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(71) Applicant: **MURATA MANUFACTURING CO., LTD.**
Nagaokakyo-shi Kyoto-fu 226 (JP)

(72) Inventors:
- **Tsuru, Teruhisa**
  Nagaokakyo-shi, Kyoto-fu (JP)
- **Mandai, Harufumi**
  Nagaokakyo-shi, Kyoto-fu (JP)
- **Shiroki, Koji**
  Nagaokakyo-shi, Kyoto-fu (JP)
- **Asakura, Kenji**
  Nagaokakyo-shi, Kyoto-fu (JP)

(74) Representative: **Schoppe, Fritz, Dipl.-Ing.**
Patentanwalt,
Georg-Kalb-Strasse 9
82049 Pullach (DE)

(54) Antenna device

(57) An antenna device (10) includes a dielectric substrate (17), at least one peripheral antenna circuit (18,19) formed inside or on a surface of the dielectric substrate (17), and a radiator (11) for receiving or transmitting a signal. The radiator (11) has a radiating portion (12) and at least a pair of opposed fixing portions (13,14) extending from the radiating portion (12) so as to form a square-bottomed U-shaped cross section. The pair of opposed fixing portions (13,14) are attached to side faces of the dielectric substrate (17) such that the radiating portion (11) and an upper surface of the dielectric substrate (17) create a space (22).

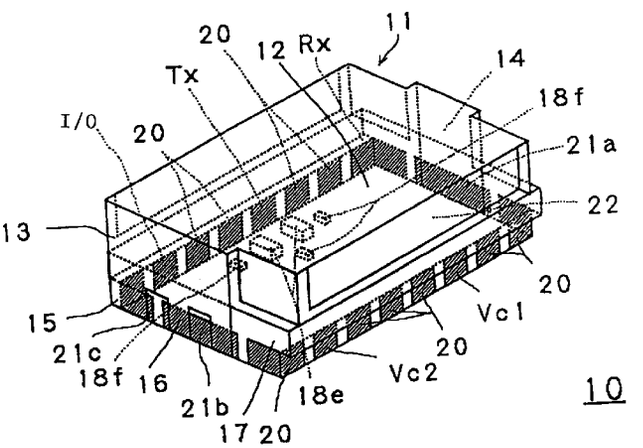

FIG. 1

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an antenna device, more particularly to a surface-mounted antenna device on which peripheral antenna circuits are mounted and which is for use in portable communication systems and wireless LANs (local area networks).

2. Background of the Related Art

An example of a conventional antenna is a microstrip type such as that shown in FIG. 7 and FIG. 8, which incorporates a high frequency amplifier and is used in portable communications equipment such as are used for the GPS (global positioning system) etc. As shown in FIGs. 7 and 8, a patch electrode 52 is formed on the front surface of a dielectric substrate 51 having a rectangular shape. A shield electrode 53 is formed on the rear surface of the dielectric substrate 51, and a printed circuit board 54 is attached to the rear surface. On the printed circuit board 54 is mounted a high frequency amplifier 56 formed from circuit elements 55 such as transistors and capacitors for example and a connector 58 connected to the high frequency amplifier 56 by a cable 57. Further, a signal feed terminal 59 extends from a signal feed point 52a of the patch electrode 52 to the printed circuit board 54. The dielectric substrate 51, printed circuit board 54 and high frequency amplifier 56 are covered and molded with a packaging resin 60 to form an antenna device 50. The antenna device 50 operates as an antenna for transmitting and receiving waves by means of the patch electrode 52.

However, in such a structure, because the patch electrode 52 is formed on the front surface of the dielectric substrate 51 and the high frequency amplifier 56 is mounted on the rear surface via the printed circuit board 54, corrugations can occur in both the front and rear surfaces of the antenna device 50 even when molded with the packaging resin 60, so that surface mounting of the antenna device 50 has not been possible.

Also, when the outer dimensions of the dielectric substrate 51 are reduced to miniaturize the antenna device, the gain of the antenna device 50 is decreased, and in practice the length of the patch electrode 52 cannot be reduced to less than 1/10th of the wavelength.

SUMMARY OF THE INVENTION

The present invention can solve the aforementioned drawbacks associated with the conventional antenna device and provide an antenna device which includes peripheral circuits on a dielectric substrate, has a small body and excellent characteristics, and can be surface mounted.

An antenna device according to an embodiment of the present invention includes: a dielectric substrate having external electrodes and connecting electrodes at side surfaces thereof; circuit elements forming at least two peripheral antenna circuits provided in the interior and on the surface of the dielectric substrate; and a radiator whose cross-sectional shape is a substantial square bottomed U-shape, the radiator including a radiating portion formed in a flat shape, fixing portions depending from one pair of opposing end portions of the radiating portion, and a signal feed terminal and ground terminal which are integral with a foremost end of one of the fixing portions. The radiator is attached with a space provided between the radiating portion of the radiator and a top surface of the dielectric base while the external electrodes are exposed outside of the radiator.

Because the circuit elements comprising at least two peripheral antenna circuits are formed in the interior and on the surface of the dielectric substrate miniaturization of the antenna device is facilitated. Also, by forming the circuit elements in the interior and on the surface of the dielectric substrate, the lower surface of the dielectric substrate can be made flat, enabling the antenna device to be surface mounted on a printed circuit board. In an additional aspect of the invention, the circuit elements comprise at least a diode and a resistor which may form an antenna switch circuit, the diode and the resistor being formed in a substantially central portion of the front surface of the dielectric substrate.

Since a diode and a resistor forming an antenna switch circuit are formed in substantially the center portion of the surface of the dielectric substrate in a space between the dielectric substrate and the radiator, the diode and resistor forming the antenna switch circuit are not affected by waves generated by the edge portions of the radiator, and therefore can be completely isolated from the transmission input portion and the reception output portion of the antenna switch circuit.

These and other features, aspects and advantages of the present invention will become better understood with reference to the following description, and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of an antenna device according to an embodiment of the present invention.

FIG. 2 is a partially exploded view of the antenna device according to the embodiment of the present invention.

FIG. 3 is a cross-sectional view of the antenna device according to the embodiment of the present invention.

FIG. 4 is a schematic diagram of an antenna switch circuit portion forming part of the antenna

device according to the embodiment of the present invention.

FIG. 5 is a schematic circuit diagram of a band pass filter circuit portion forming part of the antenna device according to the embodiment of the present invention.

FIG. 6 is a block diagram of the antenna device according to the embodiment of the present invention.

FIG. 7 is a plan view of a conventional GPS antenna device.

FIG. 8 is a cross-sectional view of a conventional GPS antenna device.

DETAILED DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

Hereinafter, an embodiment of the antenna device according to the present invention and incorporating an antenna switch circuit and a band pass filter circuit, as examples of peripheral antenna circuits, will be explained with reference to FIG. 1 through FIG. 6.

As shown in FIG. 1 through FIG. 3, an antenna device 10 includes a radiator 11 and a dielectric substrate 17. The cross-sectional shape of the radiator 11 is substantially a square bottomed U-shape and the radiator 11 is made of copper or a copper alloy, for example. The radiator 11 has a radiating portion 12 formed in a flat rectangular shape, and two fixing portions 13 and 14 bent at substantially 90° in a first direction (downward in FIGs. 1-3) from both short ends of the radiating portion 12, and a signal feed terminal 15 and ground terminal 16 being integrally formed at the foremost distal ends of the fixing portion 13. A total length *L* of the fixing portion 13 and the feed terminal 15 (or the ground terminal 16) along the first direction, and the length of the fixing portion 13, are set to be greater than the thickness *T* of the dielectric substrate 17. Thus, the fixing portion 13 itself has a shorter length than the fixing portion 14 in the first direction.

The dielectric substrate 17 has a rectangular shape and a multilayered structure including a plurality of ceramics sheets or resin sheets or the like. A transmission input portion Tx, a reception output portion Rx, and control input portions Vc1 and Vc2 of an antenna switch circuit 18; an input/output terminal I/O of a band pass filter circuit 19; and a plurality of ground electrodes 20 are provided on a pair of opposing side surfaces of the dielectric substrate 17, i.e. both side surfaces in the lengthwise direction, while connecting electrodes 21a, 21b and 21c are provided on the other pair of other opposing side surfaces, i.e. both side surfaces in the width-wise direction.

As shown in FIGs. 1-4, circuit elements including a strip line 18a, a micro-strip line 18b, a capacitor 18c and a ground pattern 18d are formed in the interior of the dielectric substrate 17, while diodes 18e and resistors 18f are mounted in substantially the central portion on the surface of the dielectric substrate 17 to form the antenna switch circuit 18. As shown in FIGs. 3 and 5, additional circuit elements including a micro-strip line 19a, a capacitor 19b, a via hole 19c and a ground pattern 19d are formed adjacent to the antenna switch circuit 18 in the interior of the dielectric substrate 17 to form the band pass filter circuit 19. The circuit elements forming the antenna switch circuit 18 and the band pass filter circuit 19 are each connected by internal electrodes. Also, the antenna switch circuit 18 and the band pass filter circuit 19 are connected in the dielectric substrate 17.

As shown in FIGs. 1 and 3, the dielectric substrate 17 is inserted in the interior of the radiator 11, and the side surfaces of the dielectric substrate 17 in the width direction abut against the inner sides of the fixing portions 13 and 14, a space 22 is provided between the radiating portion 12 of the radiator 11 and the top surface of the dielectric substrate by making the total length *L* of the fixing portion 13 and the feed terminal 15 (or the ground terminal 16) and the same length *L* of the fixing portion 14 greater than the thickness *T* of the dielectric substrate 17. The connecting electrode 21a of the dielectric substrate 17 is soldered to the fixing portion 14 of the radiator 11, and the connecting electrodes 21b and 21c of the dielectric substrate and the feed terminal 15 and ground terminal 16 of the radiator 11 are also joined by solder, to form antenna device 10.

FIGs. 4 and 5 show specific examples of equivalent circuits of the antenna switch circuit 18 and the band pass filter circuit 19, respectively. FIG. 6 shows a block diagram of the antenna device 10 shown in FIGs. 1-3. Note that in FIG. 6, the input/output terminal I/O is disconnected from the feed terminal 15 for measuring an output power of the antenna device 10 before practical use. After measurement of the output power, the input/output terminal I/O and the feed terminal 15 are electrically connected with each other and the radiator 11 is electrically connected to the input/output terminal I/O.

The band pass filter circuit 19 and antenna switch circuit 18 are connected with each other by connecting a terminal 18g of the antenna switch circuit 18 and a terminal 19e of the band pass filter circuit 19. The antenna switch circuit 18 selectively connects the terminal 18 and one of terminals Tx or Rx, in response to control voltages applied to terminals Vc1 and Vc2. In the case of transmitting operation, the terminal 18g is connected to the terminal Tx and isolated from the terminal Rx. On the other hand, in the case of receiving operation, the terminal 18g is connected to the terminal Rx and isolated from the terminal Tx.

The antenna device 10 formed in this way is mounted on a printed circuit board having a wiring pattern printed thereon (not shown) and the transmission input portion Tx, reception output portion Rx, and con-

trol input portions Vc1 and Vc2 of the antenna switch circuit 18; and the input/output terminal I/O, ground electrodes 20 and ground terminal 16 of the band pass filter circuit 19 are surface-mounted on the wiring pattern by soldering. At this time, an antenna signal circulates between the antenna switch circuit 18, band pass filter circuit 19 and radiating portion 12 via the feed terminal 15 to be transmitted or received from the radiating portion 12.

Because the antenna device 10 according to the present embodiment includes a plurality of peripheral antenna circuits, i.e. the antenna switch circuit 18 and the band pass filter circuit 19 in this example, by way of the strip line 18a, micro-strip line 18b, capacitor 18c, ground pattern 18d, diode 18e, resistor 18f, micro-strip line 19a, capacitor 19b, via hole 19c and ground pattern 19d, and because the antenna switch circuit 18 and band pass filter circuit 19 are mounted and incorporated in the dielectric substrate 17, the antenna device 10 can be easily miniaturized. Especially, incorporation of the band pass filter circuit 19 into the dielectric substrate 17 contributes to the miniaturization of the antenna device 10.

Also, because the lower surface of the dielectric substrate 17 can be flattened by forming the circuit elements in the interior and on the surface of the dielectric substrate 17, the antenna device 10 can be surface-mounted on a printed circuit board. Further, because the diodes 18e and the resistors 18f which form the antenna switch circuit 18 are formed in substantially the central portion of the surface of the dielectric substrate 17 within the space 22 between the dielectric substrate 17 and the radiator 11, they are not affected by waves generated at the edge portions of the radiator 11, so total isolation of the transmission input portion Tx and the reception output portion Rx of the antenna switch circuit 18 can be achieved. It is preferable that the diodes 18e and the resistors 18f are apart from the edge portions of the radiator 11 with a distance of about 2 mm or more.

Note that the radiator 11 and the dielectric substrate 17 can also be joined by bonding them together with an adhesive rather than by soldering. Also, the shape of the radiating portion of the radiator 11 may be square rather than rectangular, and the shape of the dielectric substrate 17 may be a cubical rather than a rectangular prism, for example.

In addition, peripheral circuits such as a surface acoustic wave filter, a low pass filter, a duplexer, a high frequency amplifier, etc., instead of or in addition the antenna switch circuit 18 and band pass filter circuit 19, can be mounted and incorporated in the dielectric substrate 17.

Although the present invention has been described in relation to particular embodiments thereof, many other variations and modifications and other uses will become apparent to those skilled in the art. Therefore, the present invention is not limited by the specific disclosure therein.

Claims

1. An antenna device (10) comprising:

   a dielectric substrate (17);

   at least one peripheral antenna circuit (18,19) formed at the dielectric substrate (17); and

   a radiator (11) connected to said at least one peripheral antenna circuit, for carrying a signal, said radiator having a radiating portion (12) and at least a pair of fixing portions (13,14) depending from the radiating portion (12) toward said dielectric substrate (17) so that said radiator has a substantially square-bottomed U-shaped cross-sectional shape, the pair of fixing portions (13,14) being attached to opposing side faces of the dielectric substrate (17), such that the radiating portion (12) and an upper surface of the dielectric substrate (17) create a space (22) therebetween.

2. The antenna device (10) according to claim 1, wherein the peripheral antenna circuit is an antenna switch circuit (18) including at least one diode (18e) and one resistor (18f), and the diode (18e) and the resistor (18f) are formed on the upper surface of the dielectric substrate (17).

3. The antenna device (10) according to claim 2, wherein the diode (18e) and the resistor (18f) are formed in substantially the central portion of the upper surface of the dielectric substrate (17).

4. The antenna device (10) according to claim 3, further comprising an additional portion of said antenna switch circuit which is formed inside the dielectric substrate (17).

5. The antenna device (10) according to claim 2, further comprising a band pass filter circuit (19) formed inside the dielectric substrate (17).

6. The antenna device (10) according to claim 1, wherein said at least on peripheral antenna circuit is formed inside the dielectric substrate (17).

7. The antenna device (10) according to claim 1, wherein said at least one peripheral antenna circuit is formed on an upper surface of the dielectric substrate (17).

8. The antenna device (10) according to claim 7, further comprising an additional portion of said at least one peripheral antenna circuit, said additional portion being formed inside the dielectric substrate (17).

9. The antenna device (10) according to claim 7 or 8, further comprising a second peripheral antenna circuit which is formed inside the dielectric substrate (17).

10. An antenna device (10) comprising:

a dielectric substrate (17) having external electrodes and connecting electrodes (20,21a,21b,21c) at side surfaces thereof;

circuit elements (18a-18f, 19a-19d) forming at least two peripheral antenna circuits (18,19), said circuit elements being provided in the interior and on the surface of the dielectric substrate (17); and

a radiator (11) whose cross-sectional shape is substantially a square-bottomed U-shape, the radiator (11) including a substantially flat radiating portion, a pair of fixing portions extending toward said dielectric substrate (17) from a pair of opposing end portions of the radiating portion (11), and a signal feed terminal (15) and ground terminal (16) formed integrally with a distal end of one of the fixing portions (13), wherein the radiator (11) is attached to the dielectric substrate (17) with a space (22) provided between the radiating portion of the radiator (12) and an upper surface of the dielectric substrate (17) with the external electrodes (20,21a,21b,22c) being exposed to the outside of the radiator.

11. The antenna device (10) according to claim 10, wherein the circuit elements comprise at least a diode (18e) and a resistor (18f), the diode (18e) and the resistor (18f) being formed in a substantially central portion of the upper surface of the dielectric substrate (17).

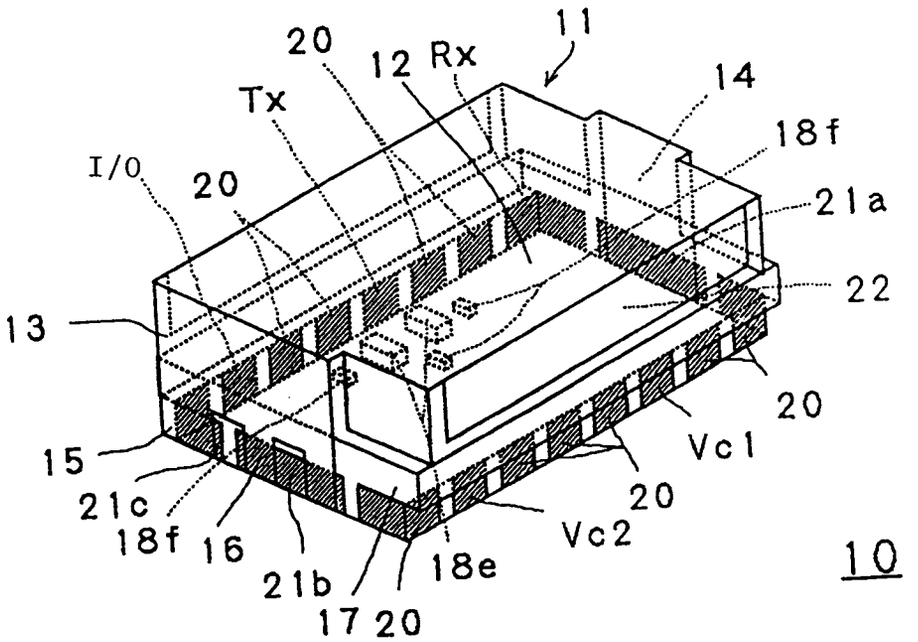
11
20
12
Rx
Tx
14
18f
I/O
20
21a
22
13
20
Vc1
15
20
21c
18f
16
Vc2
18e
10
21b
17
20

FIG. 1

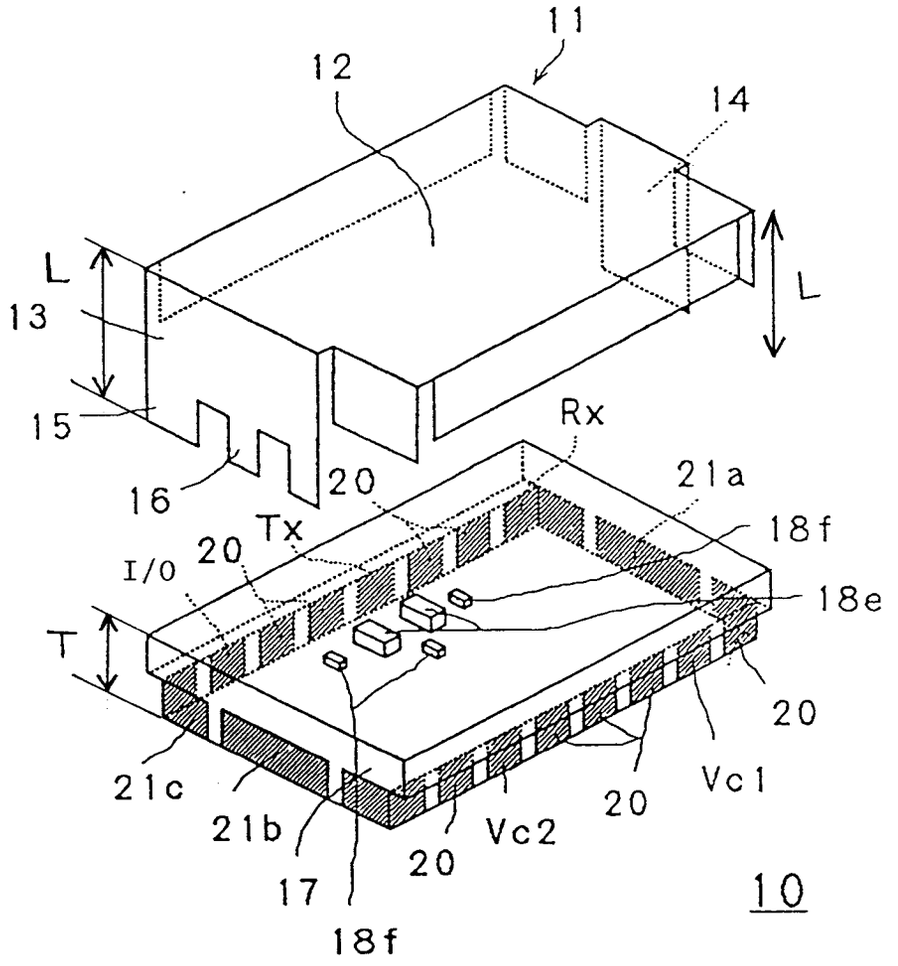
11
12
14
L
13
L
15
Rx
16
20
21a
Tx
20
18f
I/O
18e
T
20
21c
20
Vc1
21b
Vc2
20
17
10
18f

FIG. 2

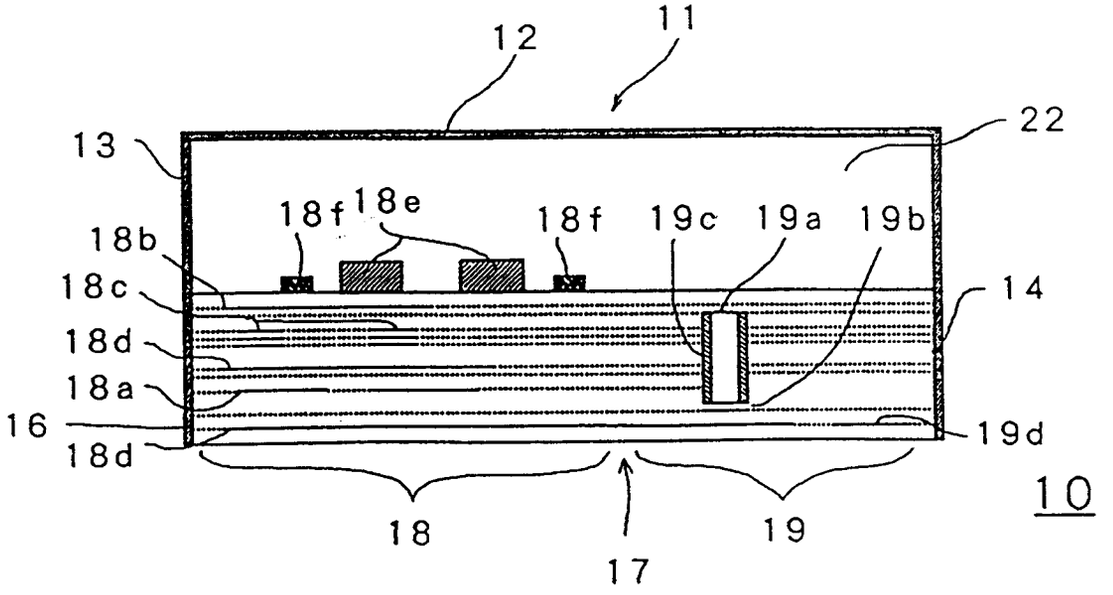
12
11
22
13
18f
18e
18f
19c
19a
19b
18b
18c
14
18d
18a
16
19d
18d
10
18
19
17

FIG. 3

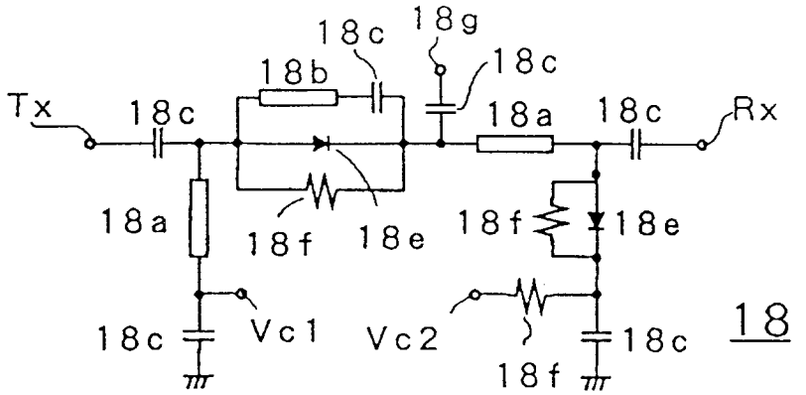

FIG. 4

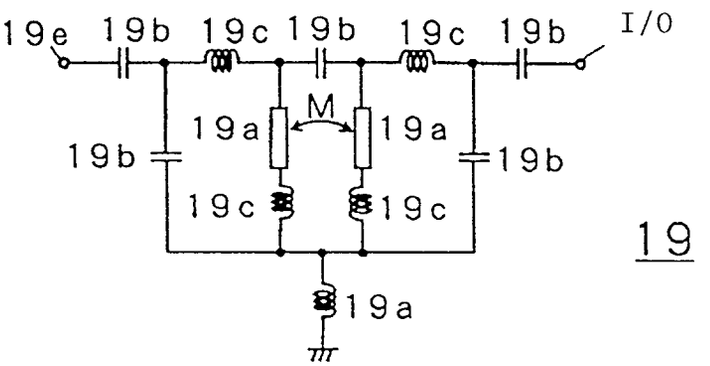

FIG. 5

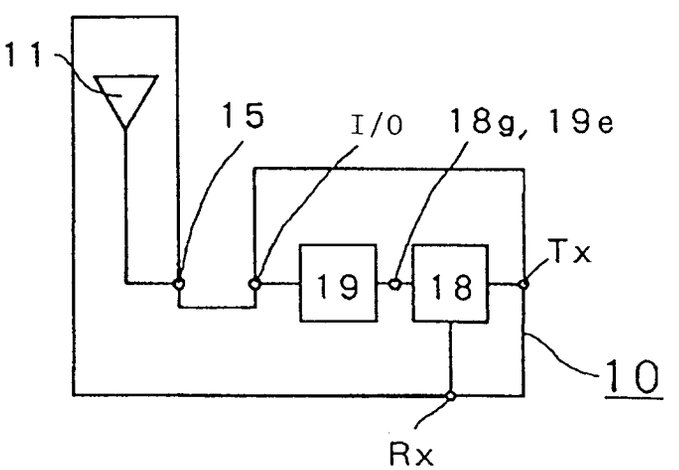

FIG. 6

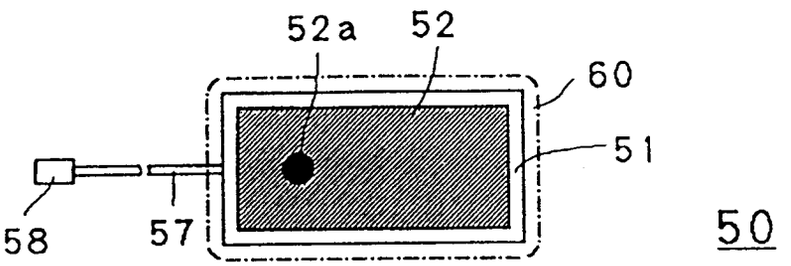

FIG. 7 (PRIOR ART)

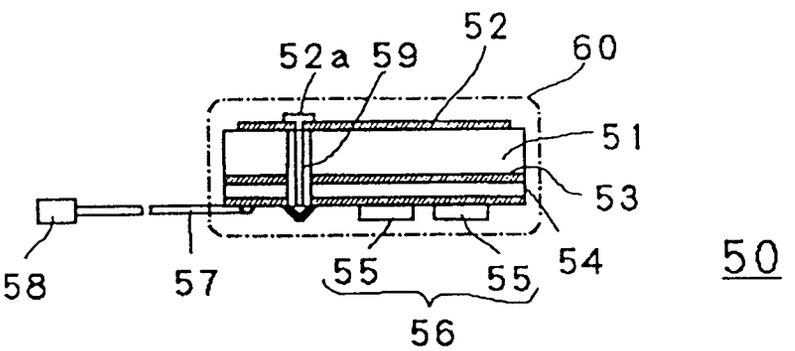

FIG. 8 (PRIOR ART)