded.

[0010] A fifth aspect of the present invention is the mobile communication terminal according to the first aspect of the present invention, in which the first casing has a first circuit board connected to the power feeding antenna, the second casing has a second circuit board in which the passive antenna is provided, and power is supplied between the power feeding antenna and a ground potential of the first circuit board.

[0011] A sixth aspect of the present invention is the mobile communication terminal according to the fifth aspect of the present invention, in which the passive antenna has a circuit pattern provided on the second circuit board.

[0012] A seventh aspect of the present invention is the mobile communication terminal according to the sixth aspect of the present invention, in which the circuit pattern has the shape of meanders.

[0013] An eighth aspect of the present invention is the mobile communication terminal according to the sixth aspect of the present invention, in which the circuit pattern has an approximately straight shape.

[0014] A ninth aspect of the present invention is the mobile communication terminal according to the fifth aspect of the present invention, in which the passive antenna has a wire provided on the second circuit board.

[0015] A tenth aspect of the present invention is the mobile communication terminal according to the fifth aspect of the present invention, in which the passive antenna has a metal plate provided on the second circuit board.

[0016] An eleventh aspect of the present invention is the mobile communication terminal according to the fifth aspect of the present invention, in which the second casing has a circuit member which is connected to the passive antenna and the ground potential of the second circuit board and which makes the passive antenna resonate at the lower limit communication frequency.

[0017] A twelfth aspect of the present invention is a mobile communication terminal including a first casing having a feeding antenna to which power is supplied and a second casing connected to the first casing, in which the second casing has a passive antenna selectively connected.

[0018] A thirteenth aspect of the present invention is the mobile communication terminal according to the twelfth aspect of the present invention, in which the first casing and the second casing can be folded to be opposed to each other, and the connection state of the passive antenna when the first casing and the second cas-

ing are not folded is changed from the connection state thereof when both the casings are folded.

[0019] A fourteenth aspect of the present invention is the mobile communication terminal according to the thirteenth aspect of the present invention, in which the power feeding antenna and the passive antenna are electromagnetically coupled when folded.

[0020] A fifteenth aspect of the present invention is the mobile communication terminal according to the twelfth aspect of the present invention, in which the first casing has the first circuit board connected to the power feeding antenna, the second casing has the second circuit board in which the passive antenna is provided, and power is supplied between the power feeding antenna and the ground potential of the first circuit board.

[0021] Accordingly, since the passive antenna is provided as described above, the deterioration of the antenna characteristics can be controlled to prevent the deterioration of the telephone speech quality of the mobile communication terminal.

BRIEF DESCRIPTION OF DRAWINGS

[0022]

FIGS. 1A and 1B are views showing an example of a mobile phone unit (mobile communication terminal) according to a first embodiment of the present invention, in which FIG. 1A is a plan view and FIG. 1B is a side section view;

FIG. 2 is a plan view showing an example of a state of a first circuit board, a second circuit board and a hinge used for the circuit boards, when a mobile phone unit according to the first embodiment of the present invention is fully opened;

FIGS. 3A to 3D are perspective views showing examples of a structure of a passive antenna;

FIG. 4 is a perspective view showing a modified example in which a circuit chip is connected between a passive antenna and a GND portion of a mobile phone unit according to the first embodiment of the present invention;

FIGS. 5A and 5B are views showing an example of a state of the first circuit, the second circuit and the hinge used for the circuit boards, when the mobile phone unit according to the first embodiment of the present invention is folded, in which FIG. 5A is a side view and FIG. 5B is a plan view;

FIGS. 6A and 6B show a comparative example, in which FIG. 6A is a plan view, and FIG. 6B is a characteristic curve of the antenna radiation efficiency;

FIGS. 7A and 7B are characteristic curves, in which FIG. 7A shows an example of the antenna radiation efficiency in a comparative example (H=165mm), and FIG. 7B shows an example of the antenna radiation efficiency according to the first embodiment of the present invention (H=165mm);

FIG. 8 is a characteristic curve showing examples of the antenna radiation efficiency, when the resonance frequency of the passive antenna according to the first embodiment of the present invention is a lower limit fL (lower limit communication frequency), the resonance frequency thereof is an upper limit fH and the resonance frequency thereof is an average fc of the lower limit and upper limit in the communication frequency band, respectively;

FIG. 9 is an explanatory view in which the directions of the antenna radiation pattern are defined;

FIGS. 10A and 10B are characteristic curves showing examples of the antenna radiation pattern in a comparative example;

FIGS. 11A and 11B are characteristic curves, in which FIG. 11A shows an example of the antenna radiation pattern in a comparative example (H=165mm) and FIG. 11B shows an example of antenna radiation pattern according to an embodiment of the present invention (H=165mm);

FIG. 12 is a characteristic curve which shows an example of the antenna radiation efficiency, when a mobile phone unit 1 is folded;

FIG. 13 is a plan view showing an example of a state of the first circuit board 12 and the second circuit board 22, when a mobile phone unit (mobile communication terminal) according to a second embodiment of the present invention is fully opened;

FIGS. 14A and 14B are connection diagrams showing an example of the connection of a passive antenna of a mobile phone unit according to the second embodiment of the present invention;

FIGS. 15A and 15B are views showing the mobile phone unit according to the second embodiment of the present invention, in which FIG. 15A is a plan view showing a state of the casing thereof, and FIG. 15B is a connection diagram showing an example of the connection of a passive antenna in the state;

FIGS. 16A and 16B are views showing a mobile phone unit according to the second embodiment of the present invention, in which FIG. 16A is a plan view showing a state of the casing thereof, and FIG. 16B is a connection diagram showing an example of the connection of a passive antenna in the state;

FIGS. 17A and 17B are views showing a mobile phone unit according to the second embodiment of the present invention, in which FIG. 17A is a plan view showing a state of the casing thereof, and FIG. 17B is a connection diagram showing an example of the connection of a passive antenna in the state;

FIGS. 18A and 18B are views showing a mobile phone unit according to the second embodiment of the present invention, in which FIG. 18A is a plan view showing a state of the casing thereof, and FIG. 18B is a connection diagram showing an example of the connection of a passive antenna in the state;

FIGS. 19A and 19B are characteristic curves showing the antenna radiation efficiency according to the second embodiment of the present invention, in

which FIG. 19A shows an example of the characteristic when a terminal is opened, and FIG. 19B shows an example thereof when the terminal is closed; and

FIG. 20 is a plan view showing a modified example of a mobile phone unit (mobile communication terminal) according to the second embodiment of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0023] Hereinafter, the first embodiment of the present invention will be explained with reference to FIGS. 1 to 12.

[0024] FIGS. 1A and 1B are views showing a mobile phone unit 1 (mobile communication terminal) according to this embodiment; FIG. 1A is a plan view and FIG. 1B is side section view. A communication frequency band that the mobile phone 1 uses for communication is predetermined in every system. The communication frequency band is from about 0.83GHz to about 0.93GHz, for example. Hereupon, the lower limit of the communication frequency band is called fL (the lower limit frequency), the upper limit thereof is called fH, and the average between the lower limit and upper limit is called fc.

[0025] The mobile phone unit 1 includes a first casing 10 and a second casing 20. As shown in FIG. 1A, buttons such as a ten-key are provided in the first casing 10. A display is provided in the second casing 20. The first casing 10 and the second casing 20 are connected by a hinge not shown in the figure. The mobile phone unit 1 can be folded by means of this hinge such that the buttons of the first casing 10 and the display of the second casing 20 are opposed to each other. In FIGS. 1A and 1B, the first casing 10 and the second casing 20 are at an angle of almost 45 degrees, and the mobile phone unit 1 is recognized as being open in such state. The angle made by the first casing 10 and the second casing 20 may not almost exist in some cases. Also, there is so-called a turning type in which the second casing 20 is rotated clockwise or counterclockwise with respect to the first casing 10 and can be folded. In the following embodiments, in the case where a mobile phone unit capable of being folded is mentioned, all the types described above are included.

[0026] As shown in FIG. 1B, the first casing 10 has a first circuit board 12 and the second casing 20 has a second circuit board 22. The first circuit board 12 and the second circuit board 22 are connected by a circuit board hinge 30. With this, the first circuit board 12 and the second circuit board 22 can change the posture flexibly depending on the folded state of the mobile phone unit 1.

[0027] FIG. 2 is a plan view showing a state of the first circuit board 12, second circuit board 22 and circuit board hinge 30, when the mobile phone unit 1 is fully opened and the first casing 10 and the second casing 20 face almost in the same direction (when opened).

[0028] A GND (ground potential) portion 14, a power feeding antenna 16, a power supply portion 17 and a feed point 18 are provided in the first circuit board 12.

[0029] The GND (ground potential) portion 14 is a portion keeping the ground potential. For example, the portion has almost a rectangular-shaped solid circuit pattern. The power feeding antenna 16 is an antenna to which high frequency electric power is supplied. The power supply portion 17 is connected to the GND portion 14 and the power feeding antenna 16 and supplies the high frequency electric power between the ground portion 14 and the power feeding antenna 16. The feed point 18 is a portion at which the power feeding antenna 16 is connected to the first circuit board 12, and the power feeding antenna 16 receives power through the feed point 18.

[0030] A GND (ground potential) portion 24 and a passive antenna 26 are attached to the second circuit board 22.

[0031] The GND (ground potential) portion 24 is a portion keeping the ground potential. For example, the portion has almost a rectangular-shaped solid circuit pattern. The passive antenna 26 is an antenna to which power is not supplied. The passive antenna 26 is connected to the ground portion 24.

[0032] Here, the whole length L = La + Lb (La: a portion parallel to the short side of the second circuit board 22, Lb: a portion parallel to the long side of the second circuit board 22) of the passive antenna 26 is approximately a quarter of a wavelength λ of a radio wave corresponding to the fL (lower limit frequency). In other words, $L=\lambda/4$. With such construction, the passive antenna 26 is made to resonate at the lower limit communication frequency fL. Note that the whole length L of the passive antenna 26 may not be $\lambda/4$ on condition that the antenna resonates at the lower limit communication frequency.

[0033] Further, the passive antenna 26 can be provided on the second circuit board 22 instead of being attached to the outside of the second circuit board 22. The modified examples are shown in FIGS. 3A to 3D.

[0034] As shown in FIG. 3A, the passive antenna 26 may have the circuit pattern of the shape of meanders. As shown in FIG. 3B, the passive antenna 26 may have the circuit pattern of an approximately straight shape in which the long side portion is considerably longer than the short side portion. Further, the passive antenna 26 may not be the circuit pattern and may be a wire as shown in FIG. 3C and may be a metal plate as shown in FIG. 3D.

[0035] In the above described examples, the passive antenna 26 is made to resonate at the lower limit communication frequency fL by adjusting the whole length L of the passive antenna 26. However, instead of adjusting the whole length L of the passive antenna 26, as shown in FIG. 4, a circuit chip 25 may be connected to the passive antenna 26 and the GND portion 24 to make

the passive antenna 26 resonate at the lower limit communication frequency fL.

[0036] FIGS. 5A and 5B show a state of the first circuit 12, second circuit 22 and circuit board hinge 30, when the mobile phone unit 1 is folded and the first casing 10 and the second casing 20 oppose to each other; FIG. 5A is a side view and FIG. 5B is a plan view.

[0037] As shown in FIG. 5A, the power feeding antenna 16 opposes to the passive antenna 26. Further, the power feeding antenna 16 is positioned at the back of the passive antenna 26 shown in FIG. 5B, and the power feeding antenna 16 opposes to the passive antenna 26. Accordingly, the power feeding antenna 16 and the passive antenna 26 are electromagnetically coupled.

[Practice Example 1]

[0038] FIGS. 6A and 6B show a comparative example to be compared with a practice example of the present invention; FIG. 6A is a plan view and FIG. 6B shows the antenna radiation efficiency.

[0039] As shown in FIG. 6A, the comparative example has no passive antenna 26. In this case, the antenna radiation efficiency changes depending on the whole length H of the circuit board that is the sum of the length of the first circuit board 12 and the length of the second circuit board 22 (refer to FIG. 6B). It is recognized that H=125mm is the case with which the radiation efficiency becomes highest in the desired communication frequency band (the desired band).

[0040] In FIGS. 7A and 7B, FIG. 7A shows the antenna radiation efficiency in a comparative example (H=165mm), and FIG. 7B shows the antenna radiation efficiency in a practice example (H=165mm) of the present invention.

[0041] As shown in FIG. 7A, the antenna radiation efficiency in the comparative example (H=165mm) is not desirable, because it becomes particularly low around the lower limit of the desired band. On the other hand, as shown in FIG. 7B, the antenna radiation efficiency in the practice example (H=165mm) of the present invention becomes almost constant within the desired band and is desirable, while the whole length H of the circuit board is the same as that of the comparative example. Hence, the antenna radiation efficiency becomes desirable in the desired band regardless of the whole length H of the circuit board according to the practice example of the present invention.

[0042] FIG. 8 shows the antenna radiation efficiency of a passive antenna 26 in the communication frequency band, in each of the cases where the resonance frequency thereof is a lower limit fL (lower limit communication frequency), is an upper limit fH and is an average fc of the lower limit and upper limit. As shown in FIG. 8, the antenna radiation efficiency becomes particularly low around the lower limit fL in the communication frequency band, when the resonance frequency of the passive antenna 26 is fH and fc, which is not favorable. On the other hand, the antenna radiation efficiency becomes excellent over the whole of the desired band, when the resonance frequency of the passive antenna 26 is fL, which is favorable.

[0043] Therefore, since the passive antenna 26 is provided in the second circuit board 22 and the resonance frequency of the passive antenna 26 is fL, the antenna radiation efficiency becomes excellent over the whole of the desired band and the desirable effectiveness can be obtained.

[0044] Here, directions are defined as shown in FIG. 9 and the antenna radiation pattern in the comparative example is shown in FIGS. 10A and 10B. It is known that the radiation pattern from the minute current element is a sine curve, and originally, the direction of maximum radiation is the side directions (90°, 270°) and should become symmetrical with the top and bottom (the directions of 0° and 180°). The case shown in FIG. 10A (H=125mm) is the original radiation pattern, and the antenna radiation efficiency is excellent (refer to FIG. 6B).

[0045] However, depending on the whole length H of the circuit board, the phase of the high-frequency current which flows on the circuit board is reversed on the path of the current, and so the offset of the radiation occurs to make the antenna radiation pattern distorted. As a result, the direction of maximum radiation will shift upward (in the directions of 0° and 360°) from the side directions (90°, 270°). It is a case (H=165 mm) shown in FIG. 10B. In this case, the radiation characteristics (efficiency and band) becomes deteriorated by the offset of the radiation (refer to FIG. 6B). While the phase reversal generally occurs by the half-wavelength in the high frequency current, the phase reversal occurs by the length shorter than the half-wavelength when the current flows in the circuit board or the like having the width and thickness.

[0046] In FIGS. 11A and 11B, FIG. 11A shows the antenna radiation pattern in the comparative example (H=165mm) and FIG. 11B shows the antenna radiation pattern in the practice example (H=165mm) of the present invention.

[0047] As shown in FIG. 11A, the antenna radiation pattern in the comparative example (H=165mm) is not desirable, because the direction of maximum radiation shifts upward (in the directions of 0° and 360°). On the other hand, as shown in FIG. 11B, the practice example of the present invention (H=165mm) is desirable, because the direction of maximum radiation comes closer to the side directions (90°, 270°), while the whole length H of the circuit board is the same as that of the comparative example. Hence, according to the practice example of the present invention, the antenna radiation pattern becomes desirable regardless of the whole length H of the circuit board.

[0048] The characteristics of the antenna when the mobile phone unit 1 is opened have heretofore been explained, hereupon, the antenna radiation efficiency

when the mobile phone unit 1 is folded is shown in FIG. 12. As is obvious from FIG. 12, the antenna radiation efficiency of the practice example 1 according to the present invention is higher than that of the comparative example in the desired band.

[0049] Next, the second embodiment of the present invention will be explained with reference to FIGS. 13 to 20. Since the second embodiment is also applied to the folding type mobile phone unit 1 (the mobile communication terminal) similarly to the first embodiment, the same reference numerals are given to the same members as those in the mobile phone unit 1 explained in the first embodiment and the detailed explanation is omitted.

[0050] FIG. 13 is a drawing of a mobile phone unit (mobile communication terminal) 1 according to this embodiment of the present invention and is a plan view showing a state of a first circuit board 12, second circuit board 22 and circuit board hinge 30, when the mobile phone unit 1 is fully opened and a first casing 10 and a second casing 20 face almost in the same direction (when opened).

[0051] A GND (ground potential) portion 14, a power feeding antenna 16, a power supply portion 17 and a feed point 18 are provided in the first circuit board 12.

[0052] The GND (ground potential) portion 14 is a portion keeping the ground potential. For example, the portion has almost a rectangular-shaped solid circuit pattern. The power feeding antenna 16 is an antenna to which the high frequency electric power is supplied. The power supply portion 17 is connected to the ground portion 14 and the power feeding antenna 16 and supplies the high frequency electric power between the power feeding antenna 16 and the GND portion 14. The feed point 18 is a portion at which the power feeding antenna 16 is connected to the first circuit board 12, and the power feeding antenna 16 receives power through the feed point 18.

[0053] The second circuit board 22 has a GND (ground potential) portion 24, and a passive antenna 26 is attached to the GND portion 24 through a switch 27.

[0054] The GND (ground potential) portion 24 is a portion keeping the ground potential. For example, the portion has almost a rectangular-shaped solid circuit pattern. The passive antenna 26 is an antenna to which power is not supplied. The passive antenna 26 is connected to the GND portion 24 through the switch 27.

[0055] The switch 27 is switched between when the mobile phone unit 1 is fully opened and the first casing 10 and the second casing 20 are opened and when the first casing 10 and the second casing 20 are closed, for example. The switching of this switch is performed by the control of a control portion (not shown in the figure) which detects the states of the opening and closing of the mobile phone unit 1, for example. Alternatively, a switch changed mechanically in accordance with the opening and closing operations of the mobile phone unit 1 may be used.

[0056] Similarly to the first embodiment, the whole length of the passive antenna 26 is preferable to be approximately a quarter of a wavelength λ of the radio wave corresponding to the fL (lower limit frequency). In other words, $L=\lambda/4$. With such construction, the passive antenna 26 is made to resonate at the lower limit communication frequency fL. Note that the whole length L of the passive antenna 26 may not be $\lambda/4$ on condition that the antenna resonates at the lower limit communication frequency.

[0057] Further, similarly to the first embodiment, the passive antenna 26 may be provided on the second circuit board 22 instead of being attached to the outside of the second circuit board 22 and may have various shapes as shown in FIGS. 3A to 3D, for example.

[0058] When the GND portion 24 and the passive antenna 26 are connected through the switch 27, circuit components (a coil, resistance, capacitor and so on) made of chip components and the like may be attached. Specifically, as shown in FIG. 14A for example, a coil 41a (this coil 41a has the inductance value of 33nH or 30nH, for example) is connected between the GND portion 24 and the passive antenna 26, when the switch 27 is closed. Further, the passive antenna 26 is made not to connect to the coil 41a and the GND portion 24, when the switch is opened.

[0059] Further, as shown in FIG. 14B for example, a switch connected to the passive antenna 26 is provided as a switch 27' which can be switched from one side to the other side, and a coil 41a is connected between the GND portion 24 and the passive antenna 26 when the switch changes to one side, and a coil 41b is connected between the GND portion 24 and the passive antenna 26 when the switch changes to the other side. The coil 41a has the inductance value of 33nH, for example, and the coil 41b has the inductance value of 30nH, for example. The inductance components formed of a chip component are used as the coils 41a and 41b.

[0060] FIGS. 15A and 15B and FIGS. 16A and 16B are drawings which show an example of a state of the passive antenna 26 when the mobile phone unit 1 is opened (FIGS. 15A and 15B), and show an example of a state of the passive antenna 26 when the mobile phone unit 1 is closed (FIGS. 16A and 16B), in the case where the connection configuration shown in FIG. 14A is employed.

[0061] When the mobile phone unit 1 is opened as shown in FIG. 15A, the switch 27 is in an open state as shown in FIG. 15B and the passive antenna 26 is in a state of being separated from the coil 41a and the GND 24 (that is, a state of being separated from the circuit board inside the second casing 20).

[0062] When the mobile phone unit 1 is closed as shown in FIG. 16A, the switch 27 is in a closed state as shown in FIG 16B and the passive antenna 26 is in a state of being connected to the GND portion 24 through the coil 41a.

[0063] FIGS. 17A and 17B and FIGS. 18A and 18B

are drawings which show an example of a state of the passive antenna 26 when the mobile phone unit 1 is opened (FIGS. 17A and 17B), and show an example of a state of the passive antenna 26 when the mobile phone unit 1 is closed (FIGS. 18A and 18B), in the case where the connection configuration shown in FIG. 14B is employed.

[0064] When the mobile phone unit 1 is opened as shown in FIG. 17A, the switch 27' is in a state of being connected to one side as shown in FIG. 17B and the passive antenna 26 is in a state of being connected to the GND portion 24 through the coil 41a.

[0065] When the mobile phone unit 1 is closed as shown in FIG. 18A, the switch 27' is in a state of being connected to the other side as shown in FIG. 18B and the passive antenna 26 is in a state of being connected to the GND portion 24 through the coil 41b.

[0066] With such construction, when the mobile phone unit 1 is closed, the characteristics as the mobile communication terminal becomes excellent, because the electromagnetic coupling e is generated between the antenna 16 on the first casing 10 side and the passive antenna 26 on the second casing 20 side as shown in FIG. 16A or 18A. Further, when the mobile phone unit 1 is opened, the characteristics in the open state can be improved, because the passive antenna 26 is in a state of being separated (FIGS. 15A and 15B) or is in another connection state (FIG. 17A and 17B).

[Practice Example 2]

[0067] FIGS. 19A and 19B are characteristic curves showing an example of the antenna radiation efficiency of a practice example (practice example 2) according to the second embodiment of the present invention. Here, FIG. 19A shows an example of the characteristic in the frequency band for the wireless communication when a mobile phone unit 1 is opened, and FIG. 19B shows an example of the characteristic in the frequency band for the wireless communication when a mobile phone unit 1 is closed.

[0068] In this practice example, with respect to each state of the mobile phone unit 1, the characteristics in three states are compared: the state in which the coil with the inductance value *a* (here, 33nH) is connected between the passive antenna 26 and the GND portion, the state in which the coil with the inductance value b (here, 30nH) is connected between the passive antenna 26 and the GND portion, and the state in which the passive antenna 26 is separated from the GND portion.

[0069] As shown in FIG. 19A, when the mobile phone unit 1 is opened, the characteristics obtained in the case of using the inductance value b and in the case of not connecting to the passive antenna are superior to the characteristic obtained in the case of using the inductance value *a*, in almost all the frequency band for the communication.

[0070] Further, as shown in FIG. 19B, when the mobile phone unit 1 is closed, the characteristics obtained in the case of using the inductance value *a* and in the case of using the inductance value b are superior to the characteristic obtained in the case of not connecting to the passive antenna, in almost all the frequency band for the communication.

[0071] Therefore, for example, both in the examples of FIGS. 15A and 15B and FIGS. 16A and 16B, excellent communication characteristics are obtained, in which when the terminal is opened, the passive antenna is not connected and in which when the terminal is closed, the passive antenna is connected to the GND portion through the coil of the inductance value *a* or *b*.

[0072] Further, for example, both in the examples of FIGS. 17A and 17B and FIGS. 18A and 18B, excellent communication characteristics are obtained, in which when the terminal is opened, the passive antenna is connected to the GND portion through the coil of the inductance value b and in which when the terminal is closed, the passive antenna is connected to the GND portion through the coil of the inductance value *a*.

[0073] Note that the radiation efficiency shown in FIG. 19 changes depending on various factors regarding a structure such as the size of a circuit board to which an antenna is connected, and the state in which characteristic is more favorable depends on the structure. Also, regarding the inductance values, the values mentioned above are examples.

[0074] Further, in the second embodiment heretofore explained, the switch 27 or 27' to switch the connection of the passive antenna is provided at the end portion where the GDN portion of the antenna is connected, however the switch may be provided in the middle of the passive antenna and a part of the passive antenna is separated depending on the state of the terminal.

[0075] Specifically, as shown in FIG. 20 for example, when a switch 28 is provided in the middle of the passive antenna 26 and the mobile phone unit is opened, about the half of the tip side of the passive antenna 26 is separated from the GND portion by making the switch 28 into the open state, and only the remaining half is connected to the GND portion. Then, when the mobile phone unit is closed, the whole of the passive antenna 26 is made to connect to the GND portion by making the switch 28 into the closed state. The circuit components such as a coil and so on may be connected in series to the switch 28.

[0076] With the above construction, the antenna characteristic in each state of the mobile phone unit can be improved.

Claims

1. A mobile communication terminal comprising:

a first casing including a power feeding antenna to which power is supplied and

a second casing connected to said first casing, wherein

said second casing includes a passive antenna to which power is not supplied and which resonates at approximately the lower limit communication frequency in a communication frequency band used for communication.

2. The mobile communication terminal according to claim 1, wherein

the electrical length of said passive antenna is a quarter of a wavelength of a radio wave corresponding to said lower limit communication frequency.

3. The mobile communication terminal according to claim 1, wherein

said first casing and said second casing can be folded to be opposed to each other.

4. The mobile communication terminal according to claim 3, wherein

said power feeding antenna and said passive antenna are electromagnetically coupled when folded.

5. The mobile communication terminal according to claim 1, wherein

said first casing has a first circuit board to which said power feeding antenna is connected,

said second casing has a second circuit board in which said passive antenna is provided, and

power is supplied between said power feeding antenna and a ground potential of said first circuit board.

6. The mobile communication terminal according to claim 5, wherein

said passive antenna has a circuit pattern provided on said second circuit board.

7. The mobile communication terminal according to claim 6, wherein

said circuit pattern has the shape of meanders.

8. The mobile communication terminal according to claim 6, wherein

said circuit pattern has an approximately straight shape.

9. The mobile communication terminal according to claim 5, wherein

said passive antenna has a wire provided on said second circuit board.

10. The mobile communication terminal according to claim 5, wherein

said passive antenna has a metal plate provided on said second circuit board.

11. The mobile communication terminal according to claim 5, wherein

said second casing has a circuit member which is connected to said passive antenna and a ground potential of said second circuit board and which makes said passive antenna resonate at said lower limit communication frequency.

12. A mobile communication terminal comprising:

a first casing including a power feeding antenna to which power is supplied and

a second casing connected to said first casing, wherein

said second casing has a passive antenna selectively connected.

13. The mobile communication terminal according to claim 12, wherein

said first casing and said second casing can be folded to be opposed to each other and

a connection state of said passive antenna is changed between the state in which said first casing and said second casing are folded and the state in which the both are not folded.

14. The mobile communication terminal according to claim 13, wherein

said power feeding antenna and said passive antenna are electromagnetically coupled when folded.

15. The mobile communication terminal according to claim 12, wherein

said first casing has a first circuit board connected to said power feeding antenna,

said second casing has a second circuit board in which said passive antenna is provided, and

power is supplied between said power feeding antenna and a ground potential of said first circuit board.

FIG. 1A

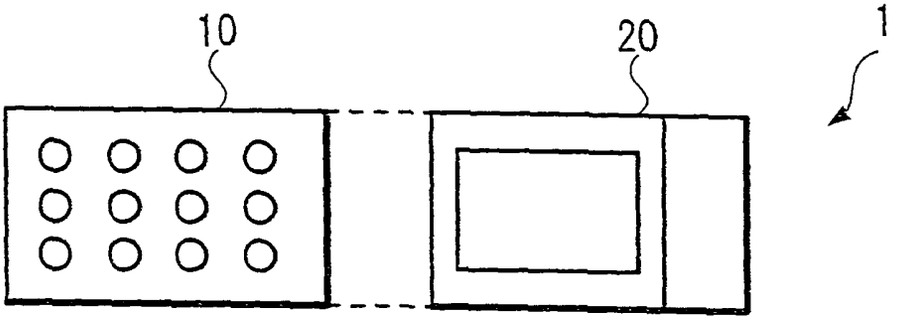


FIG. 1B

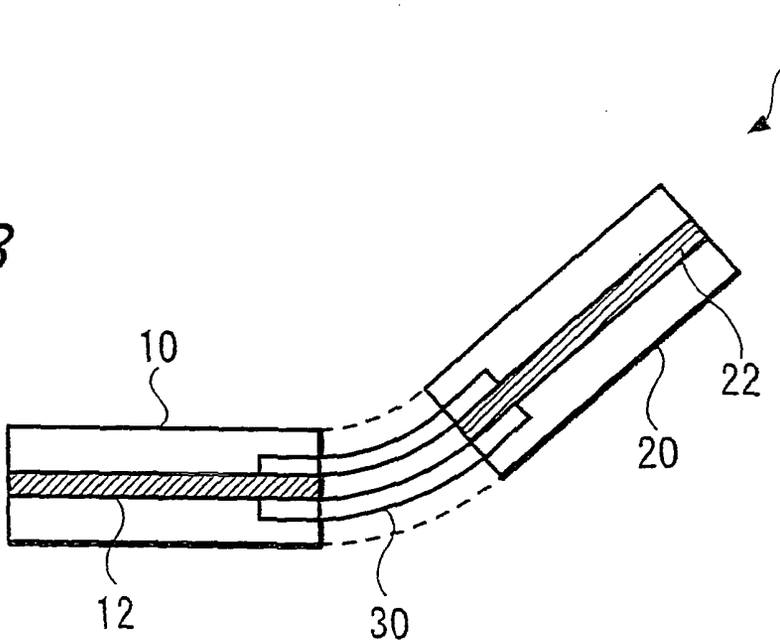


FIG. 2

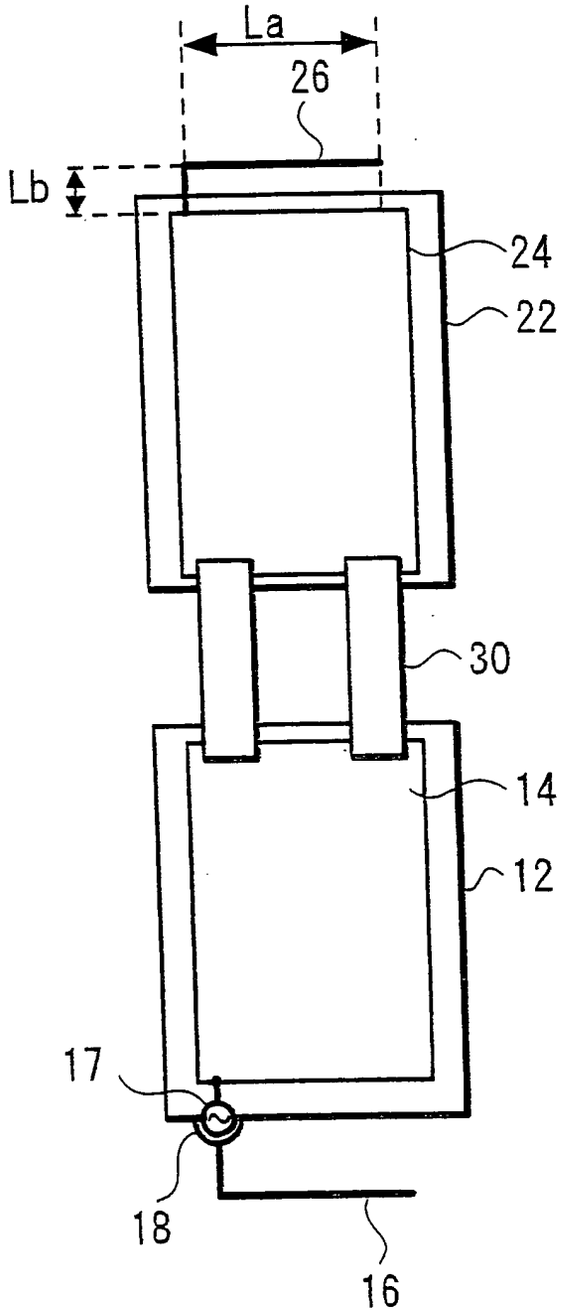


FIG. 3A

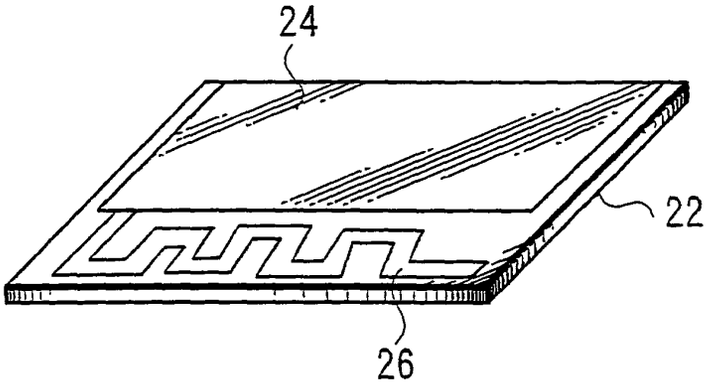


FIG. 3B

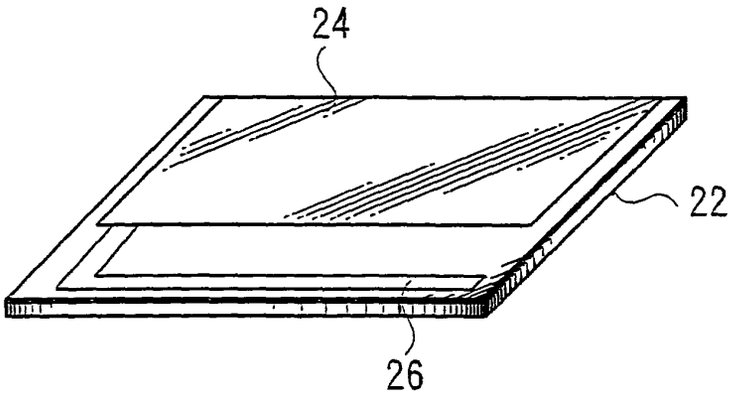


FIG. 3C

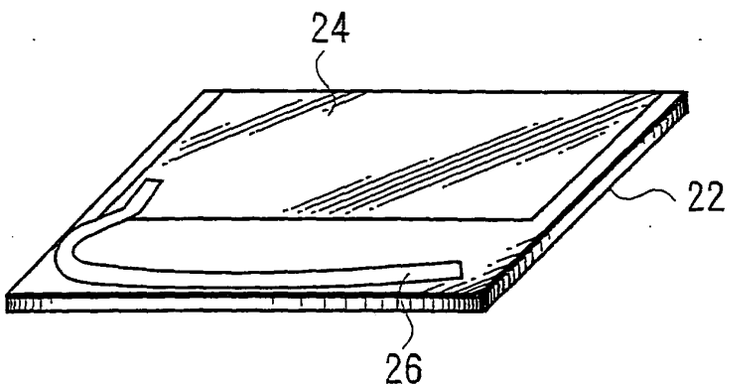


FIG. 3D

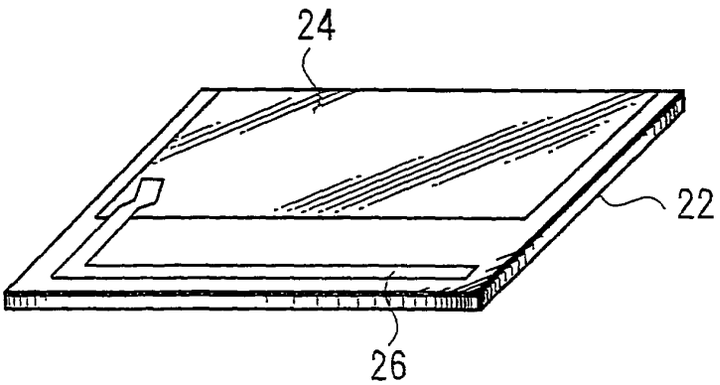


FIG. 4

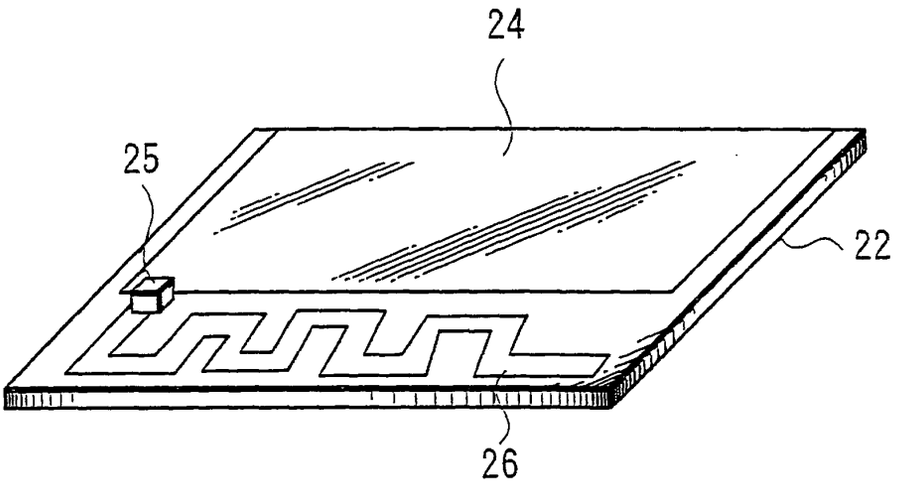


FIG. 5A

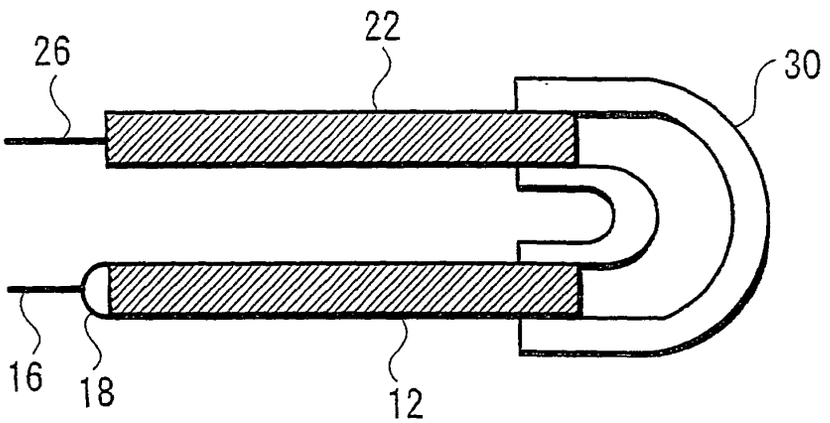


FIG. 5B

FIG. 6A

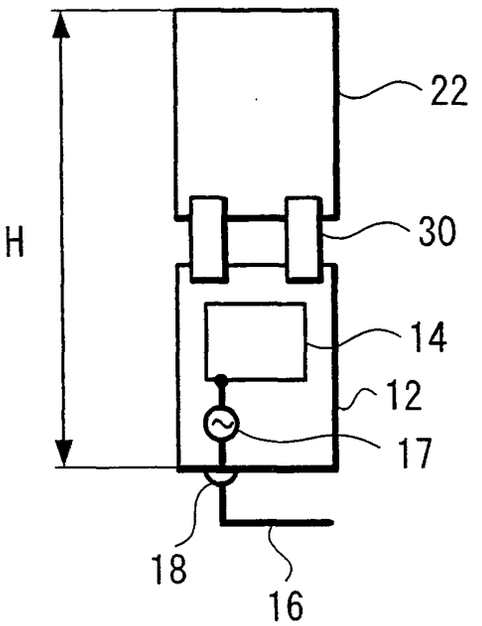

H
22
30
14
12
17
18
16

FIG. 6B

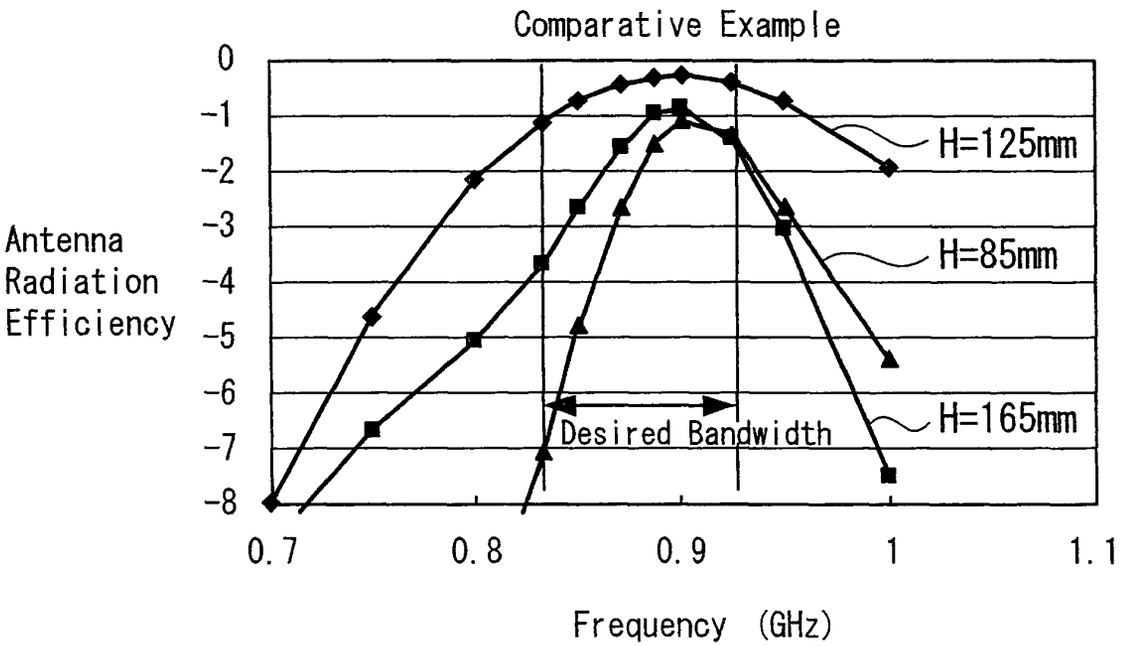

Comparative Example
Antenna Radiation Efficiency
0
-1
-2
-3
-4
-5
-6
-7
-8
H=125mm
H=85mm
H=165mm
Desired Bandwidth
0.7
0.8
0.9
1
1.1
Frequency (GHz)

FIG. 7A

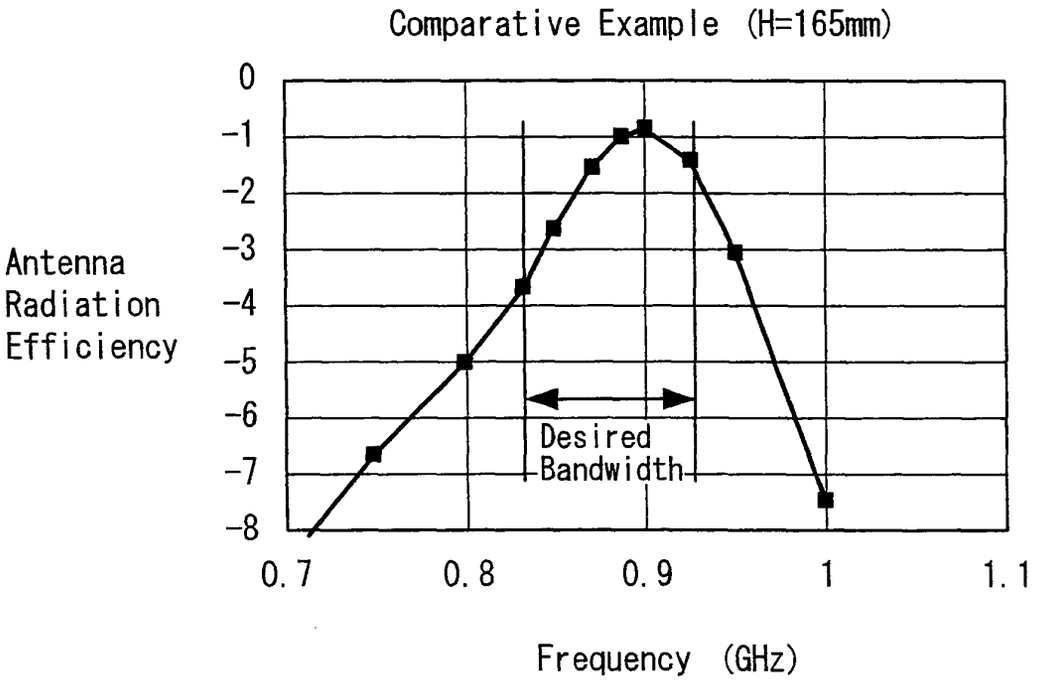

Comparative Example (H=165mm)
Antenna Radiation Efficiency
0
-1
-2
-3
-4
-5
-6
-7
-8
Desired Bandwidth
0.7
0.8
0.9
1
1.1
Frequency (GHz)

FIG. 7B

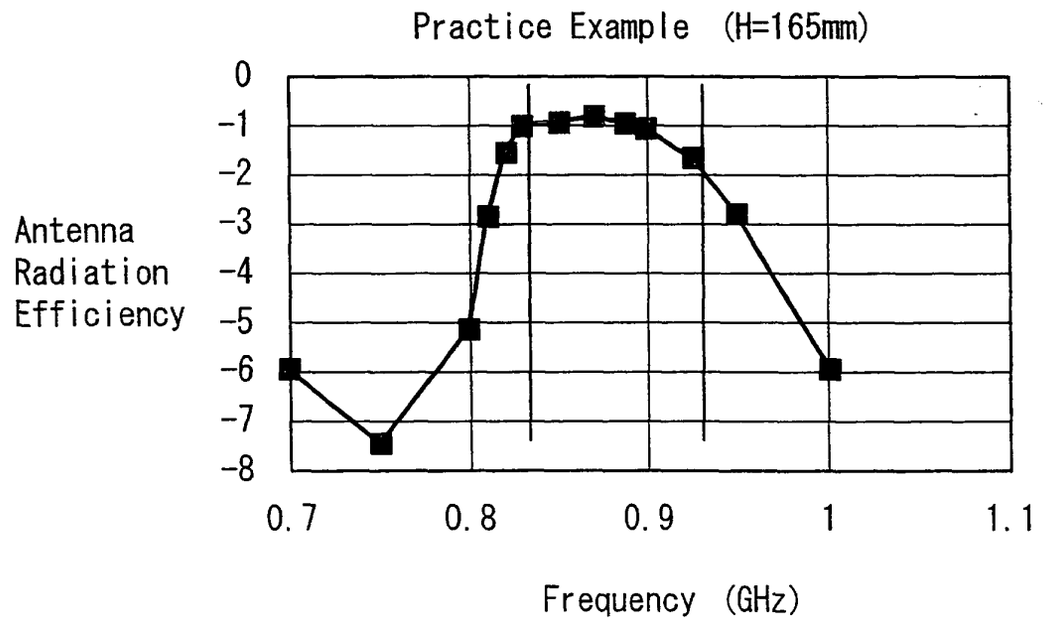

Practice Example (H=165mm)
Antenna Radiation Efficiency
0
-1
-2
-3
-4
-5
-6
-7
-8
0.7
0.8
0.9
1
1.1
Frequency (GHz)

FIG. 8

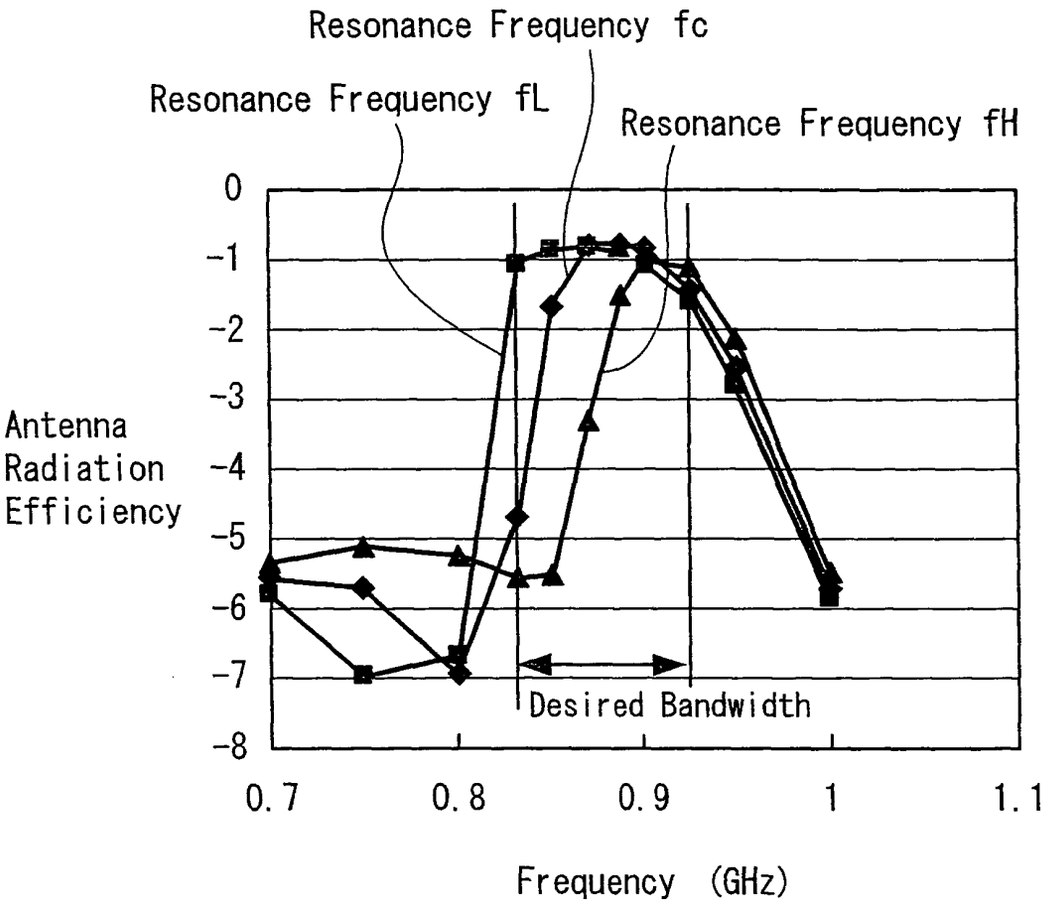

Resonance Frequency fc
Resonance Frequency fL
Resonance Frequency fH
Antenna Radiation Efficiency
0
-1
-2
-3
-4
-5
-6
-7
-8
Desired Bandwidth
0.7
0.8
0.9
1
1.1
Frequency (GHz)

FIG. 9

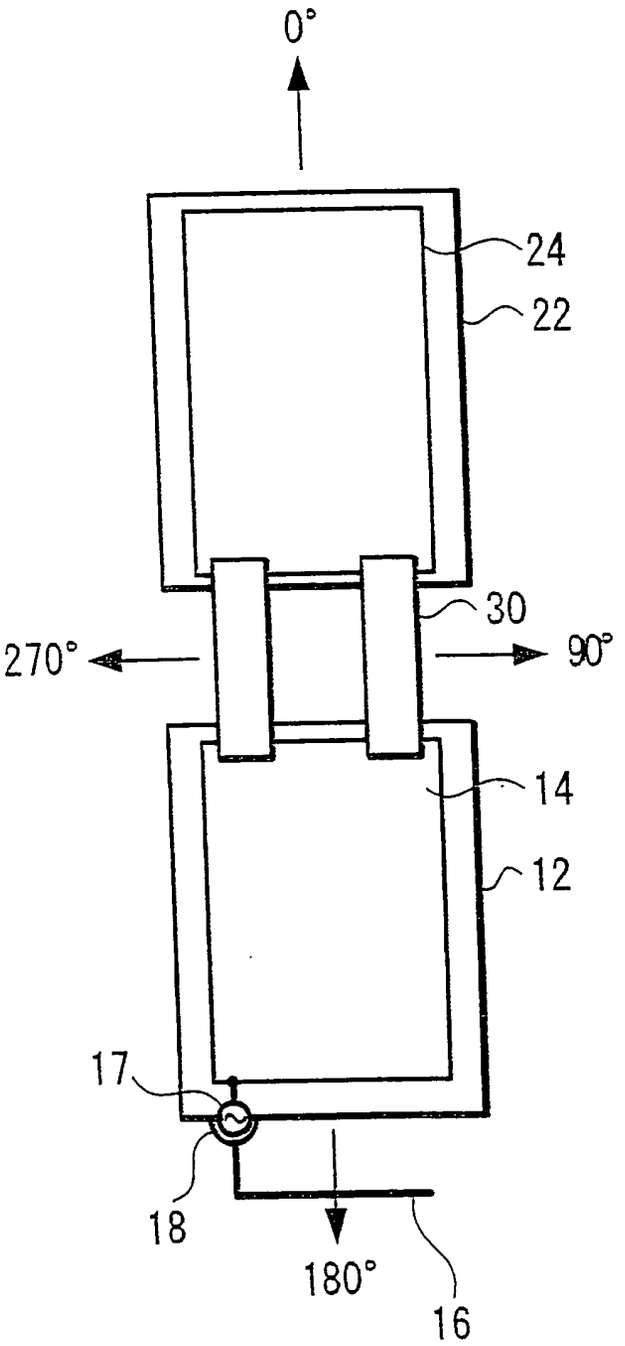


FIG. 10A

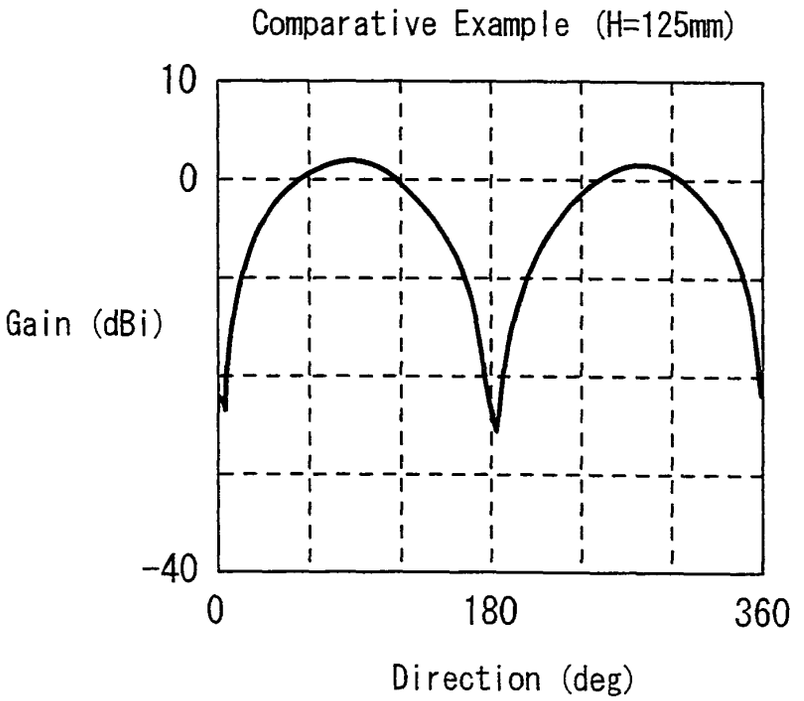


FIG. 10B

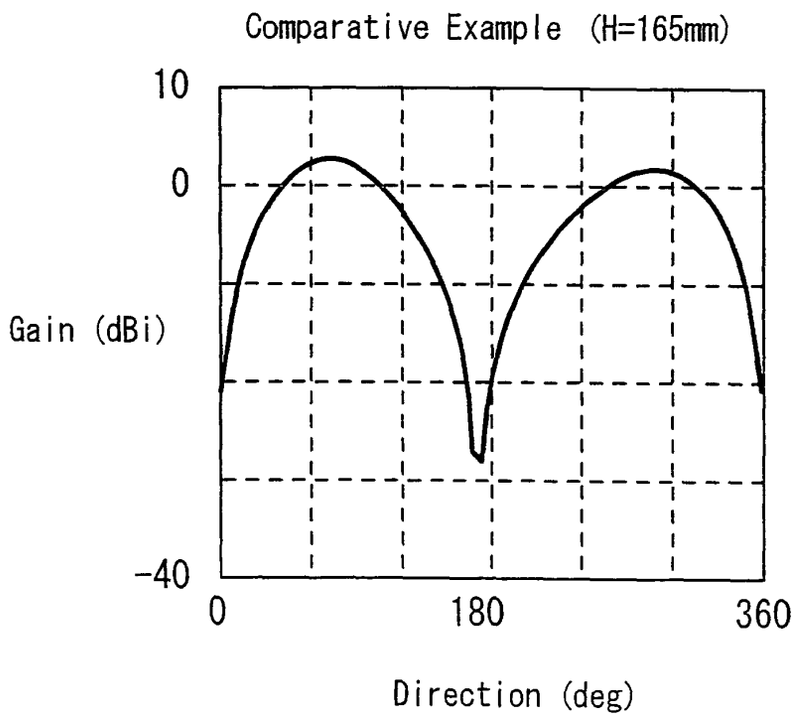


FIG. 11A

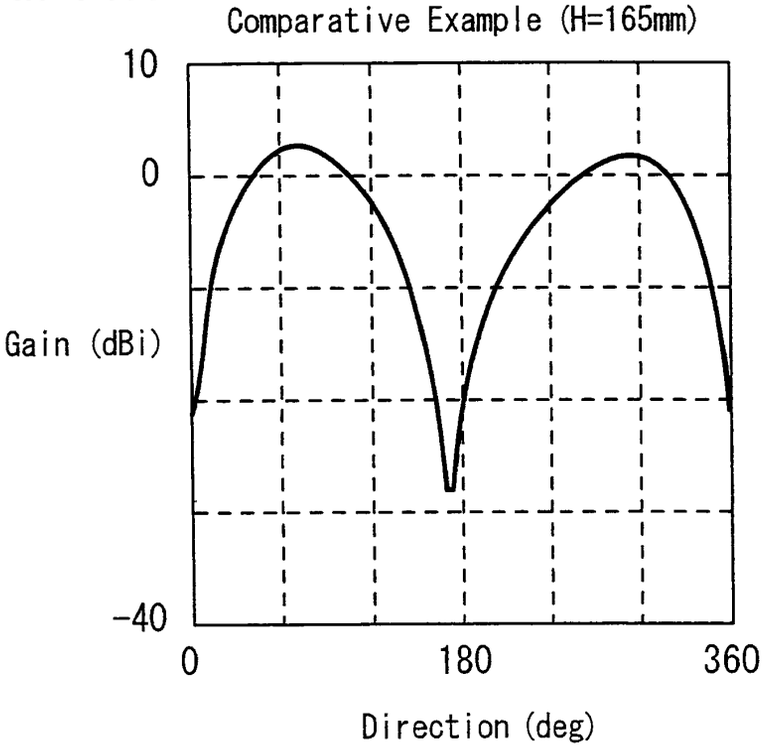


FIG. 11B

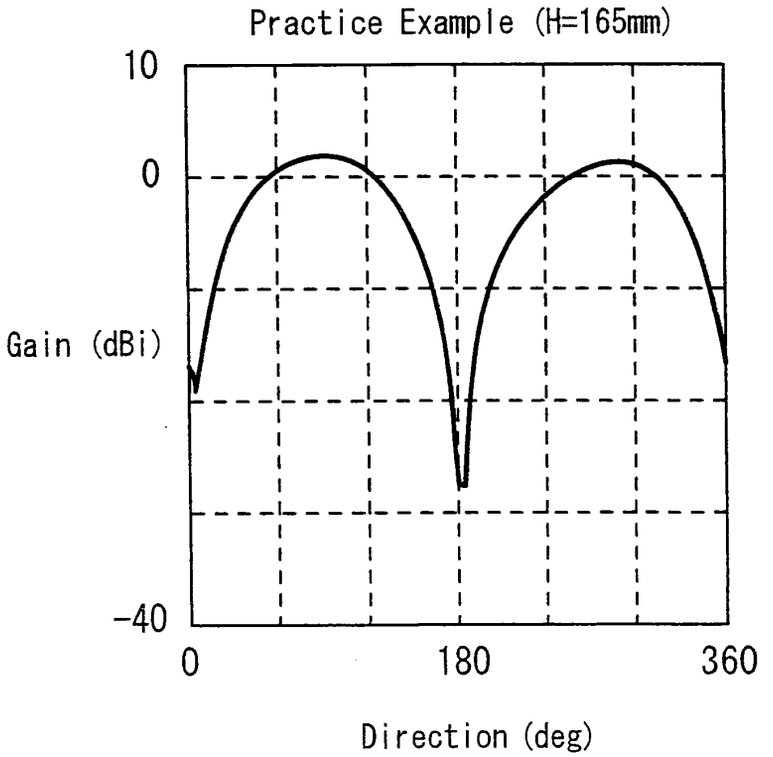


FIG. 12

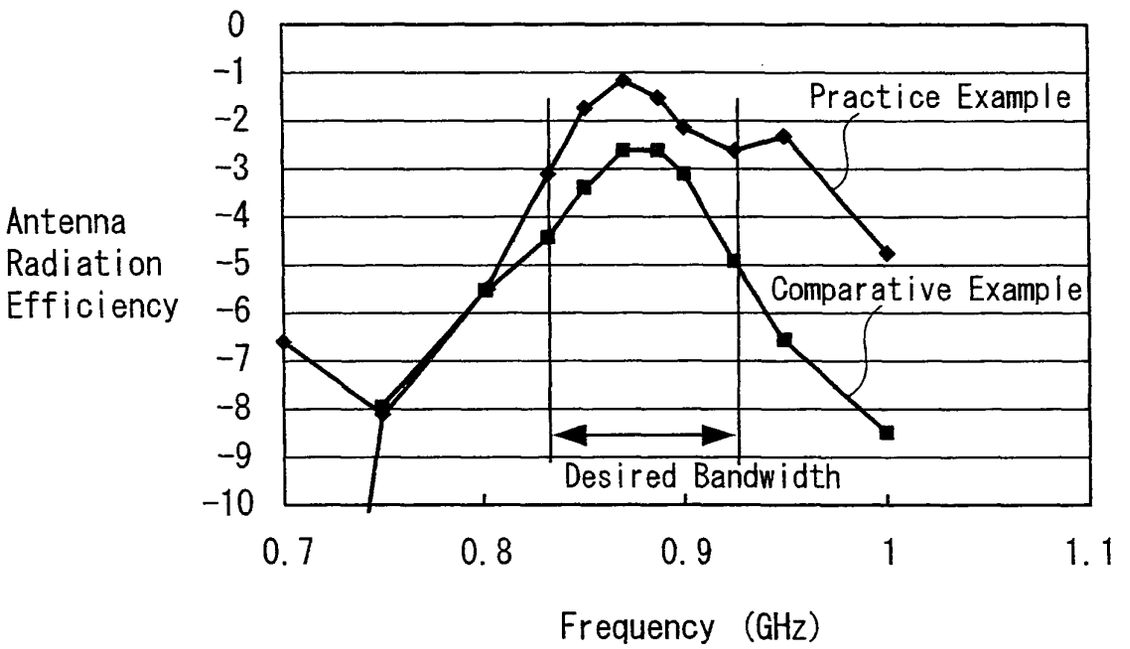

0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
Antenna
Radiation
Efficiency
Practice Example
Comparative Example
Desired Bandwidth
0.7
0.8
0.9
1
1.1
Frequency (GHz)

FIG. 13

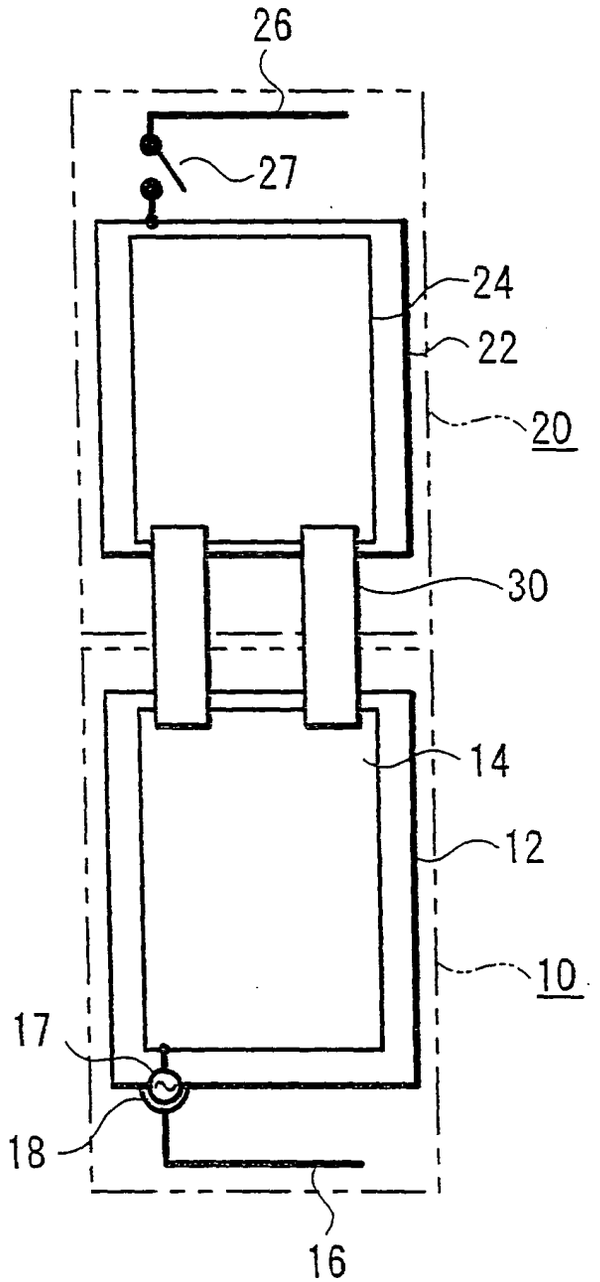


FIG. 14A

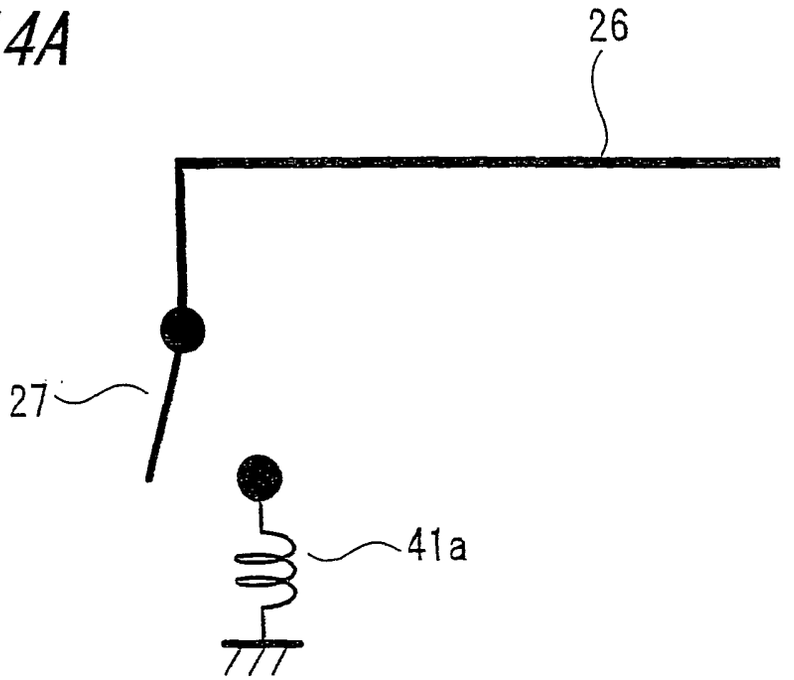


FIG. 14B

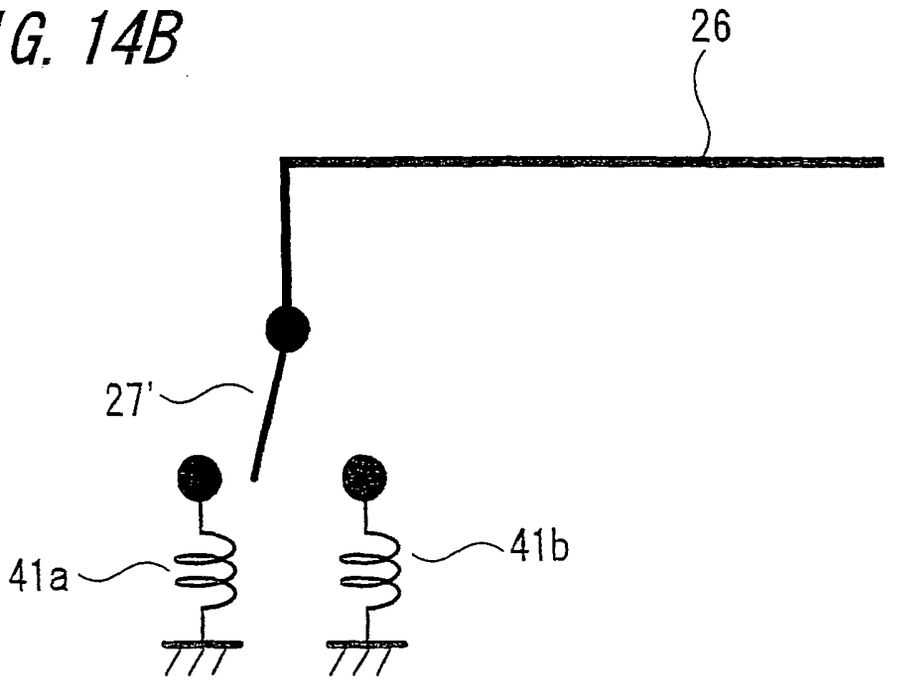


FIG. 15A

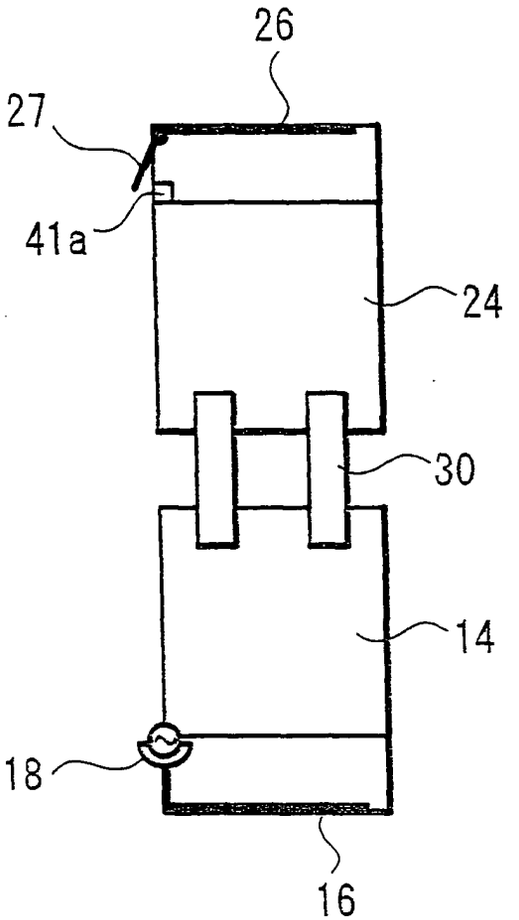


FIG. 15B

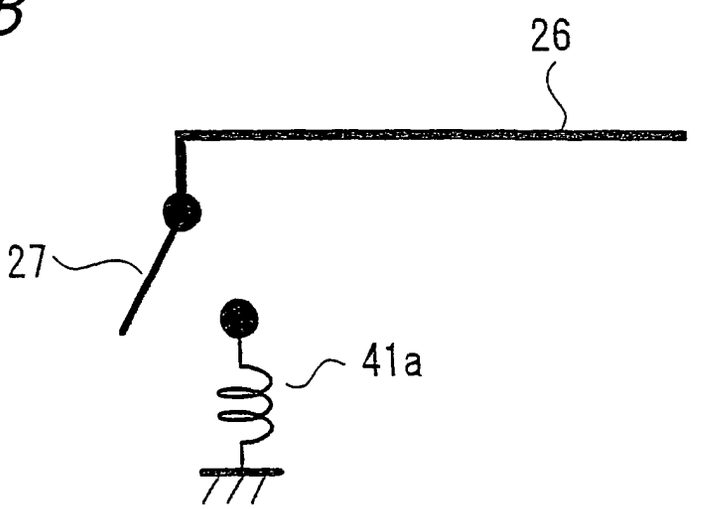


FIG. 16A

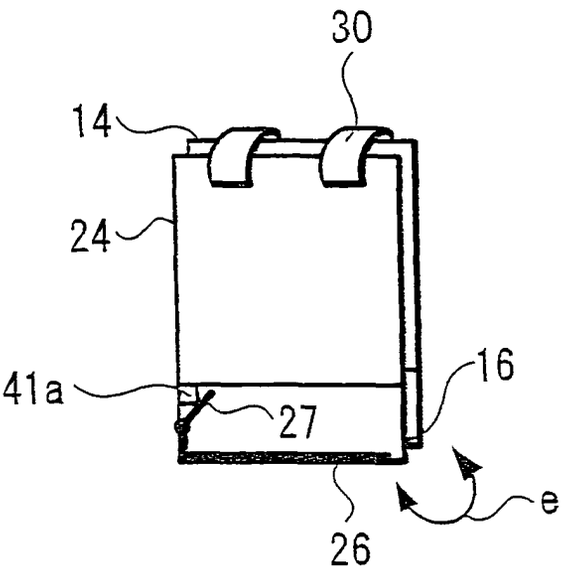


FIG. 16B

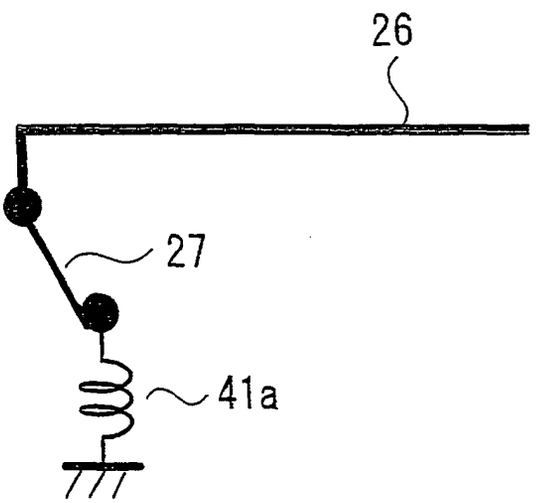


FIG. 17A

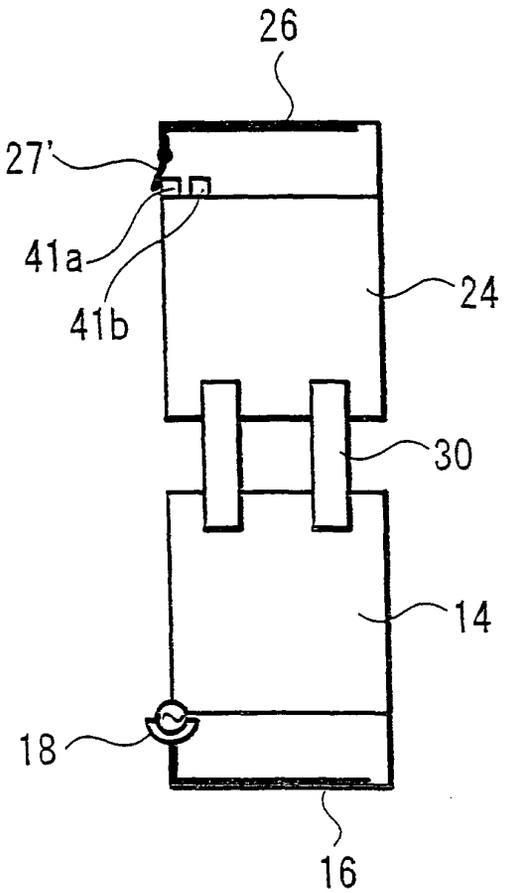


FIG. 17B

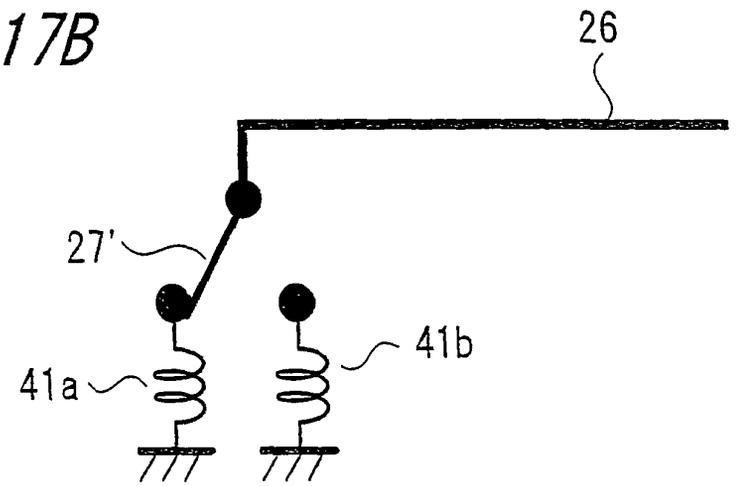


FIG. 18A

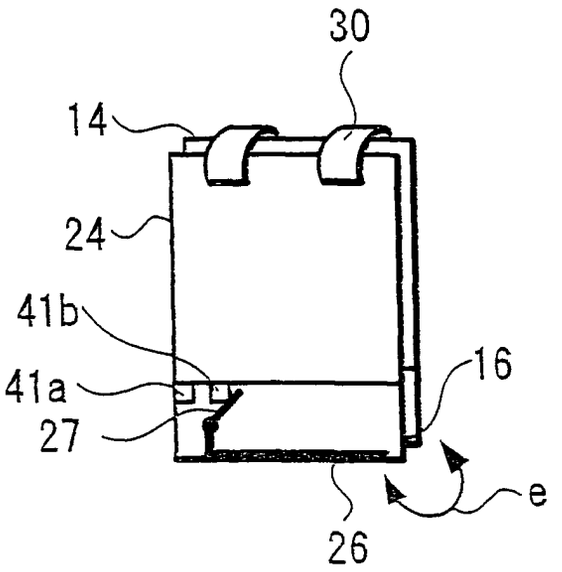


FIG. 18B

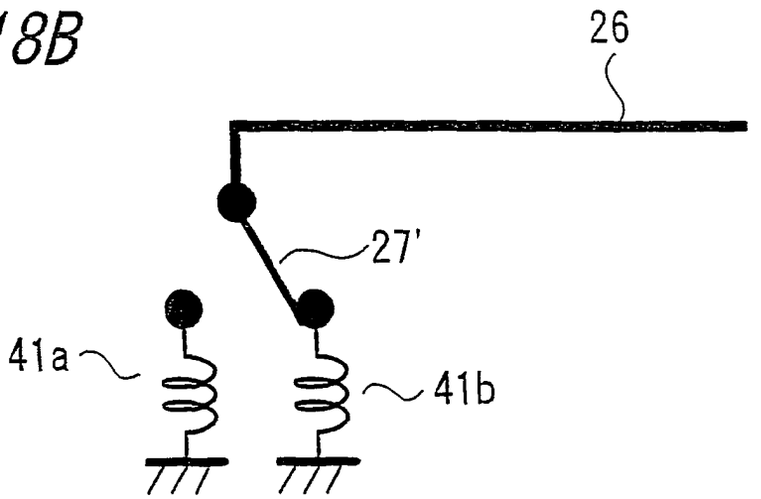


FIG. 19A

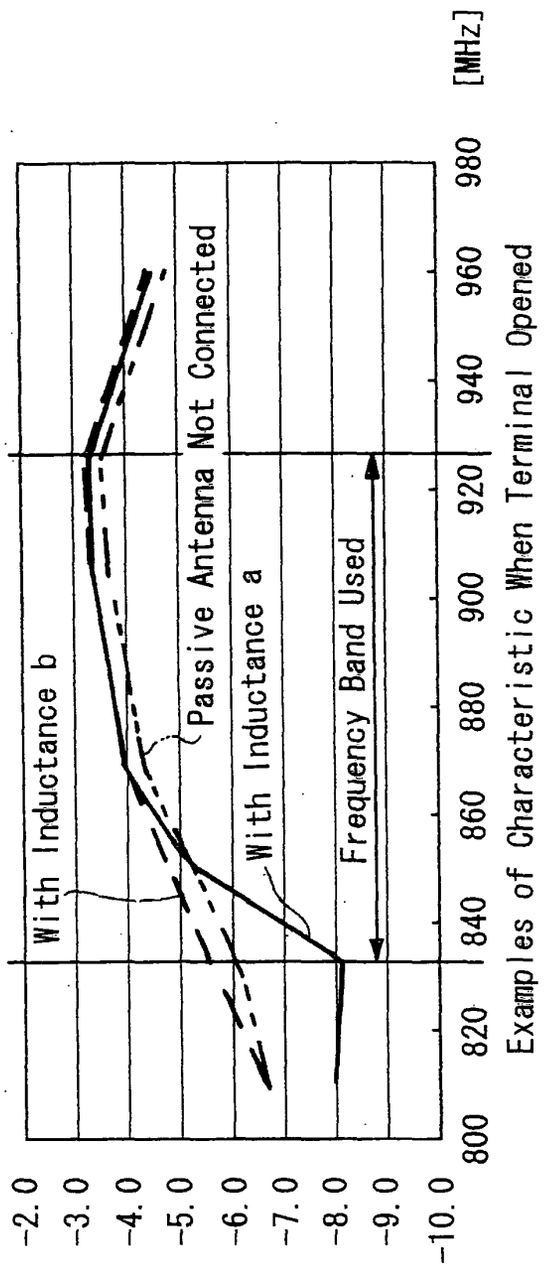


FIG. 19B

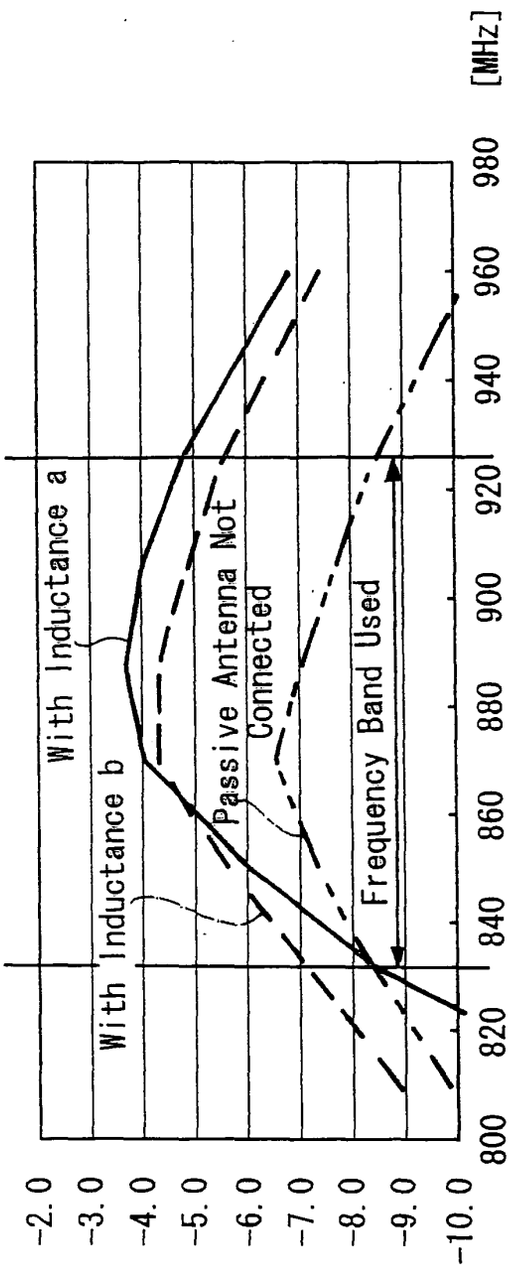
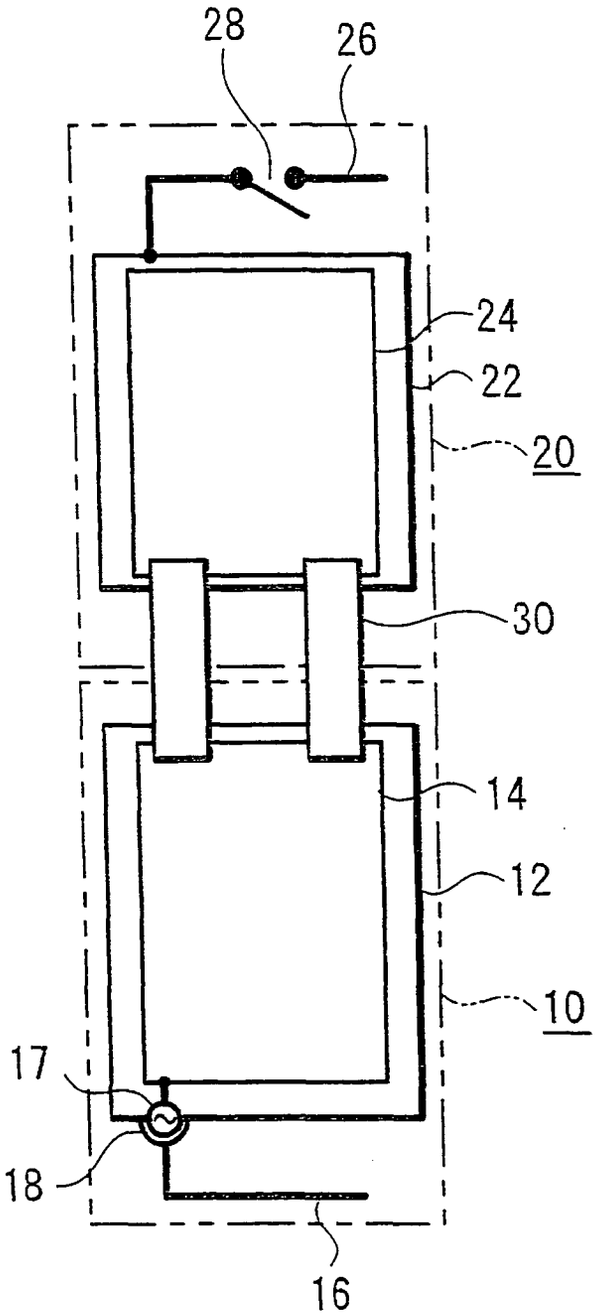


FIG. 20



DESCRIPTION OF REFERENCE NUMERALS

1 ... ... MOBILE PHONE UNIT (WIRELESS COMMUNICATION TERMINAL)

10 ... ...FIRST CASING

14 ... ...GND (GROUND POTENTIAL) PORTION

16 ... ...FEEDING ANTENNA

17 ... ...POWER SUPPLY PORTION

18 ... ...FEED POINT

20 ... ...SECOND CASING

24 ... ...GND (GROUND POTENTIAL) PORTION

25 ... ...CIRCUIT CHIP

26 ... ...PASSIVE ANTENNA

27, 27' ... ... SWITCH

28... ...SWICH

41a, 41b... ...COIL

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2004/013878

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] H01Q1/24

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] H01Q1/24, H01Q1/48, H01Q1/08, H01Q9/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2004
Kokai Jitsuyo Shinan Koho 1971-2004 Toroku Jitsuyo Shinan Koho 1994-2004

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 10-084406 A (Mitsubishi Electric Corp.), 31 March, 1998 (31.03.98), Par. Nos. [0021] to [0036]; Figs. 1 to 2 (Family: none)	1-6,8-10 7,12-15
Y	JP 11-330830 A (Murata Mfg. Co., Ltd.), 30 November, 1999 (30.11.99), Full text; Figs. 1 to 5 & EP 0944128 A1 & US 6288680 B1	7
Y	JP 2003-060417 A (Matsushita Electric Industrial Co., Ltd.), 28 February, 2003 (28.02.03), Par. Nos. [0074] to [0087]; Figs. 6 to 7 & WO 2003/015211 A1 & US 2003/0169206 A1	12-15

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 October, 2004 (08.10.04)	26 October, 2004 (26.10.04)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2004/013878

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2003-037415 A (Matsushita Electric Industrial Co., Ltd.), 07 February, 2003 (07.02.03), Par. Nos. [0030] to [0041] (Family: none)	1-15
A	JP 2002-512463 A (Allgon AB.), 23 April, 2002 (23.04.02), Full text; all drawings & WO 1999/054956 A2 & US 6342859 B1	1-15
A	JP 2003-273620 A (Sony Corp.), 26 September, 2003 (26.09.03), Par. Nos. [0018] to [0021]; Figs. 5 to 7 (Family: none)	1-15
A	JP 2003-347815 A (NEC Corp.), 05 December, 2003 (05.12.03), Full text; all drawings (Family: none)	1-15

Form PCT/ISA/210 (continuation of second sheet) (January 2004)