US 20250266618A1

(19) United States
(12) Patent Application Publication
KAJIKIYA et al.

(10) Pub. No.: US 2025/0266618 A1
(43) Pub. Date: Aug. 21, 2025

(54) **COIL COMPONENT AND COMMUNICATION DEVICE HAVING THE SAME**

(71) Applicant: **TDK Corporation**, Tokyo (JP)

(72) Inventors: **Shoma KAJIKIYA**, Tokyo (JP); **Makoto HIRAKI**, Tokyo (JP); **Toshio TOMONARI**, Tokyo (JP)

(21) Appl. No.: **19/057,131**

(22) Filed: **Feb. 19, 2025**

(30) **Foreign Application Priority Data**

Feb. 21, 2024 (JP) 2024-024451

Publication Classification

(51) **Int. Cl.**
H01Q 7/00 (2006.01)
H04B 5/26 (2024.01)

(52) **U.S. Cl.**
CPC ***H01Q 7/00*** (2013.01); ***H04B 5/26*** (2024.01)

(57) **ABSTRACT**

Disclosed herein is a coil component that includes a resin layer including insulating inorganic fillers and a binder resin, and a coil conductor embedded at least partially in the resin layer and wound in a plurality of turns. The resin layer includes a first area that overlaps the coil conductor as viewed in a coil axis direction and a second area positioned between adjacent turns of the coil conductor. The filling rate of the inorganic fillers in the resin layer is higher in the first area than in the second area.

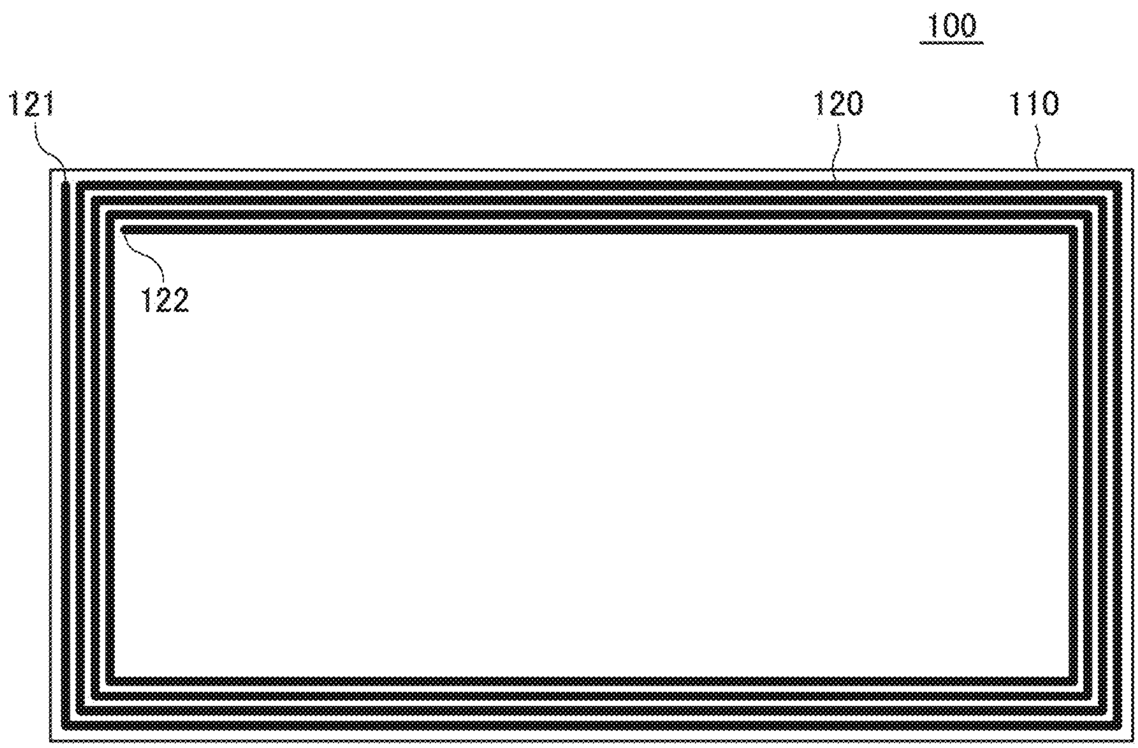


FIG. 1

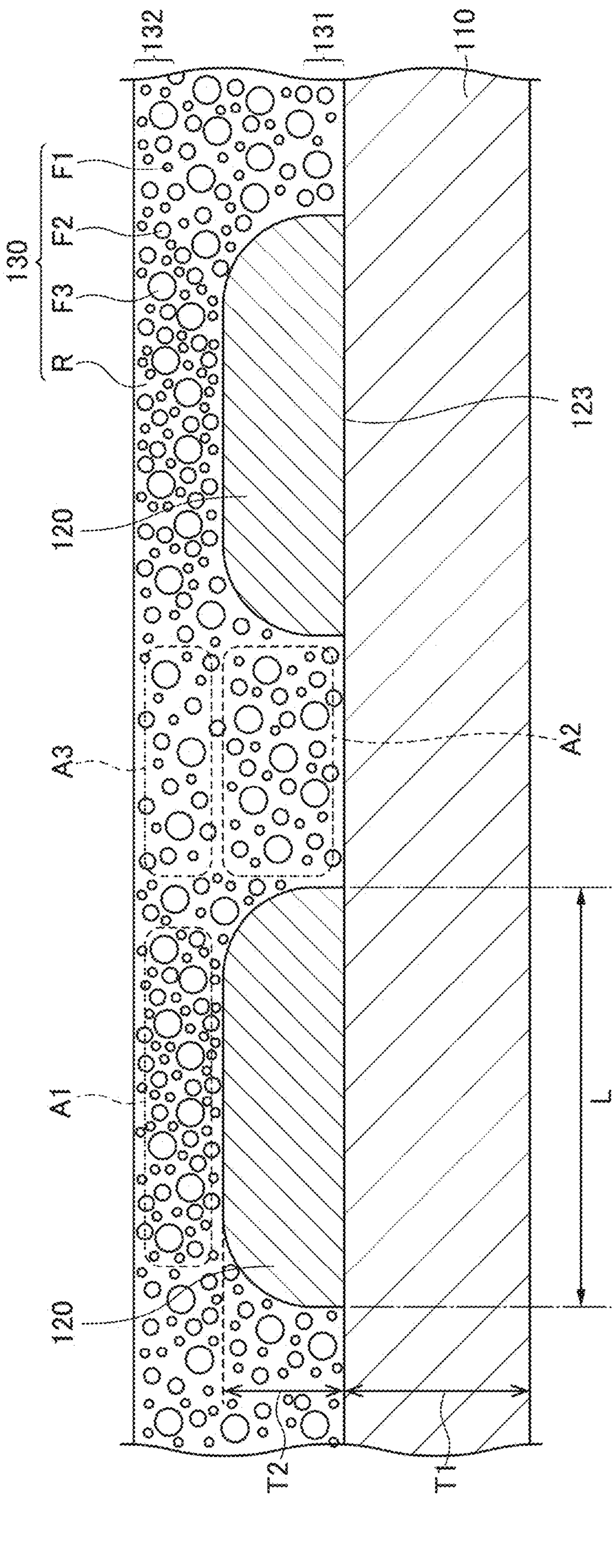


FIG. 2

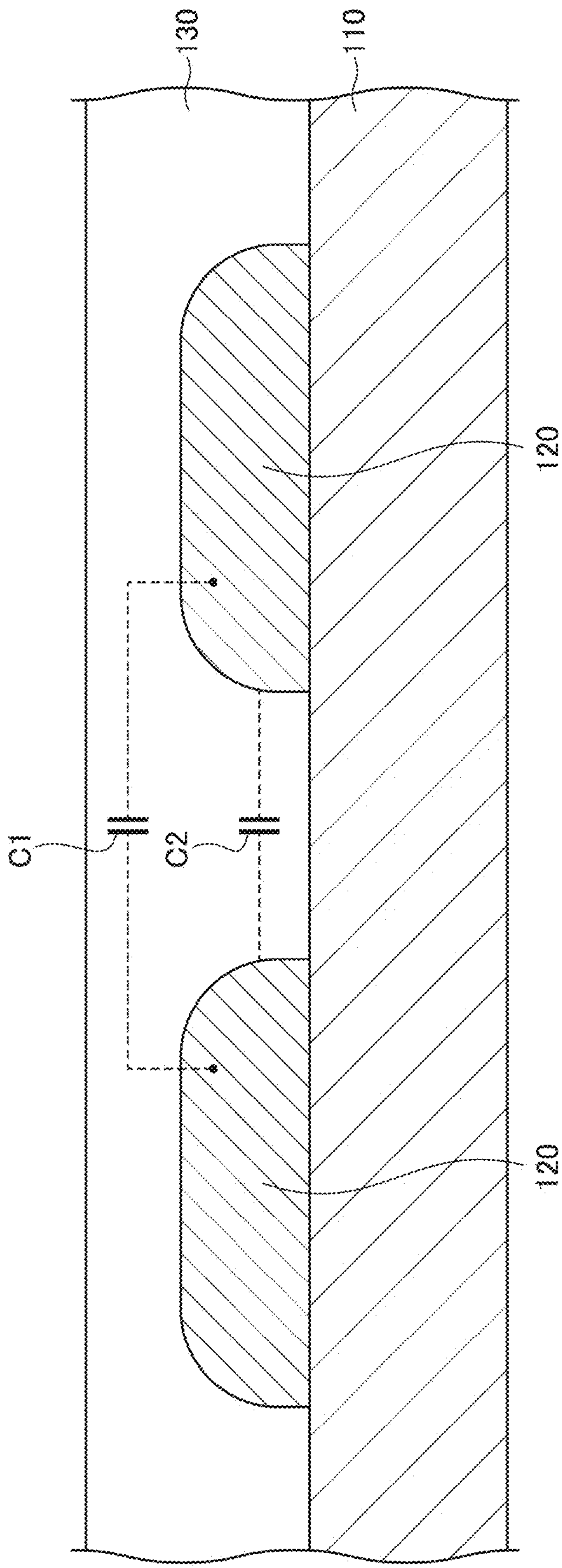


FIG. 3

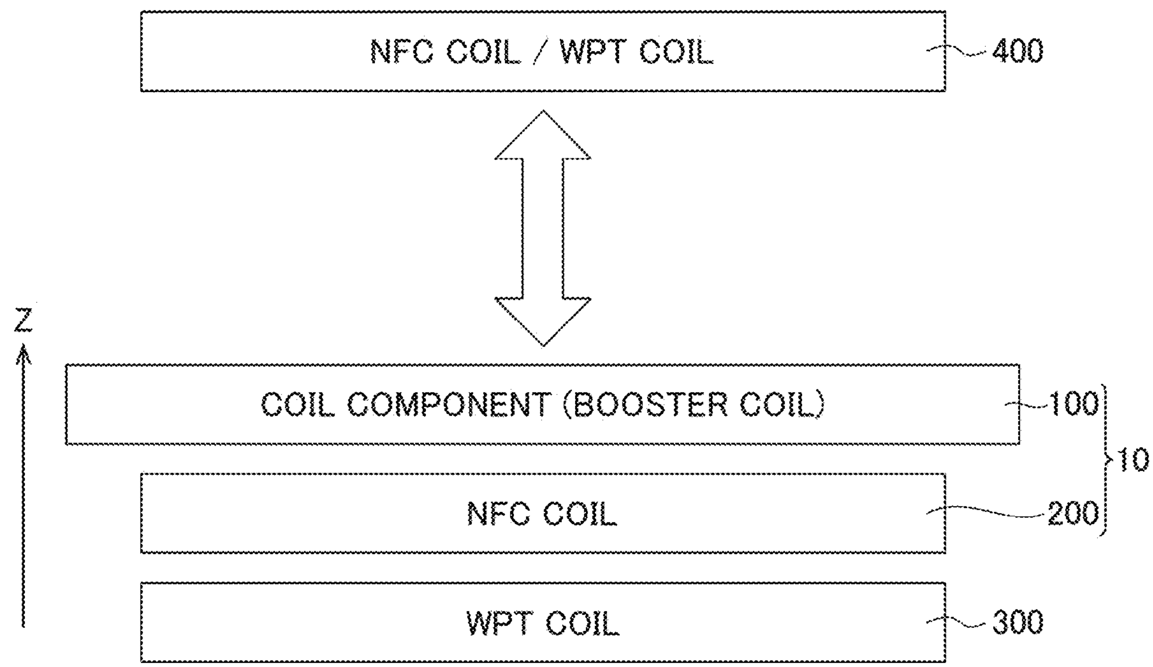

NFC COIL / WPT COIL
400
Z
COIL COMPONENT (BOOSTER COIL)
100
10
NFC COIL
200
WPT COIL
300

FIG. 4

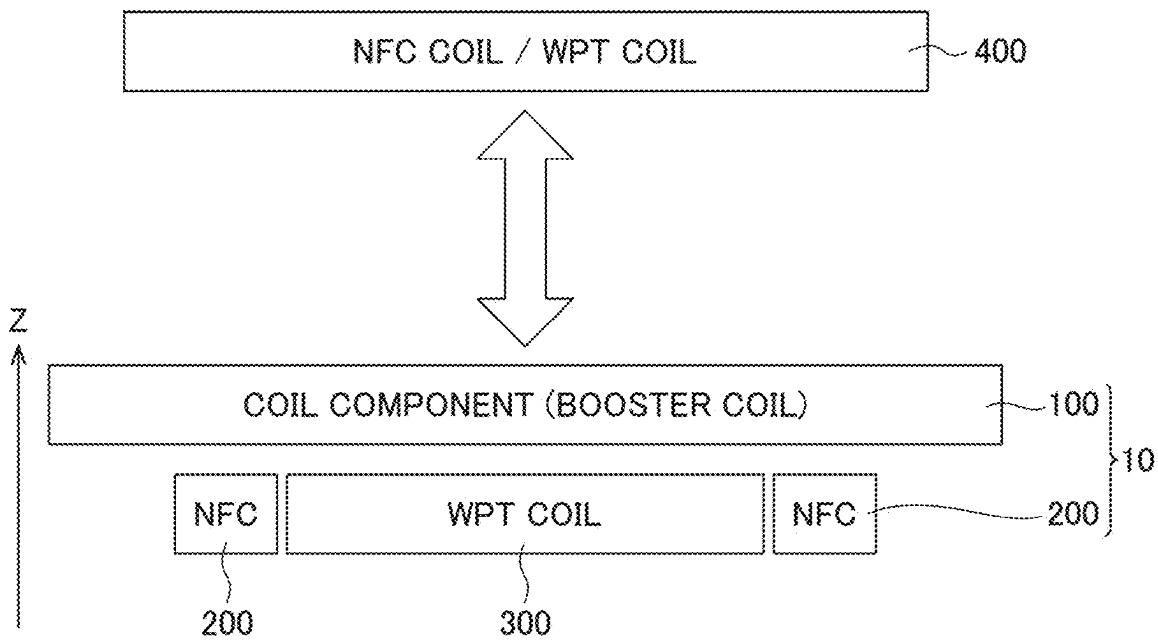

NFC COIL / WPT COIL
400
Z
COIL COMPONENT (BOOSTER COIL)
100
10
NFC
WPT COIL
NFC
200
200
300

FIG. 5

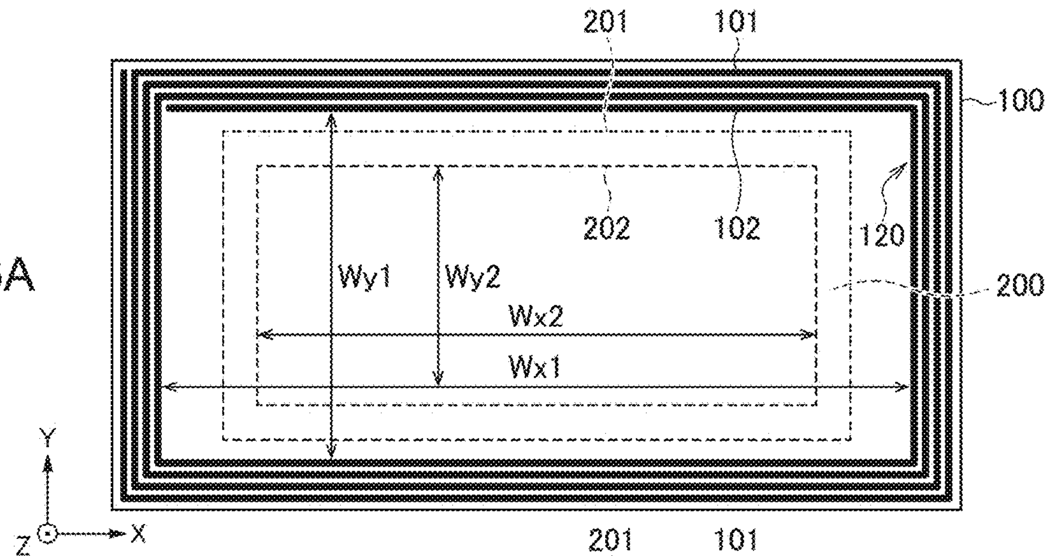


FIG. 6A

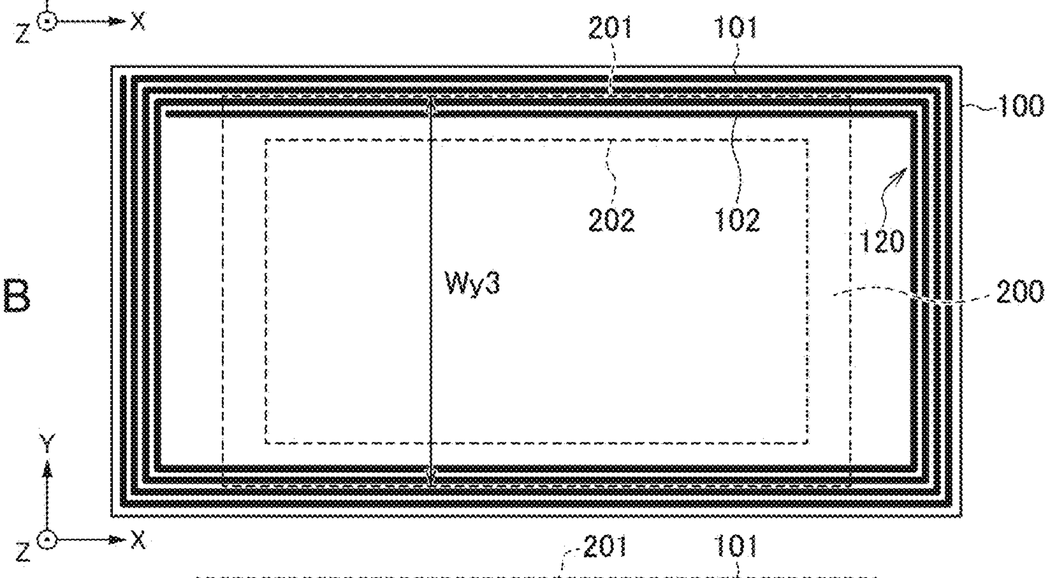


FIG. 6B

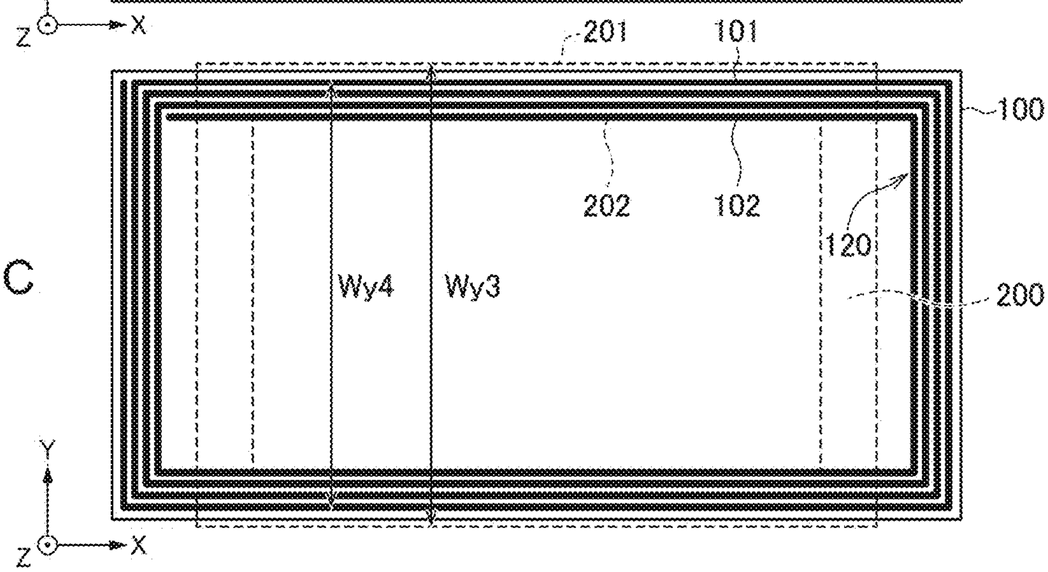


FIG. 6C

FIG. 7A

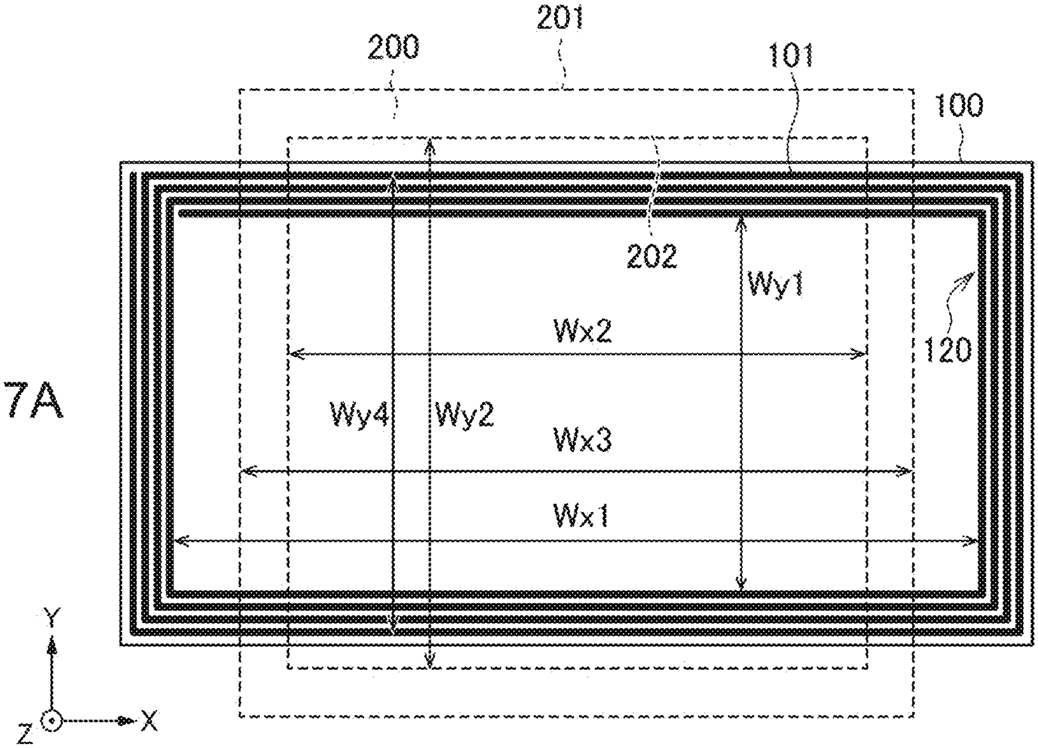
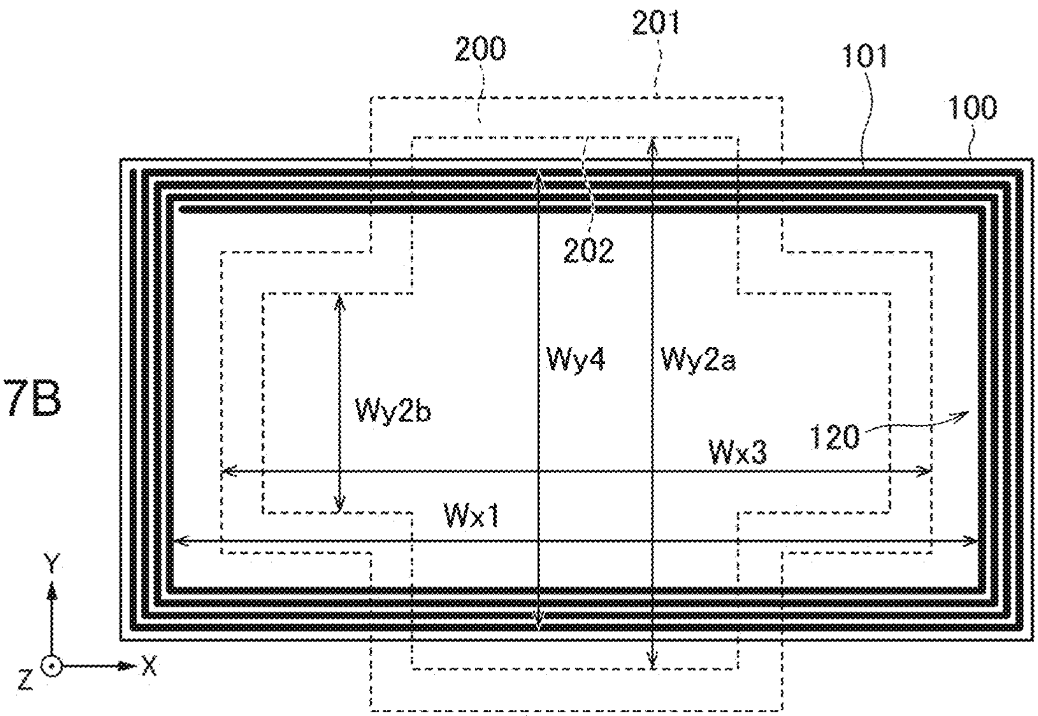

201
200
101
100
202
Wy1
120
Wx2
Wy4
Wy2
Wx3
Wx1
Y
Z
X

FIG. 7B


201
200
101
100
202
Wy4
Wy2a
Wy2b
120
Wx3
Wx1
Y
Z
X

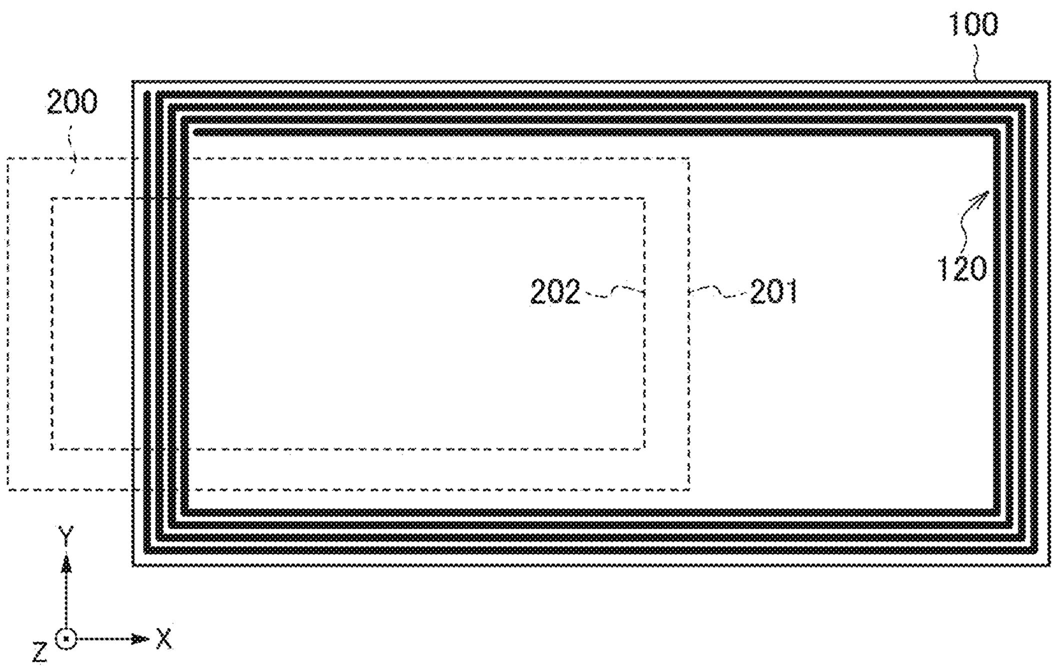


FIG. 8

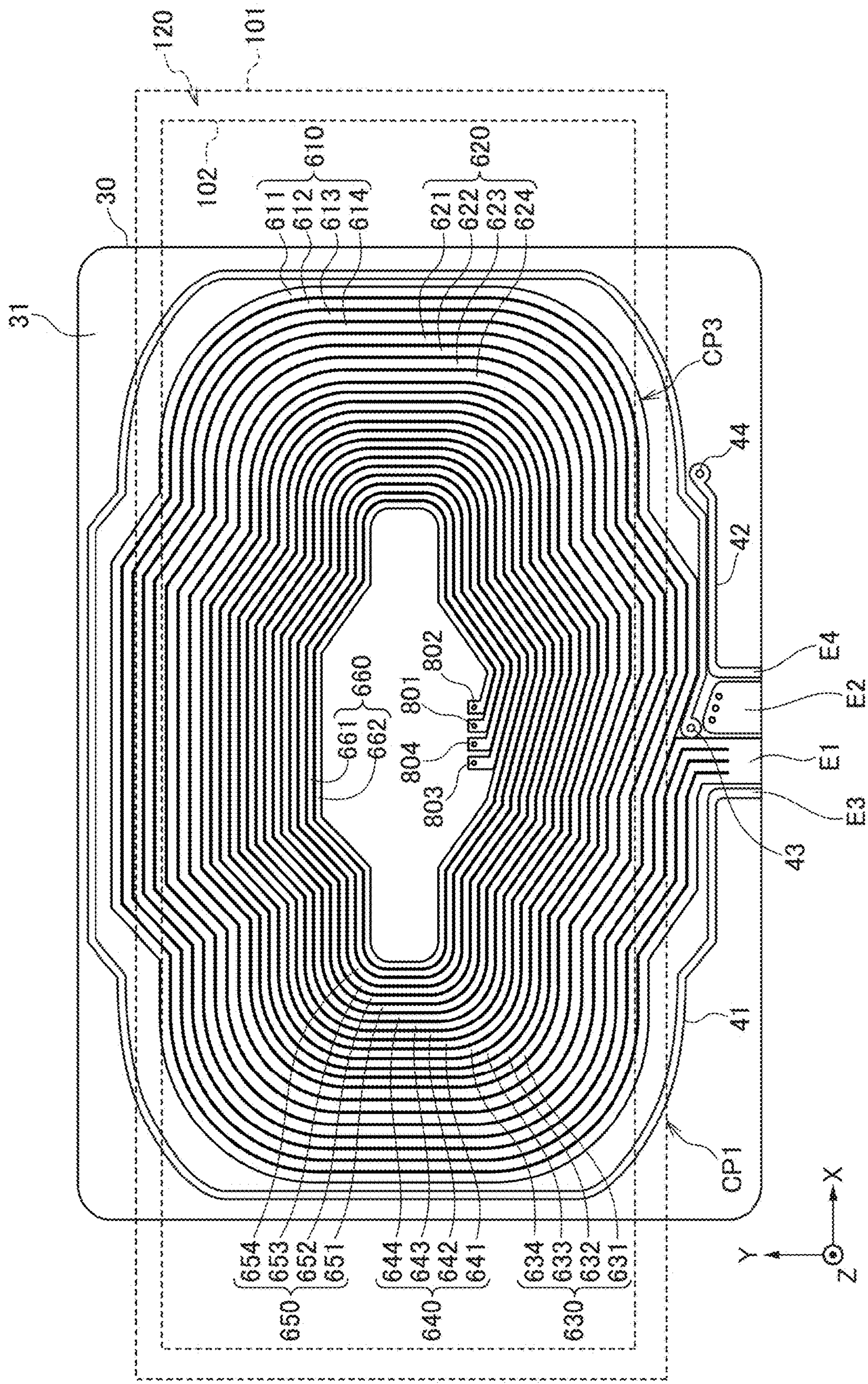


FIG. 9

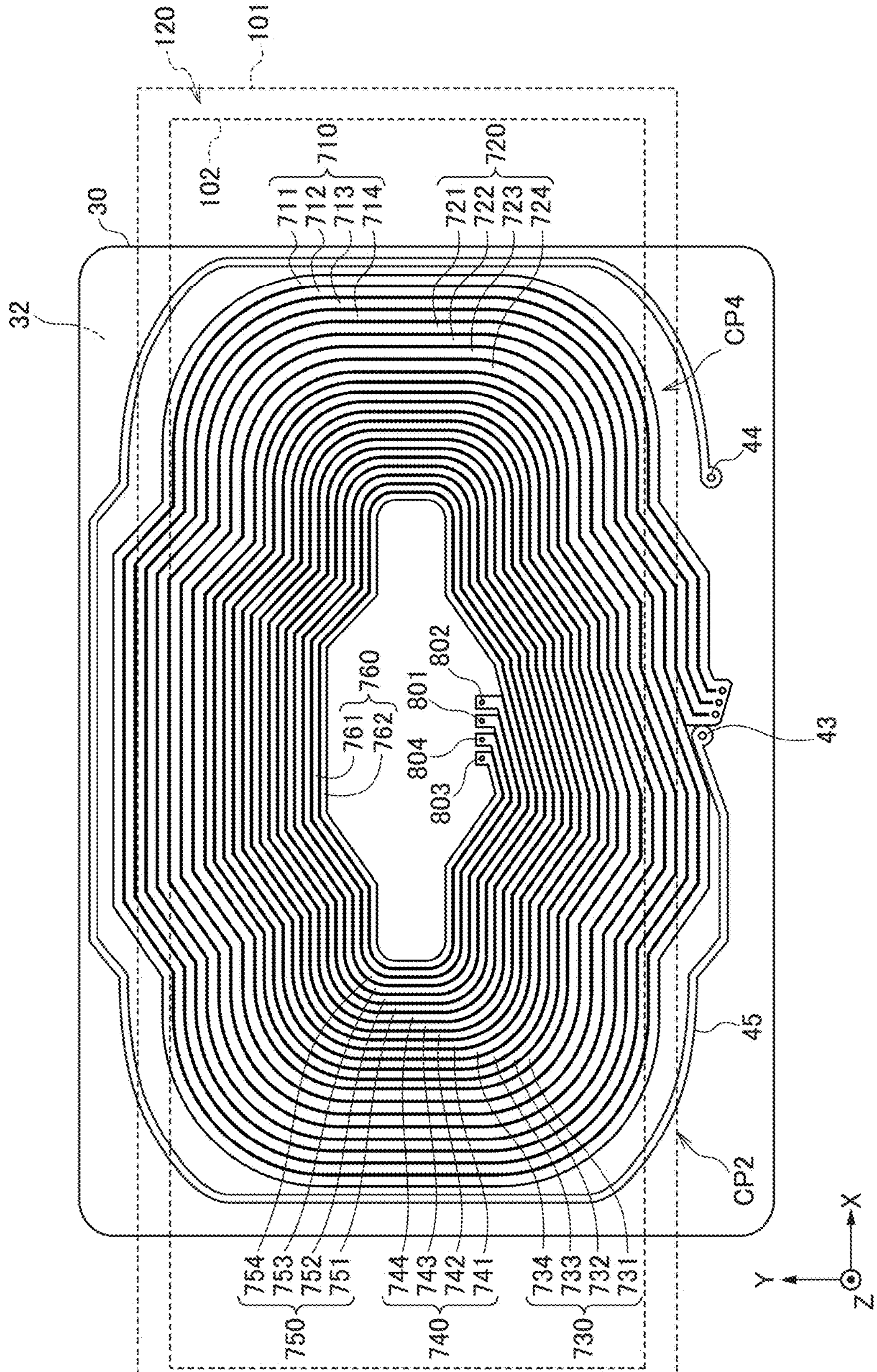

120
101
102
30
32
710
711
712
713
714
720
721
722
723
724
CP4
44
760
761
762
801
802
803
804
43
45
CP2
750
751
752
753
754
740
741
742
743
744
730
731
732
733
734
X
Y
Z

FIG. 10

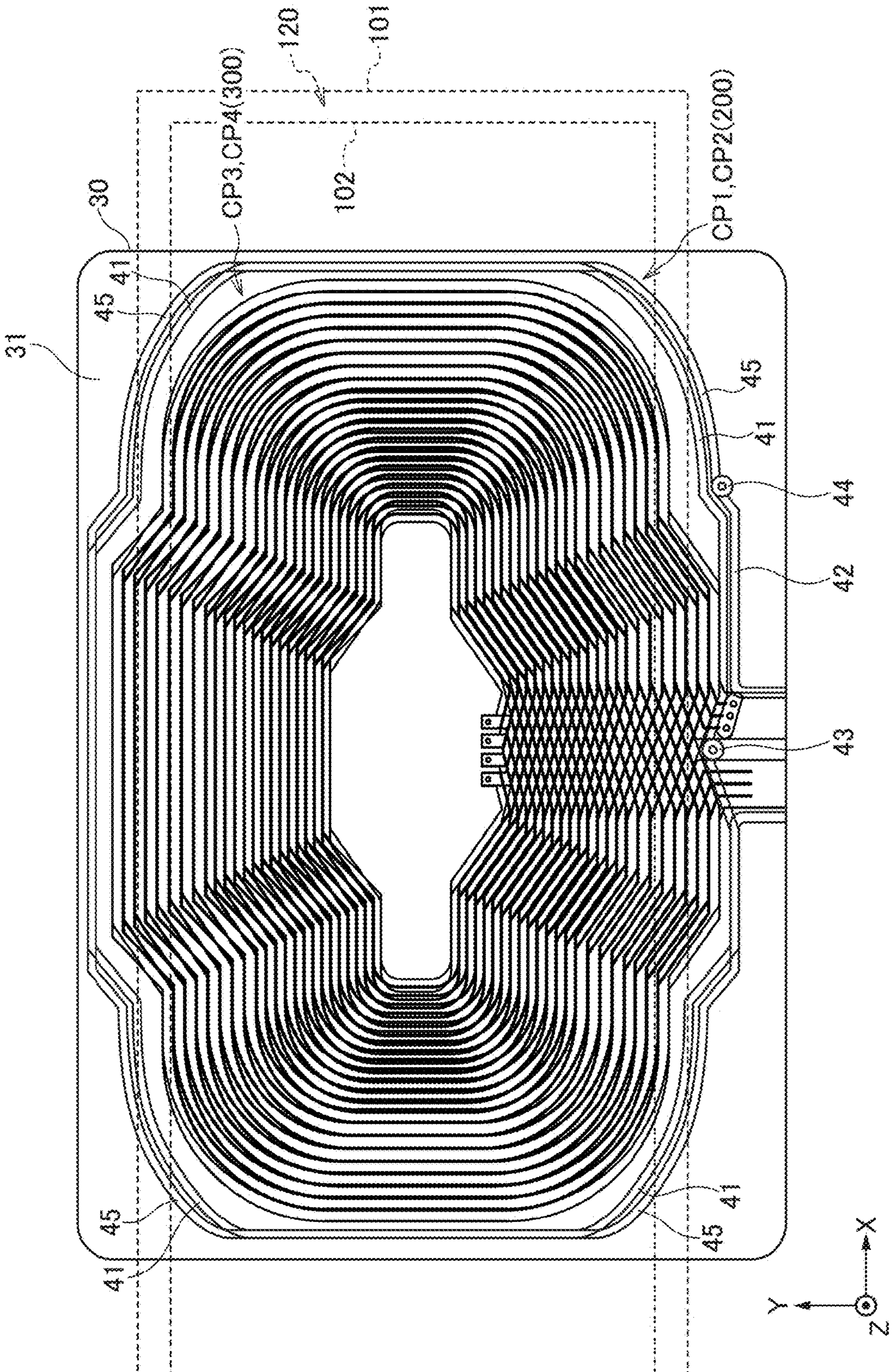
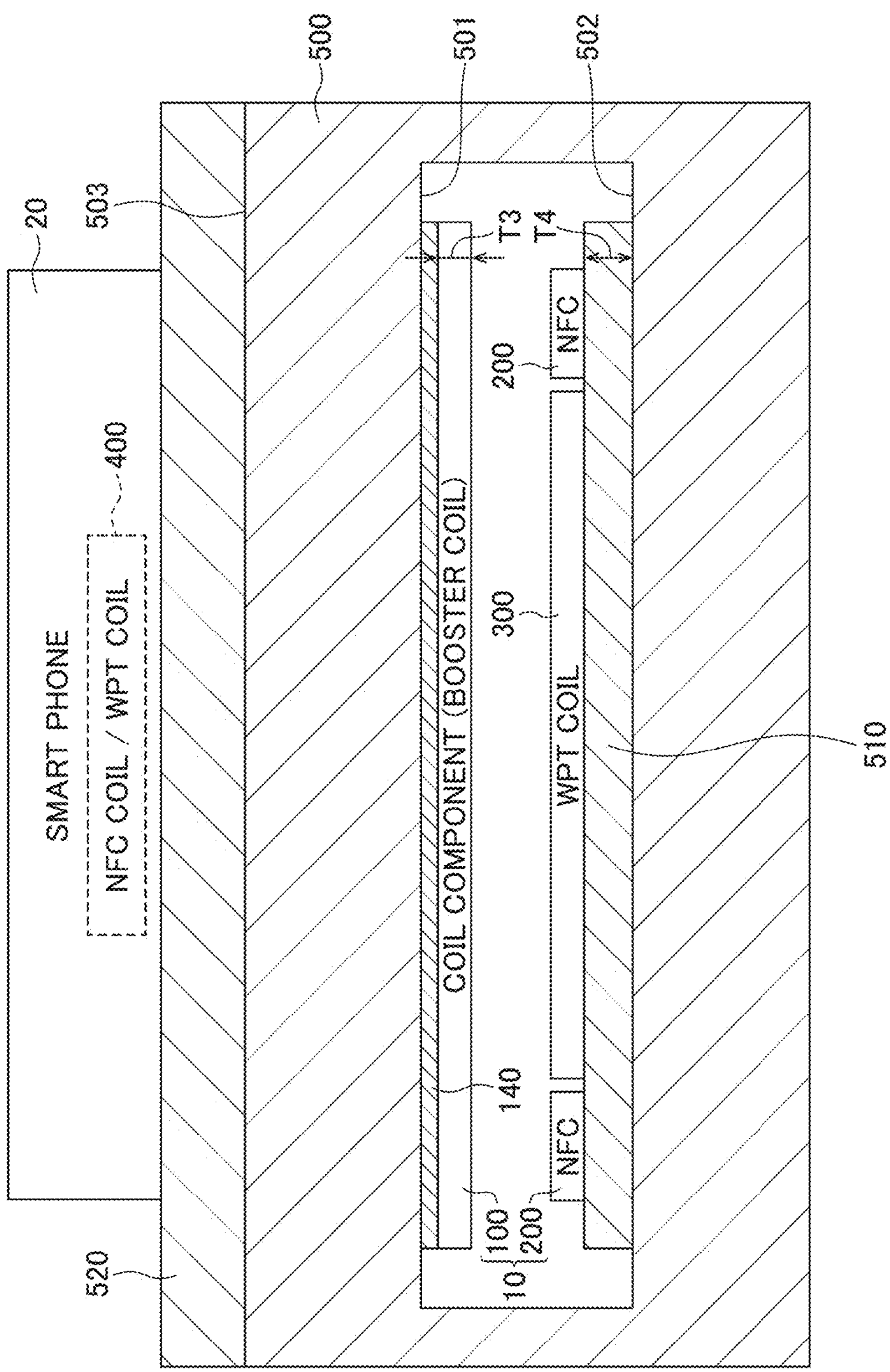

120
101
CP3,CP4(300)
102
30
CP1,CP2(200)
41
45
31
45
41
44
42
43
41
45
45
41
X
Y
Z

FIG. 11



500
501
502
503
20
SMART PHONE
400
NFC COIL / WPT COIL
T3
T4
NFC
200
COIL COMPONENT (BOOSTER COIL)
300
WPT COIL
510
140
NFC
100
200
10
520

FIG. 12

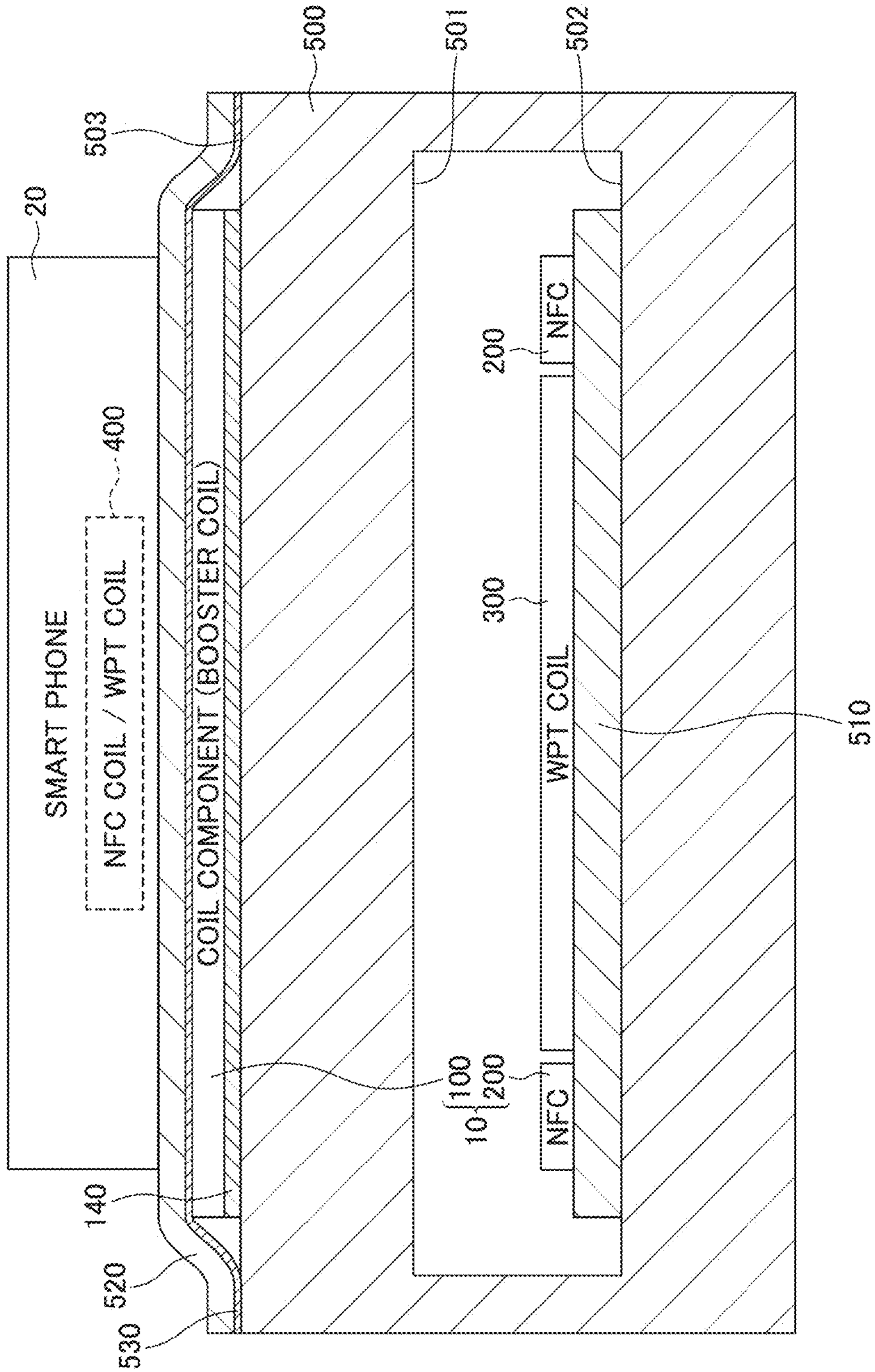

SMART PHONE
NFC COIL / WPT COIL
COIL COMPONENT (BOOSTER COIL)
WPT COIL
NFC
NFC
20
400
500
501
502
503
300
200
200
10
100
140
520
530
510

FIG. 13

COIL COMPONENT AND COMMUNICATION DEVICE HAVING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of Japanese Patent Application No. 2024-024451, filed on Feb. 21, 2024, the entire disclosure of which is incorporated by reference herein.

BACKGROUND

[0002] The present disclosure relates to a coil component and a communication device having the same.

[0003] International Publication WO 2016/199633 discloses a coil module including a coil pattern provided on the surface of a coil substrate and an adhesive layer provided on the coil substrate surface so as to embed therein the coil pattern. The adhesive layer described in International Publication WO 2016/199633 contains thermally conductive particles and adhesive resin.

[0004] In the invention disclosed in International Publication WO 2016/199633, the thermally conductive particles contained in the adhesive layer are dispersed uniformly, making it difficult to satisfy both electrical and physical characteristics.

SUMMARY

[0005] A coil component according to an embodiment of the present disclosure includes: a resin layer containing insulating inorganic fillers and binder resin; and a coil conductor embedded at least partially in the resin layer and wound in a plurality of turns. The resin layer includes a first area that overlaps the coil conductor as viewed in the coil axis direction and a second area positioned between adjacent turns of the coil conductor, and the filling rate of the inorganic fillers in the resin layer is higher in the first area than in the second area.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The above features and advantages of the present disclosure will be more apparent from the following description of some embodiments taken in conjunction with the accompanying drawings, in which:

[0007] FIG. **1** is a schematic plan view illustrating the outer appearance of a coil component **100** according to an embodiment of the present disclosure;

[0008] FIG. **2** is a schematic partial cross-sectional view of the coil component **100**;

[0009] FIG. **3** is a schematic diagram for explaining capacitors C**1** and C**2** formed by adjacent turns;

[0010] FIG. **4** is a schematic view for explaining the configuration of a communication device **10** having the coil component **100** and an antenna coil **200** for NFC.

[0011] FIG. **5** is a schematic view for explaining the configuration of the communication device **10** according to a modification;

[0012] FIGS. **6**A to **6**C are each a schematic view for explaining a difference in size between the coil pattern **120** included in the coil component **100** and the antenna coil **200**;

[0013] FIGS. **7**A and **7**B are each a schematic view for explaining a difference in shape between the coil pattern **120** included in the coil component **100** and the antenna coil **200**;

[0014] FIG. **8** is a schematic view for explaining a difference in a coil axis between the coil pattern **120** included in the coil component **100** and the antenna coil **200**;

[0015] FIG. **9** is a schematic plan view illustrating the shape of the conductor pattern formed on one surface **31** of the substrate **30**;

[0016] FIG. **10** is a schematic plan view illustrating the shape of the conductor pattern formed on the other surface **32** of the substrate **30**;

[0017] FIG. **11** is a schematic plan view illustrating an overlapping state between the coil patterns CP**1**, CP**3** and the coil patterns CP**2**, CP**4** as viewed from the surface **31** side of the substrate **30**;

[0018] FIG. **12** is a schematic view illustrating a state where the communication device **10** is accommodated in a housing **500**; and

[0019] FIG. **13** is a schematic diagram showing a state in which the antenna coil **200** is accommodated in a housing **500** and the coil component **100** is disposed outside the housing **500**.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0020] The present disclosure describes a technology for satisfying both the electrical and physical characteristics of a coil component having a coil conductor at least partially embedded in a resin layer.

[0021] Some embodiments of the present disclosure will be explained below in detail with reference to the accompanying drawings.

[0022] FIG. **1** is a schematic plan view illustrating the outer appearance of a coil component **100** according to an embodiment of the present disclosure. FIG. **2** is a schematic partial cross-sectional view of the coil component **100**.

[0023] As illustrated in FIGS. **1** and **2**, the coil component **100** according to the present embodiment includes a substrate **110**, a coil pattern **120** provided on the surface of the substrate **110**, and a resin layer **130** provided on the surface of the substrate **110** so as to embed therein at least a part of the coil pattern **120**. As the substrate **110**, an insulating film of PET (Polyethylene Terephthalate) or PI (Polyimide) can be used. The thickness of the substrate **110** is T**1**.

[0024] The coil pattern **120** is a coil conductor wound in a plurality of turns along the outer periphery of the substrate **110**. The number of turns of the coil pattern **120** is determined depending on target inductance and capacitance. Outer and inner peripheral ends **121** and **122** of the coil pattern **120** are both opened without being connected to another conductive member. Thus, the coil pattern **120** is in an electrically floating state. The coil pattern **120** is formed by applying electrolytic plating to the surface of the substrate **110**, for example. In this case, a lower surface **123** of the coil pattern **120** is in contact with the surface of the substrate **110**. The lower surface **123** of the coil pattern **120** may be formed of a seed layer containing resin. The substrate **110** may be removed after formation of the coil pattern **120**; however, when the substrate **110** is left without being removed, the lower surface **123** of the coil pattern **120** can be protected. The thickness of the coil pattern **120** is T**2**, which is smaller than a pattern width L of the coil pattern **120**, whereby the coil pattern **120** has a flat shape.

[0025] The resin layer **130** contains insulating inorganic fillers F**1** to F**3** and binder resin R. The resin layer **130** acts to protect the coil pattern **120** and adjust capacitance generated between adjacent turns of the coil pattern **120**. The inorganic fillers F**1** to F**3** all have a spherical shape but have mutually different particle diameters. The inorganic fillers F**1** are small-diameter fillers having a first particle diameter distribution whose average value is a first particle diameter. The inorganic fillers F**2** are middle-diameter fillers having a second particle diameter distribution whose average value is a second particle diameter larger than the first particle diameter. The inorganic fillers F**3** are large-diameter fillers having a third particle diameter distribution whose average value is a third particle diameter larger than the second particle diameter. Using the three inorganic fillers F**1** to F**3** having different particle diameter distributions increases the filling rate of the inorganic fillers in the resin layer **130**.

[0026] The material of the inorganic fillers F**1** to F**3** may be a nonmagnetic inorganic material such as alumina, aluminum hydroxide, talc, magnesium hydroxide, silica, calcium carbonate, barium titanate, zirconium titanate, or zinc zirconate titanate, or a magnetic material such as a ferrite or an Fe-based alloy magnetic body. The materials of the inorganic fillers F**1** to F**3** may be the same, or some of the materials thereof may be different. The dielectric constant of the inorganic fillers F**1** to F**3** may be higher than that of the binder resin R.

[0027] Examples of the material of the binder resin R**1** include acrylic resin, polyester resin, polyethylene resin, polyvinyl chloride resin, polyvinyl butyral resin, poly urethane resin, polyester urethane resin, cellulose resin, ABS (acrylonitrile-butadiene-styrene) resin, nitrile-butadiene rubber, styrene-butadiene rubber, epoxy resin, phenol resin, amide resin, polyester elastomer, and polyamide elastomer.

[0028] As illustrated in FIG. **2**, the resin layer **130** includes an area A**1** that overlaps the coil pattern **120** in the stacking direction (coil axis direction), an area A**2** positioned between adjacent turns of the coil pattern **120**, and an area A**3** that overlaps the area A**2** in the stacking direction. The area A**2** does not overlap the coil pattern **120** in the stacking direction and is positioned within the height range of the coil pattern **120**. The area A**3** does not overlap the coil pattern **120** in the stacking direction and is positioned above the height position of the coil pattern **120**.

[0029] The filling rate of the inorganic fillers F**1** to F**3** in the resin layer **130** may be higher in the area A**1** than in the area A**2**. Thus, when a material having a dielectric constant higher than that of the binder resin R is used as the material of the inorganic fillers F**1** to F**3**, the dielectric constant in the area A**1** is enhanced. As a result, the capacitance of a capacitor C**1** generated between adjacent turns and passing through the area A**1** (A**3**) as illustrated in FIG. **3** is enhanced. On the other hand, the area A**2** has a higher proportion of the binder resin R due to its lower filling rate of the inorganic fillers F**1** to F**3** than the area A**1**. This improves embedding property between adjacent turns, so that voids are unlikely to occur, and adhesion with respect to the coil pattern **120** is enhanced. With such a mechanism, it is possible to satisfy both the electrical and physical characteristics of the coil component **100**. Further, in the present embodiment, the coil pattern **120** has a flat shape in which the thickness T**2** is smaller than the pattern width L, so that the capacitance of a capacitor C**2** that passes through the area A**2** becomes smaller than that of the capacitor C**1** that passes through the area A**1**. That is, the capacitance of the capacitor C**1** becomes dominant in between adjacent turns. Further, since the dielectric constant in the area A**1** is enhanced, the capacitance occurring between adjacent turns is effectively enhanced.

[0030] Further, the resin layer **130** includes a surface layer **131** on one side thereof in the thickness direction which contacts the substrate **110** and in which the coil pattern **120** is present and a surface layer **132** positioned on the other side thereof, in which the coil pattern **120** is absent. The filling rate of the inorganic fillers F**1** to F**3** in the resin layer **130** may be higher in the surface layer **132** than in the surface layer **131**. This further enhances the capacitance of the capacitor C**1** that passes through the areas A**1** and A**3**. In addition, the shape retainability of resin layer **130** is improved to enhance the flatness of the coil component **100**.

[0031] The ratio of the inorganic fillers F**3** in the resin layer **130** may be higher in the area A**2** than in the area A**3**. This enhances the capacitance of the capacitor C**2** that passes through the area A**2**. Similarly, the ratio of the inorganic fillers F**2** in the resin layer **130** may be higher in the area A**2** than in the area A**3**. Further, as illustrated in FIG. **2**, the thickness T**2** of the coil pattern **120** may be smaller than the thickness T**1** of the substrate **110**. This can reduce the entire thickness of the coil component **100** and makes more dominant the capacitance of the capacitor C**1** that passes through the area A**1**.

[0032] The coil component **100** according to the present embodiment is disposed so as to overlap an antenna coil for near field communication (NFC) to thereby function as a booster coil for increasing communication distance.

[0033] FIG. **4** is a schematic view for explaining the configuration of a communication device **10** having the coil component **100** and an antenna coil **200** for NFC.

[0034] The antenna coil **200** illustrated in FIG. **4** has a coil axis extending in the Z-direction and is put over a wireless device **400** as a communication target in the Z-direction. The wireless device **400** also includes an antenna coil for NFC, and when the antenna coil **200** and wireless device **400** are put one over the other in the Z-direction, communication therebetween is established. In addition, when the coil component **100** according to the present embodiment is provided between the antenna coil **200** and the wireless device **400**, it functions as a booster coil to thereby increase communication distance. In the example illustrated in FIG. **4**, the coil component **100** and antenna coil **200** may be fixed to each other through an adhesive sheet or may be arranged so as to be spaced apart from each other with a space.

[0035] In the example illustrated in FIG. **4**, a power transmitting coil **300** for wireless power transmission is disposed on a side opposite to the coil component **100** with respect to the antenna coil **200**. The wireless device **400** includes a power receiving coil for wireless power transmission, and when the power transmitting coil **300** and wireless device **400** are put one over the other in the Z-direction, power is wirelessly transmitted from the power transmitting coil **300** to the wireless device **400**.

[0036] FIG. **5** is a schematic view for explaining the configuration of the communication device **10** according to a modification.

[0037] In the example illustrated in FIG. **5**, the antenna coil **200** and the power transmitting coil **300** are disposed at the same position in the Z-direction in such a manner that the antenna coil **200** surrounds the power transmitting coil **300**. The antenna coil **200** and power transmitting coil **300** may thus be coaxially arranged. In the example illustrated in FIG.

5, the coil component **100** and antenna and power transmitting coils **200** and **300** may be fixed to each other through an adhesive sheet or may be arranged so as to be spaced apart from each.

[0038] In the example illustrated in FIGS. **4** and **5**, the planar size of the coil pattern **120** included in the coil component **100** is larger than that of the antenna coil **200**. By thus making the planar size of the coil pattern **120** larger than that of the antenna coil **200**, planar communicable area is enlarged.

[0039] FIGS. **6**A to **6**C are each a schematic view for explaining a difference in size between the coil pattern **120** included in the coil component **100** and the antenna coil **200**.

[0040] In the example illustrated in FIG. **6**A, the antenna coil **200** is disposed at a position overlapping the opening area of the coil pattern **120**. The inner size of the coil pattern **120** is defined by an area surrounded by an innermost turn **102** of the coil pattern **120**, and the planar size of the coil pattern **120** is defined by an area surrounded by an outermost turn **101** of the coil pattern **120**. Similarly, the inner size of the antenna coil **200** is defined by an area surrounded by an innermost turn **202** of the antenna coil **200**, and the planar size of the antenna coil **200** is defined by an area surrounded by an outermost turn **201** of the antenna coil **200**. In the example illustrated in FIG. **6**A, the outermost turn **201** of the antenna coil **200** is positioned within the innermost turn **102** of the coil pattern **120**.

[0041] In the example illustrated in FIG. **6**A, both the coil pattern **120** and antenna coil **200** have a planer shape having a longer side in the X-direction and a shorter side in Y-direction perpendicular to the X-direction. The inner size of the coil pattern **120** in the X-direction is Wx**1**, and the inner size of the antenna coil **200** in the X-direction is Wx**2** (<Wx**1**). The inner size of the coil pattern **120** in the Y-direction is Wy**1**, and the inner size of the antenna coil **200** in the Y-direction is Wy**2** (<Wy**1**). The difference (=Wx**1**−Wx**2**) between the inner sizes of the coil pattern **120** and antenna coil **200** in the X-direction is larger than the difference (=Wy**1**-Wy**2**) between the inner sizes of the coil pattern **120** and antenna coil **200** in the Y-direction. As a result, planar communicable area is enlarged in X- and Y-directions (enlarged more in the X-direction than in the Y-direction). For example, in a mobile terminal such as a smartphone, there may be cases where the wireless device **400** is disposed at the center of the mobile terminal and where it is disposed at an end portion of the mobile terminal in the X-direction, so that by significantly further enlarging the planar communicable area in the X-direction, satisfactory communication can be achieved with respect to mobile terminals of any type.

[0042] In the example illustrated in FIG. **6**B, an outer size Wy**3** of the antenna coil **200** in the Y-direction is larger than the inner size Wy**1** of the coil pattern **120** in the Y-direction, and thus the coil pattern **120** and antenna coil **200** partially overlap each other in a plan view. Also in the example illustrated in FIG. **6**B, the inner size Wx**1** of the coil pattern **120** in the X-direction is larger than the inner size Wx**2** of the antenna coil **200** in the X-direction, and the inner size Wy**1** of the coil pattern **120** in the Y-direction is larger than the inner size Wy**2** of the antenna coil **200** in the Y-direction. Further, the difference (=Wx**1**−Wx**2**) between the inner sizes of the coil pattern **120** and antenna coil **200** in the X-direction is larger than the difference (=Wy**1**−Wy**2**) between the inner sizes of the coil pattern **120** and antenna coil **200** in the Y-direction. As described above, the coil pattern **120** and antenna coil **200** may partially overlap each other.

[0043] In the example illustrated in FIG. **6**C, the outer size Wy**3** of the antenna coil **200** in the Y-direction is larger than an outer size Wy**4** of the coil pattern **120** in the Y-direction. Accordingly, the coil pattern **120** and antenna coil **200** partially overlap each other in a plan view, and the antenna coil **200** partially protrudes from the coil pattern **120** in the Y-direction in a plan view. In the example illustrated in FIG. **6**C, the inner size Wx**1** of the coil pattern **120** in the X-direction is larger than the inner size Wx**2** of the antenna coil **200** in the X-direction, while the inner size Wy**1** of the coil pattern **120** in the Y-direction is almost the same as the inner size Wy**2** of the antenna coil **200** in the Y-direction. Further, the difference (=Wx**1**−Wx**2**) between the inner sizes of the coil pattern **120** and antenna coil **200** in the X-direction is larger than the difference (=Wy**1**−Wy**2**) between the inner sizes of the coil pattern **120** and antenna coil **200** in the Y-direction. As described above, the antenna coil **200** may partially protrude from the coil pattern **120** in a plan view.

[0044] In the example illustrated in FIG. **7**A, the inner size Wy**2** of the antenna coil **200** in the Y-direction is larger than the outer size Wy**4** of the coil pattern **120** in the Y-direction, and thus, the opening area of the antenna coil **200** is partially positioned outside the coil pattern **120** in a plan view. The outer size Wx**3** of the antenna coil **200** in the X-direction is smaller than the inner size Wx**1** of the coil pattern **120** in the X-direction. In this case, the absolute value (=|Wx**1**−Wx**2**|) of the difference between the inner sizes of the coil pattern **120** and antenna coil **200** in the X-direction may be larger than the absolute value (=|Wy**1**−Wy**2**|) of the difference between the inner sizes of the coil pattern **120** and antenna coil **200** in the Y-direction. As described above, the opening area of the antenna coil **200** may be partially positioned outside the coil pattern **120**. Even in this case, the planar size of the coil pattern **120** may be larger than that of the antenna coil **200**.

[0045] In the example illustrated in FIG. **7**B, an inner size Wy**2**a in the Y-direction at the center portion in the X-direction of the antenna coil **200** is larger than an inner size Wy**2**b in the Y-direction at both end portions in the X-direction of the antenna coil **200**. Further, the inner size Wy**2**a in the Y-direction at the center portion in the X-direction of the antenna coil **200** is larger than the outer size Wy**4** of the coil pattern **120** in the Y-direction. As a result, the opening area of the antenna coil **200** is partially positioned outside the coil pattern **120**. The outer size Wx**3** of the antenna coil **200** in the X-direction is smaller than the inner size Wx**1** of the coil pattern **120** in the X-direction. As describe above, the size of the antenna coil **200** in the Y-direction may differ depending on its position in the X-direction.

[0046] In the example illustrated in FIG. **8**, the center axis of the antenna coil **200** is offset from the center axis of the coil pattern **120** in the X-direction, and thus the antenna coil **200** partially protrudes from the coil pattern **120** in the X-direction. When the center axes of the antenna coil **200** and coil pattern **120** are thus offset from each other, the coupling coefficient therebetween can be adjusted.

[0047] FIGS. **9** to **11** are schematic plan views for explaining more specifically the configuration of the communication device **10** according to the modification illustrated in FIG. **5**. In the example illustrated in FIGS. **9** to **11**, the antenna coil **200** and power transmitting coil **300** are provided on the surface of the same substrate **30**. Further, in FIGS. **9** to **11**, the planar position of the coil pattern **120** is denoted by dashed lines.

[0048] FIG. **9** is a schematic plan view illustrating the shape of the conductor pattern formed on one surface **31** of the substrate **30**.

[0049] As illustrated in FIG. **9**, there are formed, on the surface **31** of the substrate **30**, a coil pattern CP**1** constituting a part of the antenna coil **200**, a coil pattern CP**3** constituting a part of the power transmitting coil **300**, and terminal electrodes E**1** to E**4**.

[0050] The coil pattern CP**3** has a six-turn configuration constituted of turns **610**, **620**, **630**, **640**, **650**, and **660**. The turn **610** is positioned at the outermost periphery, and the turn **660** is positioned at the innermost periphery. The turns **610**, **620**, **630**, **640**, and **650** are each radially divided into four lines by three spiral slits. The turn **660** is radially divided into two lines by one spiral slit. As a result, the turn **610** is divided into four lines **611** to **614**, the turn **620** is divided into four lines **621** to **624**, the turn **630** is divided into four lines **631** to **634**, the turn **640** is divided into four lines **641** to **644**, the turn **650** is divided into four lines **651** to **654**, and the turn **660** is divided into two lines **661** and **662**.

[0051] The lines **611**, **621**, **631**, **641**, **651**, and **661** constitute a continuous line spirally wound in six turns and are each positioned at the outermost periphery in its corresponding turn. The lines **612**, **622**, **632**, **642**, **652**, and **662** constitute a continuous line spirally wound in six turns and are each the second line counted from the outermost peripheral line in its corresponding turn. The lines **613**, **623**, **633**, **643**, and **653** constitute a continuous line spirally wound in five turns and are each the second line counted from the innermost peripheral line in its corresponding turn. The lines **614**, **624**, **634**, **644**, and **654** constitute a continuous line spirally wound in five turns and are each positioned at the innermost periphery in its corresponding turn.

[0052] The outer peripheral ends of the lines **611** to **614** are connected in common to the terminal electrode E**1**. The inner peripheral ends of the lines **661**, **662**, **653**, and **654** are connected respectively to through hole conductors **801**, **802**, **803**, and **804** penetrating the substrate **30**.

[0053] The coil pattern CP**1** includes a conductor pattern **41** disposed outside the coil pattern CP**3** so as to surround the same and a conductor pattern **42** disposed outside the coil pattern CP**3** separately from the conductor pattern **41**. The conductor pattern **41** is a continuous line wound in about one turn, and the coil pattern CP**3** is disposed within the opening area (inner diameter area) thereof. One end of the conductor pattern **41** is connected to the terminal electrode E**3**, and the other end thereof is connected to a through hole conductor **43** penetrating the substrate **30**. One end of the conductor pattern **42** is connected to the terminal electrode E**4**, and the other end thereof is connected to a through hole conductor **44** penetrating the substrate **30**.

[0054] FIG. **10** is a schematic plan view illustrating the shape of the conductor pattern formed on the other surface **32** of the substrate **30**, which illustrates a state viewed from the surface **31** side of the substrate **30** transparently through the substrate **30**.

[0055] As illustrated in FIG. **10**, there are formed, on the surface **32** of the substrate **30**, a coil pattern CP**2** constituting the remaining part of the antenna coil **200** and a coil pattern CP**4** constituting the remaining part of the power transmitting coil **300**.

[0056] The coil pattern CP**4** has the same pattern shape as that of the coil pattern CP**3**. The coil pattern CP**4** has a six-turn configuration constituted of turns **710**, **720**, **730**, **740**, **750**, and **760**. The turn **710** is positioned at the outermost periphery, and the turn **760** is positioned at the innermost periphery. The turns **710**, **720**, **730**, **740**, and **750** are each radially divided into four lines by three spiral slits. The turn **760** is radially divided into two lines by one spiral slit. As a result, the turn **710** is divided into four lines **711** to **714**, the turn **720** is divided into four lines **721** to **724**, the turn **730** is divided into four lines **731** to **734**, the turn **740** is divided into four lines **741** to **744**, the turn **750** is divided into four lines **751** to **754**, and the turn **760** is divided into two lines **761** and **762**.

[0057] The lines **711**, **721**, **731**, **741**, **751**, and **761** constitute a continuous line spirally wound in six turns and are each positioned at the outermost periphery in its corresponding turn. The lines **712**, **722**, **732**, **742**, **752**, and **762** constitute a continuous line spirally wound in six turns and are each the second line counted from the outermost peripheral line in its corresponding turn. The lines **713**, **723**, **733**, **743**, and **753** constitute a continuous line spirally wound in five turns and are each the second line counted from the innermost peripheral line in its corresponding turn. The lines **714**, **724**, **734**, **744**, and **754** constitute a continuous line spirally wound in five turns and are each positioned at the innermost periphery in its corresponding turn.

[0058] The outer peripheral ends of the lines **711** to **714** are connected in common to the terminal electrode E**2** through through hole conductors. The inner peripheral ends of the lines **761**, **762**, **753**, and **754** are connected respectively to through hole conductors **804**, **803**, **802**, and **801**. As a result, the power transmitting coil **300** having a configuration in which four lines each wound in 11 turns are connected in parallel is connected between the terminal electrodes E**1** and E**2**.

[0059] The conductor pattern **45** constituting the coil pattern CP**2** is a continuous line wound in about one turn and is disposed outside the coil pattern CP**4** in such a manner as to surround the same. That is, the coil pattern CP**4** is disposed within the opening area (inner diameter area) of the conductor pattern **45** constituting the coil pattern CP**2**. One end and the other end of the conductor pattern **45** are connected respectively to the through hole conductors **43** and **44**. As a result, the total number of turns of the antenna coil **200** constituted of the coil patterns CP**1** and CP**2** is about two turns.

[0060] FIG. **11** is a schematic plan view illustrating an overlapping state between the coil patterns CP**1**, CP**3** and the coil patterns CP**2**, CP**4** as viewed from the surface **31** side of the substrate **30**.

[0061] As illustrated in FIG. **11**, in a state where the substrate **30** on which antenna coil **200** and power transmitting coil **300** are formed and the coil pattern **120** are put one over the other, the inner size of the antenna coil **200** (CP**1**, CP**2**) in the Y-direction is partially larger and partially smaller than the outer size of the coil pattern **120** in the Y-direction as in the example illustrated in FIG. **7**B. Thus, sections of the conductor patterns **41**, **42**, and **45** of the antenna coil **200** (CP**1**, CP**2**) that extend in the X-direction each have portions positioned inside and outside the coil pattern **120**, and the outer size of the antenna coil (CP**1**, CP**2**) in the X-direction is smaller than the inner size of the coil pattern **120** in the X-direction, with the result that sections of the conductor patterns **41**, **42**, and **45** of the antenna coil **200** (CP**1**, CP**2**) that extend in the Y-direction are positioned inside the coil pattern **120**.

[0062] FIG. **12** is a schematic view illustrating a state where the communication device **10** is accommodated in a housing **500**.

[0063] In the example illustrated in FIG. **12**, the housing **500** has inner surfaces **501** and **502** facing each other. The coil component **100** is bonded to the inner surface **501** through an adhesive layer **140**, and a circuit board **510** having thereon the antenna coil **200** and power transmitting coil **300** is placed on the inner surface **502**. The adhesive layer **140** may bond the resin layer **130** of the coil component **100** and the inner surface **501** of the housing **500**. In the example illustrated in FIG. **12**, the antenna coil **200** and power transmitting coil **300** are each a pattern coil constituted by a conductor pattern formed on the circuit board **510** and are integral with the circuit board **510**. A thickness T**3** of the coil component **100** may be smaller than a thickness T**4** of the circuit board **510**, which allows the coil component **100** to be accommodated in the internal space of the housing **500** even when the internal space has a low profile.

[0064] The housing **500** has an outer surface **503** positioned opposite to the inner surface **501**. The outer surface **503** is covered with a rubber mat **520**, on which a smartphone **20** or the like can be placed. The rubber mat **520** acts to prevent damage to the smartphone **20** and to reduce sliding of the smartphone **20**. Upon placement of the smartphone **20** on the rubber mat **520**, communication can be established between the wireless device **400** included in the smartphone **20** and the antenna coil **200**, and power can be transmitted from the power transmitting coil **300** to the wireless device **400**. Since the coil component **100** according to the present embodiment is disposed between the wireless device **400** and the antenna coil **200**, communication between the wireless device **400** and the antenna coil **200** can be performed more efficiently. In particular, as described using FIGS. **6**A to **6**C, **7**A, **7**B, and **8**, when the planar size of the coil pattern **120** included in the coil component **100** is made larger than that of the antenna coil **200**, planar communicable area is enlarged, so that even if the planar position of the smartphone **20** placed on the rubber mat **520** is shifted from the center position of the antenna coil **200**, communication can be established.

[0065] In the example illustrated in FIG. **12**, both the coil component **100** and antenna coil **200** are accommodated in the housing **500**; however, as illustrated in the modification illustrated in FIG. **13**, a configuration is possible in which the circuit board **510** having thereon the antenna coil **200** and power transmitting coil **300** is accommodated in the housing **500**, and the coil component **100** is disposed on the outer surface **503** of the housing **500**. In this case, the coil component **100** is disposed between the outer surface **503** of the housing **500** and the rubber mat **520** with an adhesive layer **530** interposed between itself and the rubber mat **520**.

[0066] While the some embodiments of the present disclosure has been described, the present disclosure is not limited to the above embodiment, and various modifications may be made within the scope of the present disclosure, and all such modifications are included in the present disclosure.

[0067] For example, although the coil component **100** according to the above embodiment is configured by using the coil pattern **120** having a conductor pattern wound on the surface of the substrate **110**, it is not necessarily configured of the pattern coil, and instead a coil conductor formed of a spirally wound coated conductive wire may be used. Similarly, the configurations of the antenna coil **200** and power transmitting coil **300** are not limited to the pattern coil, and a coil conductor formed of a spirally wound insulating coated conductive wire may be used.

[0068] The technology according to the present disclosure includes the following configuration examples but not limited thereto.

[0069] A coil component according to an embodiment of the present disclosure includes: a resin layer containing insulating inorganic fillers and binder resin; and a coil conductor embedded at least partially in the resin layer and wound in a plurality of turns. The resin layer includes a first area that overlaps the coil conductor as viewed in the coil axis direction and a second area positioned between adjacent turns of the coil conductor, and the filling rate of the inorganic fillers in the resin layer is higher in the first area than in the second area. This can satisfy both electrical and physical characteristics.

[0070] In the above coil component, the resin layer may include a first surface layer on one side thereof in the thickness direction, in which the coil conductor is present and a second surface layer positioned on the other side thereof, in which the coil conductor is absent. The filling rate of the inorganic fillers in the resin layer may be higher in the second surface layer than in the first surface layer. This can increase the strength of the second surface layer.

[0071] In the above coil component, the inorganic fillers may include first inorganic fillers having a first particle diameter distribution whose average value is a first particle diameter and second inorganic fillers having a second particle diameter distribution whose average value is a second particle diameter larger than the first particle diameter. The resin layer may further include a third area that overlaps the second area as viewed in the coil axis direction, and the ratio of the second inorganic fillers in the resin layer may be higher in the second area than in the third area. This can enhance the capacitance of the coil pattern.

[0072] The above coil component may further include a substrate on which the coil conductor is formed, the coil conductor may be constituted by a coil pattern formed of a wound conductor pattern, and the thickness of the coil pattern may be smaller than that of the substrate. This can reduce the entire thickness.

[0073] In the above coil component, both ends of the coil conductor may be opened. This facilitates the manufacturing of the coil component.

[0074] In the above coil component, the dielectric constant of the inorganic fillers may be higher than that of the binder resin. This can achieve larger capacitance.

[0075] A communication device according to an embodiment of the present disclosure includes: an antenna coil; and the above-described coil component disposed so as to overlap the antenna coil. Thus, the coil component functions as a booster coil for the antenna coil.

[0076] In the above communication device, the planar size of the coil conductor included in the coil component may be larger than that of the antenna coil. This can enlarge planar communicable area.

[0077] In the above communication device, the coil conductor and antenna coil may each have a planar shape having a longer side in a first direction and a shorter side in a second direction perpendicular to the first direction, and the difference between the inner sizes of the coil conductor and antenna coil in the first direction may be larger than the difference between the inner sizes of the coil conductor and antenna coil in the second direction. This can enlarge planar communicable area more in the first direction.

[0078] In the above communication device, the coil conductor and antenna coil may each have a planar shape having a longer side in a first direction and a shorter side in a second direction perpendicular to the first direction, the outer size of the coil conductor in the first direction may be larger than that of the antenna coil in the first direction, and the inner size of the antenna coil in the second direction may be larger than the outer size of the coil conductor in the second direction. This can enlarge planar communicable area more in the first direction.

[0079] In the above communication device, the coil conductor and antenna coil may each have a planar shape having a longer side in a first direction and a shorter side in a second direction perpendicular to the first direction, the outer size of the coil conductor in the first direction may be larger than that of the antenna coil in the first direction, and the outermost turn of the antenna coil in the second direction may have a portion positioned outside the outermost turn of the coil conductor in the second direction and a portion positioned inside the innermost turn of the coil conductor in the second direction. This can enlarge planar communicable area more in the first direction.

[0080] In the above communication device, the antenna coil may be formed on a circuit board, and the thickness of the coil component may be smaller than that of the circuit board. This allows the coil component to be disposed in a narrower space.

[0081] The above communication device may further include a housing for accommodating therein the coil component and antenna coil, and the coil component may be fixed to the inner surface of the housing. This allows both the coil component and antenna coil to be accommodated in the housing, preventing the outer appearance of the housing from being impaired. Alternatively, the above communication device may further include a housing for accommodating therein the antenna coil, and a rubber mat covering the outer surface of the housing, and the coil component may be disposed between the outer surface of the housing and the rubber mat. As a result, the coil component is hidden by the rubber mat, preventing the outer appearance of the communication device from being impaired.

What is claimed is:

1. A coil component comprising:

a resin layer including insulating inorganic fillers and a binder resin; and

a coil conductor embedded at least partially in the resin layer and wound in a plurality of turns,

wherein the resin layer includes a first area that overlaps the coil conductor as viewed in a coil axis direction and a second area positioned between adjacent turns of the coil conductor, and

wherein a filling rate of the inorganic fillers in the resin layer is higher in the first area than in the second area.

2. The coil component as claimed in claim **1**,

wherein the resin layer includes:

a first surface layer on one side thereof in a thickness direction, in which the coil conductor is present; and

a second surface layer positioned on another side thereof, in which the coil conductor is absent, and

wherein a filling rate of the inorganic fillers in the resin layer is higher in the second surface layer than in the first surface layer.

3. The coil component as claimed in claim **1**,

wherein the inorganic fillers include:

first inorganic fillers having a first particle diameter distribution whose average value is a first particle diameter; and

second inorganic fillers having a second particle diameter distribution whose average value is a second particle diameter larger than the first particle diameter,

wherein the resin layer further includes a third area that overlaps the second area as viewed in the coil axis direction, and

wherein a ratio of the second inorganic fillers in the resin layer is higher in the second area than in the third area.

4. The coil component as claimed in claim **1**, further comprising a substrate on which the coil conductor is formed,

wherein the coil conductor is constituted by a coil pattern formed of a wound conductor pattern, and

wherein a thickness of the coil pattern is smaller than a thickness of the substrate.

5. The coil component as claimed in claim **1**, wherein both ends of the coil conductor are opened.

6. The coil component as claimed in claim **1**, wherein a dielectric constant of the inorganic fillers is higher than a dielectric constant of the binder resin.

7. A communication device comprising:

an antenna coil; and

a coil component disposed so as to overlap the antenna coil,

wherein the coil component comprises:

a resin layer including insulating inorganic fillers and a binder resin; and

a coil conductor embedded at least partially in the resin layer and wound in a plurality of turns,

wherein the resin layer includes a first area that overlaps the coil conductor as viewed in a coil axis direction and a second area positioned between adjacent turns of the coil conductor, and

wherein a filling rate of the inorganic fillers in the resin layer is higher in the first area than in the second area.

8. The communication device as claimed in claim **7**, wherein a planar size of the coil conductor included in the coil component is larger than a planar size of the antenna coil.

9. The communication device as claimed in claim **8**,

wherein each of the coil conductor and antenna coil has a planar shape having a longer side in a first direction and a shorter side in a second direction perpendicular to the first direction, and

wherein a difference between an inner sizes of the coil conductor and antenna coil in the first direction is larger than a difference between an inner sizes of the coil conductor and antenna coil in the second direction.

10. The communication device as claimed in claim **8**,
wherein each of the coil conductor and antenna coil has a planar shape having a longer side in a first direction and a shorter side in a second direction perpendicular to the first direction,
wherein an outer size of the coil conductor in the first direction is larger than an outer size of the antenna coil in the first direction, and
wherein an inner size of the antenna coil in the second direction is larger than an outer size of the coil conductor in the second direction.

11. The communication device as claimed in claim **8**,
wherein each of the coil conductor and antenna coil has a planar shape having a longer side in a first direction and a shorter side in a second direction perpendicular to the first direction,
wherein an outer size of the coil conductor in the first direction is larger than an outer size of the antenna coil in the first direction, and
wherein an outermost turn of the antenna coil in the second direction has a portion positioned outside an outermost turn of the coil conductor in the second direction and a portion positioned inside an innermost turn of the coil conductor in the second direction.

12. The communication device as claimed in claim **7**,
wherein the antenna coil is formed on a circuit board, and
wherein a thickness of the coil component is smaller than a thickness of the circuit board.

13. The communication device as claimed in claim **7**, further comprising a housing for accommodating therein the coil component and antenna coil,
wherein the coil component is fixed to an inner surface of the housing.

14. The communication device as claimed in claim **7**, further comprising:
a housing for accommodating therein the antenna coil; and
a rubber mat covering an outer surface of the housing,
wherein the coil component is disposed between the outer surface of the housing and the rubber mat.

* * * * *