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(54) **Receiver and antenna incorporated in the receiver.**

(57) A receiver, comprising a plurality of antennas is set in a vehicle. Each antenna comprises a cylindrical bobbin and a dipole helical antenna wound on the bobbin. The bobbin is made of a synthetic resin and has a certain permittivity. The bobbin has flanged securing members at both ends and each securing member has a notch. To secure each antenna to a printed circuit board, built into the receiver, the notch of the securing member is fitted to the board. In this case, the arrangement of the antennas is determined in accordance with the electric field intensity and the electric field vector generated for various receiver setting positions in the vehicle.

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TECHNICAL FIELD

The present invention relates generally to a receiver and an antenna, and more particularly, to an antenna incorporated in a receiver, the combination of which is used as part of a "wireless control system" for the remote control of a vehicle mounted equipment by low intensity radio waves.

RELATED BACKGROUND ART

In the recent past, various types of motor vehicle equipment have been capable of remote control operation due to various types of wireless or remote control systems, one such system, is illustrated in Fig. 11, and includes a transmitter 33 that outputs a low intensity radio wave to a receiver 35 mounted on a vehicle 34. The transmitter 33 is typically incorporated into an ignition key 31 or a key holder 32 for convenience and ease in use by the vehicle's operator. In response to the low intensity signal, the receiver 35 effects operation of the equipment 36. It is possible in this way to lock or unlock the vehicle's doors, start the vehicle's engine as well as to control other vehicle functions at a location remote from the vehicle 34.

Initially, the receiver's antenna for such a system was positioned outside the vehicle 34. Nowadays, however, it is popular to mount the combination antenna receiver 35 in the automobile 34 and to remove any related projections from the exterior surface of the vehicle 34 in order to enhance the vehicle's appearance. Often times the receiver and antenna are mounted under the seat and in the trunk.

However, when the antenna is incorporated in the receiver, the particular mounting or positioning of the receiver and antenna in the vehicle is crucial to the operation of the system. The receiver's position, in particular, effects the gain and the directivity of the antenna. Antenna gain is defined as $G = 4_{\pi}P_r/P_t$ where P_t is the total power delivered to the antenna and P_r is the power radiated per unit solid angle in a given direction. Antenna directivity is defined as $D = P_r/P_a$ where P_a is the average power radiated per unit solid angle. Due to the fact that the vehicle itself is in large part a metallic envelope, the electric field used by the receiver inside the vehicle depends greatly on position of the antenna and receiver. Consequently, changes to the electric field, and to antenna gain and directivity in particular, are directly effected by the location and positioning of the antenna and receiver inside the vehicle 34.

Unfortunately, due to the limited space available for the receiver under a seat, in the trunk, or at the back of an instrument panel, it is difficult to design an antenna, with a sufficient amount of surrounding space, that can be incorporated into the receiver. Consequently, the electric field utilized by the antenna may be significantly weakened. Moreover, if the receiver is set under an adjustable seat capable of forward and backward movement, the electric field used by the antenna invariably changes depending on the seat's particular position. It is therefore highly desirable to design a receiver having an antenna that exhibits optional receiving characteristics for any given position the receiver is set in the vehicle.

In the above system, the low intensity radio wave generally uses a frequency in the ultra high frequency (UHF) band. In the case where an antenna is incorporated a receiver using that frequency, a compact high-efficiency helical antenna is normally used. Moreover, it is popular to form the helical antenna into an hollow structure in order to improve the gain of the antenna.

Due to the very low air permittivity of hollow structured helical antenna, used in these types of applications, it is possible to enhance the receiving efficiency and greatly reduce the receiving loss of the antenna. A tradeoff of this, however, is that the resonance characteristic of the antenna becomes very sharp. Fluctuations to the receiver's tuning frequency, and advanced rates of antenna deterioration have been observed given various enhancements to the antenna's receiving efficiency. Moreover, because the antenna has a sharp resonance characteristic, impedance matching between the receiver and antenna becomes critical and difficult to achieve during the manufacturing process. Furthermore, the fluctuation of the tuning frequency of the antenna is influenced by a different electric field correspondingly to the receiver's position in an automobile. Therefore, particularly when the receiver is set under a seat, the tuning frequency of the antenna may fluctuate due to changes in the electric field state caused by changes in seat position. Moreover, due to the relatively low mechanical strength of hollow-structure helical antennas fluctuations in tuning frequency or deterioration with age is often exacerbated unless securing means are adapted. Such securing means provide yet another limitation on the relatively unavailable space needed for the antenna and receiver.

DISCLOSURE OF THE INVENTION

Accordingly, it is a primary objective of the present invention to provide a receiver incorporating an antenna, both of which exhibit optimum receiving characteristics for a particular mounting or setting position.

It is another object of the present invention to provide an antenna to be incorporated in a receiver, that limits the amount of tuning frequency fluctuations and antenna deterioration, and that facilitates impedance matching between the antenna and the receiver during their manufacture.

To achieve the foregoing and other objects and in accordance with the purpose of the present invention, a receiver positioned in a vehicle is provided. The receiver has a plurality of antennas arranged in accordance with the electric field intensity surrounding the antennas and varies depending on the position of the receiver in the vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of the present invention that are believed to be novel are set forth with particularity in the appended claims. The invention, together objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Figs. 1 to 6 illustrates a first embodiment of an antenna built into the receiver according to the present invention.

Fig. 1 is a perspective view showing a printed circuit board and one mode of antenna configuration used in the constructing the receiver according to a first embodiment of the present invention;
Fig. 2 is a perspective view showing a printed circuit board and a second mode of antenna configuration used in the construction of the receiver according to the present invention;
Fig. 3 is a perspective view showing a printed circuit board and a third mode of antenna configuration used in the construction of the receiver according to the present invention;
Fig. 4 is a block circuit diagram illustrating a remote control system;
Fig. 5 illustrates a pattern of electromagnetic field distribution corresponding to the antenna as configured according to the first mode;
Fig. 6(a) is a directional characteristic diagram of the antenna showing the radiation pattern of a signal according to the second mode;
Fig. 6(b) is a directional characteristic diagram of the antenna showing the radiation pattern of a signal according to the second mode;
Fig. 6(c) is a directional characteristic diagram of the antenna showing the radiation pattern of a signal according to the second mode;
Figs. 7 to 10 illustrate an antenna built into the receiver according to a second embodiment of the present invention.
Fig. 7 is a plan view showing an antenna to be built in the receiver of the first mode;
Fig. 8 is a side view showing an antenna to be built in the receiver of the first mode;
Fig. 9 is a plan view showing an antenna to be built in the receiver of the second mode;
Fig. 10 is a side view showing an antenna to be built in the receiver of the second mode; and
Fig. 11 is a schematic view showing a general remote control system according to the conventional art.

DETAILED DESCRIPTION OF SPECIAL EMBODIMENTS

The following is the description of the first and second embodiments of the present invention used in a remote control system to remotely control vehicle equipment. With respect to the receiver and antenna of the present invention, the basic constitution common to the both embodiments is provided with the same reference numeral for description.

(First embodiment)

A receiver incorporating an antenna of the first embodiment is described below with reference to the accompanying drawings. As shown in Fig. 4, a remote control system has a transmitter 15 incorporated in an ignition key (not shown) for transmitting low intensity electric signals. A receiver 17 positioned in an automobile 16 receives the signals from the transmitter 15. The equipment 18 mounted in the automobile 16 operates according to the signals to selectively open and close the car door. Figs. 1 to 3 are perspective views illustrating three modes or patterns in which an antenna is incorporated into a receiver built on a printed circuit board according to the first embodiment of the present invention.

Fig. 1 shows the receiver and antenna of the first mode. Two helical antennas 12a and 12b having the same constitution are set on a printed circuit board 11 to be built in the receiver 17. The central axes 13a and 13b of the antennas 12a and 12b are parallel to each other and correspond to z axis as shown in Fig. 1.

Fig. 2 shows the receiver and antenna of the second mode.

Two helical antennas 12x and 12y having the same constitution are set on a printed circuit board 11. The central axes 13x and 13y of the antennas 12x and 12y are perpendicular to each other and correspond to x and y axes shown in Fig. 2.

Fig. 3 shows the receiver and antenna of the third mode. Three helical antennas 12x to 12z having the same constitution are set on a printed circuit board 11. The central axes of 13x to 13z of the associated antennas 12x to 12z are perpendicular to each other and correspond to x, y, and z axes in Fig. 3.

As illustrated in Fig. 4, a synthetic matching circuit 13 and a receiving circuit 14 are formed on a printed circuit board 11. Signal combination and impedance matching between the antennas 12a and 12b or 12x to 12z and the receiving circuit 14 is performed by the synthetic matching circuit 13. That is, the signals from each of the antennas 12a and 12b or 12x to 12z are synthesized by the receiving circuit 14. A further function of the synthetic matching circuit 13 is as a general impedance matching circuit comprising a coil and a capacitor.

The following advantages can be obtained from each mode as illustrated. The first advantage is that the antenna volume increases and thereby the frequency band width of the antenna can be increased because each mode synthesizes operations by using the antennas 12a and 12b or 12x to 12z. As a result, it is possible to decrease the effects of a changing electric field, due to differences in the positioning or setting of the receiver, on reception characteristics of the receiver 17. This, in turn, increases the distances over which the remote control system functions, as well as improve the directivity of the system.

The second advantage, is that optimum signal reception characteristics can be obtained by properly selecting one first through third modes or antenna receiver 17 configurations appropriate to the state of the electric-field (intensity or vector magnitude of the electric field) an any given instance.

In the case of the electric-field distribution under a seat 21 set in an vehicle, the x and y axis components decrease and the z-axis component increases as shown in Fig. 5. This is because an electric field is formed between the ceiling and chassis of seat 21 of the automobile 16. Further, as shown in Fig. 5, even in the case where the receiver 17 is provided under the same seat 21, the magnitude of the z-axis component of the electric field changes depending on the position of seat 21. This is because the shapes of the ceiling, the frame of seat 21 and the chassis are respectively complicated. Moreover, when the seat 21 can be slid forward and backward, the electric field changes in accordance with the difference of the adjusted position of the seat 21.

The first mode shown in Fig. 1 is effective for setting the receiver 17 under the seat 21. This is because, referring to vector notation, even if the z-axis component of the electric field corresponding to one of the two or more vertically parallel antennas, e.g. 12a, is small, it is possible to match the z-axis component of the electric field corresponding to the other antenna 12b to a certain degree. Therefore, an adequate receiving gain can be obtained when both of the antennas 12a and 12b are used.

The electric-field vector may differ significantly depending on the receiver 17 setting or position in the automobile 16. For example, in Figs. 6(a) to 6(c), it is assumed that the antenna 12y (y axis) has the directivity, relative to the automobile 16, as shown in Fig. 6(a) and the antenna 12x (x axis) has the directivity shown in Fig. 6(b). In such a case, the second mode shown in Fig. 2 would be most effective. That is, in the second mode electric fields in two directions of x and y axes can be received. This arrangement of antennas 12x and 12y results in a radiation distribution pattern as shown in Fig. 6(c), assuring adequate reception of gain.

The third mode shown in Fig. 3 can receive electric fields in three directions of x, y, and z axes because it is provided with the antenna 12z corresponding to z axis in addition to the case of the second mode. This mode can be utilized where in a more complicated electric-field vector states exist.

Therefore, by selecting the central axis direction of each of the antennas 12a and 12b or 12x to 12z correspondingly to the difference of the electric field vector depending on the receiver setting position, the directional property of the receiver can be made almost nondirectional. Thus, the effective distance of operating a "remote control system" and the directivity of the system remain uninfluenced by differences in the receiver 17 setting position in the automobile 16.

(Second embodiment)

An antenna to be incorporated in the receiver of the second embodiment is described below by referring to the accompanying drawings. Fig. 7 shows a plan view of the antenna to be incorporated in the receiver 17 of the first mode of this embodiment and Fig. 8 shows a side view of the antenna.

An antenna 101 of the first mode comprises a cylindrical bobbin 102 and a dipole helical antenna 103 wound on the bobbin 102. The bobbin 102 is made of a material with a proper permittivity and has a flanged antenna-securing member 104 at its both ends, and the securing member 104 has a notch 104a. The notch 104a is fitted to the end of a printed circuit board 105 having an internal circuit of a receiver 17. With this structure, it is possible to secure the antenna 101 to the printed circuit board 105. Moreover, the end 103a of the antenna 103 is inserted into a through-hole 105a formed on the printed circuit board 105. Then, the end 103a is soldered to a printed pattern 105b formed on the back of the printed circuit board 105. Thus, the internal circuit of the receiver can be connected to the antenna 101.

Fig. 9 shows a plan view of an antenna to be incorporated in the receiver 17 of the second mode of this embodiment and Fig. 10 shows a side view of the antenna. An antenna 111 of this mode comprises a cylindrical bobbin 112 having the bottom and a monopole helical antenna 113 wound on the bobbin 112. The bobbin 112 is made of a material having a proper permittivity and has a threaded hole (not shown) at its bottom. The bobbin 112 is set on a printed circuit board 115 serving as a component of the receiver 17. A bolt 116 is inserted into a threaded hole (not shown) formed on the board 115 and the threaded hole at the bottom of the bobbin 112 and secured with a nut 117. With this structure, it is possible to secure the antenna 111 to the printed circuit board 115. One end 113a of the antenna 113 is inserted into a through-hole (not shown) formed on the printed circuit board 115 and soldered to a printed pattern (not shown) formed on the back of the printed circuit board 115. Thus, it is possible to connect the internal circuit of the receiver 17 to the antenna 111. The bobbin 112 has a protrusion 112a at its outer wall so as to secure a lead section 113b following the end 113a of the antenna 113 with the protrusion 112a.

As described above, by using the bobbins 102 and 112 constructed with a certain permittivity for the antennas 101 and 111 of each mode, a proper loss can be given to the antennas 101 and 111 to set widely the characteristic of resonance with the receiver 17.

For example, when the bobbins 102 and 112 are formed of a synthetic resin, a desired resonance characteristic can be obtained by properly selecting the synthetic resin. The proper permittivity values for various resins is, polypropylene (2.2), ABS (2.6), polyacetal (3.7), and nylon (4.6). As the permittivity of the bobbins 102 and 112 increases, the resonance characteristic of the antennas 101 and 111 becomes wider. Therefore, when nylon among the above synthetic resins is used as the material of the bobbins 102 and 112, the resonance characteristic of the antennas 101 and 111 becomes the widest.

The antennas 101 and 111 consequently will exhibit no significant any fluctuation in tuning frequency or deterioration over time. Moreover, this design facilitates the matching operation between the antenna and the receiver 17 during the manufacturing process. Furthermore, because the antenna has a small tuning-frequency fluctuation, it is not much effected by the electric field at the receiver 17 setting position in the automobile 16. Thus, even if the receiver 17 incorporating the antennas 101 and 111 is set under a slidable seat, the fluctuations in the tuning frequency of the antennas 101 and 111, caused by the difference of the adjusted position of the seat, can be reduced.

It should be noted that when the antennas 103 and 113 experience a loss, their efficiency will decrease. In this case, however, this presents no practical problem because a compensating receiving gain can be obtained by enlarging the size of the antennas 103 and 113, increasing the antenna's volume.

With respect to the antenna 101 as shown in Fig. 7, it is possible to form the antenna securing member 104 integrally with the bobbin 102 by forming the bobbin 102 with a synthetic resin. Also in the case of the antenna 111, the bottom of the bobbin 112 functioning as an antenna securing member can be formed integrally with the bobbin 112 by forming the bobbin 112 with a synthetic resin.

With such structure, the mechanical strength of the antennas 101 and 111 can be increased without separately providing securing means. Moreover, it is possible to firmly secure the antennas 101 and 111 to the printed circuit boards 105 and 115 respectively and solve the problems such as tuning frequency fluctuation and deterioration of the antennas 101 and 111 over time. Furthermore, because the antenna 101 is not set on the printed circuit board 105, the size of the board 105 can be reduced.

Although only two embodiments of the present invention have been described herein, it should be apparent to those skilled in the art that the present invention may be embodied in many other specific forms without departing from the spirit or scope of the invention. Particularly, it should be understood that the present invention may be embodied in the modes described below.

In the circuit constitution shown in Fig. 4, the synthetic matching circuit 13 and replaced with equivalent circuitry in the printed pattern of the input section of the receiving circuit, in order to perform impedance matching with respect to antennas 12a and 12b or 12x to 12z.

In the case of the first mode shown in Fig. 1, three or more helical antennas may be set in parallel with one another. Moreover, it is possible to use the first mode in Fig. 1 and the second mode in Fig. 2 or the third mode in Fig. 3 at the same time. That is, two or more helical antennas may be set with respect to x and y axes or x, y, and z axes.

In the modes shown in Figs. 1 to 3, it is also possible to change the angle between the antennas 12a and 12b or 12x to 12z to a proper angle other than 90° in accordance with an electric field vector.

In the modes shown in Figs. 1 to 3, the antennas 12a and 12b or 12x to 12z may be replaced with other type of antennas (e.g. rod antennas, flat antennas, or even antennas formed by printed patterns on the printed circuit board 11).

In the case of the antenna 101 shown in Figs. 7 and 8, a monopole helical antenna may also be used instead. Moreover, a dipole helical antenna may be used for the antenna 111 shown in Figs. 9 and 10.

Further, the modes shown in Figs. 1 to 3 and the modes shown in Figs. 7 to 10 can be used in combination. That is, the antennas 12a and 12b or 12x to 12z may be formed by winding them on a cylindrical bobbin made of a material with a proper permittivity. It is thus possible to construct a receiver with higher performance because of the synergistic effect obtained by the modes shown in Figs. 1 to 3 as well as the modes shown in Figs. 7 to 10.

Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope of the appended claims.

Claims

1. A receiver set in a vehicle (16) and having a receiving antenna element incorporated in the receiver and includes a plurality of helical antennas (12a and 12b or 12x to 12z) characterized in that an arrangement of the helical antennas (12a and 12b or 12x to 12z) is determined in accordance

with an electric field intensity surrounding the antenna and varying based on the position of the receiver in said vehicle (34).

2. The receiver according to Claim 1, wherein said helical antennas (12a and 12b or 12x to 12z) are formed on a printed circuit board (11) to be built in the receiver.

3. The receiver according to Claim 2, wherein said helical antennas (12a and 12b or 12x to 12z) respectively have central axes extending vertically parallel to each other.

4. The receiver according to Claim 2, wherein said helical antennas (12a and 12b or 12x to 12z) respectively have central axes extending perpendicularly to each other in the horizontal direction in respect with the printed circuit board (11).

5. The receiver according to Claim 2, wherein said helical antennas (12a and 12b or 12x to 12z) respectively have central axes extending perpendicularly to each other in the vertical and horizontal directions in respect with the printed circuit board (11).

6. The receiver according to Claim 2, wherein said printed circuit board (11) comprises a synthetic matching circuit (13) and a receiving circuit (14) and said synthetic matching circuit (13) is constituted so as to synthesize the operations of said helical antennas (12a and 12b or 12x to 12z) for said receiving circuit (14).

7. A remote control system having the receiver as claimed in any one of preceding claims, wherein said receiver receives instruction signals from a wireless remote controller using a low intensity radio wave to operate equipment mounted in the vehicle (16).

8. A receiving antenna to be incorporated in the receiver claimed in any one of Claims 1 to 6, characterized by that a helical antenna (103) is wound on a bobbin (102) made of a material having a proper permittivity.

9. The antenna according to Claim 8, wherein said bobbin (102) is made of a synthetic resin and formed into a cylinder and said helical antenna (103) is a dipole type.

10. The antenna according to Claims 8 or 9, wherein said bobbin (102) has flanged securing members (104) respectively formed at both ends of the bobbin (102), each of said securing members (104) has a notch (104a) for tightly receiving a printed circuit board (105) incorporate in the receiver (17).

11. The antenna according to Claim 10, wherein an end of said helical antenna (103) is soldered to the printed circuit board (105).

12. The antenna according to Claim 8, wherein said bobbin (112) is made of a synthetic resin and formed into a bottomed cylinder and said helical antenna (113) is a monopole type.

13. The antenna according to Claim 12, wherein said bobbin (112) is secured to a printed circuit board (115) incorporated in the receiver and said helical antenna (113) is soldered to the printed circuit board (115).

Fig.1

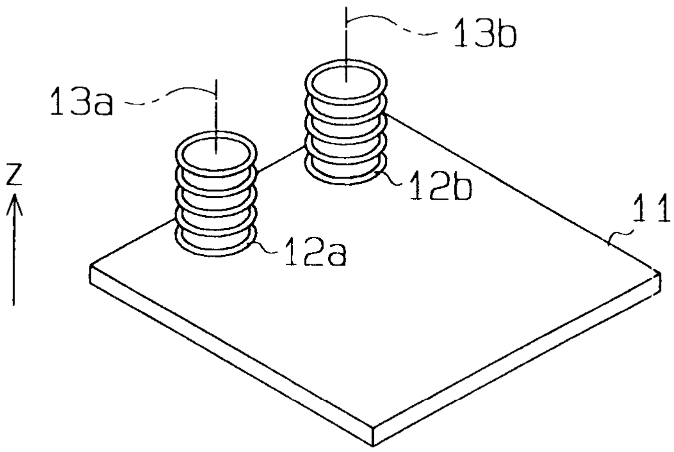


Fig.2

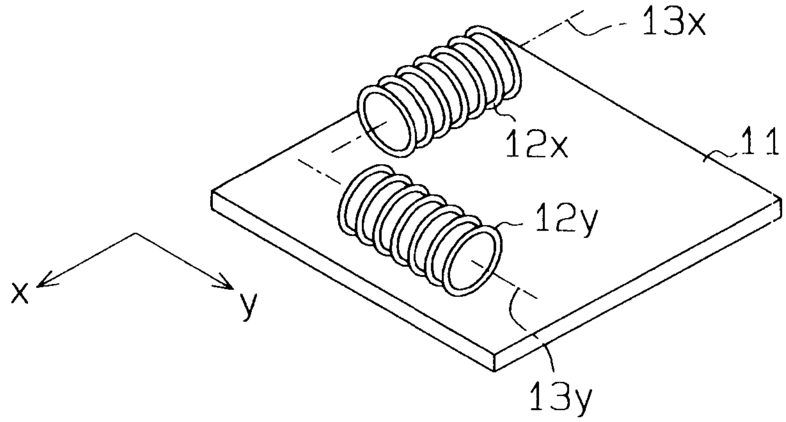
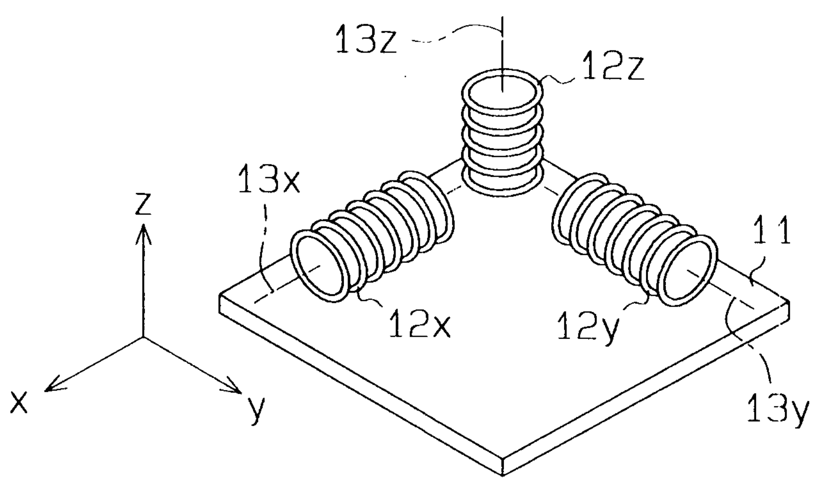


Fig.3



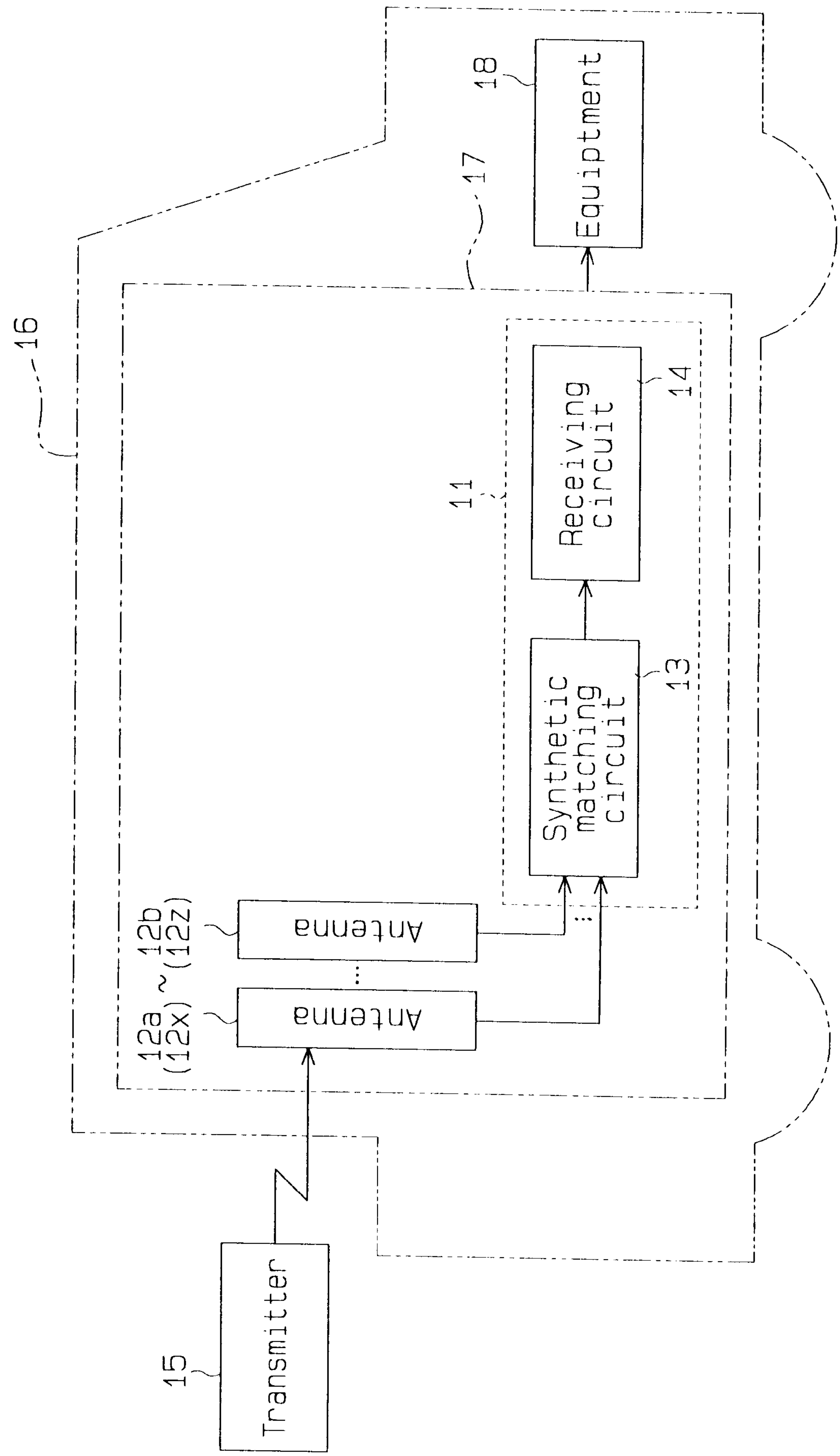
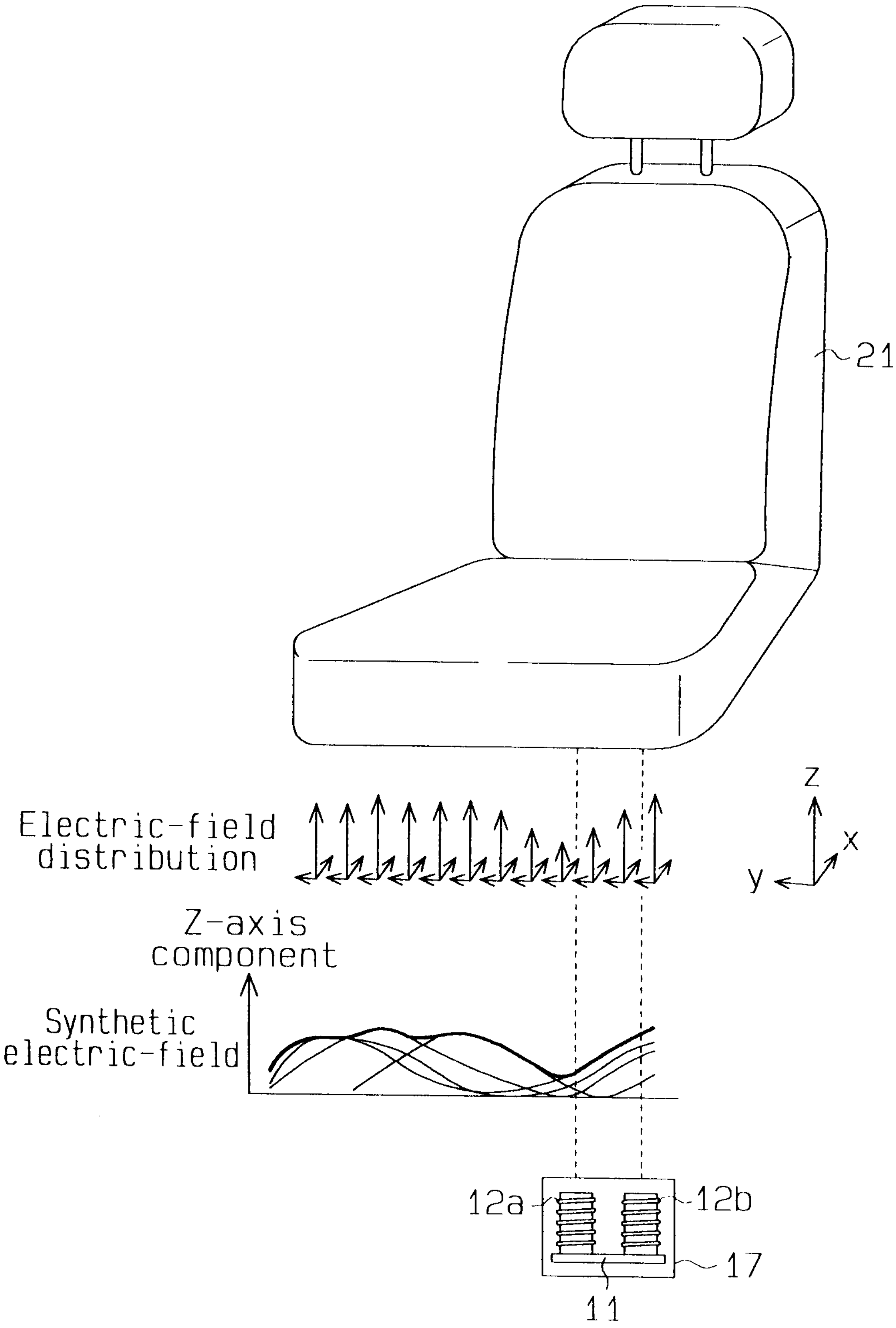

Equiptment
18
17
16
11
Receiving circuit
14
Synthetic matching circuit
13
Antenna
Antenna
12a (12x) ~ 12b (12z)
Transmitter
15

Fig. 4

FIg.5



21
Electric-field
distribution
Z
x
y
Z-axis
component
Synthetic
electric-field
12a
12b
17
11

Fig. 6

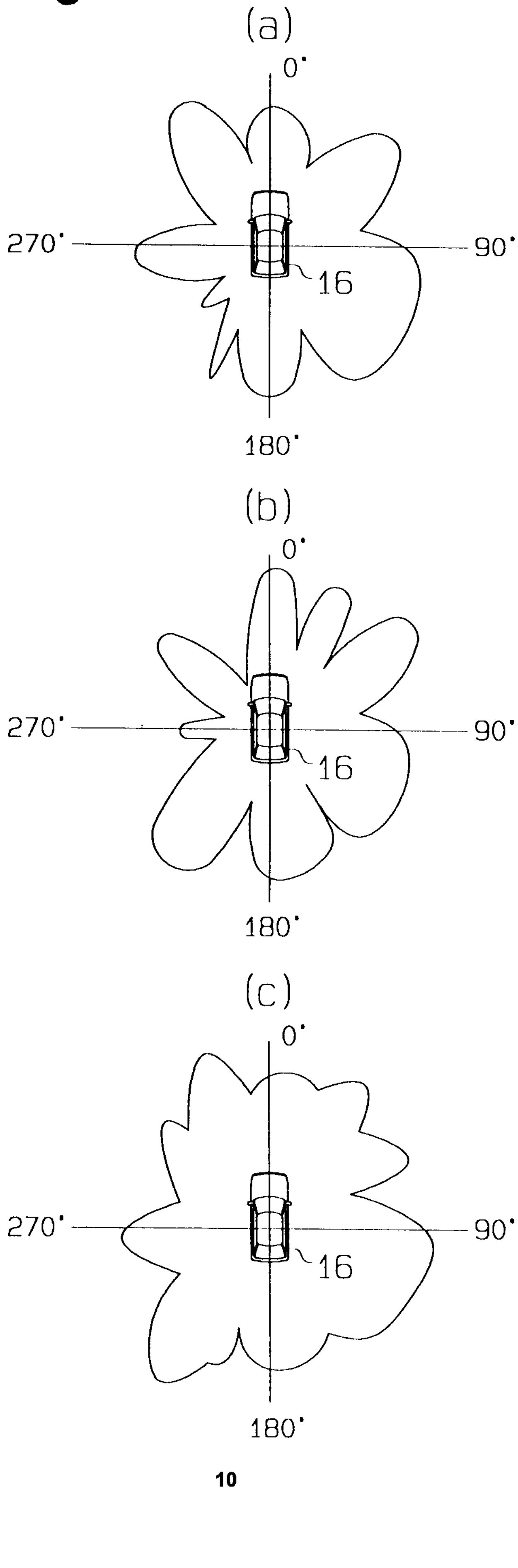
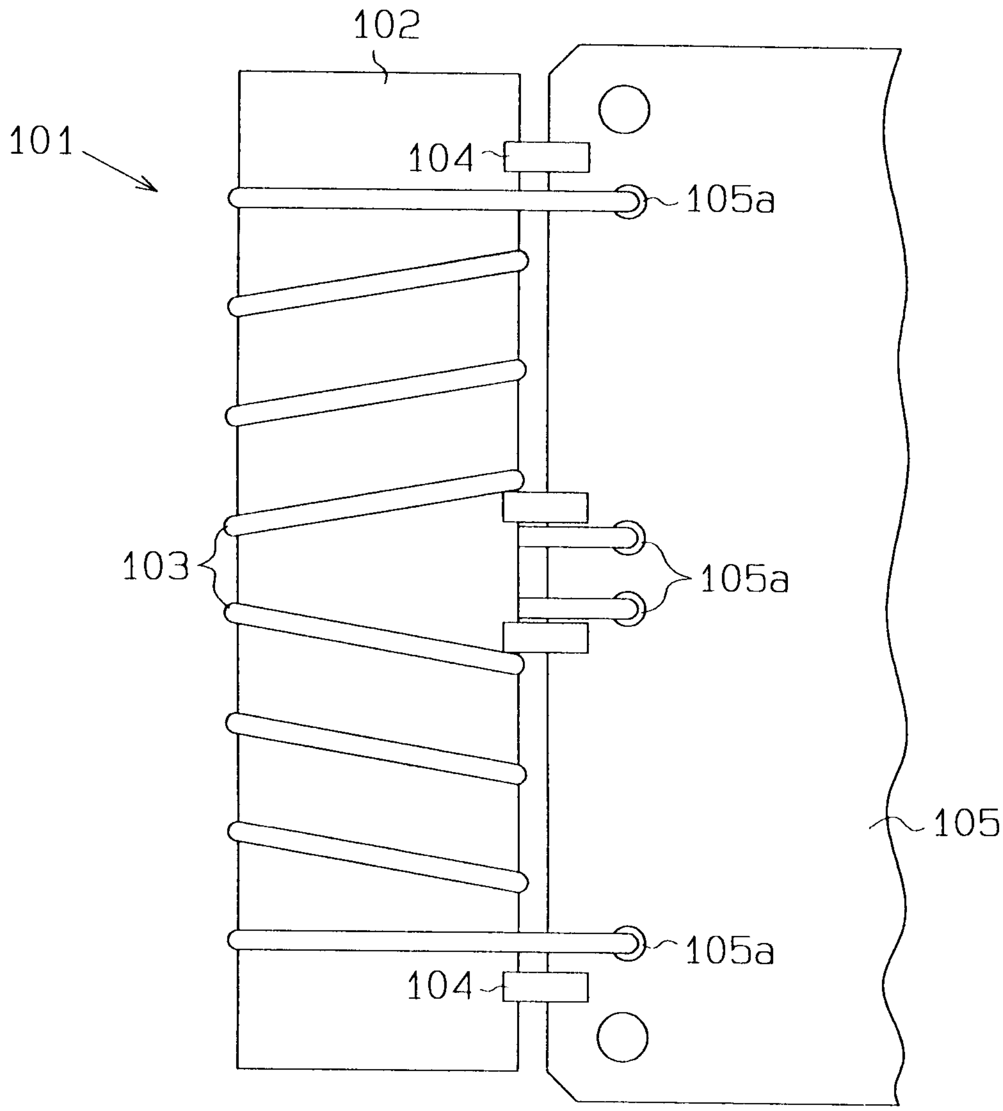
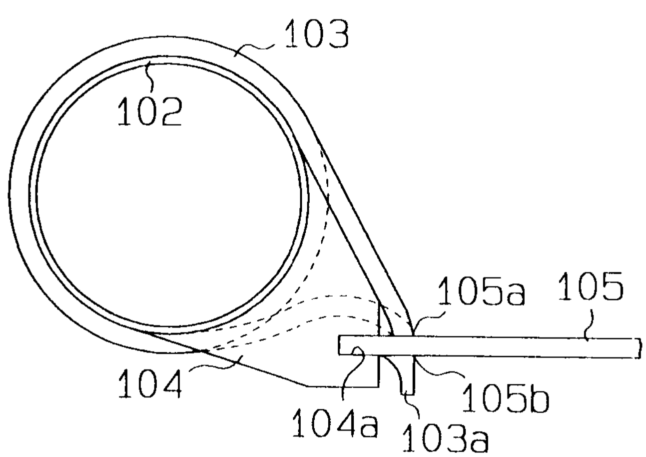


Fig.7



102
101
104
105a
103
105a
105
105a
104

Fig.8



103
102
105a
105
104
104a
103a
105b

Fig.9

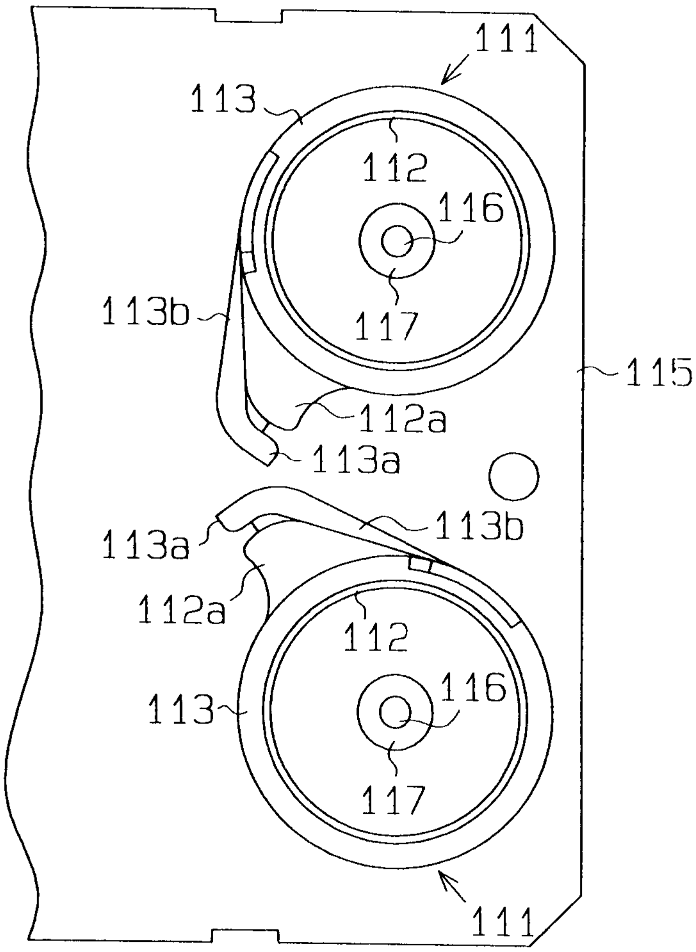

111
113
112
116
113b
117
115
112a
113a
113a
113b
112a
112
113
116
117
111

Fig.10

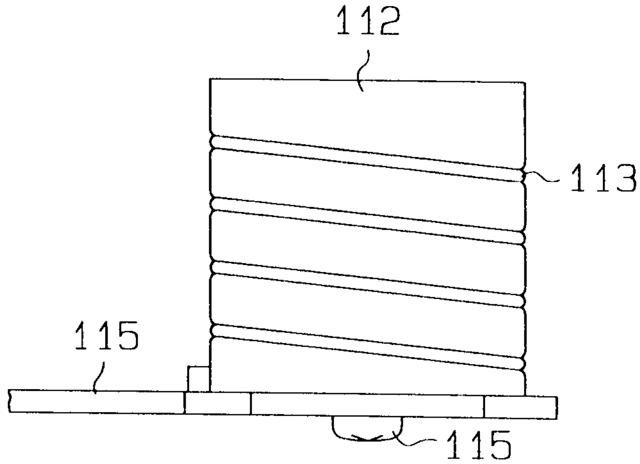

112
113
115
115

Fig.11