(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
08 February 2024 (08.02.2024)

WIPO | PCT

(10) International Publication Number
WO 2024/030682 A1

(51) International Patent Classification:
H04R 9/04 (2006.01) *H04R 7/16* (2006.01)
H04R 1/10 (2006.01)

(21) International Application Number:
PCT/US2023/029672

(22) International Filing Date:
07 August 2023 (07.08.2023)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
63/395,698 05 August 2022 (05.08.2022) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

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(54) Title: PLANAR VOICE COIL AND BOBBIN STRUCTURE FOR A LOUDSPEAKER

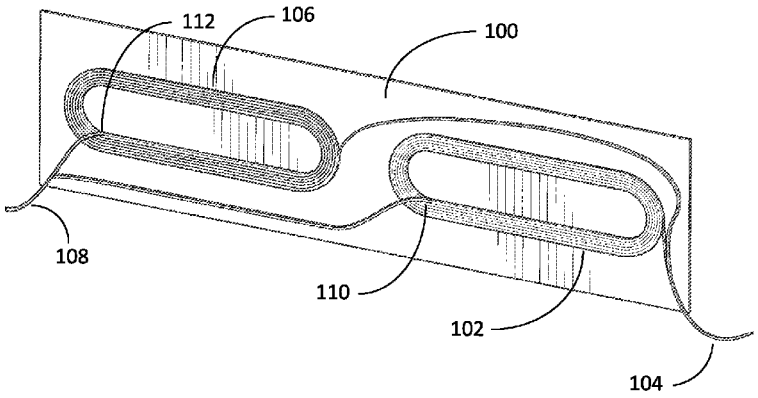

Fig. 1

(57) Abstract: This invention provides a planar voice coil system for a loudspeaker motor that can have improved manufacturing simplicity. The voice coil may be etched on a polycarbonate board ("PCB") where the planar voice coil is etched onto the PCB and the PCB substrate acts as the bobbin connected to the diaphragm. Such a PCB voice coil could contain one or more layers of copper etchings for the voice coil. The placement of two voice coils, wired in parallel, on the substrate will lower the resistance of the voice coil. Alterative embodiments integrate the voice coil through the substrate where the substrate is non- planar allowing the same voice coil to be positioned on both sides of the substrate.

[Continued on next page]

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

PLANAR VOICE COIL AND BOBBIN STRUCTURE FOR A LOUDSPEAKER

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BACKGROUND OF THE INVENTION

1. Claim of Priority

[0001] This invention claims priority to U.S. Serial No. 63/395,698 titled Coil/Bobbin Provisional Patent filed on August 5, 2022, and is incorporated by its entirety by reference.

2. Field of the Invention

[0002] This invention provides an integrated frame and motor structure for a loudspeaker. Specifically, the invention provides a structure that combines the magnetic motor steel plates with a frame that holds the loudspeaker diaphragm and spider location connections.

2. Related Art.

[0003] A common prior art cone-type speaker usually has a cylindrical shape and uses a cylindrical permanent magnet. The cone shaped loudspeaker comprises a voice coil, diaphragm, basket, and damper. Traditionally, loudspeakers have a separate frame and motor structure.

[0004] Therefore, what is needed is a loudspeaker having an optimized coil and for ease of loudspeaker motor assembly, thus reducing the total number of components in a loudspeaker system.

SUMMARY

[0005] This invention provides a planar voice coil system for a loudspeaker motor that can be manufactured with improved simplicity. The voice coil may be applied to a polycarbonate board ("PCB") where the planar voice coil is etched into the PCB and the PCB substrate acts as the bobbin moving the diaphragm. Such a PCB voice coil could contain one or more layers of electically conductive material such as copper or aluminum comprising the voice coil. The placement of two voice coils wired in parallel on the substrate will lower the resistance of the voice coil. Alterative embodiments integrate the voice coil through the substrate where the substrate has waves allowing the same voice coil to be positioned on both sides of the substrate.

[0006] Alterative embodiments integrate the voice coil through the substrate where the substrate has waves allowing the same voice coil to be positioned on both sides of the substrate. Also, the bobbin or substrate may be formed having a Y shape, L shape or box shape for added rigidity.

[0007] Other systems, methods, features, and advantages of the invention will be or will become apparent to one with skill in the art upon examination of the following figures and detailed description. It is intended that all such additional systems, methods, features and advantages be included within this description, be within the scope of the invention, and be protected by the accompanying claims.

DETAILED DESCRIPTION OF THE DRAWINGS

[0008] The components in the figures are not necessarily to scale, emphasis being placed instead upon illustrating the principles of the invention. In the figures, like reference numerals designate corresponding parts throughout the different views.

[0009] Figure 1 is a perspective view of two planar voice coils wired in parallel.

[0010] Figure 2 is a side view of two planar voice coils wired in parallel with input output leads.

[0011] Figure 3 is a perspective view of a plurality of planar voice coil positioned on a substrate having a plurality of spider attachment locations.

[0012] Figure 4 is a perspective view of a planar voice coil with input output leads mounted on a polycarbonate board ("PCB") substrate.

[0013] Figure 5 is a side view of a planar voice coil with input output leads mounted on a PCB substrate.

[0014] Figure 6 is a side view of a planar voice coil sandwiched between two PCBs substrates.

[0015] Figure 7 is an end view of a planar voice coil sandwiched between two PCBs.

[0016] Figure 8 is a perspective view of a voice coil mounted on a PCB substrate connected to a diaphragm and spider attachment locations.

[0017] Figure 9 is a perspective view of a planar voice coil where the voice coil is positioned in a corrugated substrate where the voice coil penetrates both sides of substrate and the substrate has corrugations or waves in a non-linear substrate surface.

[0018] Figure 10 is side view of a planar voice coil where the voice coil is positioned in a corrugated substrate where the voice coil penetrates both sides of substrate and the substrate has corrugations or waves in a non-linear substrate surface.

[0019] Figure 11 is top view of a planar voice coil where the voice coil is positioned in a corrugated substrate where the voice coil penetrates both sides of substrate and the substrate has corrugations or waves in a non-linear substrate surface.

[0020] Figure 12 is a perspective view of a planar voice coil positioned on a Y-substrate.

[0021] Figure 13 is an end view of a planar voice coil positioned on a Y-substrate.

[0022] Figure 14 is a side view of a planar voice coil positioned on a Y-substrate.

[0023] Figure 15 is a perspective view of a planar voice coil positioned on a L-substrate.

[0024] Figure 16 is a side view of a planar voice coil positioned on a L-substrate.

[0025] Figure 17 is an end view of a planar voice coil positioned on a L-substrate.

[0026] Figure 18 is side view of a planar voice coil positioned on a box shaped substrate.

[0027] Figure 19 is an end view of a planar voice coil positioned on a box shaped substrate.

[0028] Figure 20 is a perspective view of a planar voice coil formed in the shape of a rectangle with rounded corners.

[0029] Figure 21 is a side view of a planar voice coil formed in the shape of a rectangle with rounded corners.

DETAILED DESCRIPTION

[0030] This invention is a voice coil or bobbin system that may be configured in a variety of scenarios to optimize performance. A number of features and description of functionality of various structures may be employed by the invention which is described. With fewer components, assembly complications can be reduced during manufacturing.

[0031] Figure 1 is a perspective view of two planar voice coils wired in parallel secured to a substrate 100. The first coil 102 is positioned on the substrate 100 and is connected to a first lead 104. A second coil 106 is connected to lead 104 such that the first coil 102 is wired in parallel with the second coil 106. A second lead 108 is connected to the inner wrap 110 of the first coil 102 and the inner wrap 112 of the second coil 106 thus completing the first and second coils 102 and 106 wired in parallel. The first lead 104 and second lead 108 may be in electrical connectivity with a or surround assembly but the bobbin is directly connected to the diaphragm (not shown). The substrate 100 may be physically connected to a diaphragm capable of moving air. When electrical power is applied to the voice coils 102 and 106 while they are positioned in a magnetic field (not shown), the substrate 100 will move the diaphragm and generate sound.

[0032] The process of placing two or more planar voice coils on one substrate and wiring the voice coils in parallel reduces the impedance of the motor. As an example, if a first voice coil has a direct current ("DC") current of 8 ohms, two voice coils wired in parallel that are half the size of the first voice coil, have individual resistances of 4 ohms, which when wired in parallel generate a resistance of 2 ohms. Thus, the same amount of wire of the first voice coil can generate four (4) times the normalized electromechanical force when split into two voice coils wired in parallel.

[0033] The planar winding of the two planar voice coils 102 and 106 may be formed from electrically conductive materials (e.g., copper, aluminum, etc.) for use as a voice coil within a linear and non-circular loudspeaker motor that is adhered to a flat substrate surface of a non-magnetically conductive piece of material. Ideally, the thickness of the non-magnetically conductive piece of material is less than three (3) mm thick. The

tines of the voice coils 102 and 106 may be arranged parallel to each other within a tolerance of forty-five (45) degrees in order to maintain high performance.

[0034] Such voice coils can be wired in parallel and located on either one side or both sides of the flat substrate such that the tines of the coil are generally aligned with each other. The voice coils wired in parallel may have a thirty (30) degree tolerance relative to the lengthwise angle of the motor halves. The bobbin or substrate may be in the shape of any polygon or closed curve that allows for the substrate to be connected to a diaphragm and/or spider(s) for moving air and generating sound. The coil may be in the shape of a stadium running track with ovals on the end and straightaway. An alternative shape may be of a rounded corner rectangle or any polygon.

[0035] Figure 2 is a side view of two planar voice coils wired in parallel with input output leads. The first coil 200 is positioned on a substrate 202 connected to a first lead 204. A second coil 206 is connected to lead 204 such that the first coil 202 is wired in parallel with the second coil 206. A second lead 208 is connected to the inner wrap 210 of the first coil 202 and the inner wrap 212 of the second coil 206 thus completing the first and second coils 202 and 206 wired in parallel.

[0036] Figure 3 is a perspective view of a voice coil positioned on a substrate having a plurality of spider attachment locations. The coil 300 is positioned on a substrate 302 and is connected to a first lead 304. A second lead 306 is connected to the inner wrap 308 of the coil 300. A plurality of spiders 308 are shown in Figure 3. Optional spiders 310 may be connected to the substrate 302. The bobbin or substrate 302 may be integrated with the spiders 308 as one component. This eliminates the need for assembly of the spiders 308 to the bobbin or substrate 302, thus removing adhesive agents from the design potentially strengthening the joint and removes the steps of using fixtures or jigs from the assembly process.

[0037] Figure 4 is a perspective view of a planar voice coil with input output leads mounted on a polycarbonate board ("PCB"). The voice coil 400 may be positioned on a PCB substrate 402. The voice coil 400 is formed from an electrically conductive material that can be etched or laid down on the PCB substrate 402. The voice coil may be applied to a polycarbonate board ("PCB") where the planar voice coil is etched into the PCB and

the PCB substrate acts as the bobbin between the diaphragm and the surround. Such a PCB voice coil could contain one or more layers of copper for the voice coil.

[0038] Like other planar voice coils, this voice coil 400 has a first lead 404 connecting to the voice coil 400. The first lead may be formed on the PCB substrate 402 as part of the etching process for the voice coil when it is laid down. If the electrically conductive material is insulated the second lead 406 may be laid over top of the voice coil 400. If the electrically conductive material forming the voice coil 400 is not insulated, an insulation barrier may be laid down (not shown) and the second lead 406 laid over top of the voice coil 400.

[0039] The first lead 404 and second lead 406 that may be in electrical connectivity with a power supply (not shown). The substrate 402 may be physically connected to a diaphragm capable of moving air. When electrical power is applied to the voice coil 400 while the voice coil 400 is positioned in a magnetic field (not shown), the substrate 402 will move the diaphragm and generate sound.

[0040] Figure 5 is a side view of a planar voice coil with input and output leads mounted on a polycarbonate board ("PCB"). The voice coil 500 may be positioned on a PCB substrate 502. The voice coil 500 is formed from an electrically conductive material that can be laid down on the PCB substrate 502. Like other planar voice coils, this voice coil 500 has a first lead 504 connecting to the voice coil 500. The first lead may be formed on the PCB substrate 502 just as the voice coil is laid down. If the electrically conductive material is insulated the second lead 506 may be laid over top of the voice coil 500. If the electrically conductive material forming the voice coil 500 is not insulated, an insulation barrier may be laid down (not shown) and the second lead 406 laid over top of the voice coil 500.

[0041] The planar voice coil 500 may be laid down on one side of the PCB substrate 502 or, in the alternative, may be laid down on both sides of the PCB substrate 502 where the first lead 504 connects a first voice coil 500 in parallel with a second voice coil (not shown) laid down on the reverse side of the PCB substrate 502.

[0042] Figure 6 is a side view of a planar voice coil sandwiched between two electrically non-conductive substrates. A voice coil 600 (dotted line, hidden voice coil) may be formed so that it is sandwiched between two parallel PCB substrates 602. In the alternative, the voice coil 600 may be etched within one PCB substrate where the non-conductive sides are on the outside of the PCB substrate 602 and the voice coil 600 is etched completely within the PCB substrate 602. The voice coil 600 may have an input lead 604 and an output lead 606 that may be in electrical connectivity with a power supply (not shown). The upper or lower edge of the substrates 602 may be connected to a diaphragm (not shown) such that when the substrate sandwich 602 is placed in a magnetic field and electrical power is passed though the voice coil 600, the diaphragm will move and generate sound.

[0043] Figure 7 is an end view of a planar voice coil sandwiched between two non-electrically conductive PCB substrates. In Figure 7, the electrically conductive, voice coil element 600 is sandwiched between two PCB substrates 602. The PCB substrates 602 may be attached to the voice coil 600 by industrial adhesives or in the alternative, the voice coil 600 may be mounted on one of the PCB substrates and attached to the second PCB substrate with an industrial adhesive. The use of industrial adhesives may include Pressure Sensitive Adhesives ("PSA") for ease of manufacturing the subassembly of the voice coil and substrate system. Use of a PSA assists in the attachment of the voice coil.

[0044] Figure 8 is a perspective view of a voice coil mounted on a PCB substrate connected to a diaphragm and spider attachment locations. The voice coil 800 is attached to the PCB substrate 802 where a first lead 804 and a second lead 806 mates with or is formed from the coil wire and may be electrically coupled with a power source. A diaphragm 808 is connected to one end of the PCB substrate 802 so that when the voice coil 800 is placed in a magnetic field the PCB substrate 802 linearly moves creating sound.

[0045] Figure 9 is a perspective view of a planar voice coil where the voice coil 900 is positioned within a corrugated substrate 902 where the voice coil 900 penetrates both sides of substrate 902 and the substrate 902 has corrugations or waves in a non-linear substrate surface. The corrugated substrate 902 maybe have any 3D formation,

deformation or shape which results in the voice coil 900 being located on both sides of the substrate 902. The corrugation of the substrate 902 adds to structural stability of the voice coil 900 and the joint surface area to the diaphragm and spider (both not shown in Figure 9).

[0046] Figure 10 is side view of a planar voice coil 1000 where the voice coil 1000 is positioned in a corrugated substrate 1002 where the voice coil 1000 penetrates both sides of substrate 1002 and the substrate 1002 has corrugations or waves in a non-linear substrate surface.

[0047] Figure 11 is top view of a planar voice coil 1100 where the voice coil 1100 is positioned in a corrugated substrate 1102 where the voice coil 1100 penetrates both sides of substrate 1102 and the substrate 1102 has corrugations or waves in a non-linear substrate surface.

[0048] Figure 12 is a perspective view of a planar voice coil positioned on a Y shaped substrate. The voice coil 1200 is positioned on a Y shaped substrate 1202. The Y shaped substrate 1202 has one or more edges split into a V shape resulting in a substrate that forms the letter Y. Forming a Y shaped substrate 1202 may involve splitting the substrate thickness lengthwise along one or more of its sides. In an alternative, one or more of the edges of the substrate may be bent at an angle 1204 and another piece of substrate 1204 adhered to the substrate 1206 to form a Y shape.

[0049] Figure 13 is an end view of a planar voice coil positioned on a Y-substrate. The voice coil 1300 is positioned on the substrate 1302 and one or more edges of the substrate 1302 is formed into a Y shape. Forming a Y shaped substrate 1302 may involve splitting the substrate thickness lengthwise along one or more of its sides. In an alternative, one or more of the edges of the substrate 1302 may be bent at an angle 1304 and another piece of substrate 1304 adhered to the substrate 1306 to form a Y shape.

[0050] Figure 14 is a side view of a planar voice coil positioned on a Y-substrate. The voice coil 1400 is positioned on a substrate 1402 where one or more edges of the substrate is formed into a Y shape 1404.

[0051] Figure 15 is a perspective view of a planar voice coil positioned on an L shaped substrate. The voice coil 1500 is positioned on the substrate 1502 and one or more edges of the substrate is formed into an L shape. Forming an L shaped substrate 1502 may involve crimping the substrate 1502 lengthwise along one or more of its sides in order to form the L shape. In an alternative, one or more of the edges of the substrate 1502 may have another piece of substrate 1504 attached to the substrate 1502 for form an angle less than 180 degrees but not zero degrees. The second piece of substrate 1504 may be adhered to the substrate 1502 to form an L shape by an industrial adhesive or tape. Another alternative is to partially cut the substrate 1502 and bend the cut edges to the desired angle. The bends in the substrate 1502 can then be made permanent with application of industrial adhesives or other bonding processes. The bend itself may be designed as a hard angle or contain a chamfer or fillet as a type of transition zone form the substrate 1502 to the diaphragm.

[0052] Figure 16 is a side view of a planar voice coil positioned on an L-substrate. The voice coil 1600 is positioned on the substrate 1602 and one or more edges of the substrate is formed into an L shape. Forming an L shaped substrate 1602 may involve crimping the substrate 1602 lengthwise along one or more of the substrate's sides in order to form the L shape.

[0053] Figure 17 is an end view of a planar voice coil positioned on an L-substrate. The voice coil 1700 is positioned on the substrate 1702 and one or more edges of the substrate is formed into an L shape. Forming an L shaped substrate 1702 may involve crimping the substrate 1702 lengthwise along one or more of the substrate's sides in order to form the L shape.

[0054] Figure 18 is side view of a planar voice coil positioned on an opened box shaped substrate. The voice coil 1800 is positioned on the substrate 1802 and one or more edges of the substrate is formed into an opened box shape or double L shape. Forming a double L shaped substrate 1802 may involve crimping the substrate 1802 lengthwise along two or more of the substrate's sides in order to form the double L shape.

[0055] Figure 19 is an end view of a planar voice coil positioned on a box shaped substrate. The voice coil 1900 is positioned on the substrate 1902 and all the edges of the substrate 1902 is formed into a box shape. Forming a box shaped substrate 1902 may involve crimping the substrate 1902 lengthwise along one or more of its sides in order to form the box shape.

[0056] Figure 20 is a perspective view of a planar voice coil formed in the shape of a rectangle with rounded corners. In Figure 20, the planar voice coil 2000 is positioned on the substrate 2002 by creating a rectangular form with rounded edges. The planar voice coil 2000 may be coiled with straight, non-filleted corners, angled to create a pointed tip, or oval shaped. These alternative shapes may have a lower inductance due to the non-circular ends.

[0057] Figure 21 is a side view of a planar voice coil formed in the shape of a rectangle with rounded corners. In Figure 21, the planar coil 2100 is positioned on the substrate 2102 by creating a rectangular form with rounded edges.

[0058] In all of these examples set forth in Figures 1 through 21, have a defined substrate that the voice coil is positioned on. In a simple structure, assuming the voice coil is sufficiently rigid, the electrically conductive voice coil may act as its own substrate. Thus, a sufficiently rigid voice coil may be connected directly to a plurality of spiders on one edge and the diaphragm on the opposing edge.

[0059] While various embodiments of the invention have been described, it will be apparent to those of ordinary skill in the art that many more embodiments and implementations are possible that are within the scope of this invention.

CLAIMS

What is claimed is:

1. A loudspeaker motor comprising:
a first rigid voice coil connected along a first edge by at least one spider;
positioning the voice coil adjacent to at least one magnet; and
a diaphragm connected along a second edge of the rigid voice coil.

2. The loudspeaker motor of claim 1, further comprising a second voice coil positioned adjacent to the first voice coil and separated by an insulation so that the first and second voice coils are wired in parallel and not otherwise electrically coupled.

3. A loudspeaker motor comprising:
a first voice coil positioned on a PCB substrate;
a spider connected along a first edge of the PCB substrate;
a diaphragm connected along a second edge of the PCB substrate; and
at least one magnet positioned adjacent to the voice coil.

4. The loudspeaker motor of claim 3, further comprising a Y shaped substrate.

5. The loudspeaker motor of claim 3, further comprising an L shaped substrate.

6. The loudspeaker motor of claim 3, further comprising a double L shaped substrate.

7. The loudspeaker motor of claim 3, further comprising an opened box shaped substrate.

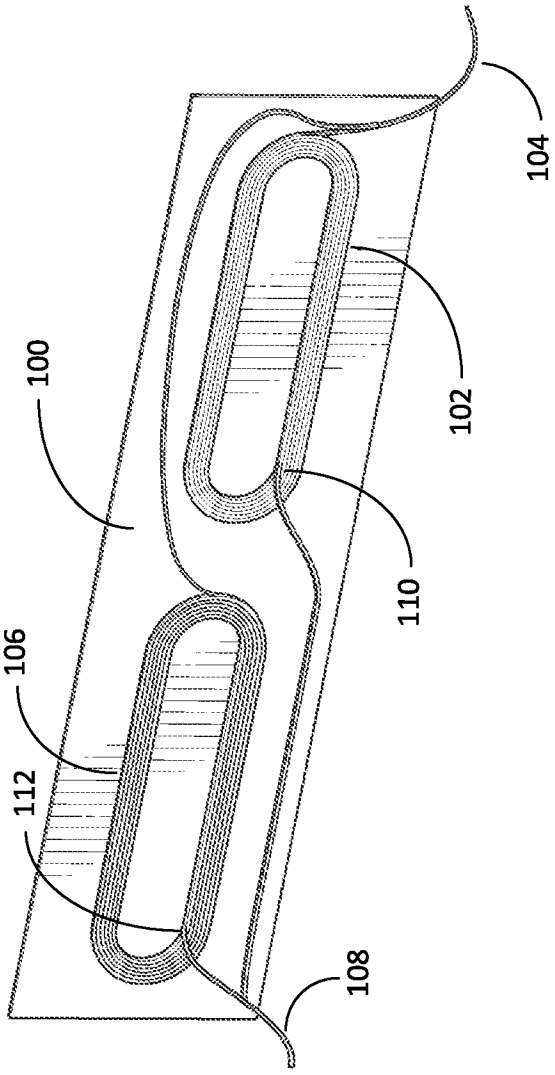

Fig. 1

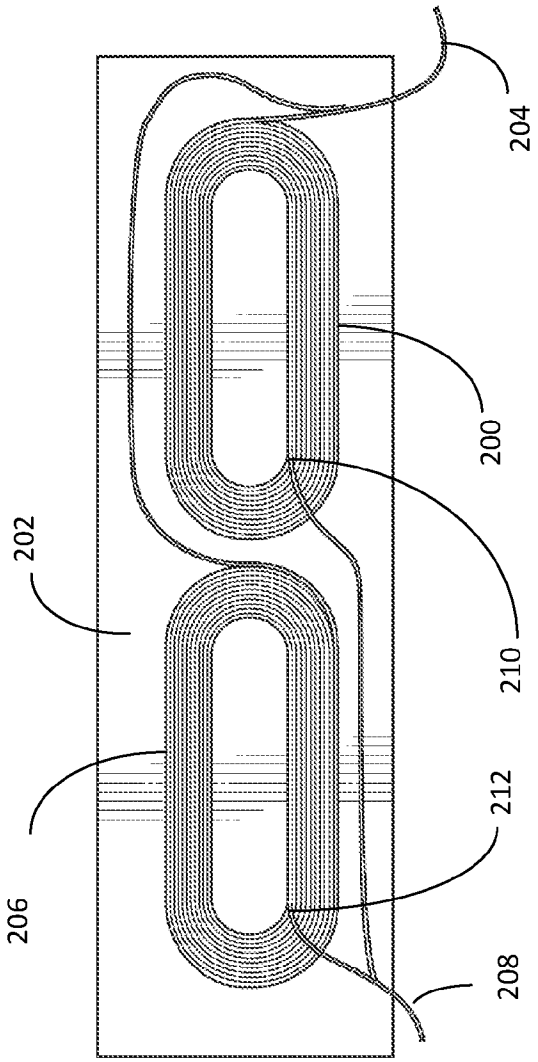

Fig. 2

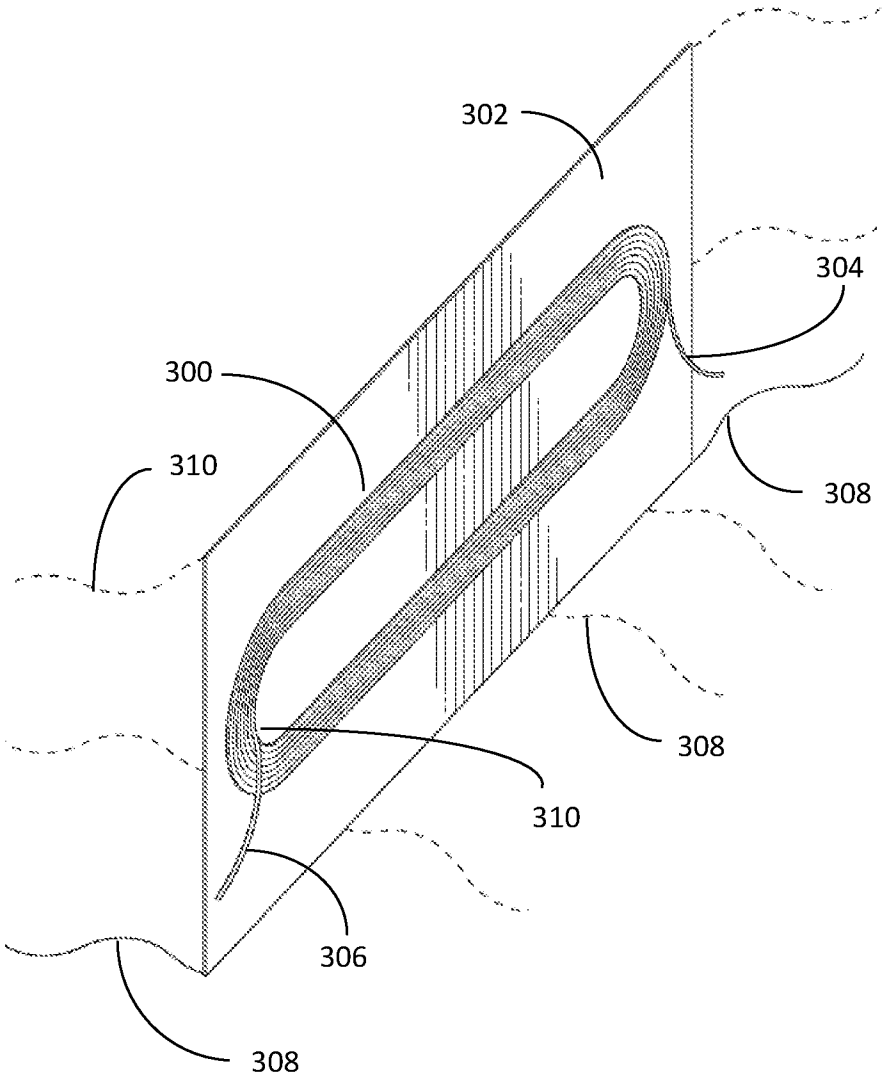

Fig. 3

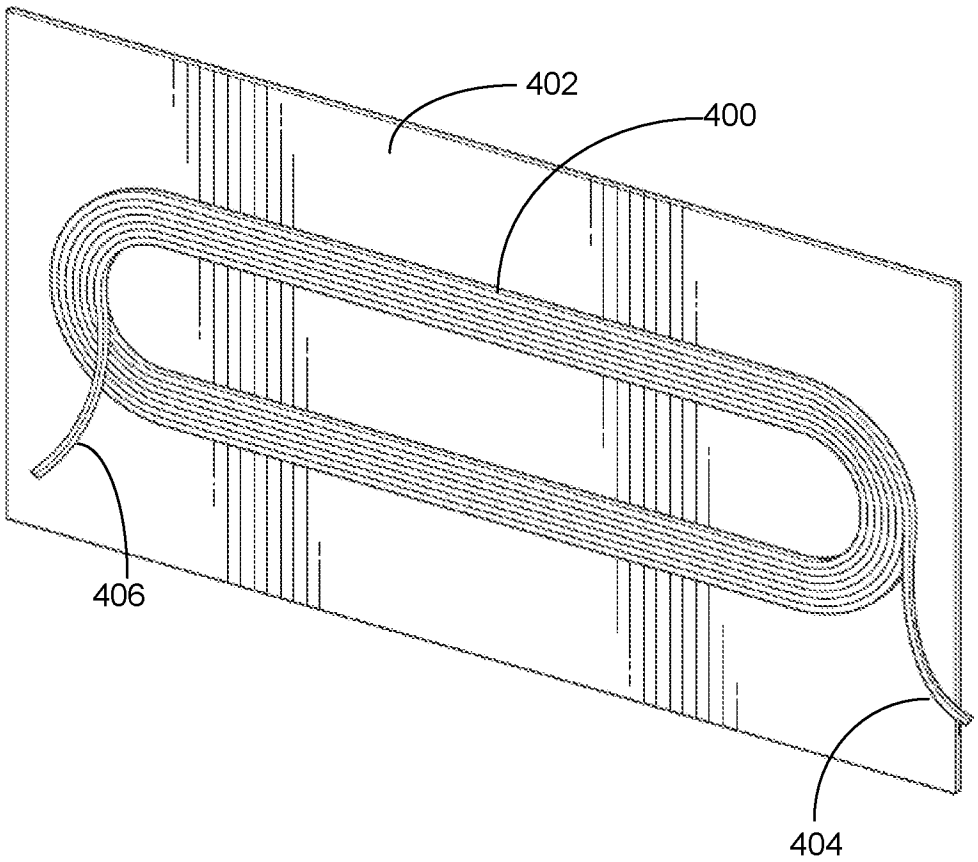

Fig. 4

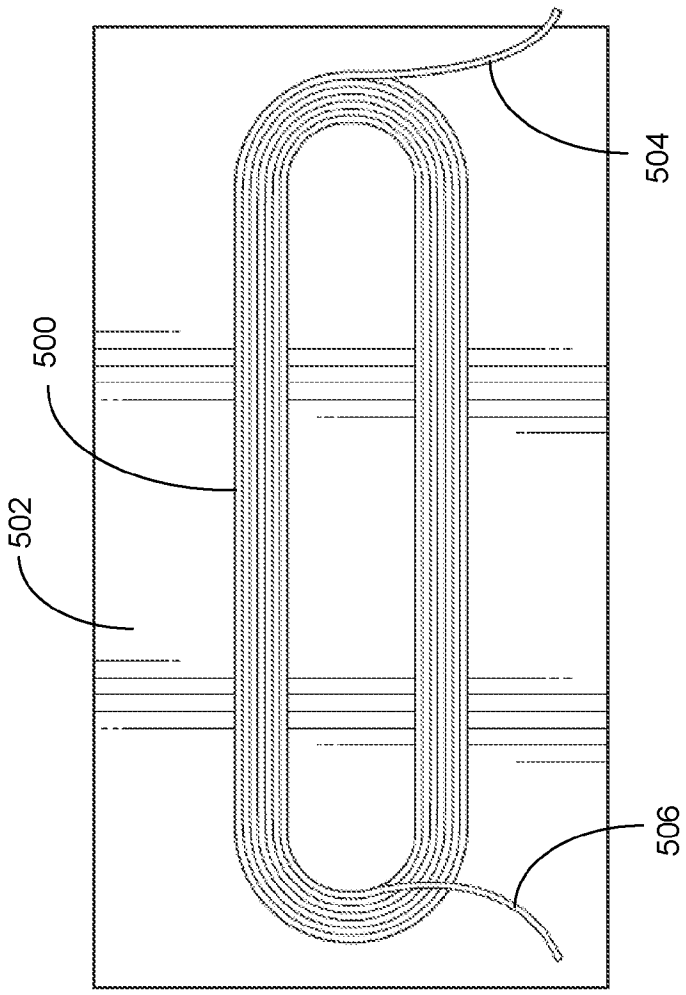

Fig. 5

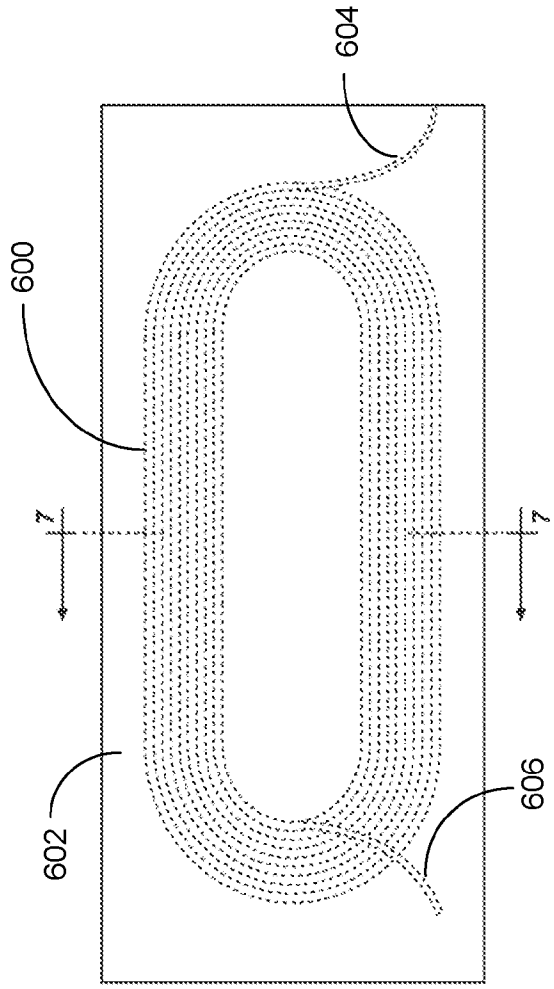

Fig. 6

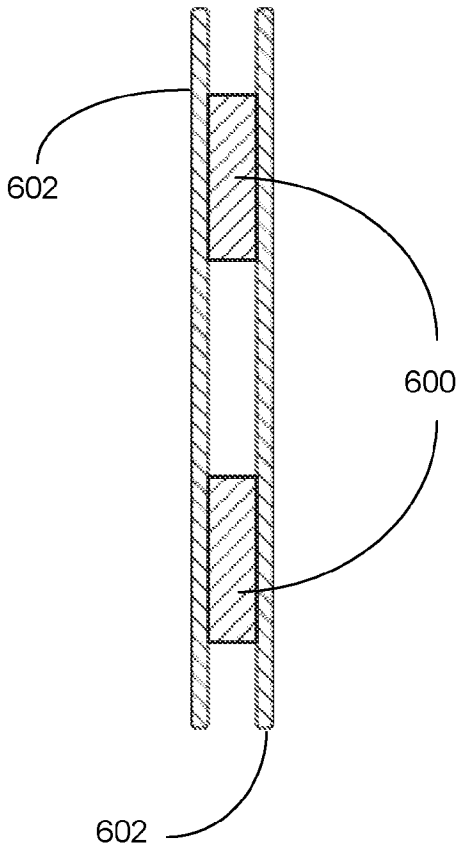

Fig. 7

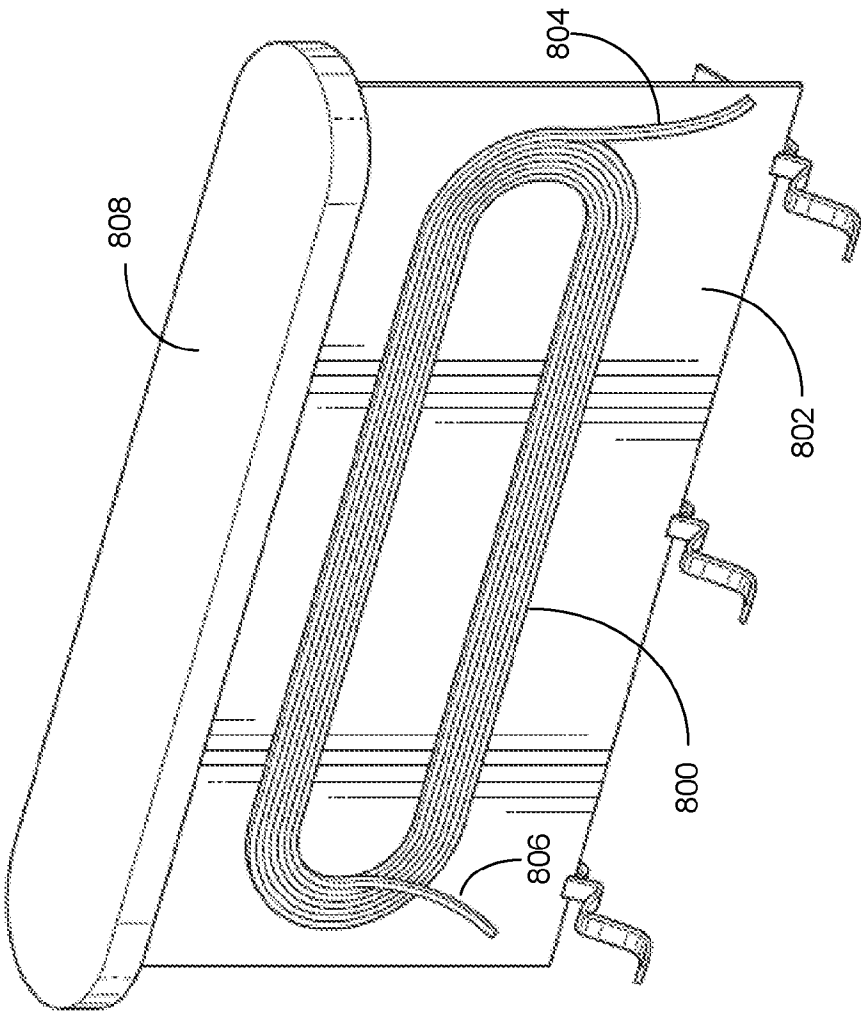

Fig. 8

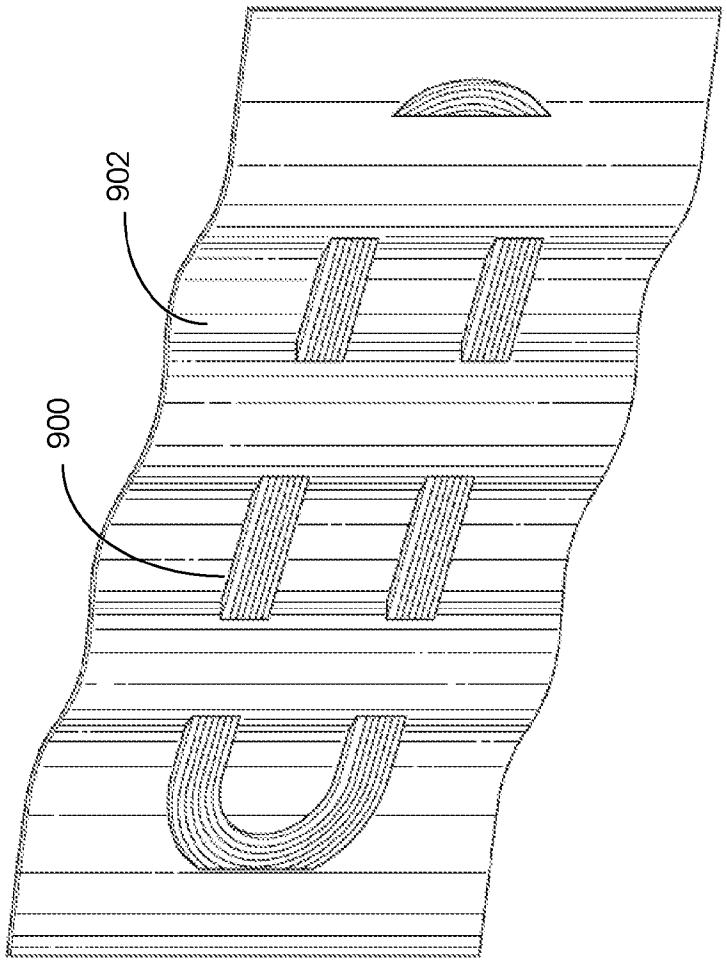

Fig. 9

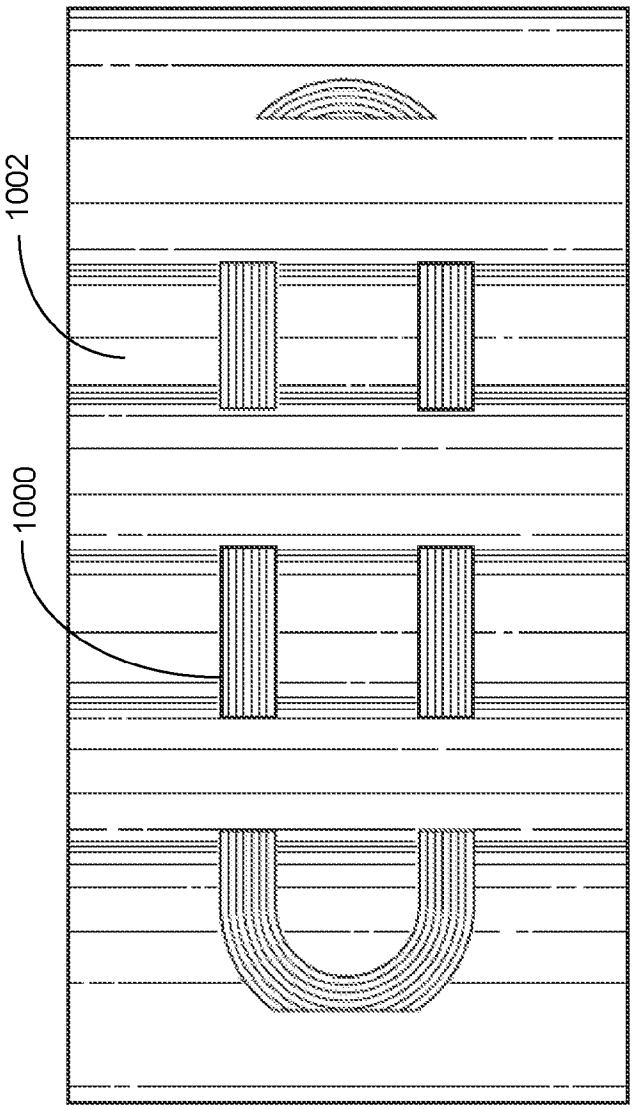

Fig. 10

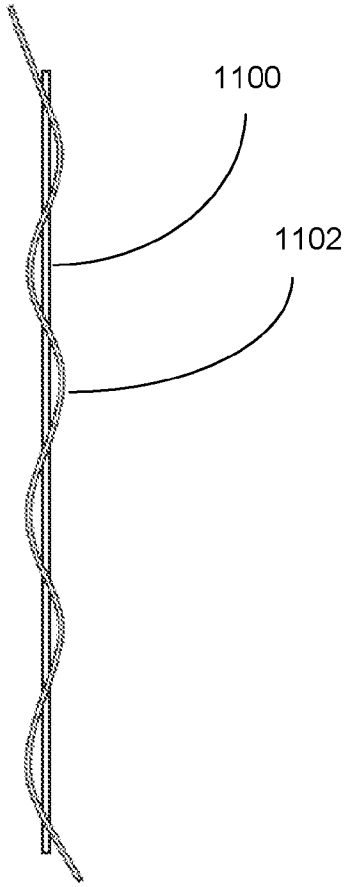

Fig. 11

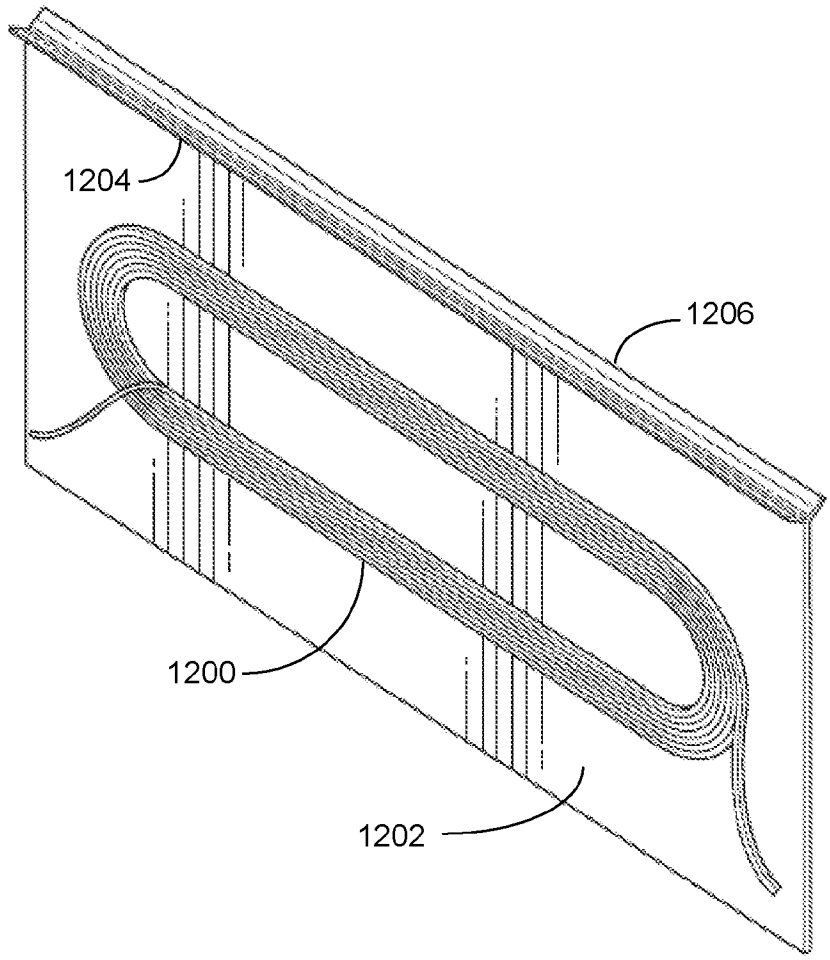

Fig. 12

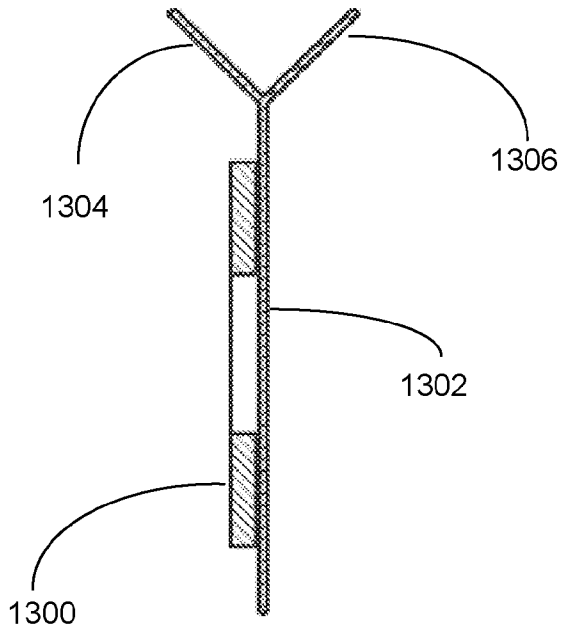

Fig. 13

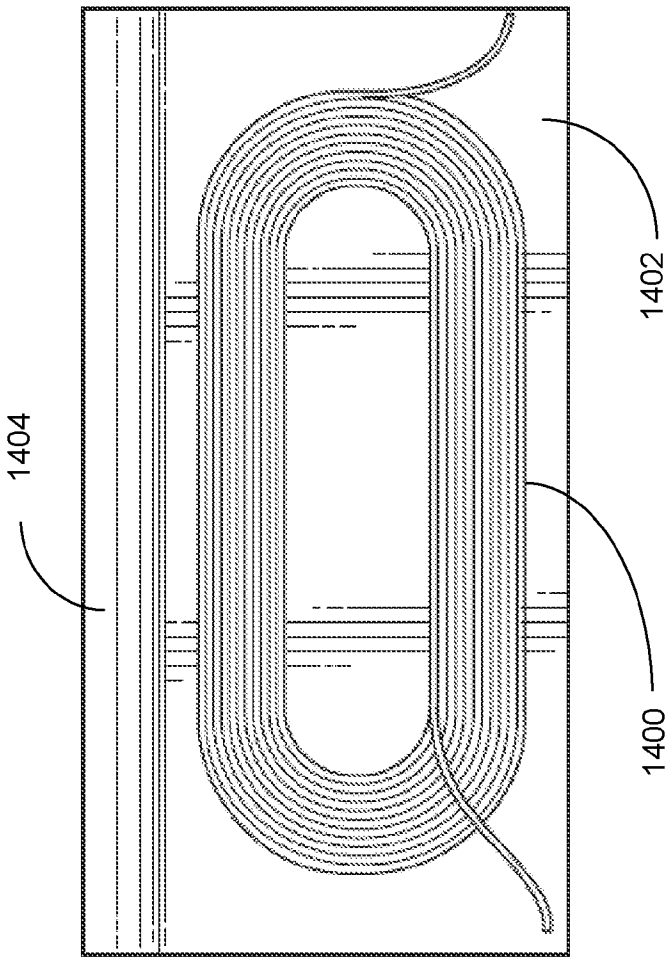

Fig. 14

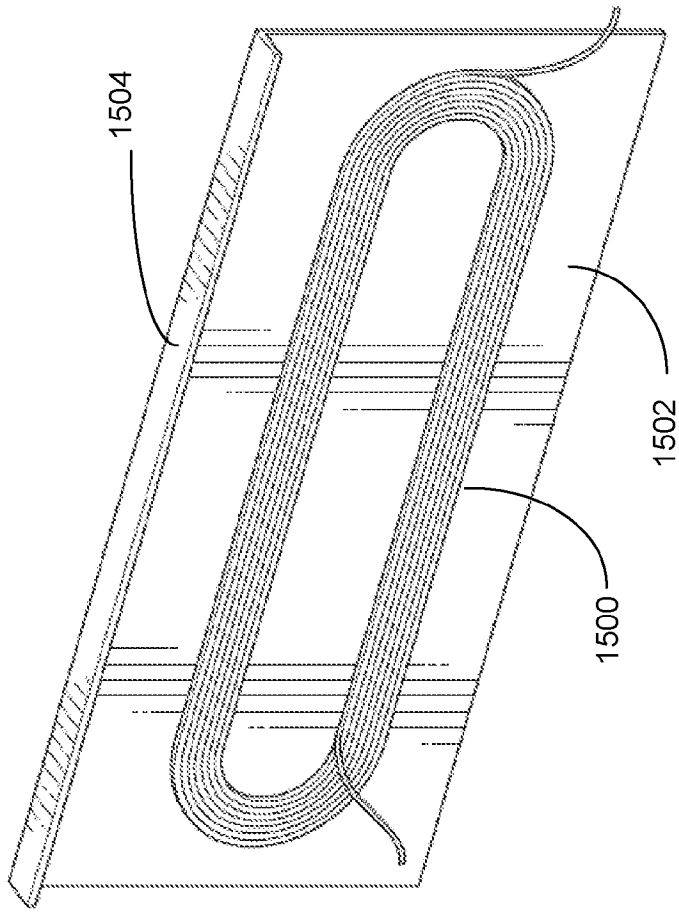

Fig. 15

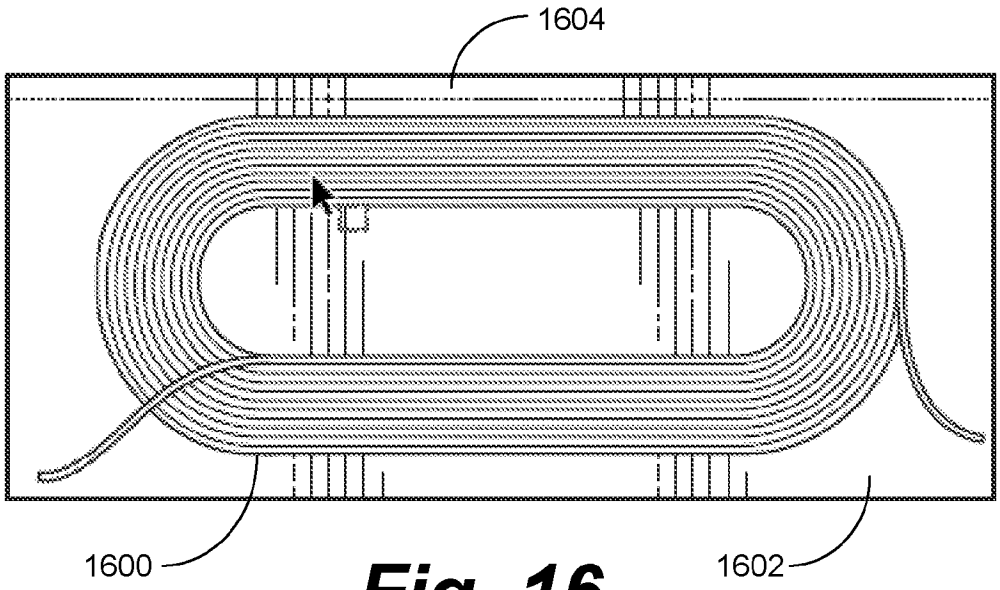

Fig. 16

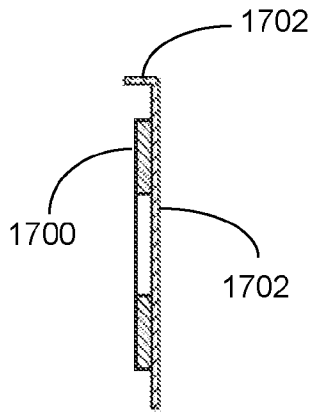

Fig. 17

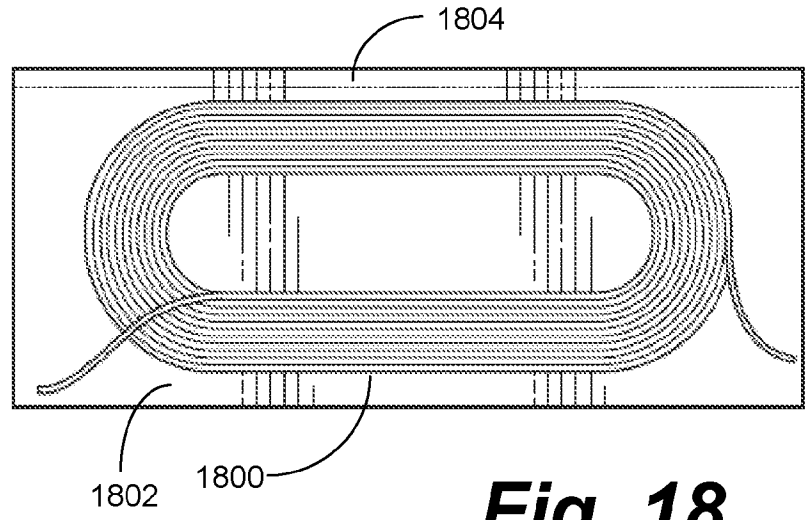

Fig. 18

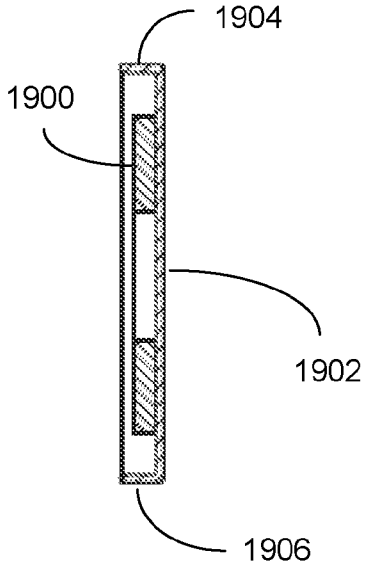

Fig. 19

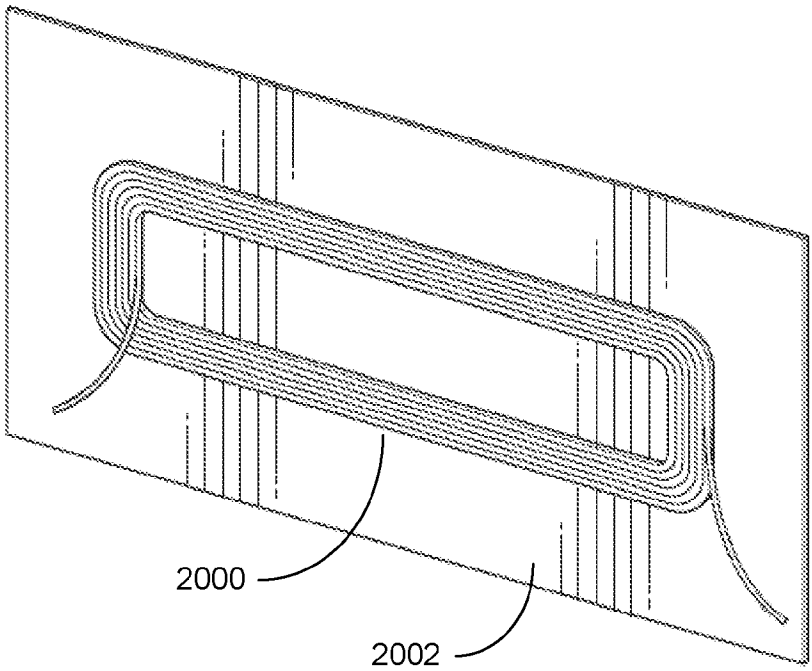

Fig. 20

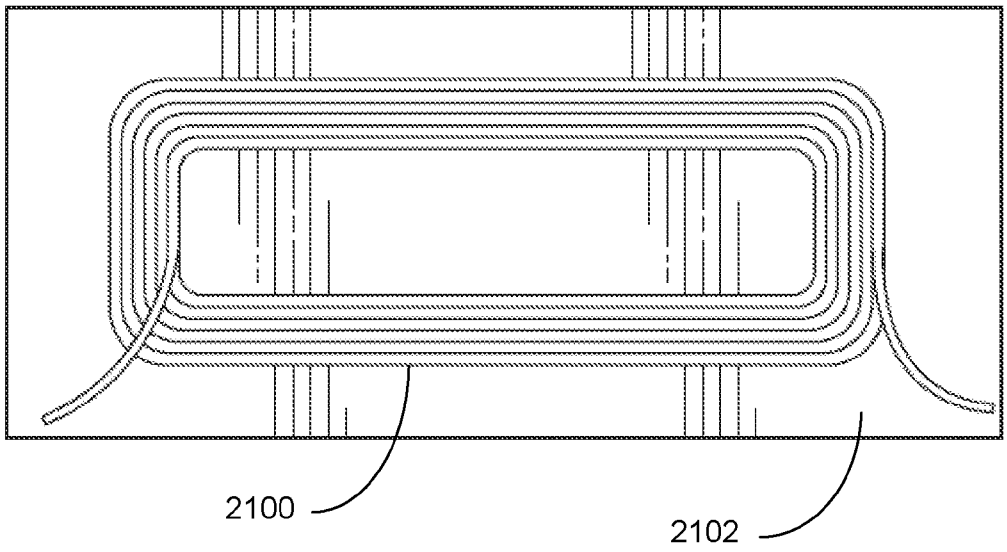

Fig. 21

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US23/29672

A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. H04R 9/04; H04R 1/00; H04R 7/16 (2023.01)
ADD.
CPC - INV. H04R 9/047; H04R 1/00; H04R 7/16; H04R 9/063

ADD. H04R 2201/003; H04R 2209/041; H04R 2209/043; H04R 2400/13

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic database consulted during the international search (name of database and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y --- A	US 2022/0070589 A1 (RESONADO INC.) 03 March 2022; FIG. 2A; paragraphs [0030], [0036]	1 --- 2 --- 3-7
X --- Y --- A	US 2020/0275190 A1 (RESONADO INC.) 27 August 2020; FIGS. 2, 3a-3d; paragraphs [0007], [0020], [0023], [0060]; claims 7, 8	3 --- 2, 4-7 --- 1
Y --- A	US 2015/0195655 A1 (WALL AUDIO INC.) 09 July 2015; FIG. 4B; paragraph [0071]	4 --- 1-3, 5-7
Y --- A	WO 2016/020835 A1 (KATZ DAVID MICAH) 11 February 2016; paragraphs [0066], [0086]; FIGS. 3B, 10A, 10B	5-7 --- 1-4

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 October 2023 (31.10.2023)	NOV 20 2023
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