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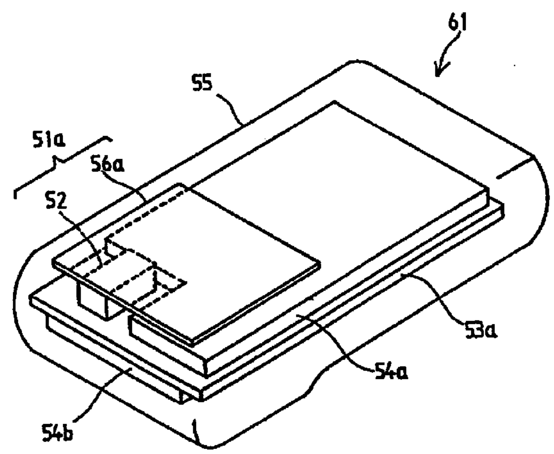
(54) Antenna device

(57) An antenna device designed so that the transmission output of an antenna circuit can be measured easily and accurately as the transmission output measured when the antenna device is removed as prescribed in the Wireless Telegraphy Act, even after the antenna device has been mounted on the main circuit board. The antenna device (51a; 51b) of the present invention has a radiating element (56a) and a current supply element (52). The current supply (52) element is formed of a metallic chassis (54; 84) having, as viewed in a cross section, the shape of a rectangle open at one side. The metallic chassis (54; 84) has an opposed portion (52a) opposed to a major surface of the radiating element (56a) in parallel with the same, and two leg portions bent (52b; 52c) downwardly and perpendicularly from shorter-side opposite ends of the opposed portion (52a). The metallic chassis (54) and a multilayer chip capacitor (68) are mounted on the obverse surface of the main circuit board (53a), and the metallic chassis (54) and a transmission output measuring terminal are connected to each other through the multilayer chip capacitor (68).

FIG.1(A)



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an antenna device for use in a mobile communication apparatus such as a portable telephone.

Description of the Related Art

As an antenna for use in conventional mobile communication apparatuses, a circuit board surface mount type antenna (hereinafter referred to as "surface mount type antenna") is proposed in the specification of Japanese Patent Application No. 6-81652 filed by the applicant of the present invention, which is not published yet. Fig. 7 shows this surface mount type antenna, and Figs. 8 to 11 show an example of the surface mount type antenna in which an antenna switch circuit is mounted as an antenna circuit.

Referring to Fig. 7, a member 1 is a dielectric substrate in the form of a rectangular prism made of, for example, a ceramic or resin, and a pair of grounding electrodes 2 are formed on opposite side surfaces of the dielectric substrate 1 corresponding to the longer sides of the two major surfaces of the dielectric substrate 1 while connection electrodes 3a, 3b, and 3c are formed on the other opposite side surfaces corresponding to the shorter sides. A member 4 is a metallic chassis made of, for example, copper or a copper alloy and having, as viewed in a cross section, the shape of a rectangle open at one side. The metallic chassis 4 has a rectangular flat radiating portion 5, and two fixing portions 6 and 7 bent downwardly and perpendicularly from shorter-side opposite ends of the radiating portion 5. A current supply terminal 8 and a grounding terminal 9 are formed integrally on the extreme end of the fixing portion 6. The fixing portion 6 is reduced in length relative to the fixing portion 7 to form the current supply terminal 8 and the grounding terminal 9. The overall length of the fixing portion 6, including the length of the current supply terminal 8 and the grounding terminal 9, and the overall length of the fixing portion 7 are respectively set so as to be larger than the thickness of the dielectric substrate 1.

The dielectric substrate 1 is inserted into the metallic chassis 4 with the shorter-side side surfaces of the dielectric substrate 1 brought into contact with inner surfaces of the fixing portions 6 and 7 of the metallic chassis 4. At this time, a vacant space 10 is formed between the radiating portion 5 of the metallic chassis 4 and the obverse surface of the dielectric substrate 1 due to the difference between the values of the thickness of the dielectric substrate 1 and the length of the fixing portion 6 including the current supply terminal 8 and the grounding terminal 9 and the fixing portion 7. The connection terminal 3a of the dielectric substrate 1 is soldered to the fixing portion 7 of the metallic chassis 4. Also, the connection terminals 3b and 3c of the dielectric substrate 1 are respectively soldered to the current supply terminal 8 and the grounding terminal 9 of the metallic chassis 4. Thus, a surface mount type antenna 13 is constructed.

A main circuit board 15 has, on its obverse surface, a micro-strip line 16 for supplying an antenna current, connected to an antenna circuit, e.g., an antenna switch circuit (not shown), and grounding electrodes 17a insulated from the micro-strip line 16. Also, a grounding electrode 17b is formed generally over the entire reverse surface of the main circuit board 15.

The surface mount type antenna 13 is placed on the obverse surface of the main circuit board 15, the current supply terminal 8 and the micro-strip line 16 are soldered to each other, and the pair of grounding electrodes 2 and the grounding electrode 9 are soldered to the grounding electrodes 17a on the obverse surface of the main circuit board 15. The surface mount type antenna 13 is thus mounted on the main circuit board 15 in a surface mount manner. Electric waves are transmitted or received through the radiating portion 5 of the metallic chassis 4.

Referring then to Figs. 8 and 9, a member 21 is a multilayer dielectric substrate in the form of a rectangular prism made of, for example, a ceramic or a resin. A transmission input portion TX, a receiving output portion RX, control input portions VC1 and VC2 of an antenna switch circuit and a plurality of grounding electrodes 22 are formed as external electrodes on opposite side surfaces of the dielectric substrate 21 corresponding to the longer sides of the two major surfaces of the dielectric substrate 21 while connection electrodes 23a, 23b, and 23c are formed on the other opposite side surfaces corresponding to the shorter sides. As circuits elements, a strip line 24a and capacitors 24b are formed in the dielectric substrate 21 while diodes 24c and printed resistors 24d are mounted on the obverse surface of the dielectric substrate 21, thus forming an antenna switch circuit 24. An antenna output portion 24e of the antenna switch circuit 24 in the dielectric substrate 21 is connected to the connection electrode 23b on the side surface, and the circuit elements are connected to each other by internal electrodes or via holes.

A member 26 is a metallic chassis made of, for example, copper or a copper alloy and having, as viewed in a cross section, the shape of a rectangle open at one side. The metallic chassis 26 has a rectangular flat radiating portion 27, and two fixing portions 28 and 29 bent downwardly and perpendicularly from shorter-side opposite ends of the radiating portion 27. A current supply terminal 30 and a grounding terminal 31 are formed integrally on the extreme end of the fixing portion 28. The fixing portion 28 is reduced in length relative to the fixing portion 29 to form the current supply terminal 30 and the grounding terminal 31. The overall length of the fixing portion 28, including the length of the current supply terminal 30 and the grounding terminal 31, and the overall length of the fixing portion 29 are respectively set so as to be larger than the thickness of the dielectric substrate 21.

The dielectric substrate 21 is inserted into the metallic chassis 26 with the shorter-side side surfaces of the dielectric substrate 21 brought into contact with inner surfaces of the fixing portions 28 and 29 of the metallic chassis 26. At this time, a vacant space 32 is formed between the radiating portion 27 of the metallic chassis 26 and the obverse surface of the dielectric substrate 21 due to the difference between the values of the thickness of the dielectric substrate 21 and the length of the fixing portion 28 including the current supply terminal 30 and the grounding terminal 31 and the fixing portion 29. The connection terminal 23a of the dielectric substrate 21 is soldered to the fixing portion 29 of the metallic chassis 26. Also, the connection terminals 23b and 23c of the dielectric substrate 21 are respectively soldered to the current supply terminal 30 and the grounding terminal 31 of the metallic chassis 26. Thus, a surface mount type antenna 35 is constructed.

Connection electrodes 37, 38, 39, and 40 and grounding electrodes 41a insulated from the connection electrodes 37 to 40 are formed on the obverse surface of a main circuit board 36. A grounding electrode 41b are formed on the entire reverse surface of the main circuit board 36.

The surface mount type antenna 35 is placed on the obverse surface of the main circuit board 36, and the transmission input portion TX, the receiving output portion RX and the control input portions VC1 and VC2 are respectively soldered to the connection electrodes 37 to 40 while the grounding electrodes 22 and the grounding terminal 31 are soldered to the grounding electrodes 41a. The surface mount type antenna 35 is thus mounted on the main circuit board 36 in a surface mount manner. Electric waves are transmitted or received through the radiating portion 27 of the metallic chassis 26.

Fig. 10 shows a well-known circuit as an example of the antenna switch circuit 24, and Fig. 11 is a block diagram of the antenna 35. An antenna circuit such as a low-pass filter or a band-pass filter may be mounted as well as the antenna circuit 24 shown in Fig. 10.

A dielectric-loaded monopole antenna capable of being mounted on a circuit board in a surface mount manner is also proposed in the specification of Japanese Patent Application No. 6-034759 filed by the applicant of the present invention, which is not published yet. Fig. 12 shows this dielectric-loaded monopole antenna. A member 71 shown in Fig. 12 is a dielectric substrate generally in the form of a rectangular prism. A generally cylindrical through hole 72 is formed in the dielectric substrate 71 so as to be open in opposite side surfaces of the same. A radiating electrode 73 made of, for example, copper is formed on the internal surface of the through hole 72. A current supply terminal 74 electrically connected to the radiating electrode 73 is continuously formed from one of the side surfaces in which the through hole 72 is open to the reverse surface of the dielectric substrate 71. Grounding terminals 75a and 75b are formed on the opposite sides of the current supply terminal 74. A grounding terminal 75c is formed on the other side surface in which the through hole 72 is open. Thus, a dielectric-loaded monopole antenna 76 is constructed.

A main circuit board 77 has, on its obverse surface, a micro-strip line 78 for supplying an antenna current, which is a transmission line connected to an antenna circuit, e.g., an antenna switch circuit (not shown), and grounding electrodes 79a insulated from the micro-strip line 78. Also, a grounding electrode 79b is formed generally over the entire reverse surface of the main circuit board 77.

The dielectric-loaded monopole antenna 76 is placed on the obverse surface of the main circuit board 77, the current supply terminal 74 and the micro-strip line 78 are soldered to each other, and the grounding terminals 75a, 75b and 75c are soldered to the grounding electrodes 79a on the obverse surface of the main circuit board 77. The dielectric-loaded monopole antenna 76 is thus mounted on the main circuit board 77 in a surface mount manner. Electric waves are transmitted or received through the radiating electrode 73.

The transmission output from the antenna circuit, e.g., an antenna switch circuit when the antenna is removed is regulated by the Wireless Telegraphy Act. Therefore, there is a need to accurately measure the value of the output.

The above-described surface mount type antenna 13 is mounted on the main circuit board 15 in a surface mount manner by soldering the current supply terminal 8, the grounding electrodes 2 and the grounding terminal 9. Therefore, it is difficult to dismount the surface mount type antenna 13, once the antenna 13 is mounted on the main circuit board 15. On the other hand, after the surface mount type antenna 13 has been mounted on the surface of the main circuit board 15, the transmission output of the antenna switch circuit is loaded with the impedance of the surface mount type antenna 13, because the current supply terminal 8 is connected to the antenna switch circuit through the micro-strip line 16. In such a situation, the transmission output of the antenna switch circuit cannot be accurately measured.

The surface mount type antenna 35 is mounted on the main circuit board 36 by soldering the transmission input portion TX, the receiving output portion RX, the control input portions VC1 and VC2, the grounding electrode 22 and grounding terminal 31. Therefore, it is difficult to dismount the antenna 35 once the antenna 35 is mounted on the main circuit board 36. After the surface mount type antenna 35 has been mounted on the surface of the main circuit board 36, the transmission output of the antenna switch circuit 24 is loaded with the impedance of the surface mount type antenna 35, because the current supply terminal 30 is connected to the antenna output portion 24e of the antenna switch circuit 24. As a result, the transmission output of the antenna switch circuit 24 cannot be accurately measured.

Further, the dielectric-loaded monopole antenna 76 is mounted on the main circuit board 77 in a surface mount manner by soldering the current supply terminal 74 and the grounding terminals 75a, 75b and 75c. Therefore, it is difficult to dismount the antenna 76 once the antenna 76 is mounted on the main circuit board 77. After the dielectric-loaded monopole antenna 76 has been mounted on the surface of the main circuit board 77, the transmission output of the antenna switch circuit is loaded with the impedance of dielectric-loaded monopole antenna 76, because the current supply terminal 74 is connected to the antenna switch circuit through the micro-strip line 78. As a result, the transmission output of the antenna switch circuit cannot be accurately measured.

Therefore, an electrical or mechanical switch for a change to a transmission output measuring terminal is required to accurately measure the transmission output of the antenna circuit, i.e., an antenna switch circuit or the like. If such a switch is provided, the manufacturing cost is increased.

SUMMARY OF THE INVENTION

In view of the above-described problems, an object of the present invention is to provide an antenna device designed so that the transmission output of an antenna circuit when the antenna device is removed, regulated by the Wireless Telegraphy Act, can be measured easily and accurately without using any electrical or mechanical switch for a change to a transmission output measuring terminal, even after the antenna device has been mounted on a main circuit board.

To achieve the above-described object, according to one aspect of the present invention, there is provided an antenna device comprising a current supply element, and a radiating element provided in combination with the current supply element and separable from the current supply element, wherein a transmission output measuring terminal is connected to the current supply element through a capacitor.

In the above-described antenna device, according to another aspect of the invention, the radiating element is accommodated in a gap formed between a main circuit board on which the current supply element is mounted and an outer case in which the main circuit board is accommodated, one major surface of the radiating element facing the current supply element.

In the above-described antenna device, according to still another aspect of the invention, the current supply element is connected to a first transmission line which is formed on the main circuit board to supply an antenna current, and a multilayer chip capacitor and the transmission output measuring terminal are connected to the first transmission line.

In the above-described antenna device, according to a further aspect of the invention, the current supply element is formed by inserting a dielectric substrate into a metallic chassis, and an incorporated capacitor connected to the transmission output measuring terminal is formed in the dielectric substrate by providing a first capacitor electrode connected to the first transmission line and a second capacitor electrode connected to a second transmission line for transmission output measurement formed on the main circuit board.

In the above-described antenna device, according to still a further aspect of the invention, a space is provided between the metallic chassis and the dielectric substrate.

In the above-described arrangement, the current supply element is mounted on the main circuit board with the radiating element accommodated in the gap formed between the main circuit board and the outer case in which the main circuit board is accommodated. Therefore, it is possible to easily separate the radiating element from the current supply element by removing the outer case from the main circuit board, even after the current supply element has been mounted on the main circuit board.

The transmission output measuring terminal is connected to the current supply element through the multilayer chip capacitor or the incorporated capacitor. Accordingly, the capacitance of the multilayer chip capacitor or the incorporated capacitor is added to the transmission output from the current supply element at the transmission output measuring terminal. The influence of the inductance of the current supply element upon the measured value of the transmission output from the current supply element at the transmission output terminal can be canceled by the capacitance of the multilayer chip capacitor or the incorporated capacitor connected to the current supply element. Consequently, the transmission output of the antenna circuit can be measured accurately by removing the influence of the inductance of the current supply element.

According to the above-described arrangement, even after the current supply element has been mounted on the main circuit board, the radiating element can be removed to accurately measure the transmission output of the antenna circuit as the transmission output measured when the antenna device is removed as prescribed in the Wireless Telegraphy Act.

Also, the need for an electrical or mechanical switch for a change to a transmission output measuring terminal, required to measure the transmission output in the conventional art, is eliminated to reduce the total manufacturing cost.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1(A) through 1(C) are a perspective view, a front view and a side view, respectively, of an antenna device in accordance with a first embodiment of the present invention seen through a case;
Fig. 2 is a perspective view of a current supply element in the antenna device of the first embodiment;
Fig. 3 is a block diagram showing connections in the antenna device of the first embodiment;
Figs. 4(A) through 4(C) are a perspective view, a front view and a side view, respectively, of an antenna device in accordance with a second

embodiment of the present invention seen through a case;

Fig. 5 is a perspective view of a current supply element in the antenna device of the second embodiment;

Fig. 6 is a block diagram showing connections in the antenna device of the second embodiment;

Fig. 7 is a perspective view of a surface mount type antenna proposed in the specification of Japanese Patent Application No. 6-81652;

Fig. 8 is a perspective view of a surface mount type antenna proposed in the specification of Japanese Patent Application No. 6-81652 incorporating an antenna switch circuit;

Fig. 9 is a cross-sectional view of Fig. 8;

Fig. 10 is a circuit diagram of an antenna switch circuit;

Fig. 11 is a block diagram of the antenna shown in Fig. 8; and

Fig. 12 is a perspective view of a dielectric-loaded monopole antenna proposed in the specification of Japanese Patent Application No. 6-034759.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will be described below with reference to the accompanying drawings.

Figs. 1 and 2 show an antenna device 51a and a current supply element 52 in accordance with a first embodiment of the present invention. The antenna device 51a is incorporated in a portable telephone 61. Figs. 1(A), 1(B), and 1(C) are a perspective view, a front view and a side view, respectively, of the antenna device seen through a case, and Fig. 2 is a perspective view of the current supply element 52.

Referring to Figs. 1 and 2, the antenna device 51a has the current supply element 52 and a radiating element 56a, and is mounted on a main circuit board 53a with the current supply element 52 placed on a major surface of the main circuit board 53a. The current supply element 52 is connected to a first micro-strip line 66, which is a first transmission line formed on the main circuit board 53a to supply an antenna current. The radiating element 56a is accommodated in a vacant space formed between the main circuit board 53a and an outer case 55 in which the main circuit board 53a is accommodated. The current supply element 52 is grounded to a grounding electrode 67a formed on the main circuit board 53a and insulated from the first micro-strip line 66 while the radiating element 56a is grounded to the outer case 55. One major surface of the radiating element 56a is opposed to and maintained in contact with the current supply element 52.

To protect the main circuit board 53a, shield covers 54a and 54b are attached to the two surfaces of the main circuit board 53a over the entire areas thereof excepting the area where the current supply element 52 is placed.

The current supply element 52 is formed of a metallic chassis 54 made of, for example, copper or a copper alloy and has, as viewed in a cross section, the shape of a rectangle open at one side. The metallic chassis 54 has a rectangular flat opposed portion 52a opposed to the major surface of the radiating element 56a in parallel with the same, and two leg portions 52b and 52c bent downwardly and perpendicularly from shorter-side opposite ends of the opposed portion 52a. A current supply terminal 52d is formed integrally on the extreme end of the leg portion 52b while a grounding terminal 52e is formed integrally on the extreme end of the leg portion 52c.

A grounding electrode 67b is formed generally over the entire reverse surface of the main circuit board 53a. The first micro-strip line 66 is connected to, for example, an antenna switch circuit (not shown).

To mount the metallic chassis 54 in a surface mount manner, the metallic chassis 54 is placed on the obverse surface of the main circuit board 53a, the current supply terminal 52d and the first micro-strip line 66 are soldered to each other, and the grounding terminal 52e and the grounding electrode 67a are soldered to each other.

A multilayer chip capacitor 68 is also mounted in a surface mount manner by being placed on the obverse surface of the main circuit board 53a, with external electrodes 68a and 68b of the multilayer chip capacitor 68 soldered to the first micro-strip line 66. Further, a transmission output measuring terminal (not shown) of the antenna switch circuit is connected to the current supply terminal 52d and to the first micro-strip line 66 through the multilayer chip capacitor 68. The current supply element 52 is thus constructed.

In this embodiment, the current supply element 52 and the radiating element 56a are maintained in contact with each other. Alternatively, the current supply element 52 and the radiating element 56a may be separated with a spacing such as to be electromagnetically connected to each other.

The shape of the current supply element 52 is not limited to that shown in Fig. 2, and the current supply element 52 may have any other shape as long as at least one current supply terminal 52d and at least one grounding terminal 52e are provided and a transmitted electric wave output can be supplied to the radiating element 56a electrically or electromagnetically. For example, the current supply element 52 may be formed of a metallic block. The positional relationship between the current supply terminal 52d and the grounding terminal 52e is not limited to that shown in Fig. 2. For example, the current supply terminal 52d and the grounding terminal 52e may be respectively formed on the longer sides of the current supply element 52.

In this embodiment, a micro-strip line is used as a transmission line. However, a coplanar line may alternatively be used.

Fig. 3 is a block diagram showing connections of the antenna device 51b. As shown in Fig. 3, the current supply element 52 and the radiating element 56a in contact with each other are electrically connected, and a transmitted electric wave output from the current supply element 52 is radiated through the radiating element 56a. The above-mentioned transmission output measuring terminal is connected to the current supply element 52. C1 represents a stray capacity of the radiating element 56a.

The thus-constructed antenna device 51a is mounted by attaching the current supply element 52 to the main circuit board 53a and accommodating the radiating element 56a in the gap formed between the main circuit board 53a and the outer case 55. Therefore, the radiating element 56a can easily be separated from the current supply element 52 by removing the outer case 55 from the main circuit board 53a, even after the current supply element 52 has been mounted on the main circuit board 53a.

The above-mentioned transmission output measuring terminal is connected to the current supply element 52 through the multilayer chip capacitor 68, and the capacitance of the multilayer chip capacitor 68 is therefore added to the transmission output from the current supply element 52 at the transmission output measuring terminal. That is, the capacitance of the multilayer chip capacitor 68 connected to the current supply element 52 can be used to cancel the influence of an inductance of the current supply element 52 upon the measured value of the transmission output from the current supply element 52 at the transmission output measuring terminal. It is therefore possible to accurately measure the transmission output of the antenna switch circuit by canceling the influence of the inductance of the current supply element 52.

By using the above-described means and by removing the radiating element 56a, the transmission output of the antenna switch circuit when the antenna device 51a is removed, regulated by the Wireless Telegraphy Act, can be measured easily and accurately even after the current supply element 52 has been mounted on the main circuit board 53a. Therefore, transmission output level checking at the time of forwarding can be performed easily.

Also, there is no need for an electrical or mechanical switch for a change to a transmission output measuring terminal, required to measure the transmission output. The manufacturing cost of the portable telephone can therefore be reduced.

Figs. 4 and 5 show an antenna device 51b and a current supply element 52z in accordance with a second embodiment of the present invention. The components identical or corresponding to those shown in Figs. 1 and 2 are indicated by the same reference characters and the description for them will not be repeated. The antenna device 51b is incorporated in a portable telephone 61. Figs. 4(A), 4(B), and 4(C) are a perspective view, a front view and a side view, respectively, of the antenna device 51b seen through a case. Fig. 5 is a perspective view of the current supply element 52z.

Referring to Figs. 4 and 5, the current supply element 52z of the antenna device 51b is placed on a major surface of a main circuit board 53a to be connected to a first micro-strip line 66a, which is first transmission line for supplying an antenna current, and to a second micro-strip line 66b, which is a second transmission line for measuring a transmission output. The current supply element 52z is also connected to a grounding electrode 67a. One major surface of a radiating element 56a is opposed to the current supply element 52z and maintained in contact with the same.

The first and second micro-strip lines 66a and 66b are formed on the main circuit board 53a. The second micro-strip line 66b is insulated from the first micro-strip line 66a and the grounding electrode 67a, and is connected to the transmission output measuring terminal (not shown).

A member 81 is a dielectric substrate in the form of a rectangular prism made of, for example, a ceramic or a resin. A transmission output measuring electrode 82 is formed on one of longer-side side surfaces of the dielectric substrate 81 while connection electrodes 83a and 83b are formed on shorter-side side surfaces of the dielectric substrate 81. A first capacitor electrode 85a connected to the connection electrode 83a and a second capacitor electrode 85b connected to the transmission output measuring electrode 82 are provided in the dielectric substrate 81, thereby forming an incorporated capacitor 85.

A member 84 is a metallic chassis made of, for example, copper or a copper alloy and having, as viewed in a cross section, the shape of a rectangle open at one side. The metallic chassis 84 has a current supply terminal 52d and a grounding terminal 52e formed through a length corresponding to the thickness of the dielectric substrate 81. The lengths of leg portions 52b and 52c, including the lengths of the current supply terminal 52d and the grounding terminal 52e, respectively, are set so as to be larger than the thickness of the dielectric substrate 81.

The dielectric substrate 81 is inserted into the metallic chassis 84. At this time, shorter-side side surfaces of the dielectric substrate 81 are brought into contact with inner surfaces of the current supply terminal 52d and the grounding terminal 52e of the metallic chassis 84, and a space 90 is formed between an opposed portion 52a of the metallic chassis 84 and the obverse surface of the dielectric substrate 81 due to the difference between the thickness of the dielectric substrate 81 and the lengths of the leg portions 52b and 52c including the current supply terminal 52d and the grounding terminal 52e. The connection electrode 83a of the dielectric substrate 81 and the current supply terminal 52d of the metallic chassis 84 are soldered to each other while the connection electrode 83b of the dielectric substrate 81 and the grounding terminal 52e of the metallic chassis 84 are soldered to each other.

The metallic chassis 84 in which the dielectric substrate 81 is inserted is mounted on the main circuit board

53a in a surface mount manner by being placed on the obverse surface of the main circuit board 53a, with the current supply terminal 52d, the grounding terminal 52e and the transmission output measuring electrode 82 soldered to the first micro-strip line 66a, the grounding electrode 67a and the second micro-strip line 66b, respectively. The current supply element 52z is thus constructed.

Fig. 6 is a block diagram showing connections of the antenna device 51b. Components identical or corresponding to those shown in Fig. 3 are indicated by the same reference characters and the description for them will not be repeated. Referring to Fig. 6, the current supply element 52z and the radiating element 56a in contact with each other are electrically connected to each other, and a transmitted electric wave output from the current supply element 52z is radiated through the radiating element 56a. The above-mentioned transmitting output measuring terminal is connected to the current supply element 52z.

The thus-constructed current supply element 52z is mounted on the main circuit board 53a while the radiating element 56a is accommodated in the gap formed between the main circuit board 53a and the outer case 55 in which the main circuit board 53a is accommodated. Also, the transmission output measuring terminal is connected to the current supply element 52z through the incorporated capacitor 85 provided in place of the multilayer chip capacitor 68 in the current supply element 52 of the first embodiment. Therefore, the same effect as that of the first embodiment can be obtained.

In the current supply element 52z, the dielectric substrate 81 is inserted in the metallic chassis 84, so that the current supply element 52z has a large capacitance. The resonance frequency of the antenna device 51b can be reduced thereby. The space 90 is provided between the opposed portion 52a of the metallic chassis 84 and the obverse surface of the dielectric substrate 81, so that an eddy current in the grounding surface, caused by a magnetic field generated around a high-frequency current flowing through the opposed portion 52a, is limited, and so that the electric field caused by the magnetic field cannot concentrate easily in the dielectric substrate 81. Therefore, the efficiency at which the transmission output is transmitted to the radiating element 56a is further improved and the gain of the antenna device 51b is further increased. Further, the impedance of the current supply element 52z can be adjusted at the time of designing by setting the incorporated capacitor 85 in the dielectric substrate 81. Therefore, there is no need to select and adjust the capacitance of a capacitor connected to the current supply element 52z when the current supply element 52z is mounted on the main circuit board 53a. Also, it is possible to reduce the area on the main circuit board 53a in which the current supply element 52z is mounted.

As described above, the antenna device of the present invention is mounted by placing the current supply element on the main circuit board and by accommodating the radiating element in the gap formed between the main circuit board and the outer case in which the main circuit board is accommodated. Therefore, it is possible to easily separate the radiating element from the current supply element by removing the outer case from the main circuit board, even after the current supply element has been mounted on the main circuit board.

Since the transmission output measuring terminal is connected to the current supply element through the multilayer chip capacitor or the incorporated capacitor, the capacitance of the capacitor is added to the transmission output from the current supply element at the transmission output measuring terminal. The influence of the inductance of the current supply element upon the measured value of the transmission output from the current supply element at the transmission output terminal can be canceled by the capacitance of the multilayer chip capacitor or incorporated capacitor connected to the current supply element. Consequently, the transmission output of the antenna circuit can be measured accurately by removing the influence of the inductance of the current supply element.

According to the above-described arrangement, even after the current supply element has been mounted on the main circuit board, the radiating element can be removed to accurately measure the transmission output of the antenna circuit as the transmission output measured when the antenna device is removed as prescribed in the Wireless Telegraphy Act. Therefore, transmission output level checking at the time of forwarding can be performed easily.

The need for an electrical or mechanical switch for a change to a transmission output measuring terminal, required to measure the transmission output, is eliminated to reduce the total manufacturing cost.

The dielectric substrate is inserted into the metallic chassis in the current supply element to increase the capacitance of the current supply element. The resonance frequency of the antenna device can be reduced thereby. A space is provided between the opposed portion of the metallic chassis and the dielectric substrate, so that an eddy current in the grounding surface, caused by a magnetic field generated around a high-frequency current flowing through the opposed portion, is limited, and so that the electric field caused by the magnetic field cannot concentrate easily in the dielectric substrate. Therefore, the efficiency of transmission of the transmission output to the radiating element is further improved and the gain of the antenna device is further increased. Further, the impedance of the current supply element can be adjusted at the time of designing by setting an incorporated capacitor in the dielectric substrate. Therefore, there is no need to select and adjust the capacitance of a capacitor connected to the current supply element when the current supply element is mounted on the main circuit board. Further, it is possible to reduce the area on the main circuit board in which the current supply element is mounted.

Claims

1. An antenna device (51a; 51b) comprising: a current supply element (52; 52z); and a radiating element (56a) provided in combination with said current supply element (52; 52z) and separable from said current supply element (52; 52z), wherein a transmission output measuring terminal is connected to said current supply element (52; 52z) through a capacitor (68; 85).

2. An antenna device (51a; 51b) according to Claim 1, wherein said radiating (56a) element is accommodated in a gap formed between a main circuit board (53a) on which said current supply element (52; 52z) is mounted and an outer case (55) in which said main circuit board (53a) is accommodated, one major surface of said radiating element (56a) facing said current supply element (52; 52z).

3. An antenna device (51a) according to Claim 1 or 2, wherein said current supply element (52) is connected to a first transmission line (66) which is formed on said main circuit board (53a) to supply an antenna current, and a multilayer chip capacitor (68) and said transmission output measuring terminal are connected to said first transmission line (66).

4. An antenna device (51b) according to Claim 1 or 2, wherein said current supply element (52z) is provided by inserting a dielectric substrate (81) into a metallic chassis (84), and an incorporated capacitor (85) connected to said transmission output measuring terminal is provided in said dielectric substrate (81) by providing a first capacitor electrode (85a) connected to a first transmission line (66a) and a second capacitor electrode (85b) connected to a second transmission line (66b) for transmission output measurement formed on said main circuit board (53a).

5. An antenna device (51b) according to Claim 4, wherein a space is provided between said metallic chassis (84) and said dielectric substrate (81).

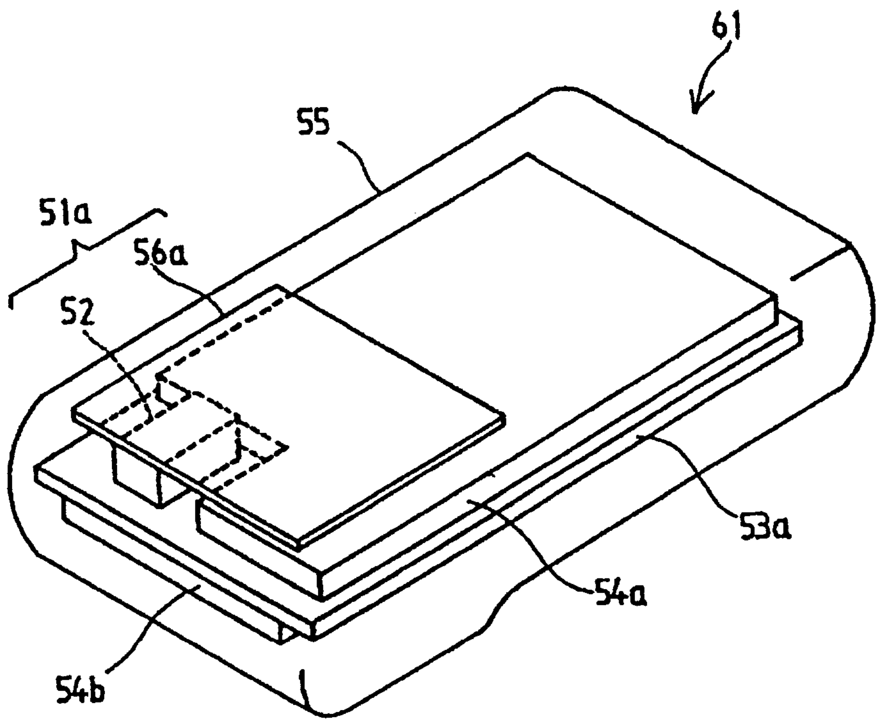

FIG.1(A)

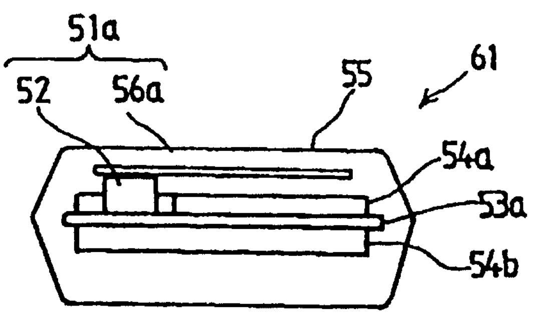

FIG.1(B)

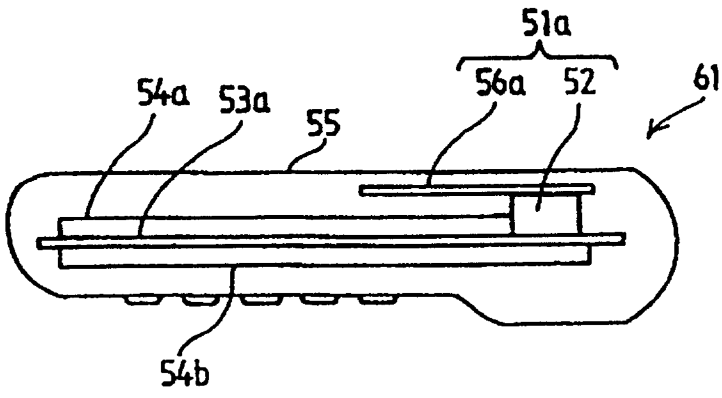

FIG.1(C)

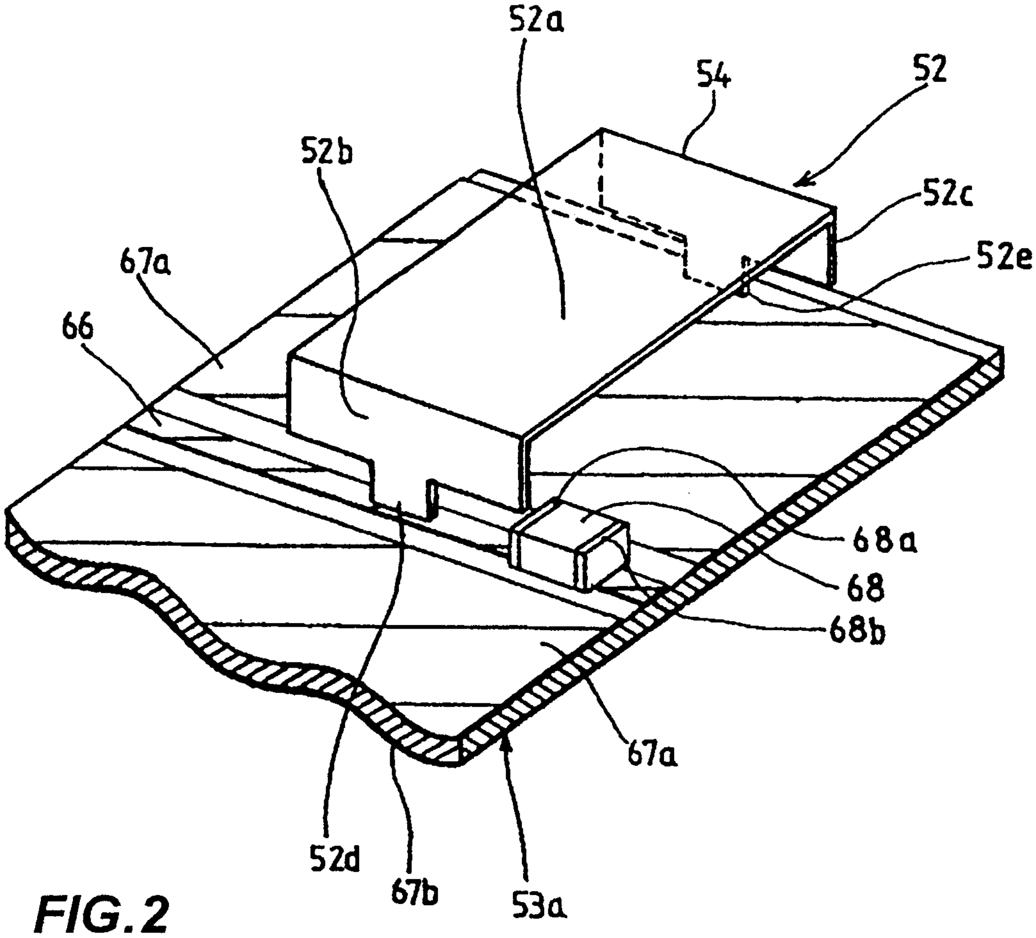
52a
54
52
52b
52c
52e
67a
66
68a
68
68b
67a
52d
67b
53a

FIG.2

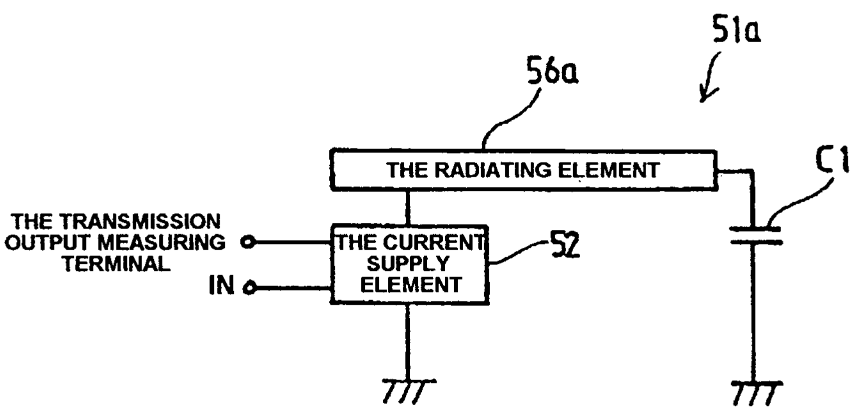
51a
56a
THE RADIATING ELEMENT
C1
THE TRANSMISSION
OUTPUT MEASURING
TERMINAL
THE CURRENT
SUPPLY
ELEMENT
52
IN

FIG.3

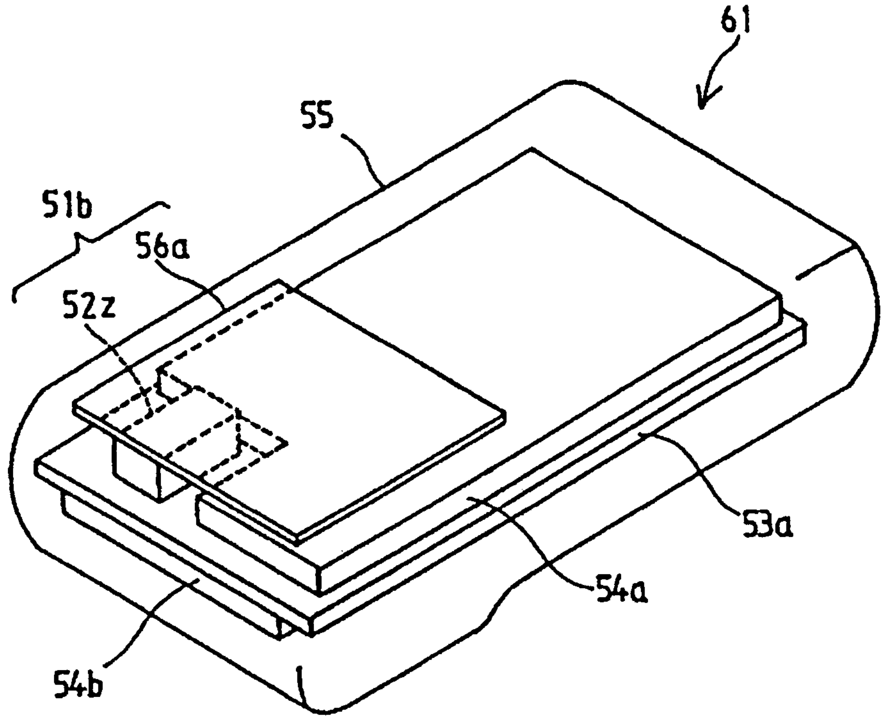

FIG.4(A)

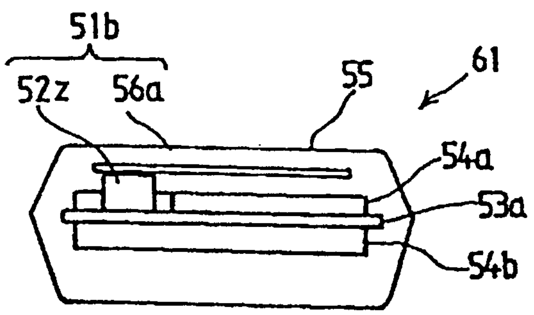

FIG.4(B)

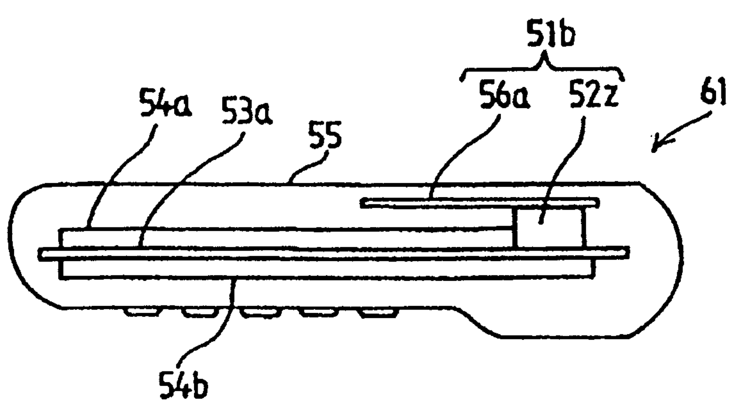

FIG.4(C)

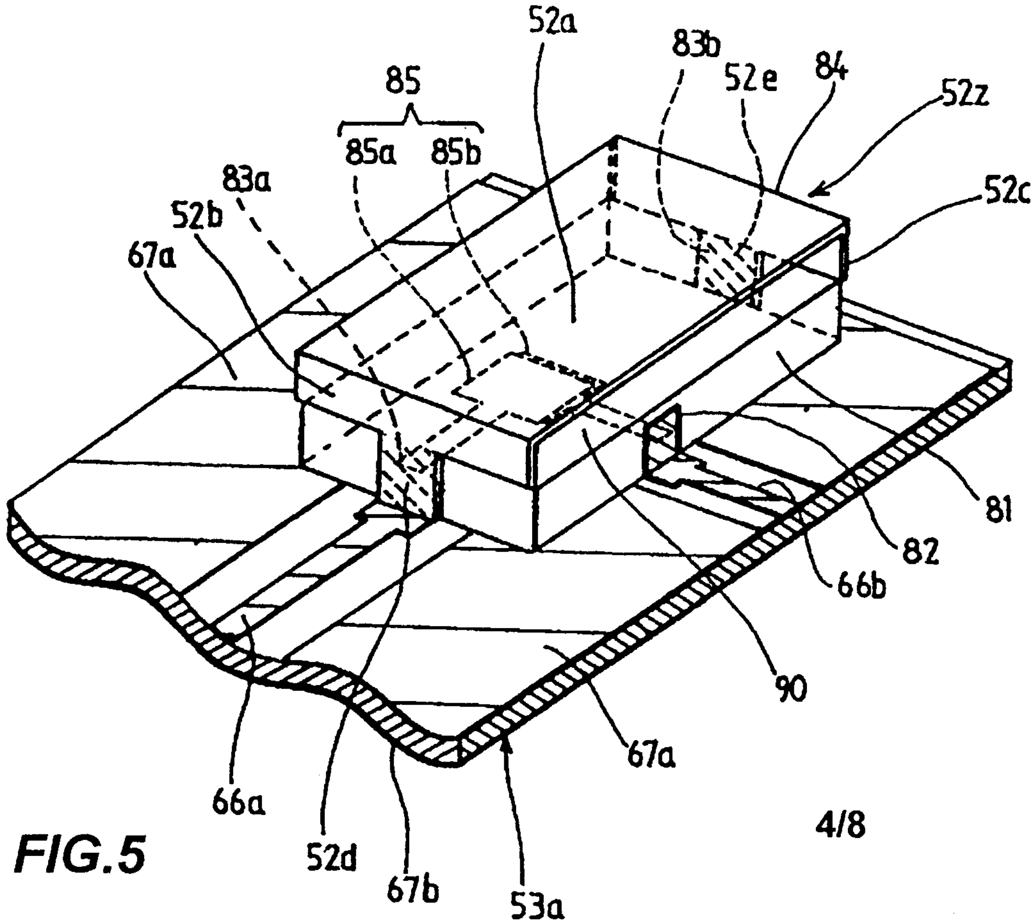
52a
83b
52e
84
52z
85
85a
85b
83a
52b
67a
52c
81
82
66b
90
67a
66a
52d
67b
53a

FIG.5

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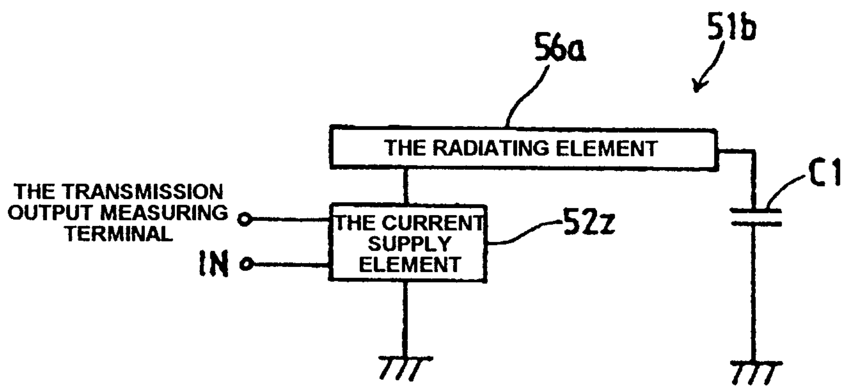
56a
51b
THE RADIATING ELEMENT
C1
THE TRANSMISSION OUTPUT MEASURING TERMINAL
THE CURRENT SUPPLY ELEMENT
52z
IN

FIG.6

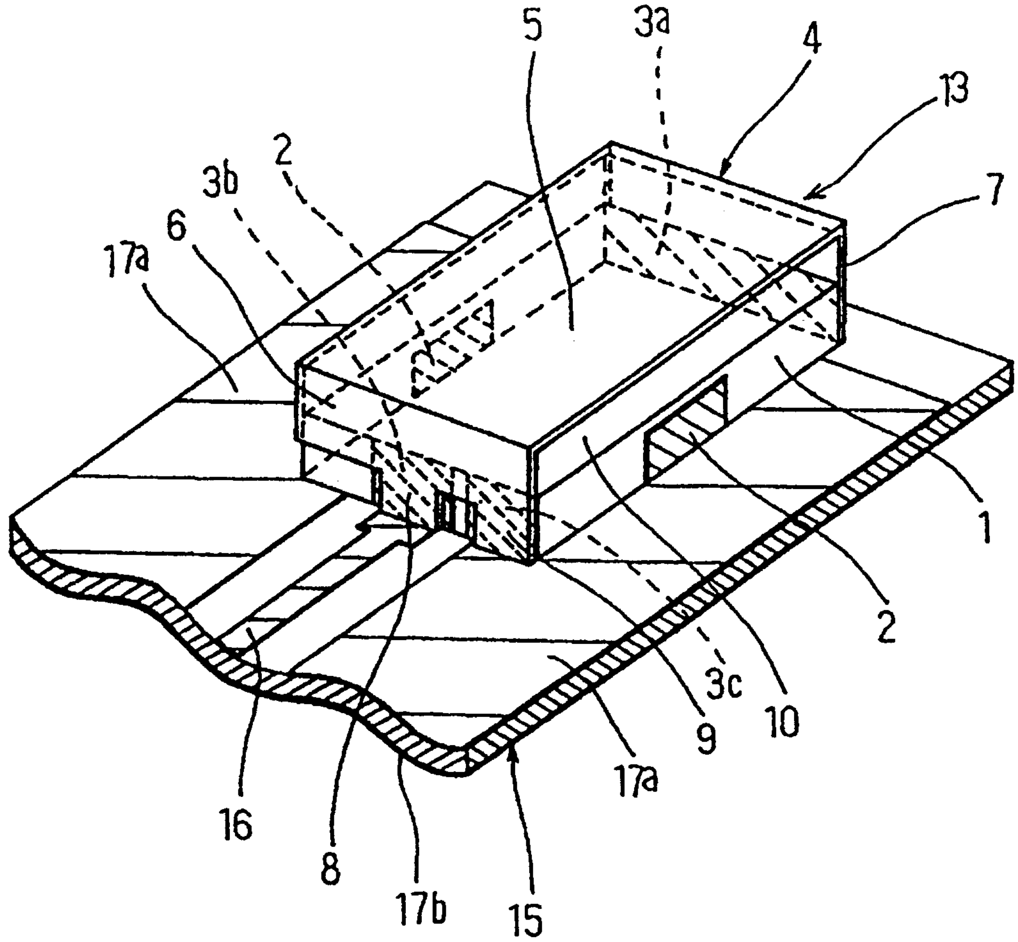

FIG.7

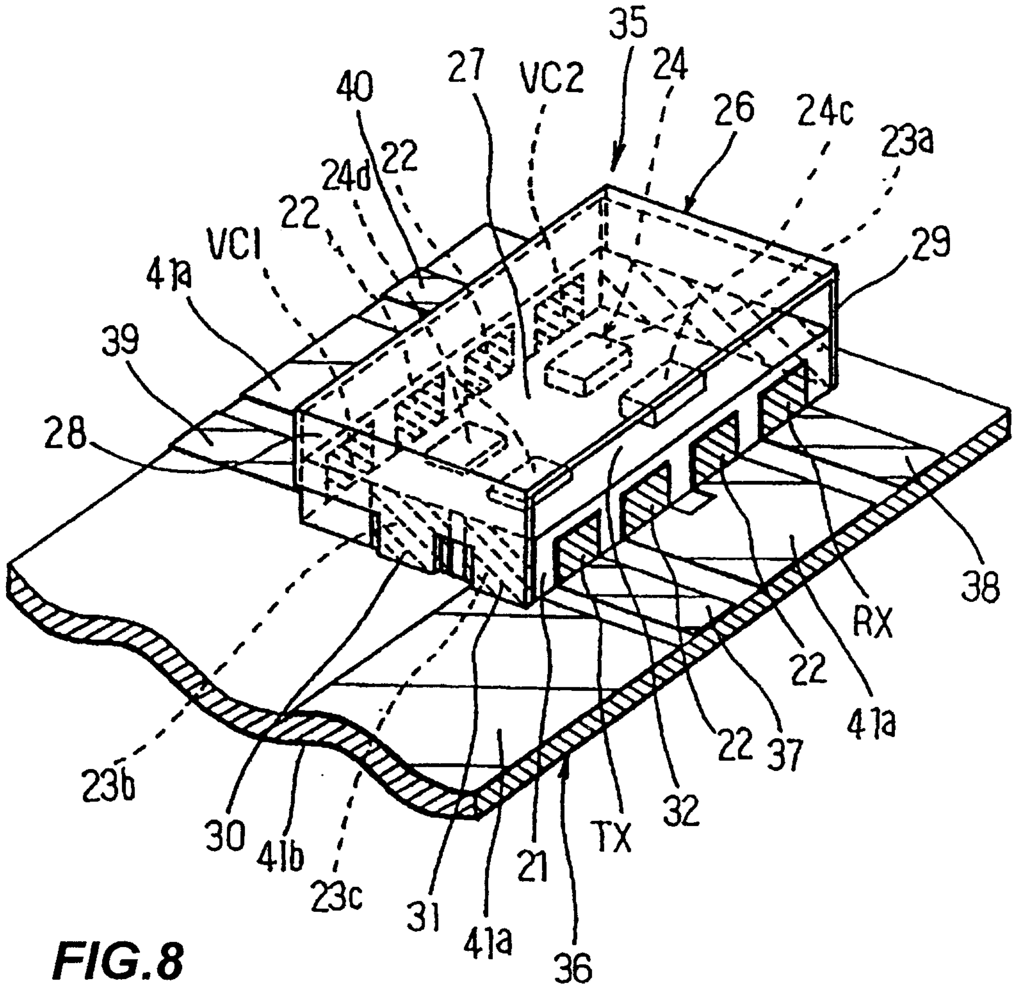
35
27
VC2
24
40
26
24c
23a
24d
22
22
VC1
29
41a
39
28
38
RX
22
41a
22
37
23b
32
TX
30
41b
21
23c
31
41a
36

FIG.8

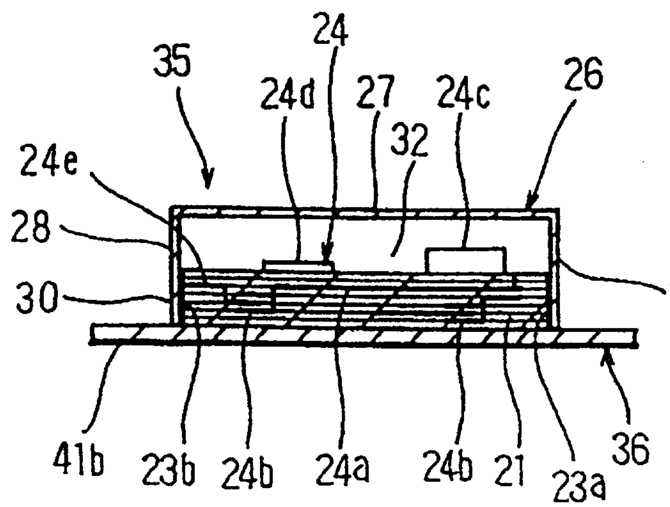
24
35
24d
27
24c
26
32
24e
28
30
29
36
41b
23b
24b
24a
24b
21
23a

FIG.9

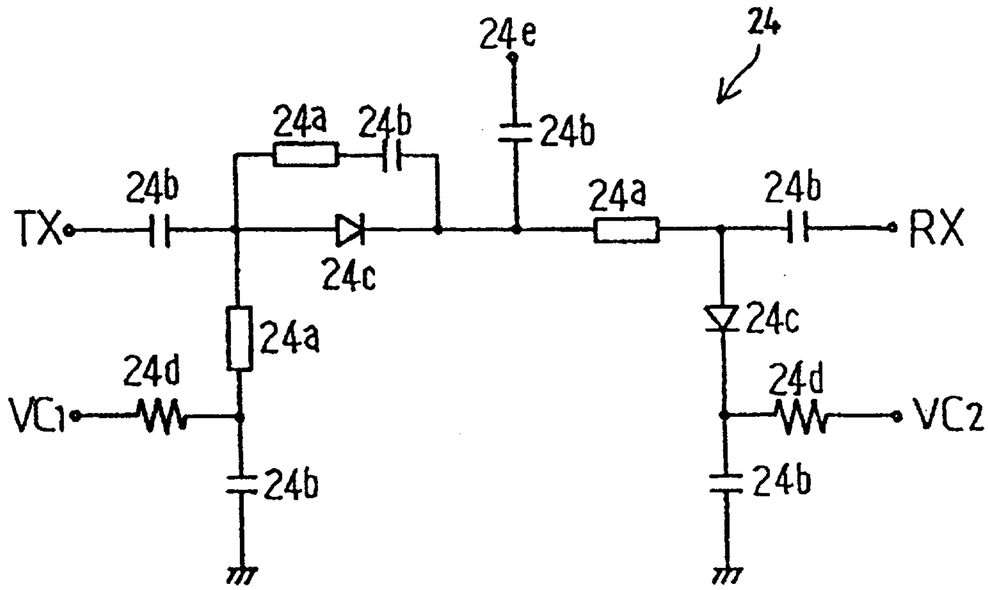
24e
24
24a
24b
24b
24b
24a
24b
TX
24c
RX
24c
24a
24d
24d
VC1
VC2
24b
24b

FIG.10

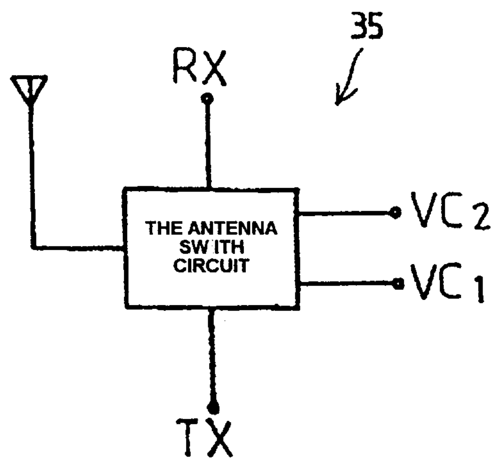
35
RX
THE ANTENNA
SW ITH
CIRCUIT
VC 2
VC 1
TX

FIG.11

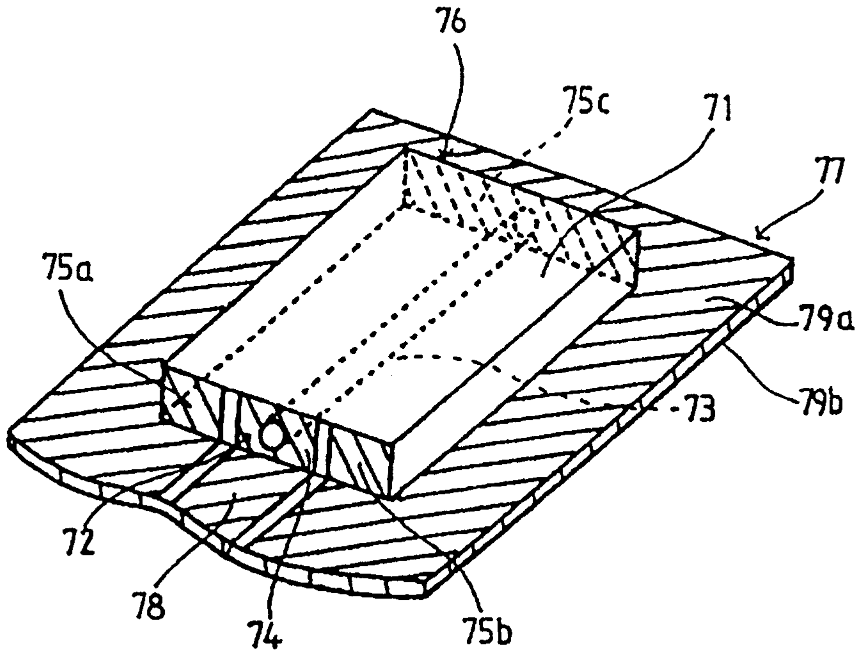

FIG.12

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 11 4485

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)
X	FR-A-2 553 586 (SOCIETE TECHNIQUE D`APPLICATION ET DE RECHERCHE ELECTRONIQUE) * page 5, line 14 - page 6, line 19; figure 4 *	1	H01Q9/04 H01Q1/24
A	EP-A-0 526 643 (MITSUBISHI) * abstract; figures 1-6,9 *	1-5	
A	EP-A-0 246 026 (UNIDEN) * claims 1-7; figures 4,5 *	1-5	
A	EP-A-0 400 872 (HARADA) * claims 1-18; figures 1,3A,4A *	1-5	
P,A	EP-A-0 621 653 (MURATA) * abstract; figures 1-40C *	1-5	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
H01Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	25 January 1996	Angrabeit, F

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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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

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