



(11)

EP 4 506 971 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
12.02.2025 Bulletin 2025/07

(51) International Patent Classification (IPC):
H01F 27/32 ^(2006.01)

(21) Application number: **22936525.9**

(52) Cooperative Patent Classification (CPC):
H05B 6/108; H01F 27/32; H05B 6/44

(22) Date of filing: **07.04.2022**

(86) International application number:
PCT/JP2022/017258

(87) International publication number:
WO 2023/195126 (12.10.2023 Gazette 2023/41)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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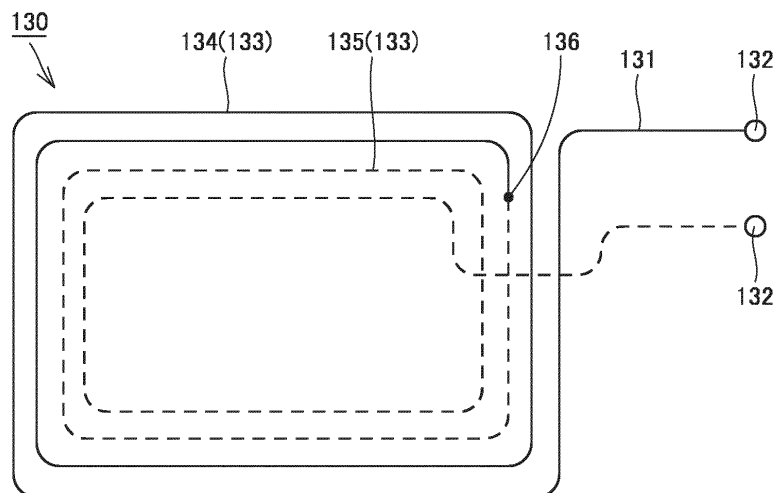
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(54) **STATIONARY INDUCTION APPARATUS**

(57) A stationary induction apparatus includes a core (110) and a plurality of plate windings (130). The plurality of plate windings (130) are arranged side by side in an axial direction of the core (110), and wound around the core (110). Each of the plurality of plate windings (130) includes a conductor portion (131) and an insulating coating portion (133). The insulating coating portion

(133) is spirally wound around the conductor portion (131) to cover the conductor portion (131). In at least one plate winding (130) of the plurality of plate windings (130), a plurality of types of insulating coating portions (133) having different heat resistances from each other are seamed together as the insulating coating portion (133) to cover the conductor portion (131).

FIG.4



Description

TECHNICAL FIELD

[0001] The present disclosure relates to a stationary induction apparatus.

BACKGROUND ART

[0002] Japanese Patent Laying-Open No. 09-045551 (PTL 1) is a prior art document that discloses the configuration of a gas-insulated stationary induction apparatus. The gas-insulated stationary induction apparatus described in PTL 1 includes a core and a plurality of windings. The plurality of windings are wound around the core. The plurality of windings are vertically stacked to form vertical parallel windings. The plurality of windings have insulating coating layers of different materials. An upper portion of the windings, which will have the highest temperature, is provided with an insulating coating layer having the highest heat resistance, as compared to a lower portion of the windings, which undergoes a small temperature increase.

CITATION LIST

PATENT LITERATURE

[0003] PTL 1: Japanese Patent Laying-Open No. 09-045551

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] Generally, in one plate winding of a plurality of plate windings, temperature increase due to heat generation varies with location. A conductor portion of one plate winding is coated with an insulating coating portion having heat resistance corresponding to a location of the highest temperature. This can ensure heat resistance of the winding, but results in excessive use of the costly insulating coating portion having high heat resistance at a location of low temperature of one plate winding.

[0005] The present disclosure was made in view of the problem described above, and has an object to provide a stationary induction apparatus that can suppress the amount of use of a costly insulating coating portion having high heat resistance, while ensuring heat resistance of a winding.

SOLUTION TO PROBLEM

[0006] A stationary induction apparatus based on the present disclosure includes a core and a plurality of plate windings. The plurality of plate windings are arranged side by side in an axial direction of the core, and wound around the core. Each of the plurality of plate windings

includes a conductor portion and an insulating coating portion. The insulating coating portion is spirally wound around the conductor portion to cover the conductor portion. In at least one plate winding of the plurality of plate windings, a plurality of types of insulating coating portions having different heat resistances from each other are seamed together as the insulating coating portion to cover the conductor portion.

ADVANTAGEOUS EFFECTS OF INVENTION

[0007] According to the present disclosure, in at least one plate winding of a plurality of plate windings, a conductor portion is coated with a plurality of types of insulating coating portions having different heat resistances corresponding to respective locations of the conductor portion. It is thus possible to suppress the amount of use of a costly insulating coating portion having high heat resistance, while ensuring heat resistance of the winding.

BRIEF DESCRIPTION OF DRAWINGS

[0008]

Fig. 1 is a perspective view showing the configuration of a stationary induction apparatus according to a first embodiment.

Fig. 2 is a cross-sectional view showing the configuration of the stationary induction apparatus according to the first embodiment.

Fig. 3 is an exploded perspective view showing the configuration of a winding group included in the stationary induction apparatus according to the first embodiment.

Fig. 4 is a schematic diagram showing the configuration of a plate winding included in the stationary induction apparatus according to the first embodiment.

Fig. 5 is a schematic diagram showing the configuration of a portion where insulating coating portions are seamed together in the plate winding according to the first embodiment.

Fig. 6 is a schematic diagram showing the configuration of a portion where insulating coating portions are seamed together in each of a plurality of plate windings according to a second embodiment.

DESCRIPTION OF EMBODIMENTS

[0009] A stationary induction apparatus according to each embodiment will be described hereinafter with reference to the drawings. In the following description of the embodiments, the same or corresponding parts in the drawings are denoted by the same reference characters and description thereof will not be repeated.

First Embodiment

[0010] Fig. 1 is a perspective view showing the configuration of a stationary induction apparatus according to a first embodiment. Fig. 2 is a cross-sectional view showing the configuration of the stationary induction apparatus according to the first embodiment. Fig. 3 is an exploded perspective view showing the configuration of a winding group included in the stationary induction apparatus according to the first embodiment. To facilitate understanding of a structure inside the stationary induction apparatus, a tank is not shown in Fig. 1.

[0011] As shown in Figs. 1 to 3, a stationary induction apparatus 100 according to the first embodiment of the present disclosure is an on-vehicle transformer. Stationary induction apparatus 100 according to the present embodiment is a so-called shell-type transformer. Stationary induction apparatus 100 includes a core 110, a winding group 120, and a tank 150.

[0012] As shown in Fig. 1, core 110 includes a main leg 111 and side legs 112. Side legs 112 are connected to main leg 111.

[0013] As shown in Figs. 1 to 3, winding group 120 includes a plurality of plate windings 130 and a plurality of insulating plates 140.

[0014] Each of the plurality of plate windings 130 is wound around core 110. Specifically, each of the plurality of plate windings 130 is wound around main leg 111 while being passed between main leg 111 and side legs 112. The plurality of plate windings 130 are arranged side by side in an axial direction (DR1 direction) of core 110.

[0015] Each of the plurality of insulating plates 140 is located so as to be sandwiched between plate windings 130 adjacent to each other in the plurality of plate windings 130. Each of the plurality of insulating plates 140 provides insulation between plate windings 130 adjacent to each other.

[0016] Each of the plurality of insulating plates 140 is made of an insulating material, for example, an insulating paper such as a pressboard or an insulating material such as polyamide. Each of the plurality of insulating plates 140 has a substantially rectangular outer shape as seen in the DR1 direction, and is provided with an opening in its center into which core 110 is inserted.

[0017] The plurality of insulating plates 140 are provided with a plurality of spacers 141. Each of the plurality of spacers 141 is made of an insulating material, for example, an insulating paper such as a pressboard or an insulating resin such as polypropylene. Each of the plurality of spacers 141 is sandwiched between plate winding 130 and insulating plate 140 facing each other, to form a flow path 10 through which insulating oil (not shown) flows.

[0018] Tank 150 contains core 110, the plurality of plate windings 130, and the plurality of insulating plates 140. Tank 150 is filled with the insulating oil. Tank 150 is configured to allow the insulating oil to flow in a direction (DR2 direction) orthogonal to the axial direction of core

110 in tank 150.

[0019] Circulation pipes 151 are connected to tank 150. Circulation pipes 151 are connected to opposite ends of tank 150 in the DR2 direction. Circulation pipes 151 are provided with a pump and a cooling container (neither shown). Operation of the pump causes the insulating oil to circulate through tank 150, circulation pipes 151 and the cooling container. The insulating oil is cooled in the cooling container.

[0020] The insulating oil flowing into tank 150 through one of circulation pipes 151 flows in the DR2 direction. In winding group 120, the insulating oil flows through flow path 10 formed between the plurality of plate windings 130 adjacent to each other. Heat of plate windings 130 adjacent to flow path 10 is thereby transferred to the insulating oil. As a result, the plurality of plate windings 130 are cooled.

[0021] Fig. 4 is a schematic diagram showing the configuration of the plate winding included in the stationary induction apparatus according to the first embodiment. Fig. 5 is a schematic diagram showing the configuration of a portion where insulating coating portions are seamed together in the plate winding according to the first embodiment. To facilitate understanding of a structure of the plate winding, a conductor portion covered with an insulating coating portion is indicated by a single solid line or dotted line in Fig. 4.

[0022] As shown in Figs. 4 and 5, each of the plurality of plate windings 130 includes a conductor portion 131 and an insulating coating portion 133.

[0023] Conductor portion 131 is made of copper or aluminum, for example. Conductor portion 131 is wound to have a flat plate shape. Conductor portion 131 is provided with terminals 132 at its opposite ends. Terminals 132 are connected to a conductor portion of an adjacent plate winding, a converter (not shown), or the like.

[0024] Insulating coating portion 133 is spirally wound around conductor portion 131 to cover conductor portion 131. Insulating coating portion 133 provides insulation between adjacent conductor portions 131 of wound conductor portions 131.

[0025] Insulating coating portion 133 is made of an insulating paper such as a pressboard, for example. When an insulating paper is used, insulating coating portion 133 may be formed of a single layer of insulating paper or a plurality of layers of insulating paper.

[0026] In at least one plate winding 130 of the plurality of plate windings 130, a plurality of types of insulating coating portions 133 having different heat resistances from each other are seamed together as insulating coating portion 133 to cover conductor portion 131. Specifically, in insulating coating portion 133 of this at least one plate winding 130 in the present embodiment, a first insulating coating portion 134 and a second insulating coating portion 135 are seamed together to cover conductor portion 131.

[0027] First insulating coating portion 134 has lower

heat resistance than second insulating coating portion 135. Specifically, first insulating coating portion 134 has heat resistance classified into Class A of the JIS standard (JIS C 4003:2010), for example. On the other hand, second insulating coating portion 135 has heat resistance classified into Class B, for example. First insulating coating portion 134 and second insulating coating portion 135 are not limited to have heat resistances classified into Class A or Class B as long as they have different heat resistances from each other.

[0028] In each plate winding 130 including the plurality of types of insulating coating portions 133, an insulating coating portion having the lowest heat resistance has the highest arrangement ratio. In plate winding 130 according to the present embodiment, first insulating coating portion 134 having lower heat resistance than second insulating coating portion 135 has the highest arrangement ratio.

[0029] Although insulating coating portion 133 according to the present embodiment is formed by the two types of insulating coating portions, that is, first insulating coating portion 134 and second insulating coating portion 135, insulating coating portion 133 is not limited to this formation, and may be formed by three or more types of insulating coating portions. In addition, not all of the plurality of plate windings 130 in winding group 120 are required to have the plurality of types of insulating coating portions 133 having different heat resistances from each other.

[0030] In one plate winding 130, temperature increase due to heat generation caused by application of a voltage varies with location, due to a difference in the amount of magnetic flux transmitted through one plate winding 130 or a difference in the flow rate of a cooling medium. In plate winding 130 according to the present embodiment, for example, temperature tends to increase on the inner side of plate winding 130, and becomes higher than that on the outer side of plate winding 130.

[0031] In this case, second insulating coating portion 135 is arranged on the inner side of one plate winding 130 with respect to first insulating coating portion 134. As a result, in one plate winding 130, insulating coating portion 133 can coat conductor portion 131 with second insulating coating portion 135 having high heat resistance at the location of high temperature, and coat conductor portion 131 with first insulating coating portion 134 having low heat resistance at the location of low temperature. In this manner, the different types of insulating coating portions 133 can be arranged in accordance with the temperature distribution in one plate winding 130. When the inner side has a lower temperature than the outer side in one plate winding 130, second insulating coating portion 135 is arranged on the outer side of one plate winding 130 with respect to first insulating coating portion 134.

[0032] As shown in Fig. 5, first insulating coating portion 134 and second insulating coating portion 135 are seamed together at a seam portion 136. Seam portion 136 in the present embodiment is formed by bonding of

first insulating coating portion 134 and second insulating coating portion 135 together with an adhesive tape 137. A method for seaming first insulating coating portion 134 and second insulating coating portion 135 together is not limited to the seaming method with adhesive tape 137, as long as first insulating coating portion 134 and second insulating coating portion 135 are connected to each other.

[0033] In a method for manufacturing this plate winding 130, seam portion 136 is first formed in insulating coating portion 133 by seaming first insulating coating portion 134 and second insulating coating portion 135 together with adhesive tape 137. Seam portion 136 is formed in consideration of a location of plate winding 130 where seam portion 136 is to be arranged.

[0034] Then, insulating coating portion 133 having first insulating coating portion 134 and second insulating coating portion 135 seamed together is spirally wound around conductor portion 131. Conductor portion 131 having insulating coating portion 133 wound therearound is formed in a flat plate shape. As a result, plate winding 130 is formed in which the two types of insulating coating portions 133 having different heat resistances are seamed together to cover conductor portion 131.

[0035] In stationary induction apparatus 100 according to the first embodiment of the present disclosure, in one plate winding 130, conductor portion 131 is coated with the plurality of types of insulating coating portions 133 corresponding to the respective locations of conductor portion 131. It is thus possible to suppress the amount of use of costly insulating coating portion 133 having high heat resistance, while ensuring heat resistance of plate winding 130. Consequently, stationary induction apparatus 100 with ensured heat resistance of plate winding 130 can be formed at low cost.

[0036] In stationary induction apparatus 100 according to the first embodiment of the present disclosure, the amount of use of costly insulating coating portion 133 having high heat resistance can be suppressed by setting a ratio of the amount of use of low-cost insulating coating portion 133 having low heat resistance to the highest ratio.

Second Embodiment

[0037] A stationary induction apparatus according to a second embodiment will be described hereinafter. The stationary induction apparatus according to the second embodiment is different from stationary induction apparatus 100 according to the first embodiment only in the configuration of the plate windings. Therefore, description of the remaining configuration will not be repeated.

[0038] Fig. 6 is a schematic diagram showing the configuration of a portion where insulating coating portions are seamed together in each of a plurality of plate windings according to the second embodiment. To facilitate understanding of a structure of each plate winding, a conductor portion covered with an insulating coating

portion is indicated by a single solid line or dotted line in Fig. 6.

[0039] As shown in Fig. 6, in a stationary induction apparatus 200 according to the second embodiment, in two or more plate windings 230 of a plurality of plate windings 230, a plurality of types of insulating coating portions 233 are sealed together to cover a conductor portion 231. In each plate winding 230 according to the present embodiment, insulating coating portions 233 have a first insulating coating portion 234 and a second insulating coating portion 235.

[0040] In these two or more plate windings 230, respective arrangements of the plurality of types of insulating coating portions 233 in respective plate windings 230 are different from each other. Specifically, each plate winding 230 has a seam portion 236. One plate winding 230a is provided with a first seam portion 236a. The other plate winding 230b is provided with a second seam portion 236b. First seam portion 236a and second seam portion 236b are arranged differently in plate windings 230 as seen in the axial direction (DR1 direction) of the core. Consequently, in plate windings 230a and 230b, the respective arrangements of first insulating coating portion 234 and second insulating coating portion 235 are different from each other.

[0041] In the present embodiment, each plate winding 230 has a different temperature distribution depending on the position of stacked plate winding 230. By adjustment of the arrangement of seam portion 236 of insulating coating portion 233 in accordance with the temperature distribution in each of plate windings 230a and 230b, the respective arrangements of first insulating coating portion 234 and second insulating coating portion 235 in plate windings 230a and 230b can be different from each other. Therefore, costly insulating coating portion 233 having high heat resistance can be used only at a location of high temperature.

[0042] Although the present embodiment describes the insulating oil as flowing along the direction (DR2 direction) orthogonal to the axial direction of the core, the flow direction of the insulating oil is not limited to the direction orthogonal to the axial direction of the core. The insulating oil may flow, for example, along the axial direction (DR1 direction) of the core. In this case, a plate winding on the downstream side of a flow of the insulating oil increases in temperature due to heat exchange between the insulating oil and the winding group. Therefore, it is desirable to have a higher arrangement ratio of the insulating coating portion having high heat resistance in the downstream plate winding than in a plate winding on the upstream side of the flow of the insulating oil.

[0043] In stationary induction apparatus 200 according to the second embodiment of the present disclosure, when plate winding 230 has a different temperature distribution depending on the position of stacked plate winding 230, by adjustment of the arrangement of seam portion 236 of insulating coating portion 233 in accordance with each plate winding 230, costly insulating

coating portion 233 having high heat resistance can be arranged only at a location of high temperature of each plate winding 230. It is thus possible to suppress the amount of use of costly insulating coating portion 233, while ensuring heat resistance of plate winding 230. Consequently, stationary induction apparatus 200 with ensured heat resistance of plate winding 230 can be formed at low cost.

[0044] It should be understood that the embodiments disclosed herein are illustrative in every respect, and do not serve as a basis for restrictive interpretation. Therefore, the technical scope of the present disclosure is not interpreted based on the foregoing embodiments only, and encompasses all modifications and variations equivalent in meaning and scope to the claims. In the description of the foregoing embodiments, configurations that can be combined with each other may be combined together.

REFERENCE SIGNS LIST

[0045] 10 flow path; 100, 200 stationary induction apparatus; 110 core; 111 main leg; 112 side leg; 120 winding group; 130, 230, 230a, 230b plate winding; 131, 231 conductor portion; 132 terminal; 133, 233 insulating coating portion; 134, 234 first insulating coating portion; 135, 235 second insulating coating portion; 136, 236 seam portion; 137 adhesive tape; 140 insulating plate; 141 spacer; 150 tank; 151 circulation pipe; 236a first seam portion; 236b second seam portion.

Claims

1. A stationary induction apparatus comprising:

a core; and
a plurality of plate windings arranged side by side in an axial direction of the core and wound around the core, wherein
each of the plurality of plate windings includes a conductor portion, and an insulating coating portion spirally wound around the conductor portion to cover the conductor portion, and
in at least one plate winding of the plurality of plate windings, a plurality of types of insulating coating portions having different heat resistances from each other are sealed together as the insulating coating portion to cover the conductor portion.

2. The stationary induction apparatus according to claim 1, wherein in two or more plate windings of the plurality of plate windings, the plurality of types of insulating coating portions are sealed together to cover the conductor portion, and respective arrangements of the plurality of types of insulating coating portions in the respective plate windings are different

from each other.

3. The stationary induction apparatus according to claim 1 or 2, wherein in each plate winding including the plurality of types of insulating coating portions, an insulating coating portion having lowest heat resistance has a highest arrangement ratio.

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FIG.1

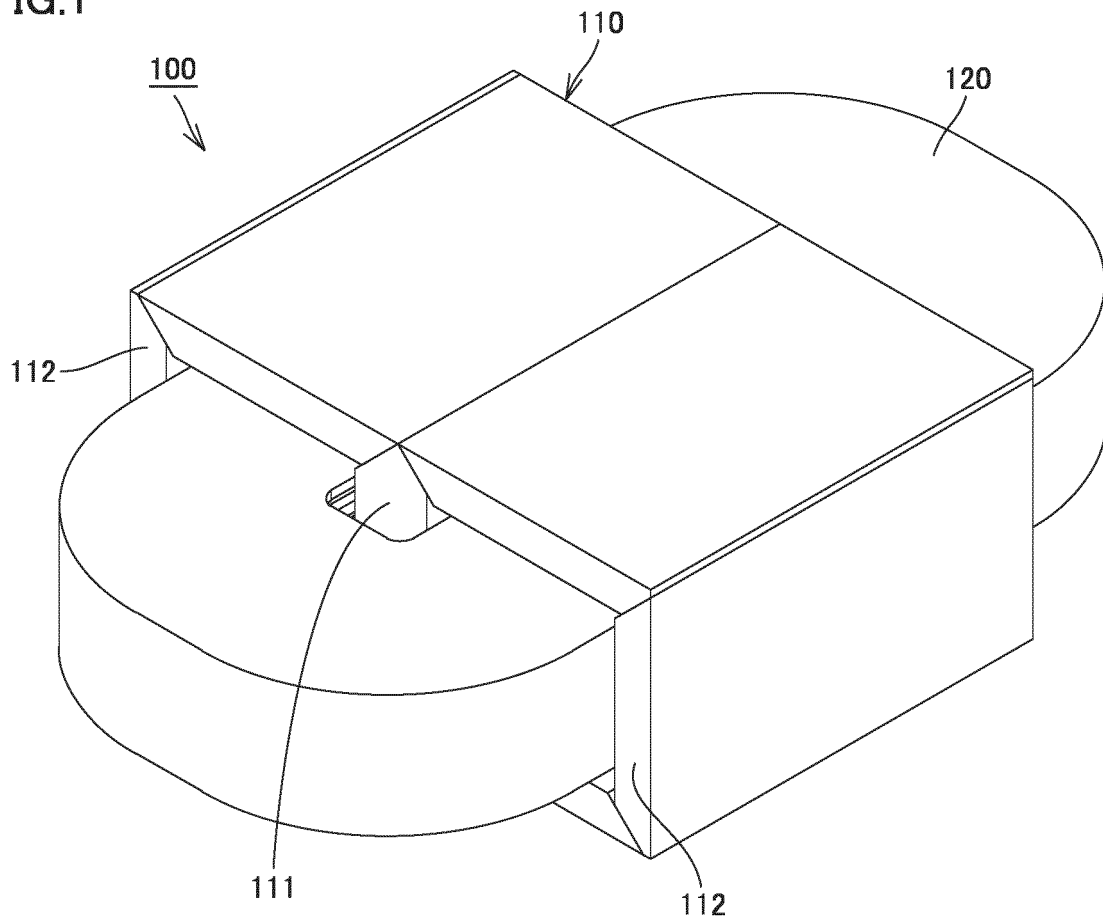


FIG.2

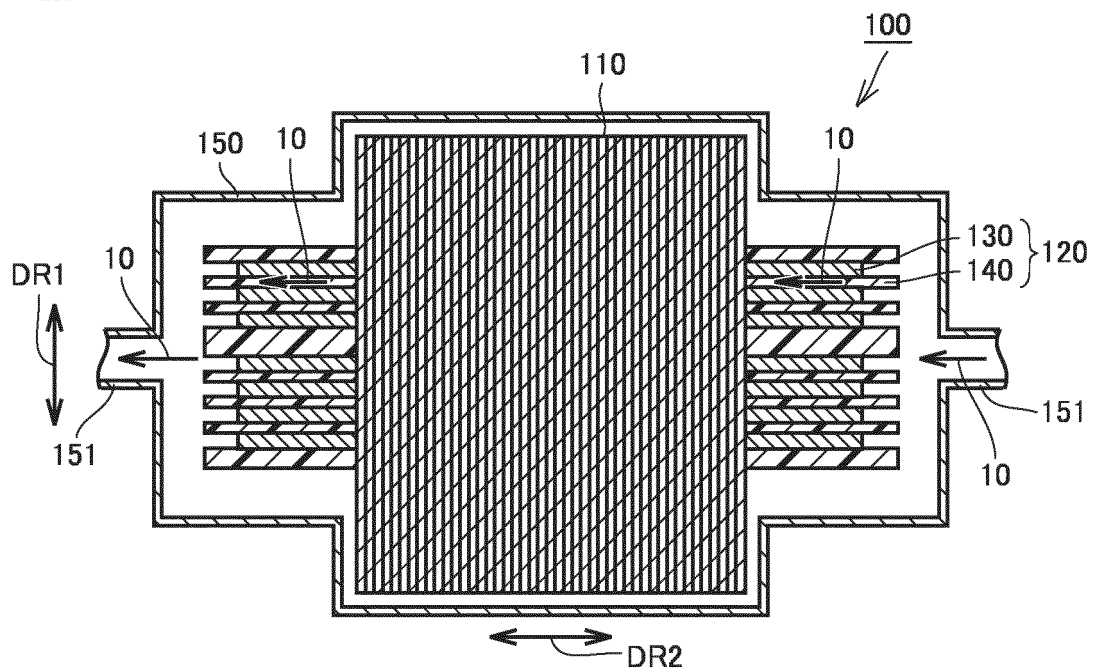


FIG.3

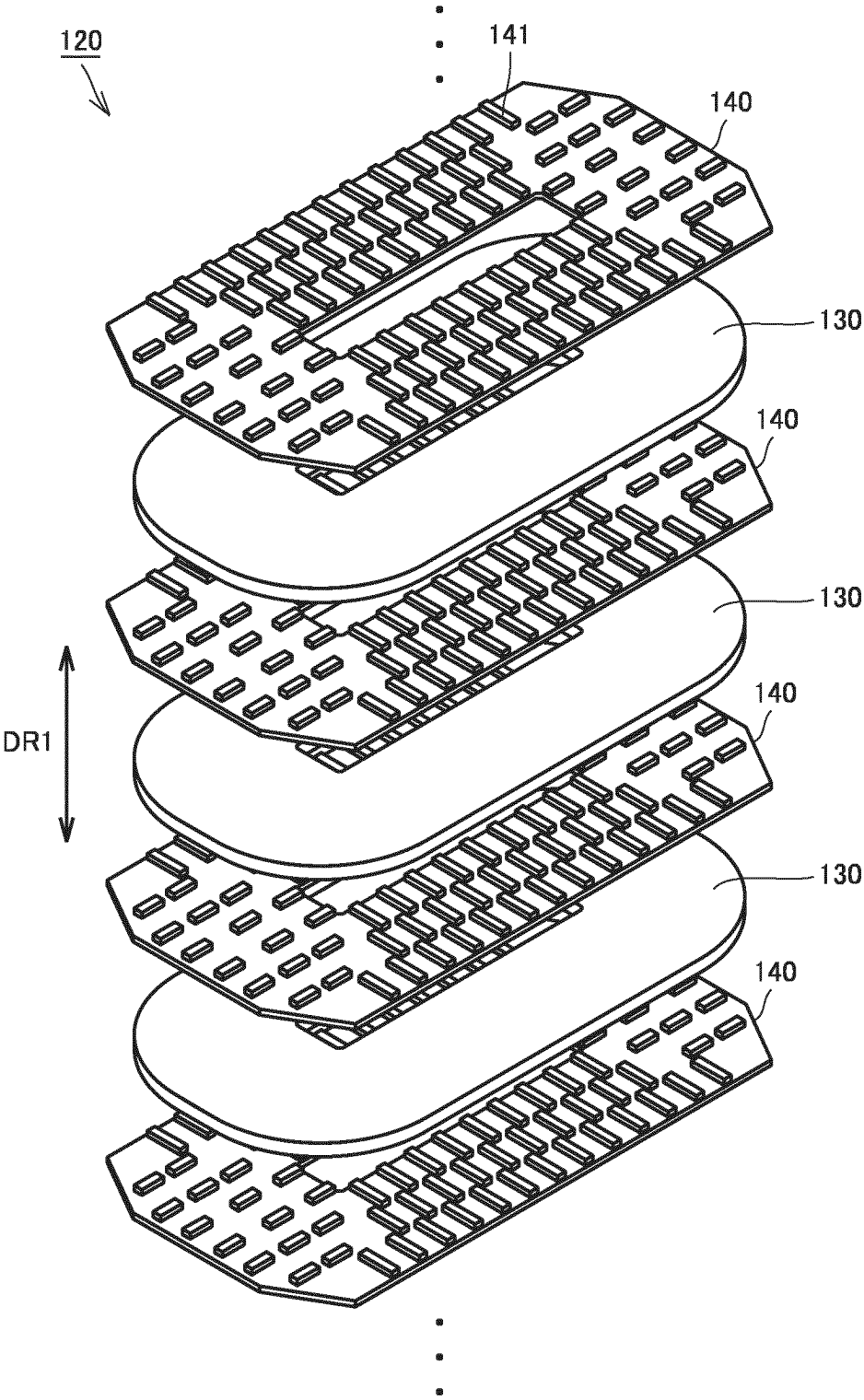


FIG.4

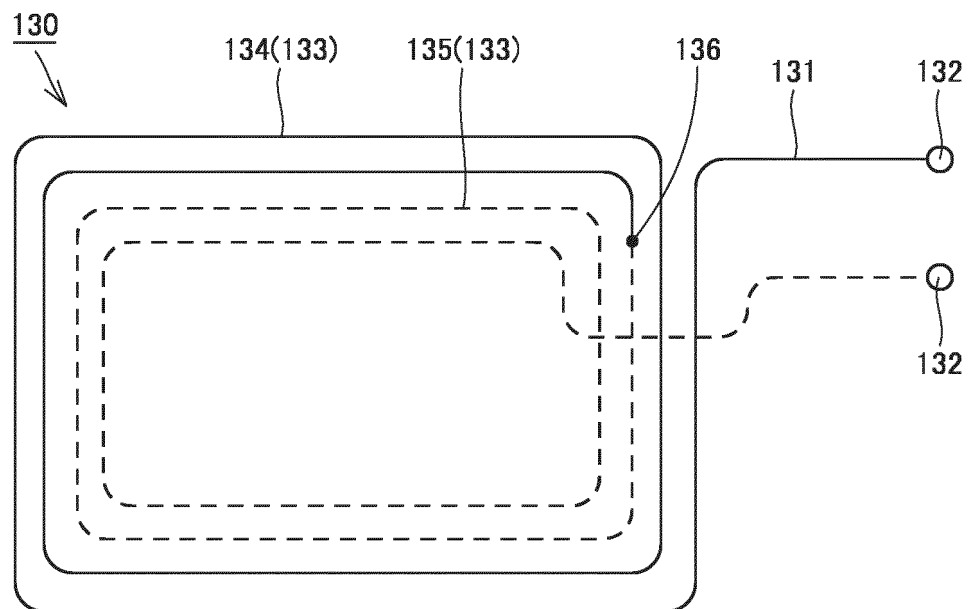


FIG.5

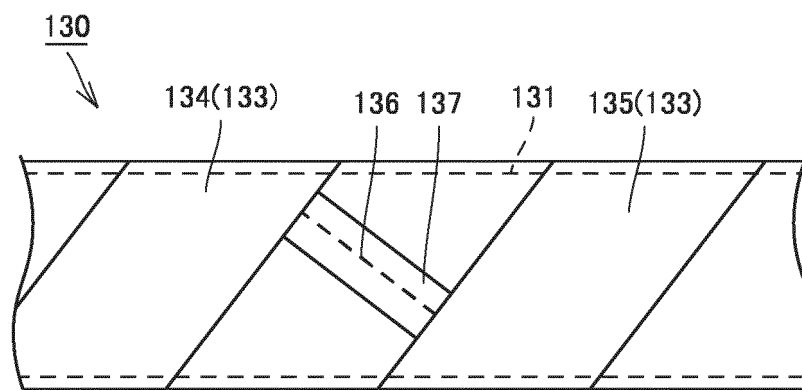
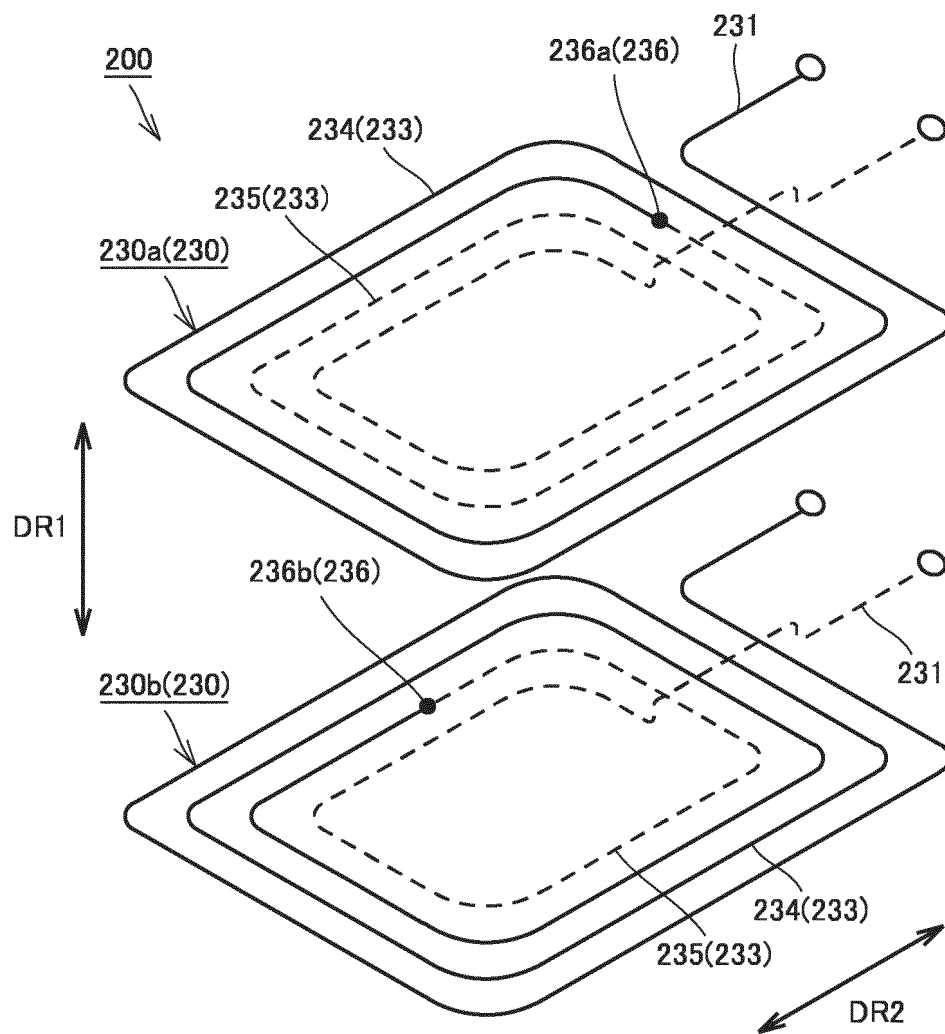


FIG.6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/017258

A. CLASSIFICATION OF SUBJECT MATTER

H01F 27/32(2006.01)i
FI: H01F27/32 140

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)

H01F27/32; H01F5/06; H02K3/30-3/52; H01B7/00-7/02

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 6-11009 B2 (HITACHI LTD) 09 February 1994 (1994-02-09) column 4, line 43 to column 5, line 27, fig. 7-9	1-3
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 158012/1983 (Laid-open No. 66014/1985) (HITACHI LTD) 10 May 1985 (1985-05-10), claims, description, p. 2, line 20 to p. 4, line 2, fig. 3	1-3
A	JP 9-17649 A (HITACHI LTD) 17 January 1997 (1997-01-17) paragraphs [0007], [0035], fig. 2	1-3
A	JP 9-45551 A (HITACHI LTD) 14 February 1997 (1997-02-14) paragraphs [0010]-[0018], fig. 1-4	1-3
A	JP 2011-159500 A (JAPAN AE POWER SYSTEMS CORP) 18 August 2011 (2011-08-18) paragraphs [0016], [0018]-[0022], fig. 1-4	1-3
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 157080/1979 (Laid-open No. 78311/1981) (MITSUBISHI ELECTRIC CORP) 25 June 1981 (1981-06-25), description, p. 3, lines 13-20, p. 4, line 15 to p. 5, line 9, fig. 2-5	1-3

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

* Special categories of cited documents:

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“&” document member of the same patent family

Date of the actual completion of the international search

28 June 2022

Date of mailing of the international search report

05 July 2022

Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)
3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915
Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/017258

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 55-46051 B2 (HITACHI LTD) 21 November 1980 (1980-11-21) column 2, lines 18-22, column 3, lines 30-39, fig. 1, 4	1-3
A	JP 49-18656 Y1 (MEIDENSHA CORPORATION) 18 May 1974 (1974-05-18) column 1, line 38 to column 2, line 20, fig. 1, 3	1-3

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2022/017258

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 6-11009 B2	09 February 1994	(Family: none)	
JP 60-66014 U1	10 May 1985	(Family: none)	
JP 9-17649 A	17 January 1997	(Family: none)	
JP 9-45551 A	14 February 1997	(Family: none)	
JP 2011-159500 A	18 August 2011	(Family: none)	
JP 56-78311 U1	25 June 1981	(Family: none)	
JP 55-46051 B2	21 November 1980	(Family: none)	
JP 49-18656 Y1	18 May 1974	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 9045551 A [0002] [0003]