



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) **EP 0 929 116 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
14.07.1999 Bulletin 1999/28

(51) Int. Cl.⁶: **H01Q 1/36**, H01Q 1/38,
H01Q 9/28

(21) Application number: **98124040.1**

(22) Date of filing: **17.12.1998**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE**
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **06.01.1998 JP 88398**

(71) Applicant:
Murata Manufacturing Co., Ltd.
Nagaokakyo-shi Kyoto-fu 617-8555 (JP)

(72) Inventors:
• **Kanba, Seiji**
c/o Intellectual Property Dept.
Nagaokakyo-shi, Kyoto-fu 617-8555 (JP)

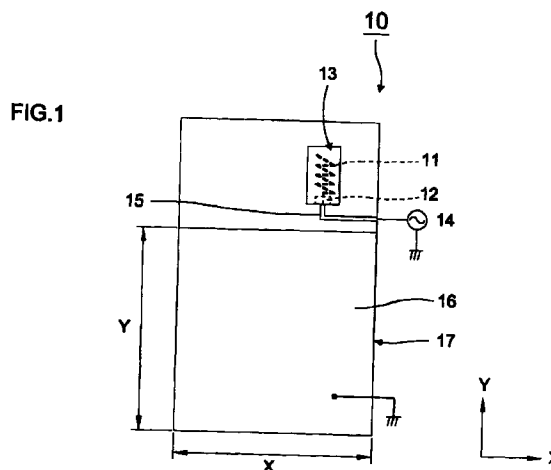
• **Tsuru, Teruhisa**
c/o Intellectual Property Dept.
Nagaokakyo-shi, Kyoto-fu 617-8555 (JP)
• **Mandai, Harufumi**
c/o Intellectual Property Dept.
Nagaokakyo-shi, Kyoto-fu 617-8555 (JP)

(74) Representative:
Schoppe, Fritz, Dipl.-Ing.
Schoppe & Zimmermann
Patentanwälte
Postfach 71 08 67
81458 München (DE)

(54) **Antenna device**

(57) The invention provides an antenna device (10), comprising: an antenna unit (13) including; a basic body made of at least one of dielectric ceramic and magnetic ceramic, at least one conductor (11) disposed inside or on a surface of the basic body, and a feeding electrode (12) for applying a voltage to the conductor (11), disposed on the surface of the basic body; a mounting board (17) on which said antenna unit (13) is mounted; a ground part (16) in association with said mounting board (17) and adapted to resonate with said antenna unit (13); and a length in the polarization direction of a radio wave of said ground part (16) being about $\lambda/4$ or more, where λ is a wavelength of the radio wave.

The above antenna device (10) achieves a small-size and high-gain.



EP 0 929 116 A1

Description**BACKGROUND OF THE INVENTION****1. Field of the Invention**

[0001] The present invention relates to an antenna device, and in particular relates to an antenna device for use in a radio equipment such as a mobile communication apparatus, a radio communication LAN (Local Area Network), a television, a radio, etc.

2. Description of the Related Art

[0002] Conventionally, as a small-sized antenna to be used in a radio equipment, an inverted F-type antenna is known. One example of an inverted F-type antenna is explained in reference to Fig. 8. The inverted F-type antenna 50 is composed of a printed-circuit board 52 which is made of a glass-filled epoxy resin of a relative dielectric constant of 4 to 5 and on a surface of which a ground electrode 51 connected to the ground electric potential is provided, and a radiator plate 53 which is made of a metal plate arranged in parallel with the printed-circuit board 52 and above the printed-circuit board 52. The radiator plate 53 fulfills the function of radiating a radio wave, and its length is $\lambda/4$ (λ : wavelength of the radio wave). On the side edge of the radiator plate 53 a short pin 54 extended toward the printed-circuit board 52 is integrally provided with the radiator plate 53. The short pin 54 is electrically connected to the ground electrode 51 on the printed-circuit board 52. That is, the radiator plate 53 is short-circuited to the ground electrode 51 through the short pin 54. On the printed-circuit board 52, a coaxial cable connection portion 52a is provided, and to the coaxial cable connection portion 52a a coaxial cable, a connector, etc. (not illustrated) through which a load dispatching to the radiator plate 53 takes place, are connected through a connection terminal 53a led out from the radiator plate 53.

[0003] However, in the above described inverted F-type antenna, there were cases, in which in order to realize a small-sized antenna, a dielectric substance is inserted between the ground electrode on the printed-circuit board and the radiator plate, and the wavelength shortening effect of the dielectric substance is used. And in these cases there was a problem that the antenna gain is decreased because of the effect of the dielectric substance.

SUMMARY OF THE INVENTION

[0004] Preferred embodiments of the present invention are provided to overcome the above described problems, and provide an antenna device of small size and having a high gain.

[0005] The preferred embodiment of the present invention provides an antenna device, comprising: an antenna unit including; a basic body made of at least one of dielectric ceramic and magnetic ceramic, at least one conductor disposed inside or on a surface of the basic body, and a feeding electrode for applying a voltage to the conductor, disposed on the surface of the basic body; a mounting board on which said antenna unit is mounted; a ground part in association with said mounting board and adapted to resonate with said antenna unit; and a length in the polarization direction of a radio wave of said ground part being about $\lambda/4$ or more, where λ is a wavelength of the radio wave.

[0006] In the above described antenna device, said ground part may comprise at least one of a ground electrode disposed on said mounting board and a ground portion of a high-frequency circuit portion mounted on said mounting board together with said antenna unit.

[0007] According to the above describes structure and arrangement, because the antenna device comprises an antenna unit and a ground part resonant with the antenna unit having $\lambda/4$ as the length in the polarization direction of a radio wave, the antenna unit is able to function as one pole of a dipole antenna and the ground part resonant with the antenna unit is able to function as the other pole of the dipole antenna. Therefore, at a resonant point the antenna unit and ground part are able to act as a pair of antennas like a dipole antenna. As the result, an antenna device having as high a gain as a dipole antenna is made available although the antenna device is small-sized.

[0008] Further, a radio equipment mounted with such a small-sized antenna device having a high gain is also able to be made of small size and of a high gain. Other features and advantages of the present invention will become apparent from the following description of the invention which refers to the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0009]

Fig. 1 is a top view of a first preferred embodiment relating to an antenna device of the present invention.

Fig. 2 is a perspective view of an antenna unit constituting the antenna device in Fig. 1.

Fig. 3 is an exploded perspective view of the antenna unit in Fig. 2.

Fig. 4 is a perspective view showing a modification of the antenna unit in Fig. 2.

Fig. 5 is a perspective view showing another modification of the antenna unit in Fig. 2.

Fig. 6 is a top view of a second preferred embodiment relating to an antenna device of the present invention.

Fig. 7 is a top view of a third preferred embodiment relating to an antenna device of the present invention.

Fig. 8 is a perspective view of a conventional inverted F-type antenna.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0010] Referring to Fig. 1, the antenna device 10 is composed of an antenna unit 13 having a conductor 11 and a feeding electrode 12 connected to one end of the conductor 11, a power supply 14 connected to the feeding electrode 12, and a mounting board 17 having a linear conductor pattern 15 formed by printing conductive material on the surface and a ground electrode 16 is substantially rectangular shape.

[0011] Further, the antenna unit 13 is mounted on the mounting board 17, and the feeding electrode 12 on the antenna unit 13 and the power supply 14 are connected through the conductor pattern 15 on the surface of the mounting board 17. At this time, the ground electrode 16 on the surface of the mounting board 17 becomes a ground part resonant with the antenna unit 13. And the length in the polarization direction of a radio wave (horizontally polarized wave: direction x in Fig. 1, vertically polarized wave: direction y in Fig. 1) of the ground electrode 16 on the surface of the mounting board 17 as the ground part is $\lambda/4$ or more (λ : wavelength of a radio wave).

[0012] According to the above described structure and arrangement, the antenna unit 13 comes to function as one pole of a dipole antenna, and the ground electrode 16 on the surface of the mounting board 17 as the ground part resonant with the antenna unit 13 comes to function as the other pole of the dipole antenna.

[0013] As shown in Fig. 2, the antenna unit 13 is composed of a basic body of a rectangular solid, a conductor 11 spirally wound in the longitudinal direction of the basic body 18 inside the basic body 18, and a feeding electrode 12 for applying a voltage to the conductor 11, provided on the surface of the basic body 18.

[0014] In Fig. 3, an exploded perspective view of the antenna unit 13 of Fig. 2 is shown. The basic body 18 is composed of rectangular thin layers 19a through 19c laminated which are made of dielectric ceramic having barium oxide, aluminium oxide, silica as its main components. Out of these thin layers, on the surface of the thin layers 19a, 19b substantially L-shaped or substantially straight conductor patterns 20a through 20h of copper or copper alloy are formed by screen printing, evaporation, or plating. And at fixed positions (both ends of conductor patterns 20e through 20g, one end of conductor pattern h), via holes are formed in the thickness direction.

[0015] Further, after the thin layers 19a through 19c have been laminated and conductor patterns 20a through 20h have been connected by way of via holes 21, a conductor 11 spirally wound in the longitudinal direction of the basic body 18 inside the basic body 18 is formed by sintering.

[0016] At this time, one end of the conductor 11 (one end of conductor pattern 20a) led out to the end surface of the basic body 18 constitutes a power supply portion 22 and is connected to a feeding electrode 12 disposed on the surface of the basic body 18. And the other end of the conductor 11 (the other end of conductor pattern 20h) constitutes an open end 23 inside the basic body 18.

[0017] In Figs. 4 and 5, perspective views of modifications of the antenna unit 13 in Fig. 2 are shown. In an antenna unit 13a in Fig. 4, a basic body 18a of a rectangular solid, a conductor 11a spirally wound in the longitudinal direction of the basic body 18a along the surface of the basic body 18a, and a feeding electrode 12a disposed on the surface of the surface of the basic body 18a are given. At this time, one end of the conductor 11a is connected to the feeding electrode 12a for applying a voltage to the conductor 11a on the surface of the basic body 18a. Further, the other end of the conductor 11a constitutes an open end 23a on the surface of the basic body 18a. According to the antenna unit 13a constructed in this way, because the conductor 11a is able to be easily formed by screen printing, etc. in a spiral way on the surface of the basic body 18a, the manufacturing processes of the antenna unit 13a can be simplified.

[0018] In the antenna unit 13b in Fig. 5, a basic body 18b of a rectangular solid, a conductor 11b meanderingly provided on the surface of the basic body 18b, and a feeding electrode 12b formed on the surface of the basic body 18b are given. At this time, one end of the conductor 11b is connected to the feeding electrode 12b for applying a voltage to the conductor 11b on the surface of the basic body 18b. And the other end of the conductor 12b constitutes an open end 23b on the surface of the basic body 18b. According to the antenna unit 13b constructed in this way, because the conductor 11b is meanderingly provided on only one major surface of the basic body 18b, it becomes possible lower the height of the basic body 18b and it becomes possible to lower the height of the antenna unit 13b accordingly. Further, even if the conductor 11b of a meandering shape is provided inside the basic body 18b, the same effect can be obtained.

[0019] Here, the maximum gain (dBd) practically measured using the antenna device 10 (Fig. 1) is shown in Table 1. At this time, an antenna unit having the dimensions of 8 mm (transverse) x 5 mm (longitudinal) x 2.5 mm (height) was used, and by changing the transverse length (X in Fig. 1) and the longitudinal length (Y in Fig. 1) of the ground electrode

16 as the ground part of the antenna unit 13 the change of the maximum gain (dBd) of a horizontally polarized wave (polarized wave in the direction of X in Fig. 1) and a vertically polarized wave (polarized wave in the direction of Y in Fig. 1) was investigated.

[Table 1]

X	Y	Horizontally polarized wave maximum gain [dBd]	Vertically polarized wave maximum gain [dBd]
$\lambda/8$	$\lambda/8$	-8.9	-7.2
$\lambda/8$	$3\lambda/16$	-8.4	-3.6
$\lambda/8$	$\lambda/4$	-8.3	-0.8
$\lambda/8$	$5\lambda/16$	-7.6	-0.2
$3\lambda/16$	$\lambda/8$	-6.5	-7.7
$3\lambda/16$	$3\lambda/16$	-6.6	-3.5
$3\lambda/16$	$\lambda/4$	-6.1	-0.8
$3\lambda/16$	$5\lambda/16$	-5.2	-0.3
$\lambda/4$	$\lambda/8$	-0.8	-7.0
$\lambda/4$	$3\lambda/16$	-0.9	-3.4
$\lambda/4$	$\lambda/4$	-0.8	-1.0
$\lambda/4$	$5\lambda/16$	-0.8	-0.1
$5\lambda/16$	$\lambda/8$	-0.4	-6.9
$5\lambda/16$	$3\lambda/16$	-0.5	-3.6
$5\lambda/16$	$\lambda/4$	-0.4	-0.5
$5\lambda/16$	$5\lambda/16$	-0.4	-0.3

[0020] According to Table 1, it is understood that by making the length in the polarization direction of a radio wave of the ground electrode X (transverse) for horizontally polarized wave, Y (longitudinal) for vertically polarized wave in Fig. 1) $\lambda/4$ or more (λ : wavelength of a radio wave), the maximum gain of a horizontally polarized wave and vertically polarized wave becomes - 1.0 (dBd) or more, that is, as much as that of a dipole antenna, and the antenna device 10 (Fig. 1) has a high gain. Further, the length of $\lambda/4$ means about 40 mm for a radio wave of 1.9 GHz.

[0021] In Fig. 6, a top view of a second preferred embodiment of an antenna device according to the present invention is shown. The antenna device 30 is composed of an antenna unit 13 having a conductor 11 and a feeding electrode 12 with one end of the conductor 11 connected, a high-frequency circuit portion 32 with the feeding electrode 12 connected and with a ground portion 31 made of a metal chassis, and a mounting board 33 having a linear conductor pattern 15 formed by printing conductive material on the surface.

[0022] Further, the antenna unit 13 and the high-frequency circuit portion 32 are mounted on the mounting board 33, and the feeding electrode 12 of the antenna unit 13 and the high-frequency circuit portion 32 are connected through the conductor pattern 15 on the surface of the mounting board 33. At this time, the ground portion 31 of the high-frequency circuit portion 32 mounted on the mounting board 33 constitutes a ground part resonant with the antenna unit 13. More, the length in the polarization direction of a radio wave of the ground portion 31 as the ground part, of the high-frequency circuit portion 32 has been more than $\lambda/4$ (λ : wavelength of a radio wave) (horizontally polarized wave: direction x in Fig. 6, vertically polarized wave: direction y in Fig. 6).

[0023] According to the antenna device 30 constructed in the above described way, the antenna unit 13 comes to act as one pole of a dipole antenna, and the ground portion 31 of the high-frequency circuit portion 32 in the function of the ground part resonant with the antenna unit 13 as the other pole of the dipole antenna.

[0024] In Fig. 7, a top view of a third preferred embodiment of an antenna device according to the present invention is shown. The antenna device 40 is composed of an antenna unit 13 having a conductor 11 and a feeding electrode 12 with one end of the conductor 11 connected, a high-frequency circuit portion 32 with the feeding electrode 12 connected and with a ground portion 31 made of a chassis, and a mounting board 17 having a linear conductor pattern 15

formed by printing conductive material on the surface and a ground electrode 16 in substantially rectangular form.

[0025] Further, the antenna unit 13 and the high-frequency circuit portion 32 are mounted on the mounting board 33, and the feeding electrode 12 of the antenna unit 13 and the high-frequency circuit portion 32 are connected through the conductor pattern 15 on the surface of the mounting board 17. At this time, the ground electrode 16 on the surface of the mounting board 17 and the ground portion 31 of the high-frequency circuit portion 32 mounted on the mounting board 17 constitute a ground part resonant with the antenna unit 13. Furthermore, the length in the polarization direction of a radio wave (horizontally polarized wave: direction x in Fig. 7, vertically polarized wave: direction y in Fig. 7) of the ground electrode 16 on the surface of the mounting board 17 and the grounding portion 31 of the high-frequency circuit portion 32 both of which function as the ground part, has been more than $\lambda/4$ (λ : wavelength of a radio wave).

[0026] According to the antenna device 40, the antenna unit 13 comes to function as one pole of a dipole antenna, and the ground electrode 16 on the surface of the mounting board 17 and the grounding portion 31 of the high-frequency circuit portion 32 which function as the ground part resonant with the antenna unit 13 as the other pole of the dipole antenna.

[0027] As described above, according to an antenna device of the first through third preferred embodiments, because an antenna unit and a ground part resonant with the antenna unit of the length of $\lambda/4$ in the polarization direction of a radio wave are given, the antenna unit is able to act as one pole of a dipole antenna, and the ground part resonant with the antenna unit as the other pole of the dipole antenna.

[0028] Therefore, at a resonance point an antenna unit and a ground part are able to act as one pair of antennas like a dipole antenna. As the result, an antenna device having as high a gain as a dipole antenna is able to be obtained although it is small-sized.

[0029] In addition, a radio equipment mounted with such a small-sized antenna device having a high gain becomes of small size and of a high gain.

[0030] Further, according to an antenna device of the first preferred embodiment, because the antenna device is able to be applied to an antenna device in which the power is supplied to the antenna unit from a power supply, an antenna device which is of small size and is more simplified is realized.

[0031] Furthermore, according to an antenna device of the second preferred embodiment, because the antenna device is able to be applied to an antenna device in which the power is supplied to the antenna unit from a high-frequency circuit portion such as a VCO, a switching circuit, etc., the antenna device is able to be mounted on a radio equipment as it is, and as the result the manufacturing processes of the radio equipment is made simplified.

[0032] More, according to an antenna device of the second preferred embodiment, because a ground electrode on the surface of a mounting board to mount an antenna unit and a ground portion of a high-frequency circuit portion constitute a ground part resonant with the antenna unit, even if the antenna device has been made of small size, the length in the polarization direction of a radio wave of the ground part resonant with the antenna unit comes to satisfy the condition of about $\lambda/4$ or more. Therefore, the antenna device becomes further small-sized and a radio equipment mounted with this antenna device is able to become of small size.

[0033] More, in an antenna device according to the first and third preferred embodiments, the cases in which the ground electrode on the surface of the mounting board is nearly of a rectangular form were explained, but if the length in the polarization direction of a radio wave satisfies the condition of more than $\lambda/4$, the same effect can be obtained under a ground electrode of whatever form.

[0034] More, in an antenna device according to the second and third preferred embodiments, the cases in which the ground portion of the high-frequency circuit portion is made of a metal chassis were explained, but if the length in the polarization of a radio wave satisfies the condition of more than $\lambda/4$, the same effect can be obtained whatever ground electrode is formed in the high-frequency circuit portion.

[0035] Furthermore, the cases in which the basic body of the chip-antenna is made of dielectric material having barium oxide, aluminium oxide, silica as its main components were explained, but the material of the basic body is not limited to them. Even if a dielectric material having titanium oxide and neodymium oxide as its main components, a magnetic material having nickel, cobalt, and iron as its main components, or a combination of dielectric material and magnetic material is used, the same effect can be obtained.

[0036] While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the forgoing and other changes in form and details may be made therein without departing from the spirit of the invention.

Claims

1. An antenna device (10; 30; 40), comprising:

an antenna unit (13; 13a; 13b) including; a basic body made of at least one of dielectric ceramic and magnetic ceramic, at least one conductor (11; 11a; 11b) disposed inside or on a surface of the basic body, and a feeding

electrode (12; 12a; 12b) for applying a voltage to the conductor, disposed on the surface of the basic body;
a mounting board (17; 33) on which said antenna unit is mounted;
a ground part (16; 31) in association with said mounting board and adapted to resonate with said antenna unit;
and
5 a length in the polarization direction of a radio wave of said ground part (16; 31) being about $\lambda/4$ or more, where λ is a wavelength of the radio wave.

2. The antenna device (10; 30; 49) according to Claim 1, wherein

10 said ground part (16; 31) comprises at least one of a ground electrode (16) disposed on said mounting board (17) and a ground portion (31) of a high-frequency circuit portion mounted on said mounting board (33) together with said antenna unit (13; 13a; 13b).

FIG.1

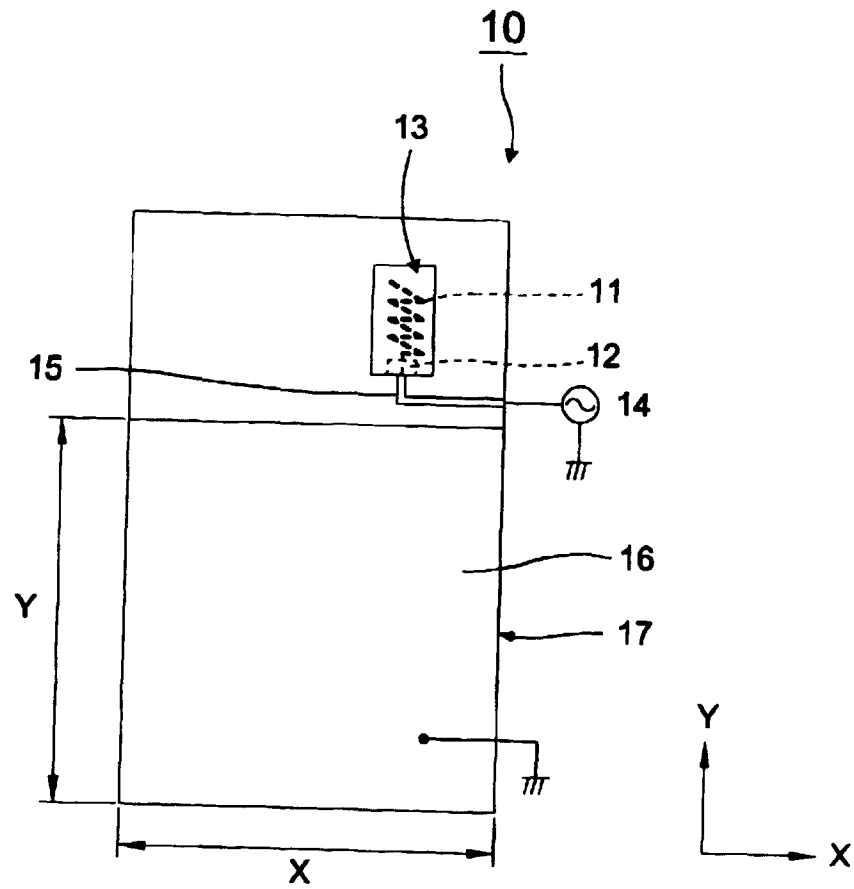


FIG.2

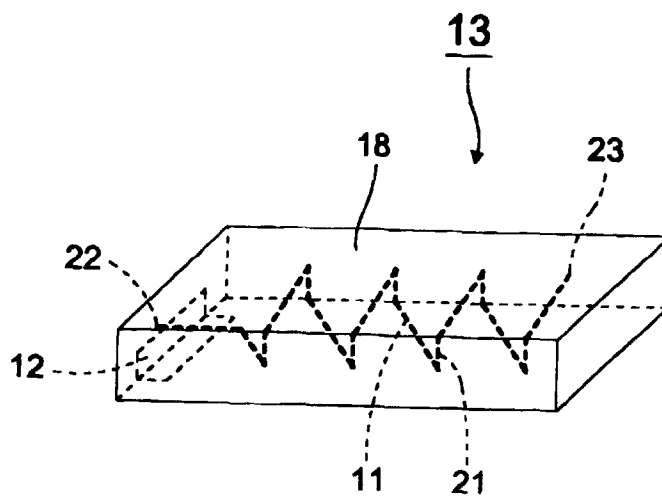


FIG.3

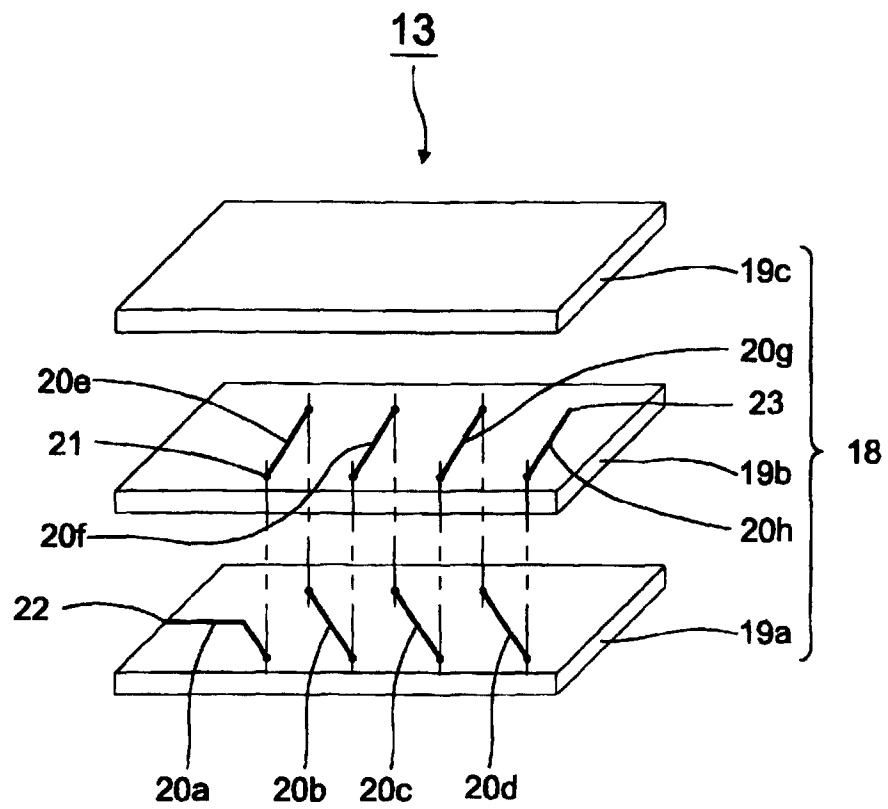


FIG.4

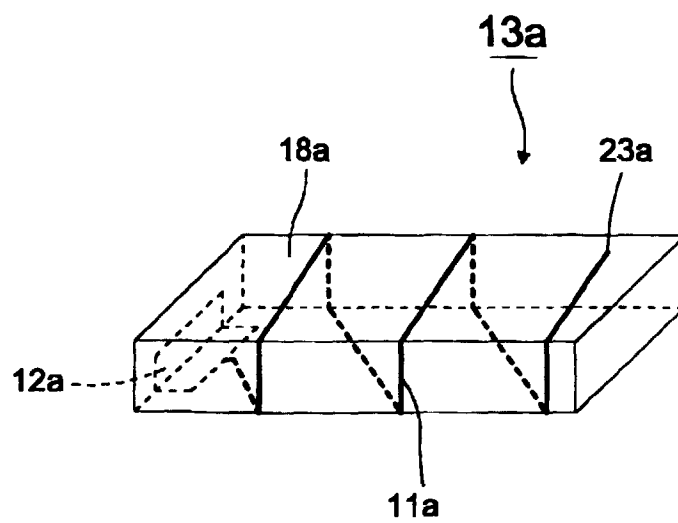


FIG.5

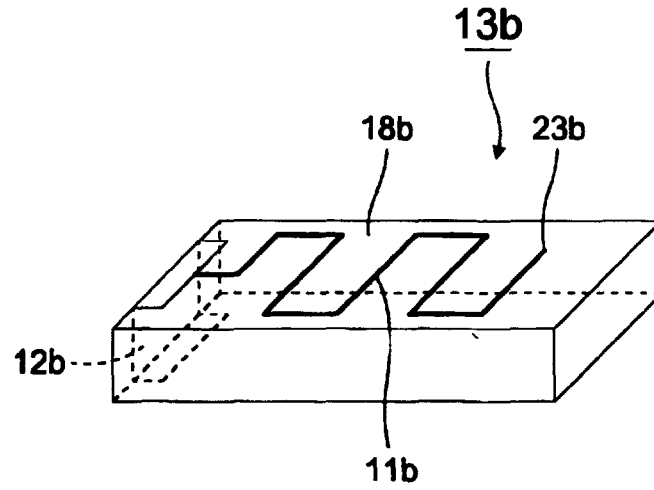


FIG.6

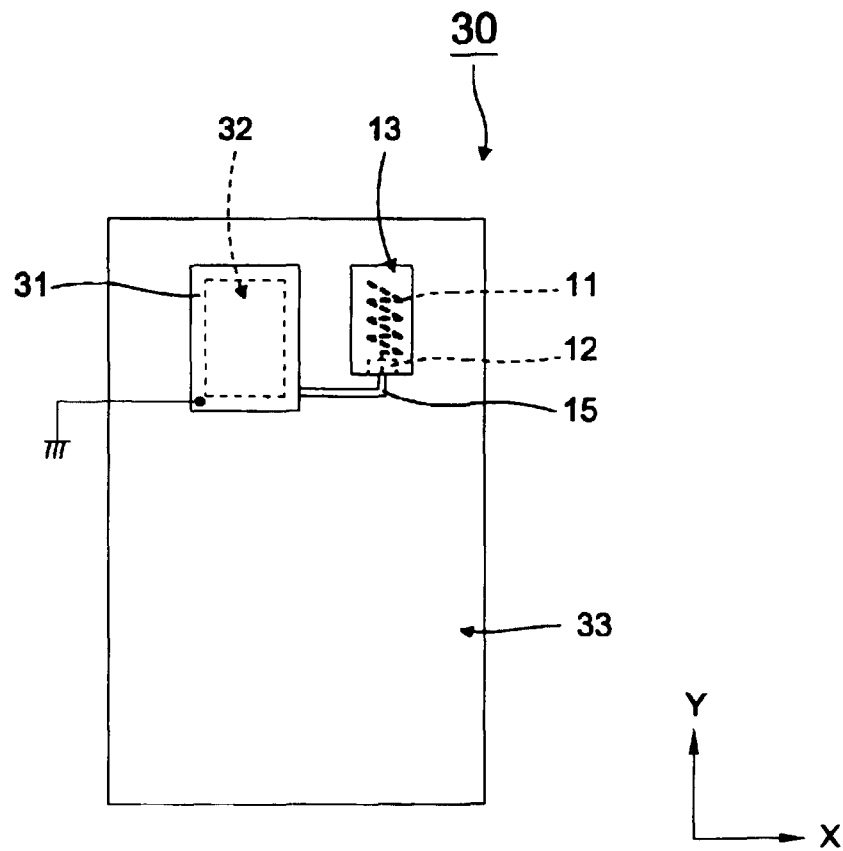


FIG.7

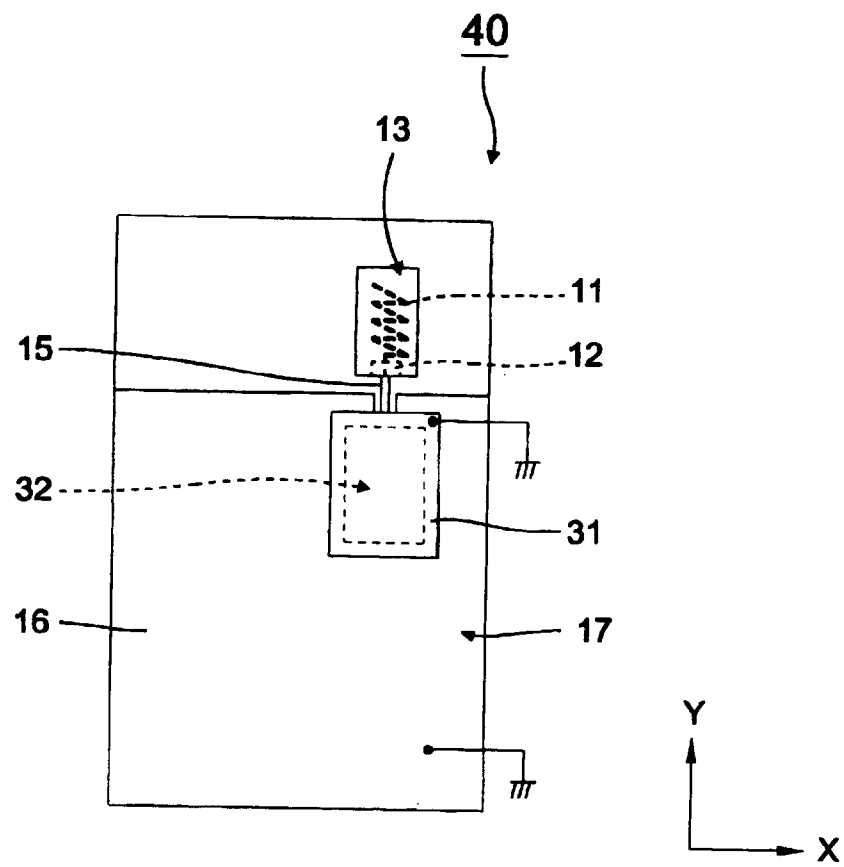
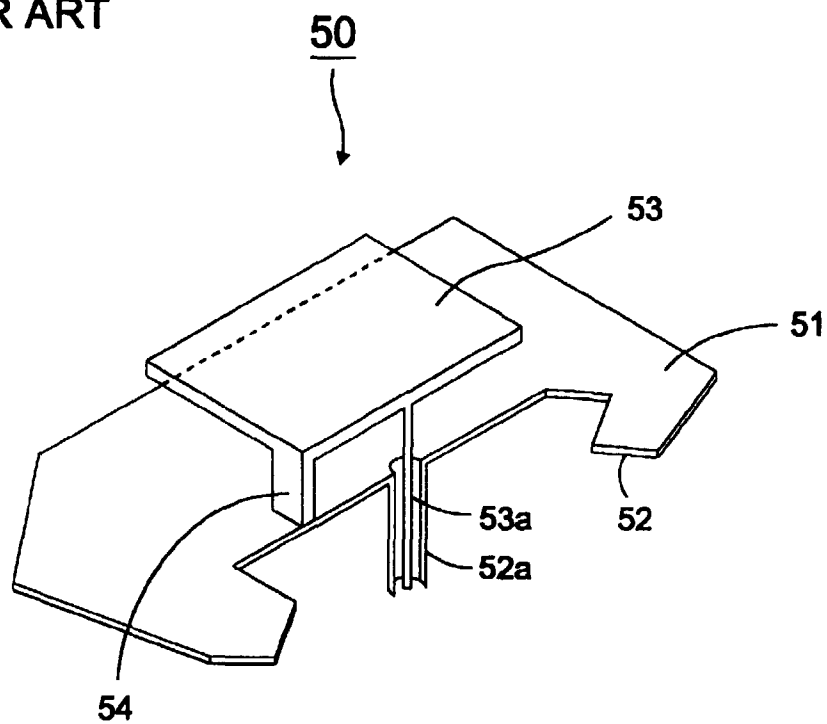


FIG.8
PRIOR ART





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 12 4040

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	EP 0 795 922 A (MURATA MANUFACTURING) 17 September 1997 * column 1, line 16 - line 45 * * column 3, line 43 - column 4, line 25; figures 2,8 *	1,2	H01Q1/36 H01Q1/38 H01Q9/28
Y	EP 0 706 231 A (MITSUBISHI) 10 April 1996 * abstract; figure 1 * * column 5, line 24 - line 56 * * column 8, line 22 - line 32; figures 1,4,7-11 *	1,2	
A	WO 95 05011 A (MOTOROLA) 16 February 1995 * abstract; figures 2-5 *	1,2	
A	EP 0 590 534 A (NTT MOBILE COMMUNICATIONS NETWORK) 6 April 1994 * abstract; figures 2-18 *	1,2	
P,A	EP 0 828 310 A (MURATA MANUFACTURING) 11 March 1998 * abstract; figures 1,7-11 *	1,2	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			H01Q
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 25 March 1999	Examiner Angrabeit, F
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 98 12 4040

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

25-03-1999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0795922 A	17-09-1997	JP 9307331 A	28-11-1997
		US 5874926 A	23-02-1999
EP 0706231 A	10-04-1996	JP 8107304 A	23-04-1996
		AU 673976 B	28-11-1996
		AU 3281195 A	18-04-1996
		CN 1126382 A	10-07-1996
		US 5541610 A	30-07-1996
WO 9505011 A	16-02-1995	AU 7372594 A	28-02-1995
		US 5495260 A	27-02-1996
EP 0590534 A	06-04-1994	JP 2809365 B	08-10-1998
		JP 6112722 A	22-04-1994
		DE 69320435 D	24-09-1998
		DE 69320435 T	18-03-1999
		US 5412392 A	02-05-1995
EP 0828310 A	11-03-1998	JP 10145125 A	29-05-1998