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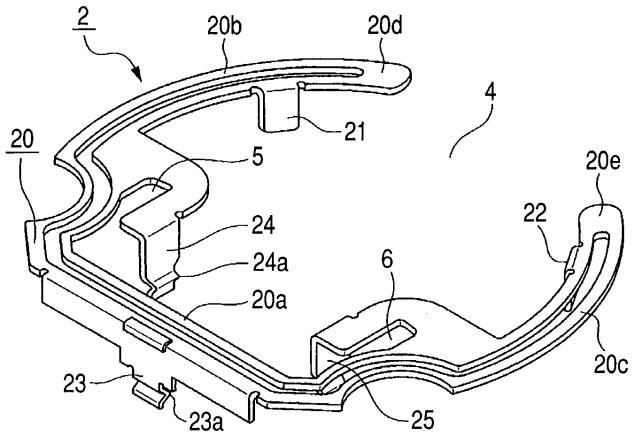
(54) Antenna device

(57) An antenna device includes a circuit board (3) on which a ground conductor layer (33) is provided, and a sheet-metal antenna element (2) that is mounted on the circuit board (3). The antenna element (2) includes a radiation conductor plate (20), a power supply metal piece (24), a ground metal piece (25), a first support metal piece (21), and a second support metal piece (22). The radiation conductor plate (20) is formed of a substantially C-shaped metal flat plate of which both ends face each other with an opened portion interposed therebetween, and is disposed substantially parallel to the circuit board (3) with a predetermined distance between the circuit board (3) and the radiation conductor plate (20). The power supply metal piece (24) and the ground metal piece (25) include power supply portions of the radiation conductor plate (20) as base ends, protrude toward the circuit board (3), and are electrically connected to the circuit board (3). The first support metal piece (21) includes a base end formed at a position deviated by a predetermined distance from one end of the radiation conductor plate (20) toward the power supply metal piece (24), and protrudes toward the circuit board (3). The second support metal piece (22) includes a base end formed at a position that is deviated by a predetermined distance from the other end of the radiation conductor plate (20) toward the ground metal piece (25), and protrudes toward the circuit board (3). The first and second support metal pieces (21 and 22) are mounted on the circuit board (3) at positions close to the ground conductor layer (33). The radiation conductor plate (20) is supported by the support metal pieces, the power supply metal piece (24), and the ground metal piece (25).

FIG. 1



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Description

Cross Reference to Related Application

[0001] The present invention contains subject matter related to Japanese Patent Application No. 2008-281550 filed in the Japanese Patent Office on October 31, 2008, the entire contents of which being incorporated herein by reference.

BACKGROUND

1. Technical Field

[0002] The present invention relates to an antenna device where a sheet-metal antenna element is mounted on a circuit board, and more particularly, to an antenna device that is suitable for being built in a main body of a headset.

2. Related Art

[0003] A wireless headset has been used in recent years. The wireless headset can receive audio signals such as music, which are sent from a sound source device such as portable audio equipment as near field communication signals, by antenna devices, and can output the audio signals from speakers as reproduced sound. When being used, this kind of headset is put on over the ears of a human body. An antenna device and a speaker are built in each main body of the headset.

[0004] An antenna device, where a sheet-metal antenna element is mounted on one surface of a substantially disk-shaped circuit board and the antenna element is operated as a dipole antenna, has been known in the related art of a built-in antenna for a headset (for example, see Japanese Unexamined Patent Application Publication No. 2008-92138). In the antenna device, a radiation conductor plate of the antenna element is formed of a metal flat plate that is disposed substantially parallel to the circuit board with a predetermined distance between the circuit board and the radiation conductor plate. The radiation conductor plate is formed in a substantially C shape and extends along the outer edge of the circuit board. Further, the antenna element is provided with a pair of metal pieces that is bent at a substantially right angle from two power supply portions of the radiation conductor plate and protrudes toward the circuit board. One metal piece of the metal pieces is connected to a power supply circuit by soldering, and functions as a power supply terminal. The other metal piece is connected to a ground circuit by soldering, and functions as a ground terminal. The pair of metal pieces is connected to the circuit board by soldering, so that the radiation conductor plate is supported by the metal pieces. As a result, the radiation conductor plate is maintained at an attitude that is substantially parallel to the circuit board. Further, it may be possible to make the radiation conductor plate, of which both ends are open ends, resonate by supplying a predetermined radio-frequency signal to the radiation conductor plate from the power supply circuit. The principle of the operation of the radiation conductor plate is the same as that of a half-wavelength dipole antenna.

[0005] Meanwhile, if a distance between both the ends of the substantially C-shaped radiation conductor plate is set to be small in the above-mentioned antenna device in the related art, it may be possible to increase the length of the radiation conductor plate without changing the size of the circuit board. Accordingly, it may be possible to reduce the size of the antenna device. Further, if the thickness of the antenna device is reduced by reducing the height of the radiation conductor plate with respect to the circuit board, the length of the radiation conductor plate should be set to be large in consideration of the influence of a ground conductor layer formed on the circuit board. For this reason, the distance between both the ends of the radiation conductor plate is reduced even in this case. However, as the distance between both ends of the radiation conductor plate is reduced, electric fields generated at both the ends offset each other, so that cancel components are increased. For this reason, the radiation efficiency of the antenna device deteriorates. Therefore, in the antenna device in the related art, required radiation efficiency has been secured by sufficiently increasing the distance between both the ends of the radiation conductor plate. However, as a result, there is a problem in that it is difficult to reduce the size or thickness of the antenna device.

[0006] Further, the radiation conductor plate formed of a metal flat plate is supported by a pair of metal pieces (the power supply terminal and the ground terminal) in the above-mentioned antenna device in the related art, so that the radiation conductor plate is maintained at an attitude that is substantially parallel to the circuit board. However, since only two portions of the substantially C-shaped radiation conductor plate are supported, it is difficult to secure stability, so that the radiation conductor plate is inclined. As a result, there is concern that the antenna characteristics deteriorate.

[0007] Furthermore, in the antenna device in the related art, the pair of metal pieces supporting the radiation conductor plate is connected to the power supply circuit and the ground circuit by soldering while being inserted into corresponding mount holes formed at the circuit board, respectively. However, since slight clearance exists between the metal piece and the inner wall of the mount hole in consideration of the workability when the metal pieces are inserted into the mount holes, the deviation corresponding to the clearance has occurred in the mounting position of the antenna element relative to the circuit board. That is, the deviation of the mounting position of the antenna element is apt to occur on the plane parallel to the principal surface of the circuit board. For this reason, when the size of the antenna device is reduced, there is a concern that the deviation of the antenna characteristics is caused.

SUMMARY

[0008] An advantage of some aspects of the invention is to provide an antenna device of which the size or thickness is easily reduced and which may prevent the deterioration of antenna characteristics caused by the inclination of a radiation conductor plate.

[0009] According to an aspect of the invention, an antenna device includes a circuit board on which a ground conductor layer is provided, and a sheet-metal antenna element that is mounted on the circuit board. The antenna element includes a radiation conductor plate, a power supply metal piece, a ground metal piece, a first support metal piece, and a second support metal piece. The radiation conductor plate is formed of a substantially C-shaped metal flat plate of which both ends face each other with an opened portion interposed therebetween, and is disposed substantially parallel to the circuit board with a predetermined distance between the circuit board and the radiation conductor plate. The power supply metal piece and the ground metal piece include power supply portions of the radiation conductor plate as base ends, protrude toward the circuit board, and are electrically connected to the circuit board. The first support metal piece includes a base end formed at a position deviated by a predetermined distance from one end of the radiation conductor plate toward the power supply metal piece, and protrudes toward the circuit board. The second support metal piece includes a base end formed at a position deviated by a predetermined distance from the other end of the radiation conductor plate toward the ground metal piece, and protrudes toward the circuit board. The first and second support metal pieces are mounted on the circuit board at positions close to the ground conductor layer. The radiation conductor plate is supported by the support metal pieces, the power supply metal piece, and the ground metal piece.

[0010] In the antenna device having the above-mentioned structure, plural portions of the substantially C-shaped radiation conductor plate may be supported by the first and second support metal pieces, the power supply metal piece, and the ground metal piece so as to be balanced. Accordingly, the alignment of the radiation conductor plate, which is disposed substantially parallel to the circuit board, is stable, so that the concern over the inclination of the radiation conductor plate is decreased. As a result, the deterioration of the antenna characteristics, which is caused by the inclination of the radiation conductor plate, hardly occurs. Further, since the first and second support metal pieces are mounted on the circuit board at positions close to the ground conductor layer, charges are accumulated between the ground conductor layer and each of the support metal pieces during the supply of electric power. Accordingly, the resonant frequency of the antenna element is lowered, so that it may be possible to reduce the size of the antenna element that can resonate at a desired frequency. Alternatively, due to the same reason, it may be possible to increase the length of the radiation conductor plate without changing the resonant frequency. Accordingly, it may be possible to reduce the thickness of the antenna device by reducing the height of the radiation conductor plate with respect to the circuit board.

[0011] In the antenna device having the above-mentioned structure, the antenna element may include a third support metal piece. The third support metal piece may include a base end formed at a portion of the radiation conductor plate most distant from the opened portion, and protrude toward the circuit board along a plane substantially orthogonal to the power supply metal piece and the ground metal piece that face each other so as to be substantially parallel to each other. Locking protrusions may be formed at the ends of the third support metal piece, the power supply metal piece, and the ground metal piece, respectively. The three metal pieces may be inserted into corresponding mount holes formed at the circuit board, respectively, and be snap-fitted to the circuit board. In this case, since five portions of the substantially C-shaped radiation conductor plate may be supported by the first to third support metal pieces, the power supply metal piece, and the ground metal piece so as to be balanced, the attitude of the radiation conductor plate is more stable. Therefore, there is no concern that the radiation conductor plate is inclined. Further, the power supply metal piece, the ground metal piece, and the third support metal piece are inserted into corresponding mount holes of the circuit board, respectively, and are snap-fitted to the circuit board, so that it may be possible to temporarily fix the antenna element to the circuit board. As a result, it may be possible to easily mount the antenna element. In addition, the power supply metal piece and the ground metal piece, which face each other so as to be substantially parallel to each other, are snap-fitted to the circuit board. Accordingly, the antenna element is positioned in an X direction orthogonal to the opposite surfaces of the power supply metal piece and the ground metal piece. Further, the third support metal piece, which is substantially orthogonal to the power supply metal piece and the ground metal piece, is snap-fitted to the circuit board. Accordingly, the antenna element is positioned in a Y direction orthogonal to the X direction. Therefore, the mounting position accuracy of the antenna element on a plane parallel to the principal surface of the circuit board is improved. As a result, the deviation of the antenna characteristics, which is caused by the deviation of the mounting position of the antenna element, hardly occurs.

[0012] Further, in the antenna device having the above-mentioned structure, the circuit board may have a substantially disk shape and the radiation conductor plate may extend along the outer edge of the circuit board. Accordingly, it may be possible to integrate the antenna element and the circuit board so that the antenna element and the circuit board become compact. Therefore, this is suitable for reducing the antenna device. In this case, the antenna element and the circuit board may

be built in each of main bodies of a headset, so that a near field communication signal can be received. Accordingly, the size of the main body is easily reduced, so that it may be possible to obtain a compact headset.

[0013] In the antenna device according to the aspect of the invention, the radiation conductor plate may be supported by the first and second support metal pieces, the power supply metal piece, and the ground metal piece so as to be balanced. Accordingly, the attitude of the radiation conductor plate, which is disposed substantially parallel to the circuit board, is stable, so that it may be possible to prevent the deterioration of antenna characteristics caused by the inclination of the radiation conductor plate. Further, since the first and second support metal pieces are mounted on the circuit board at positions close to the ground conductor layer, charges are accumulated between the ground conductor layer and each of the support metal pieces during the supply of electric power. Accordingly, it may be possible to easily reduce the size or thickness of the antenna element.

[0014] In addition, in the antenna device according to the aspect of the invention where the power supply metal piece, the ground metal piece, and the third support metal piece are inserted into the corresponding mount holes of the circuit board, respectively, and are snap-fitted to the circuit board, the attitude of the radiation conductor plate is more stable. Therefore, there is no concern that the radiation conductor plate is inclined, the mounting workability of the antenna element is improved, and the mounting position accuracy of the antenna element on a plane parallel to the principal surface of the circuit board is improved. As a result, the deviation of the antenna characteristics, which is caused by the deviation of the mounting position of the antenna element, hardly occurs.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1 is a perspective view of an antenna element according to an embodiment of the invention.

Fig. 2 is a perspective view of the entire antenna device where the antenna element is mounted on a circuit board.

Fig. 3 is a plan view of the antenna device.

Fig. 4 is a sectional view taken along a line A-A of Fig. 3.

Fig. 5 is an enlarged view of a C portion of Fig. 4.

Fig. 6 is a sectional view taken along a line B-B of Fig. 3.

Fig. 7 is a characteristic diagram showing the reflective properties of the antenna element and a comparative example.

Fig. 8 is a view showing the modification of a locking protrusion that is formed at the antenna element.

Fig. 9 is a view showing the appearance of a headset where the antenna devices are built in main bodies.

DESCRIPTION O+F EXEMPLARY EMBODIMENTS

[0016] An embodiment of the invention will be described with reference to the drawings. Fig. 1 is a perspective view of an antenna element according to an embodiment of the invention. Fig. 2 is a perspective view of the entire antenna device where the antenna element is mounted on a circuit board. Fig. 3 is a plan view of the antenna device. Fig. 4 is a sectional view taken along a line A-A of Fig. 3. Fig. 5 is an enlarged view of a C portion of Fig. 4. Fig. 6 is a sectional view taken along a line B-B of Fig. 3. Fig. 7 is a characteristic diagram showing the reflective properties of the antenna element and a comparative example. Meanwhile, wiring patterns or electronic components, which are mounted on a circuit board, are not shown in Figs. 2 to 6 in order to avoid complicating the drawings.

[0017] An antenna device 1 shown in Figs. 2 to 6 has a schematic structure where a sheet-metal antenna element 2 is mounted on a circuit board 3. Metal pieces 23 to 25 (to be described below) of the antenna element 2 are inserted into mount holes 30 to 32 that are formed at a circuit board 3. The circuit board 3 has a substantially disk shape, and a ground conductor layer 33 is formed on substantially the entirety of one principal surface of the circuit board, which faces a radiation conductor plate 20 of the antenna element 2. Further, an antenna circuit (not shown), which includes a power supply circuit, a matching circuit, or the like, is provided on the other principal surface of the circuit board 3.

[0018] The antenna element 2 includes a radiation conductor plate 20 and five metal pieces 21 to 25. The radiation conductor plate 20 is formed of a metal flat plate that is disposed substantially parallel to the circuit board 3 with a predetermined distance between the circuit board and the radiation conductor plate. The five metal pieces 21 to 25 are bent at five predetermined portions of the radiation conductor plate 20 at a substantially right angle and protrude toward the circuit board 3. As shown in Fig. 1, the radiation conductor plate 20 has a substantially C shape where curved portions 20b and 20c extend from both ends of a linear portion 20a toward an opened portion 4, and cuts 5 and 6 for adjusting impedance are formed at the curved portions 20b and 20c, respectively. Further, both ends 20d and 20e of the radiation conductor plate 20, which correspond to the ends of the curved portions 20b and 20c, face each other with the opened portion 4 interposed therebetween. The radiation conductor plate 20 extends along the outer edge of the circuit board 3.

[0019] The five metal pieces 21 to 25 of the antenna element 2 are composed of first to third support metal pieces 21 to 23, a power supply metal piece 24, and a ground metal piece 25. Among the metal pieces, the first support metal piece 21 includes a base end formed at a predetermined position near the end 20d, and extends downward from the curved portion 20b so as to be perpendicular to the curved portion. Further, the second sup-

port metal piece 22 includes a base end formed at a predetermined position near the end 20e, and extends downward from the curved portion 20c so as to be perpendicular to the curved portion. The position of the first support metal piece 21 is symmetrical with the position of the second support metal piece 22. The third support metal piece 23 includes a base end formed at a middle portion of the linear portion 20a, and extends downward from the linear portion at a position equidistant from the support metal pieces 21 and 22 so as to be perpendicular to the curved portion. As shown in Figs. 4 and 5, a locking protrusion 23a, which snap-fits the third support metal piece to the circuit board 3, is formed at the end of the third support metal piece 23. The power supply metal piece 24 and the ground metal piece 25 include power supply portions of the radiation conductor plate 20 as base ends, respectively, and extend downward from the curved portions 20b and 20c so as to be perpendicular to the curved portions. The position of the power supply metal piece 24 is symmetrical with the position of the ground metal piece 25. The power supply metal piece 24 is connected to a power supply circuit of the circuit board 3 by soldering, and functions as a power supply terminal. The ground metal piece 25 is connected to a ground circuit of the circuit board 3, and functions as a ground terminal. Further, as shown in Figs. 1 and 6, like the third support metal piece 23, locking protrusions 24a and 25a, which are snap-fitted to the circuit board 3, are formed at the ends of the metal pieces 24 and 25, respectively.

[0020] Meanwhile, the three metal pieces 23 to 25, which include the locking protrusions 23a to 25a at the ends thereof, are longer than the first and second support metal pieces 21 and 22 that are formed in the flat plate shape (see Fig. 4). Further, in this embodiment, the locking protrusions 23a to 25a have been formed in the shape of a protrusion by bending. However, the shape of the locking protrusions 23a to 25a may be appropriately selected. For example, like a locking protrusion 24a shown in Fig. 8, the locking protrusion may be formed in the shape that is locally protruded by a punch or the like.

[0021] When the antenna element 2 is mounted on the circuit board 3, first, three long metal pieces 23 to 25 are inserted and snap-fitted to the corresponding mount holes 30 to 32 of the circuit board 3, respectively. That is, when the third support metal piece 23 is inserted into the mount hole 30 to a predetermined depth, the locking protrusion 23a is locked to the lower edge of the mount hole 30 due to the elasticity thereof (see Fig. 5). Likewise, the power supply metal piece 24 and the ground metal piece 25 are also locked to the lower edges of the mount holes 31 and 32, respectively (see Fig. 6). In this case, the power supply metal piece 24 and the ground metal piece 25, which face each other so as to be substantially parallel to each other, include the locking protrusions 24a and 25a on the opposite surfaces thereof. Accordingly, when the metal pieces 24 and 25 are snap-fitted to the circuit board, the area of the circuit board 3 between the mount holes 31 and 32 can be held by the locking protrusions 24a and 25a. As a result, the antenna element 2 is positioned in an X direction (in a horizontal direction of Fig. 6) that is orthogonal to the opposite surfaces.. Further, the third support metal piece 23 protrudes from linear portion 20a toward the circuit board 3 along a plane that is substantially orthogonal to the opposite surfaces of the metal pieces 24 and 25, and the locking protrusion 23a faces the area of the circuit board between the mount holes 31 and 32. Accordingly, when the third support metal piece 23 is snap-fitted to the circuit board, the locking protrusion 23a may push the metal pieces 24 and 25 against the side walls of the respective mount holes 31 and 32. As a result, the antenna element 2 is positioned in a Y direction (in a horizontal direction of Fig. 4) that is orthogonal to the X direction.

[0022] When the three metal pieces 23 to 25 are snap-fitted to the circuit board 3 in this way, the first and second support metal pieces 21 and 22 shorter than the metal pieces 23 to 25 are mounted on the areas of the circuit board 3 where the ground conductor layer 33 is not formed. Accordingly, the end of each of the support metal pieces 21 and 22 is disposed at a position close to the ground conductor layer 33 (see Fig. 2). As a result, the radiation conductor plate 20 having a substantially C shape is temporarily fixed to the circuit board 3 while five portions of the radiation conductor plate are supported by the first to third support metal pieces 21 to 23, the power supply metal piece 24, and the ground metal piece 25 so as to be balanced. Further, the three metal pieces 23 to 25 are snap-fitted to the circuit board as described above, so that the antenna element 2 is positioned in the X and Y directions on the plane parallel to the principal surface of the circuit board 3. Accordingly, the mounting position accuracy of the antenna element 2 on the circuit board 3 is also high.

[0023] After that, the power supply metal piece 24 and the ground metal piece 25 are connected to the power supply circuit and the ground circuit of the circuit board 3, respectively, by soldering, so that the antenna element 2 is really fixed to the circuit board 3. Meanwhile, since the impedance of the antenna device 1 may be adjusted by changing the dimensions of the cuts 5 and 6 formed at the curved portions 20b and 20c, the positions of the power supply portions do not need to be changed to adjust the impedance.

[0024] Since five portions of the radiation conductor plate 20, which is disposed substantially parallel to the circuit board 3, are supported by the metal pieces 21 to 25 so as to be balanced, the attitude of the radiation conductor plate 20 is stable. As a result, there is no concern that the antenna device 1, which has been completely assembled in this way, is inclined. Further, it may be possible to make the radiation conductor plate 20, of which both ends 20d and 20e are open ends, resonate by supplying a predetermined radio-frequency signal to the radiation conductor plate 20 from the power supply circuit of the circuit board 3. The principle of the operation of the radiation conductor plate is the same as that of a half-

wavelength dipole antenna. However, when electric power is supplied to the antenna element 2, a predetermined amount of charges are accumulated between the first support metal piece 21 and the ground conductor layer 33 or between the second support metal piece 22 and the ground conductor layer 33. Accordingly, the resonant frequency of the antenna element 2 is lowered due to the increase of the amount of charges near a voltage loop. Specifically, the resonant frequency of an antenna element according to a comparative example, which does not include the first and second support metal pieces 21 and 22, is about 2.6 GHz as shown by a broken line curve in Fig. 7. However, the resonant frequency of the antenna element 2 according to this embodiment is about 2.4 GHz as shown by a solid line curve in Fig. 7. For this reason, according to the antenna device 1, it may be possible to reduce the size of the antenna element 2 that can be resonated at a desired frequency. Further, due to the same reason, it may be possible to increase the length of the radiation conductor plate 20 without changing the resonant frequency. Accordingly, it may be possible to reduce the thickness of the antenna device 1 by reducing the height of the radiation conductor plate 20 with respect to the circuit board 3.

[0025] Since five portions of the substantially C-shaped radiation conductor plate 20 of the antenna device 1 according to this embodiment are supported by the first to third metal pieces 21 to 23, the power supply metal piece 24, and the ground metal piece 25 so as to be balanced as described above, the attitude of the radiation conductor plate 20, which is disposed substantially parallel to the circuit board 3, is very stable. For this reason, according to the antenna device 1, it may be possible to reliably prevent the deterioration of antenna characteristics that is caused by the inclination of the radiation conductor plate 20. Further, since the first and second support metal pieces 21 and 22 are mounted on the circuit board 3 at positions close to the ground conductor layer 33, charges are accumulated between the ground conductor layer 33 and each of the support metal pieces 21 and 22 during the supply of electric power. As a result, it may be possible to easily reduce the size or thickness of the antenna element 2. In addition, since the radiation conductor plate 20 extends along the outer edge of the substantially disk-shaped circuit board 3, it may be possible to integrate the antenna element 2 and the circuit board 3 so that the antenna element and the circuit board become compact. Even in this regard, it may be possible to easily reduce the size of the antenna device 1.

[0026] Meanwhile, if the first support metal piece 21 is disposed close to the end 20d or the second support metal piece 22 is disposed close to the end 22e, it may be possible to further reduce the size of the antenna element 2. However, since the first and second support metal pieces 21 and 22 are excessively close to each other in this case, cancel components of the electric field are increased. As a result, radiation efficiency deteriorates. For this reason, like this embodiment, it is preferable that the support metal pieces 21 and 22 be provided at positions deviated by a predetermined distance from the ends 20d and 22e of the radiation conductor plate 20 toward the power supply metal piece 24 and the ground metal piece 25, respectively.

[0027] Further, in the antenna device 1, the third support metal piece 23, the power supply metal piece 24, and the ground metal piece 25 are inserted into the corresponding mount holes 30, 31, and 32, respectively, and are snap-fitted to the circuit board 3. Accordingly, workability is good when the antenna element 2 is mounted on the circuit board 3. In addition, the three metal pieces 23 to 25 are snap-fitted to the circuit board, so that the antenna element 2 is positioned in both the X and Y directions on the plane parallel to the principal surface of the circuit board 3. Accordingly, the mounting position accuracy of the antenna element 2 on the circuit board 3 is improved. For this reason, the deviation of the antenna characteristics, which is caused by the deviation of the mounting position of the antenna element 2, hardly occurs.

[0028] Fig. 9 is a view showing the appearance of a headset where the antenna devices 1 are built in main bodies 10 and 11. The headset is a hands-free earphone, and a pair of main bodies 10 and 11, which are put on the left and right ears of a human body, are connected to each other by an elastic band 12. The structure of the main body 10 is basically the same as that of the main body 11, and the antenna device 1 or a speaker (not shown) are built in each of the main bodies. Meanwhile, the antenna device is designed so that the ground conductor layer of the circuit board 3 is positioned between the antenna element 2 and the ear of the human body when the antenna device is put on. Accordingly, since the ground conductor layer may function as a shielding member that electromagnetically shields the head of the human body from the antenna element 2, the antenna characteristics are stable. Further, the band 12 has a curve shape that corresponds to the shape of the head of the human body.

[0029] The headset where the antenna devices 1 are built in the main bodies 10 and 11 may receive audio signals such as music, which are sent from a sound source device such as portable audio equipment existing at a short distance, by the antenna devices 1 having an NFC (Near Field Communication) function, and may output the audio signals from speakers as reproduced sound. Since the size or thickness of the antenna element 2 is easily reduced as described above, the size and thickness of each of the main bodies 10 and 11 are easily reduced. As a result, a compact headset is obtained. Meanwhile, for example, Bluetooth (registered trademark) or the like is suitable as an NFC (Near Field Communication) protocol. Further, the headset may be formed to perform diversity reception by using the pair of antenna devices 1 that is built in the main bodies 10 and 11, respectively.

[0030] The antenna device 1 may be built in any one of the main bodies 10 and 11. Furthermore, if the antenna device 1 is built even in a headset other than a hands-free earphone, it may be possible to expect the same advantages.

[0031] It should be understood by those skilled in the art that various modifications, combinations, sub-combinations and alterations may be carried out depending on design requirements and other factors insofar as they are within the scope of the appended claims of the equivalents thereof.

Claims

1. An antenna device comprising:

a circuit board (3) on which a ground conductor layer (33) is provided; and
a sheet-metal antenna element (2) that is mounted on the circuit board (3),
characterized in that the antenna element (2) includes

a radiation conductor plate (20) that is formed of a substantially C-shaped metal flat plate of which both ends face each other with an opened portion interposed therebetween, and is disposed substantially parallel to the circuit board (3) with a predetermined distance between the circuit board (3) and the radiation conductor plate (20),
a power supply metal piece (24) and a ground metal piece (25) that include power supply portions of the radiation conductor plate (20) as base ends, protrude toward the circuit board (3), and are electrically connected to the circuit board (3),
a first support metal piece (21) that includes a base end formed at a position deviated by a predetermined distance from one end of the radiation conductor plate (20) toward the power supply metal piece (24), and protrudes toward the circuit board (3), and
a second support metal piece (22) that includes a base end formed at a position deviated by a predetermined distance from the other end of the radiation conductor plate (20) toward the ground metal piece (25), and protrudes toward the circuit board (3),

the first and second support metal pieces (21 and 22) are mounted on the circuit board (3) at positions close to the ground conductor layer (33), and
the radiation conductor plate (20) is supported by the support metal pieces, the power supply metal piece (24), and the ground metal piece (25).

2. The antenna device according to claim 1,
characterized in that the antenna element (2) includes a third support metal piece (23) that includes a base end formed at a portion of the radiation conductor plate (20) most distant from the opened portion and protrudes toward the circuit board (3) along a plane substantially orthogonal to the power supply metal piece (24) and the ground metal piece (25) that face each other so as to be substantially parallel to each other,
locking protrusions (23a, 23b, and 23c) are formed at the ends of the third support metal piece (23), the power supply metal piece (24), and the ground metal piece (25), respectively, and
the three metal pieces (23 to 25) are inserted into corresponding mount holes (30 to 32) formed at the circuit board (3), respectively, and are snap-fitted to the circuit board (3).

3. The antenna device according to claim 1 or 2,
characterized in that the circuit board (3) has a substantially disk shape, and
the radiation conductor plate (20) extends along the outer edge of the circuit board (3).

4. The antenna device according to claim 3,
characterized in that the antenna element (2) and the circuit board (3) are built in each of main bodies of a headset, so that a near field communication signal is received.

FIG. 1

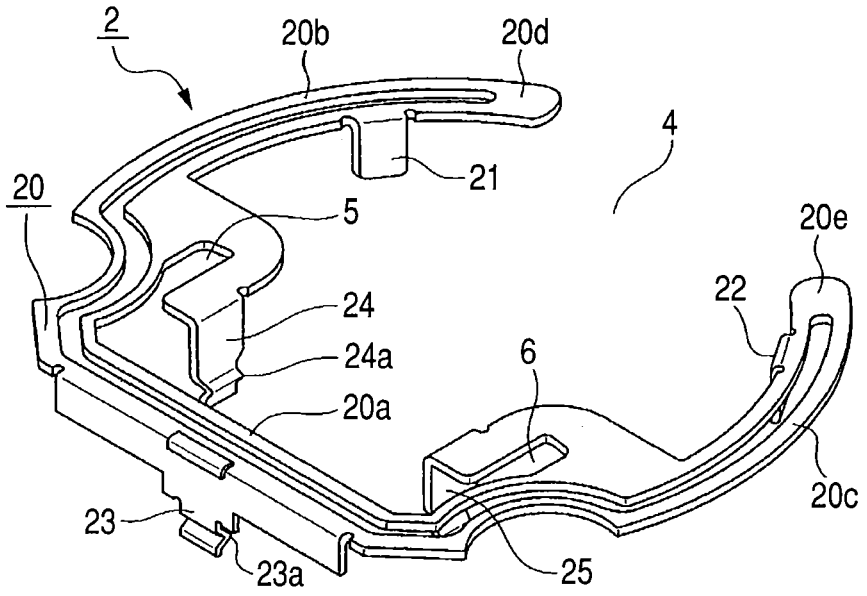
2
20b
20d
4
21
20
5
20e
22
24
24a
6
20a
20c
23
23a
25

FIG. 2

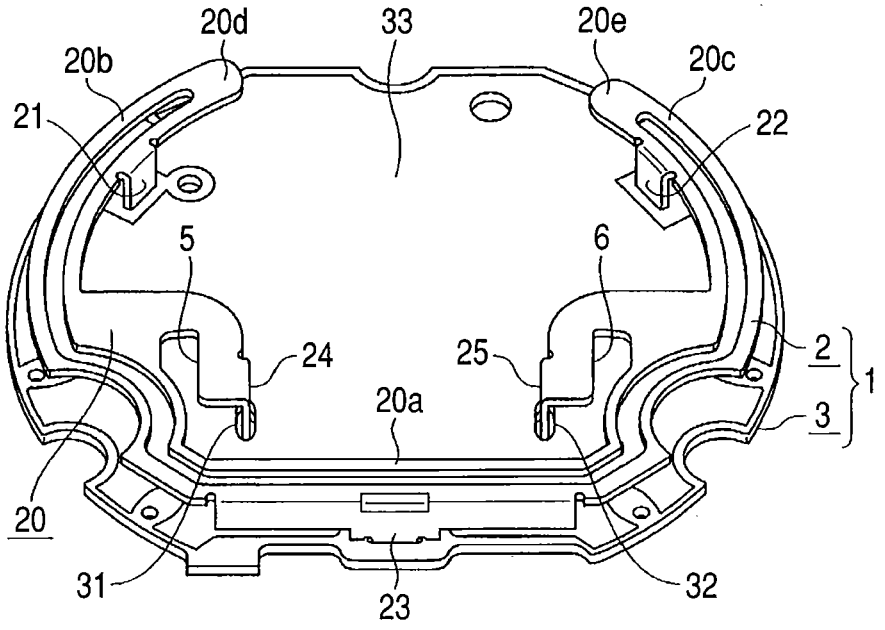
20d
33
20e
20b
20c
21
22
5
6
24
25
2
1
20a
3
20
31
23
32

FIG. 3

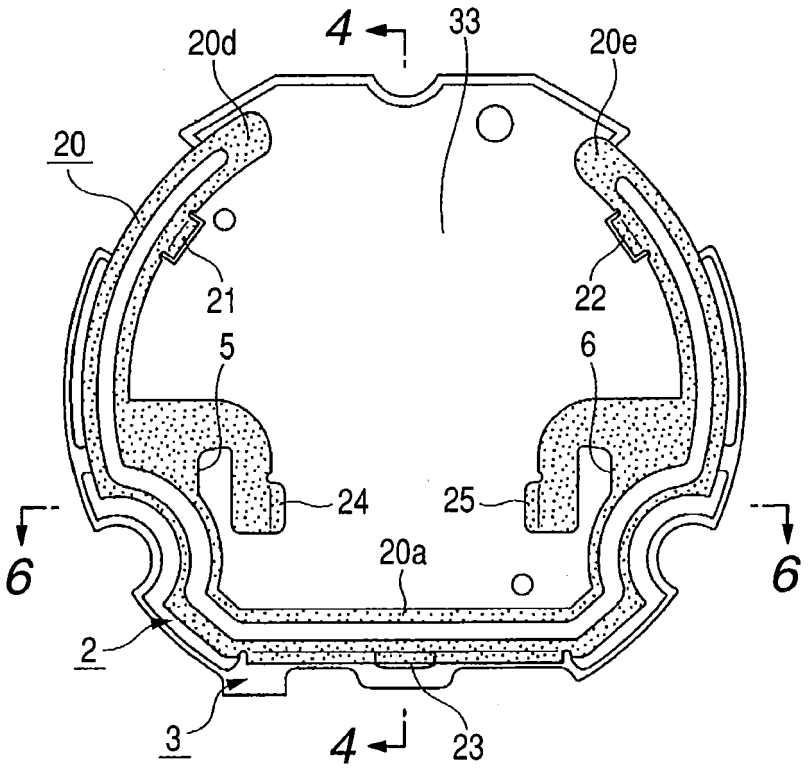

FIG. 4

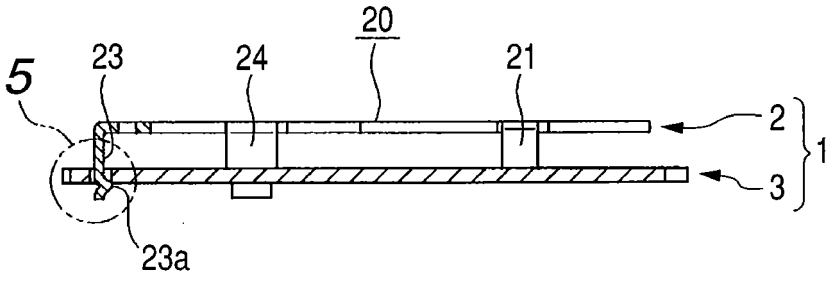

FIG. 5

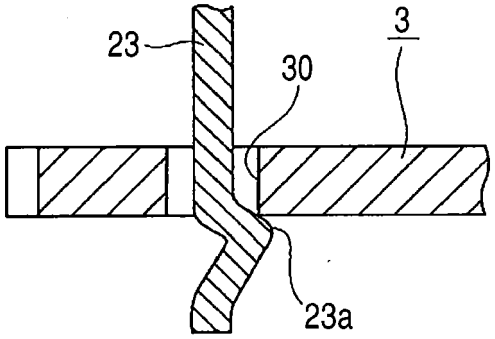

FIG. 6

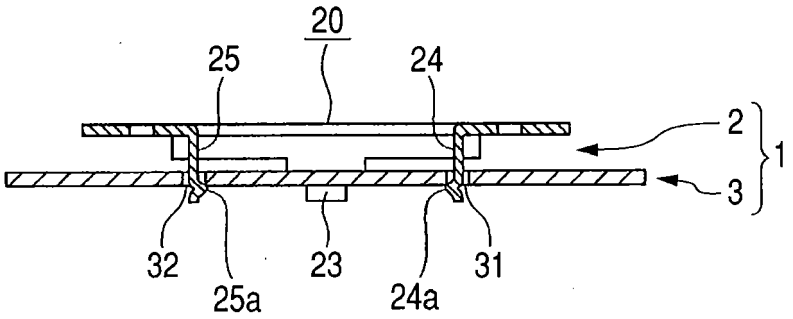

FIG. 7

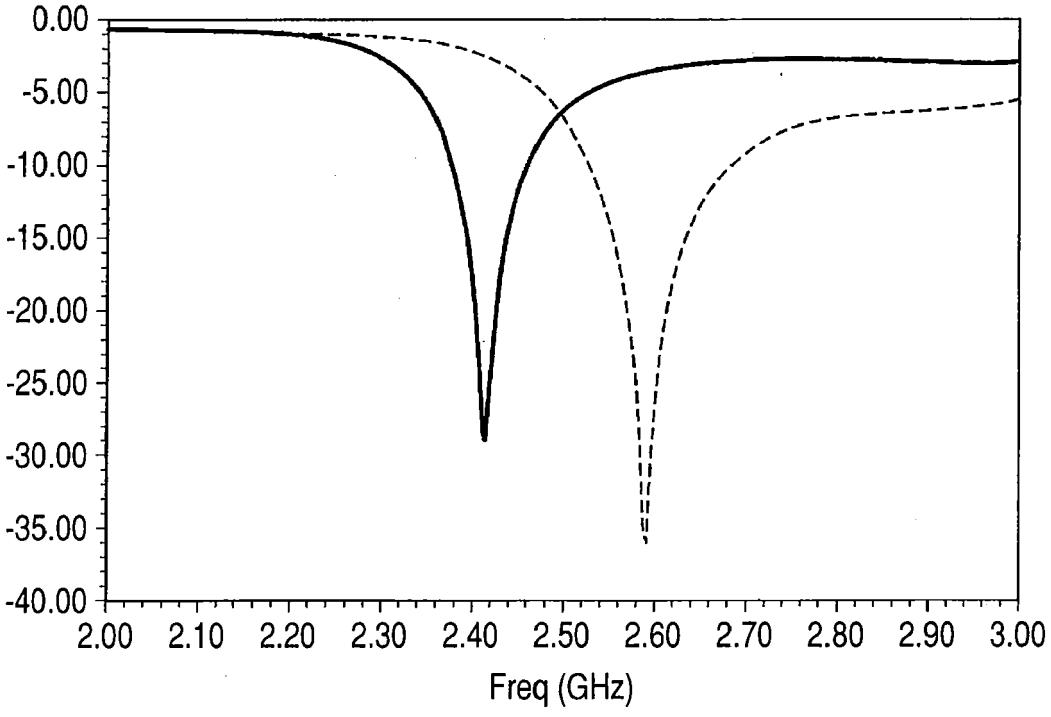

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FIG. 8

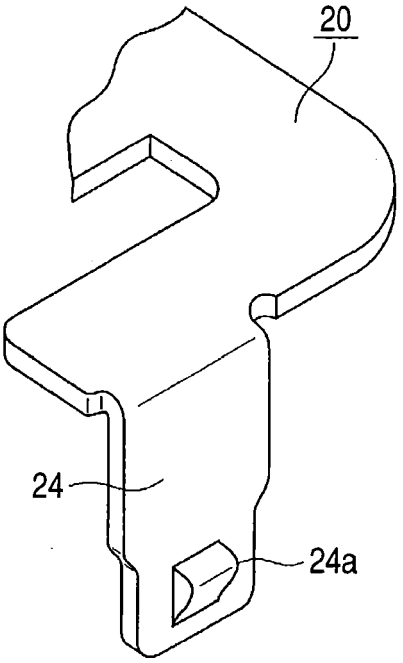
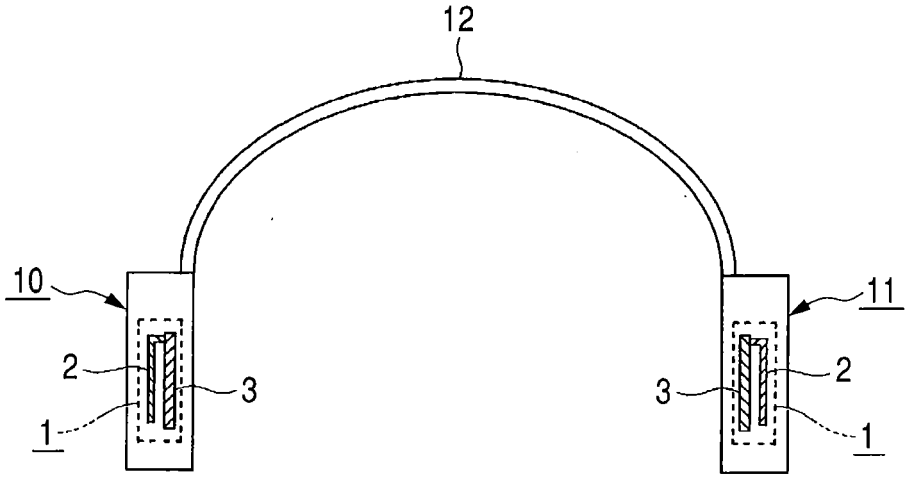


FIG. 9



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Application Number
EP 09 17 4505

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TECHNICAL FIELDS SEARCHED (IPC)

H01Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	30 November 2009	Van Dooren, Gerry

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