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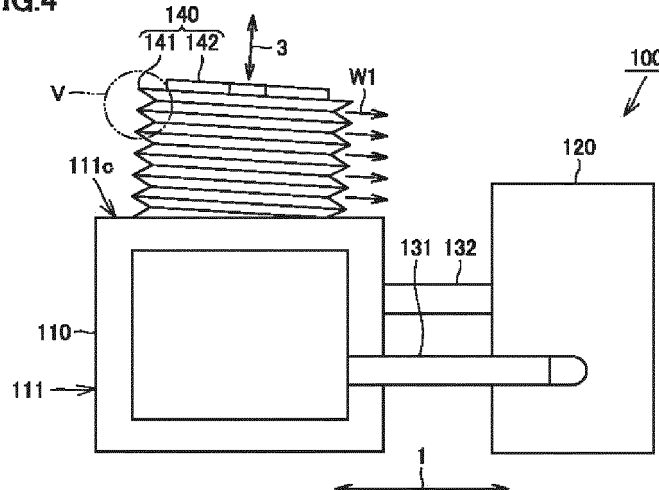
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(54) **TRANSFORMER FOR VEHICLES**

(57) A vehicle transformer includes a transformer body (110), a cooler (120), and a conservator (140). The transformer body (110) has an iron core, a winding wound around the iron core, and a tank (111) to contain the iron core and the winding that are immersed in refrigerant. The cooler (120) is in communication with an interior of the tank (111), and cools the refrigerant by heat exchange with outside air. The conservator (140) is provided on a

ceiling (111c) of the tank (111), and has a metallic bellows (141) filled with the refrigerant. The transformer body (110) and the cooler (120) are arranged side by side on a roof of a vehicle along a traveling direction of the vehicle. The bellows (141) extends and contracts over the ceiling (111c) of the tank (111) in response to a change in volume of the refrigerant. An outer surface of the bellows (141) is exposed and in contact with outside air.

FIG.4



Description

TECHNICAL FIELD

[0001] The present invention relates to a vehicle transformer.

BACKGROUND ART

[0002] Japanese Patent Laying-Open No. 2018-37518 (PTL 1) is a prior art document disclosing the configuration of a vehicle transformer. The vehicle transformer described in PTL 1 includes a tank, a cooler, a bushing, a conservator, and an oil pump. The tank contains an iron core and a winding along with insulating oil. The conservator has a housing, and a metallic bellows disposed in the housing. The metallic bellows is sealed at one end side, and has an air hole and is oil-tight welded to the housing at the other end side.

CITATION LIST

PATENT LITERATURE

[0003] PTL 1: Japanese Patent Laying-Open No. 2018-37518

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] In the vehicle transformer described in PTL 1, the insulating oil is cooled only by the cooler. Accordingly, there is scope for improving efficiency of the cooling of the insulating oil.

[0005] The present invention was made in view of the problem described above, and has an object to provide a vehicle transformer that allows size reduction of a cooler while efficiently cooling insulating oil.

SOLUTION TO PROBLEM

[0006] A vehicle transformer based on the present invention includes a transformer body, a cooler, and a conservator. The transformer body has an iron core, a winding wound around the iron core, and a tank to contain the iron core and the winding that are immersed in refrigerant. The cooler is in communication with an interior of the tank, and cools the refrigerant by heat exchange with outside air. The conservator is provided on a ceiling of the tank, and has a metallic bellows filled with the refrigerant. The transformer body and the cooler are arranged side by side on a roof of a vehicle along a traveling direction of the vehicle. The bellows extends and contracts over the ceiling of the tank in response to a change in volume of the refrigerant. An outer surface of the bellows is exposed and in contact with outside air.

ADVANTAGEOUS EFFECTS OF INVENTION

[0007] According to the present invention, since the outer surface of the metallic bellows is exposed and in contact with outside air, contact between running wind and the bellows can be ensured, and, accordingly, the cooler can be reduced in size while insulating oil is efficiently cooled by the use of the running wind.

BRIEF DESCRIPTION OF DRAWINGS

[0008]

Fig. 1 is a side view showing the outer appearance of a vehicle having a vehicle transformer according to a first embodiment of the present invention mounted thereon.

Fig. 2 is a side view showing a bellows of a conservator in a contracted state in the vehicle transformer according to the first embodiment of the present invention.

Fig. 3 is a plan view of the vehicle transformer in Fig. 2 as seen in a direction of an arrow III.

Fig. 4 is a side view showing the bellows of the conservator in an extended state in the vehicle transformer according to the first embodiment of the present invention.

Fig. 5 is a side view showing a portion V of the vehicle transformer in Fig. 4 in an enlarged manner.

Fig. 6 is a side view showing a bellows of a conservator in a contracted state in a vehicle transformer according to a second embodiment of the present invention.

Fig. 7 is a plan view of the vehicle transformer in Fig. 6 as seen in a direction of an arrow VII.

Fig. 8 is a side view showing the bellows of the conservator in an extended state in the vehicle transformer according to the second embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0009] Vehicle transformers according to embodiments of the present invention will be described below with reference to the drawings. In the following description of the embodiments, the same or corresponding parts in the drawings are designated by the same characters and a description thereof will not be repeated.

First Embodiment

[0010] Fig. 1 is a side view showing the outer appearance of a vehicle having a vehicle transformer according to a first embodiment of the present invention mounted thereon. Fig. 2 is a side view showing a bellows of a conservator in a contracted state in the vehicle transformer according to the first embodiment of the present invention. Fig. 3 is a plan view of the vehicle transformer

in Fig. 2 as seen in a direction of an arrow III. Fig. 4 is a side view showing the bellows of the conservator in an extended state in the vehicle transformer according to the first embodiment of the present invention. Fig. 5 is a side view showing a portion V of the vehicle transformer in Fig. 4 in an enlarged manner.

[0011] As shown in Figs. 1 to 5, a vehicle transformer 100 according to the first embodiment of the present invention includes a transformer body 110, a cooler 120, and a conservator 140. Transformer body 110 has an iron core, a winding wound around the iron core, and a tank 111 to contain the iron core and the winding that are immersed in refrigerant. Cooler 120 is in communication with the interior of tank 111, and cools the refrigerant by heat exchange with outside air. Conservator 140 is provided on a ceiling 111c of tank 111, and has a metallic bellows 141 filled with the refrigerant. Transformer body 110 and cooler 120 are arranged side by side on the roof of a vehicle 10 along a traveling direction 1 of vehicle 10. Bellows 141 extends and contracts over ceiling 111c of tank 111 in response to a change in volume of the refrigerant. An outer surface of bellows 141 is exposed and in contact with outside air.

[0012] Each component of vehicle transformer 100 according to the first embodiment of the present invention is described below in detail. As shown in Fig. 1, traveling direction 1 of vehicle 10 is a direction along a rail 20 on which vehicle 110 runs. As shown in Fig. 3, a direction orthogonal to traveling direction 1 of vehicle 10 is defined as an orthogonal direction 2.

[0013] Tank 111 of transformer body 110 has a substantially rectangular parallelepiped outer shape. Specifically, as shown in Fig. 3, a central portion of tank 111 in orthogonal direction 2 is larger than each of opposite end portions of tank 111 in orthogonal direction 2 in dimensions including the width in traveling direction 1 of vehicle 10, the length in orthogonal direction 2, and the height in an upward and downward direction.

[0014] Ceiling 111c of tank 111 is a ceiling of the central portion of tank 111 in orthogonal direction 2, and substantially horizontally positioned. Conservator 140 is provided on ceiling 111c of tank 111. Specifically, ceiling 111c of tank 111 is provided with an opening. Bellows 141 of conservator 140 is attached to an edge of the opening in ceiling 111c of tank 111.

[0015] As shown in Fig. 3, one end of tank 111 in orthogonal direction 2 is connected to cooler 120 by a first pipe 131. The other end of tank 111 in orthogonal direction 2 is connected to cooler 120 by a second pipe 132. The refrigerant is forcibly circulated between tank 111 and cooler 120 through first pipe 131 and second pipe 132.

[0016] Outside air can pass and flow through cooler 120. Cooler 120 is configured to allow running wind to pass and flow therethrough. As a result of heat exchange between the outside air and the forcibly circulated refrigerant inside cooler 120, the refrigerant is cooled. The refrigerant is insulating oil in the present embodiment.

[0017] Cooler 120 has a substantially rectangular parallelepiped outer shape. Cooler 120 is disposed to face the central portion of tank 111 in traveling direction 1 of vehicle 10. As shown in Fig. 3, in orthogonal direction 2, a length L3 of cooler 120 is equal to a length of the central portion of tank 111. As shown in Fig. 2, in the upward and downward direction, cooler 120 is higher than the central portion of tank 111. Although vehicle transformer 100 according to the present embodiment includes only one cooler 120, vehicle transformer 100 is not limited to include one cooler 120, and may include a plurality of coolers 120.

[0018] As shown in Figs. 1 to 4, conservator 140 includes bellows 141 and a top plate 142. Bellows 141 is formed of a plurality of connected annular metal plates arranged to overlie one another, the connection being such that an inner peripheral side and an outer peripheral side of the metal plates adjacent to each other in the upward and downward direction are welded alternately, and is thereby configured to extend and contract in an extending and contracting direction 3 shown in Fig. 4.

[0019] As seen in extending and contracting direction 3 of bellows 141, bellows 141 has a quadrangular outer shape including a pair of sides spaced from each other in traveling direction 1 of vehicle 10 and extending in orthogonal direction 2. Specifically, as shown in Fig. 3, the pair of sides is formed of a first side 141a located on the cooler 120 side and a second side 141b located on the side opposite to the cooler 120 side in traveling direction 1 of the vehicle. The quadrangular outer shape of bellows 141 further includes a third side 141c and a fourth side 141d spaced from each other in orthogonal direction 2 and extending in traveling direction 1 of the vehicle.

[0020] In the present embodiment, the quadrangular outer shape of bellows 141 is a rectangular shape. As shown in Fig. 3, when first side 141a has a length L1 and second side 141b has a length L2, $L1 = L2 < L3$ holds. In other words, in orthogonal direction 2, the length of each of first side 141a and second side 141b is shorter than the length of the outer shape of cooler 120.

[0021] Note that the outer shape of bellows 141 as seen in extending and contracting direction 3 of bellows 141 is not limited to the quadrangular shape including the pair of sides spaced from each other in traveling direction 1 of vehicle 10 and extending in orthogonal direction 2, and may be a quadrangular shape having all sides intersecting with respect to traveling direction 1 of vehicle 10, or may be a polygonal shape, a triangular shape, a circular shape, or the like.

[0022] Top plate 142 is joined by welding to the upper end of bellows 141, whereby a sealed space is formed within bellows 141. As seen in extending and contracting direction 3 of bellows 141, top plate 142 has a quadrangular outer shape substantially the same as the outer shape of bellows 141, and is provided with an upwardly bulging portion in the shape of a cross.

[0023] The lower end of bellows 141 is joined by weld-

ing to the edge of the opening in ceiling 111c of tank 111. In vehicle transformer 100 according to the present embodiment, as shown in Fig. 4, bellows 141 is reduced in height at a portion located on the cooler 120 side than at a portion located on the side opposite to the cooler 120 side in traveling direction 1 of vehicle 10.

[0024] Specifically, the annular metal plate located at the lower end of bellows 141 decreases in thickness toward cooler 120 in traveling direction 1 of vehicle 10, to substantially zero thickness at the end on the cooler 120 side. As a result, extending and contracting direction 3 of bellows 141 is inclined toward cooler 120 with respect to ceiling 111c of tank 111. Thus, first side 141a of bellows 141 is located below second side 141b at all times regardless of whether bellows 141 is extending or contracting. Note that extending and contracting direction 3 of bellows 141 may be parallel to the upward and downward direction.

[0025] As shown in Figs. 4 and 5, a plurality of surfaces 141f that form portions of bellows 141 extending in orthogonal direction 2 and that are folded over one another during the contraction of bellows 141 each have a corrugated shape as seen in orthogonal direction 2. Specifically, the plurality of annular metal plates forming bellows 141 are each bent in a zigzag pattern as seen in orthogonal direction 2. Note that the plurality of surfaces 141f may each be a flat surface.

[0026] Operation of vehicle transformer 100 according to the first embodiment of the present invention is described below.

[0027] When the refrigerant in tank 110 increases in temperature and expands, the refrigerant flows into bellows 141 of conservator 140, causing bellows 141 to extend as shown in Fig. 4. Since bellows 141 protrudes from ceiling 111c of tank 111, the outer surface of bellows 141 and running wind can be brought into contact with each other.

[0028] By ensuring the contact between the running wind generated by running of vehicle 10 and bellows 141, the refrigerant that has flowed into bellows 141 can be cooled by heat exchange with the running wind. As a result, vehicle transformer 100 according to the present embodiment can cool the refrigerant by efficiently using the running wind.

[0029] In particular, when a high-temperature refrigerant flows into bellows 141 to result in extension of bellows 141, the surface area of contact between the outer surface of bellows 141 and the running wind increases as compared to when bellows 141 is in the contracted state, and, accordingly, the high-temperature refrigerant can be cooled more effectively.

[0030] When the refrigerant in tank 110 decreases in temperature and contracts, the refrigerant flows out of bellows 141 into tank 110, causing bellows 141 to contract as shown in Fig. 2.

[0031] By cooling the refrigerant by conservator 140 as described above, cooling performance required of cooler 120 can be reduced, and, accordingly, cooler 120

can be reduced in size.

[0032] In the present embodiment, transformer body 110 and cooler 120 are arranged side by side on the roof of vehicle 10 along traveling direction 1 of vehicle 10, and the length of each of first side 141a and second side 141b is shorter than the length of the outer shape of cooler 120 in orthogonal direction 2. Thus, running wind flowing along each of third side 141c and fourth side 141d can pass through cooler 120. Accordingly, the running wind passing through cooler 120 can be ensured.

[0033] In the present embodiment, since extending and contracting direction 3 of bellows 141 is inclined toward cooler 120 with respect to ceiling 111c of tank 111, running wind W1 flowing along each of third side 141c and fourth side 141d can be directed toward cooler 120, as shown in Fig. 4. Accordingly, the running wind passing through cooler 120 can be increased to improve the cooling performance of cooler 120.

[0034] In the present embodiment, since the plurality of surfaces 141f that form portions of bellows 141 extending in orthogonal direction 2 and that are folded over one another during the contraction of bellows 141 each have a corrugated shape as seen in orthogonal direction 2, the area of contact between the running wind and bellows 141 can be increased. In addition, the running wind hitting the plurality of surfaces 141f can be turned into a turbulent flow, to improve the efficiency of heat exchange with the running wind at the outer surface of bellows 141. Accordingly, the refrigerant can be cooled by efficient use of the running wind in cooler 120.

Second Embodiment

[0035] A vehicle transformer according to a second embodiment of the present invention is described below with reference to the drawings. The vehicle transformer according to the second embodiment of the present invention is different from vehicle transformer 100 according to the first embodiment of the present invention only in the outer shape of the bellows as seen in the extending and contracting direction of the bellows. Thus, the description of the configuration similar to that of vehicle transformer 100 according to the first embodiment of the present invention will not be repeated.

[0036] Fig. 6 is a side view showing a bellows of a conservator in a contracted state in the vehicle transformer according to the second embodiment of the present invention. Fig. 7 is a plan view of the vehicle transformer in Fig. 6 as seen in a direction of an arrow VII. Fig. 8 is a side view showing the bellows of the conservator in an extended state in the vehicle transformer according to the second embodiment of the present invention.

[0037] As shown in Figs. 6 to 8, a vehicle transformer 200 according to the second embodiment of the present invention includes transformer body 110, cooler 120, and a conservator 240. Conservator 240 includes a bellows 241 and top plate 142.

[0038] As seen in extending and contracting direction 3 of bellows 241, bellows 241 has a quadrangular outer shape including a pair of sides spaced from each other in traveling direction 1 of vehicle 10 and extending in orthogonal direction 2. Specifically, as shown in Fig. 7, the pair of sides is formed of a first side 241a located on the cooler 120 side and a second side 241b located on the side opposite to the cooler 120 side in traveling direction 1 of the vehicle. The quadrangular outer shape of bellows 241 further includes a third side 241c and a fourth side 241d spaced from each other in orthogonal direction 2 and extending in traveling direction 1 of the vehicle.

[0039] In the present embodiment, the quadrangular outer shape of bellows 241 is a trapezoidal shape. As shown in Fig. 7, when first side 241a has a length L_4 and second side 241b has length L_2 , $L_4 < L_2 < L_3$ holds. In other words, in orthogonal direction 2, the length of each of first side 241a and second side 241b is shorter than the length of the outer shape of cooler 120, and first side 241a is shorter than second side 241b.

[0040] Accordingly, as shown in Fig. 7, each of third side 241c and fourth side 241d can be inclined toward a central portion of cooler 120, as seen in extending and contracting direction 3 of bellows 241. Thus, as shown in Fig. 8, a greater amount of running wind W_2 flowing along each of third side 241c and fourth side 241d can be directed toward cooler 120. Accordingly, the running wind passing through cooler 120 can be increased to improve the cooling performance of cooler 120.

[0041] In the description of the foregoing embodiments, configurations that can be combined may be combined with each other.

[0042] It is noted 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 invention should not be interpreted based on the foregoing embodiments only. Further, any modifications within the scope and meaning equivalent to the terms of the claims are included.

REFERENCE SIGNS LIST

[0043] 10 vehicle; 20 rail; 100, 200 vehicle transformer; 110 transformer body; 111 tank; 111c ceiling; 120 cooler; 131 first pipe; 132 second pipe; 140, 240 conservator; 141, 241 bellows; 141a, 241a first side; 141b, 241b second side; 141c, 241c third side; 141d, 241d fourth side.

Claims

1. A vehicle transformer comprising:

a transformer body having an iron core, a winding wound around the iron core, and a tank to contain the iron core and the winding that are immersed in refrigerant;

a cooler in communication with an interior of the tank, to cool the refrigerant by heat exchange with outside air; and

a conservator provided on a ceiling of the tank, and having a metallic bellows filled with the refrigerant, wherein

the transformer body and the cooler are arranged side by side on a roof of a vehicle along a traveling direction of the vehicle,

the bellows extends and contracts over the ceiling of the tank in response to a change in volume of the refrigerant, and

an outer surface of the bellows is exposed and in contact with outside air.

2. The vehicle transformer according to claim 1, wherein

as seen in an extending and contracting direction of the bellows, the bellows has a quadrangular outer shape including a pair of sides spaced from each other in the traveling direction of the vehicle and extending in a direction orthogonal to the traveling direction of the vehicle, and

in the direction orthogonal to the traveling direction of the vehicle, a length of each of the pair of sides is shorter than a length of an outer shape of the cooler.

3. The vehicle transformer according to claim 2, wherein

a first side of the pair of sides located on the cooler side is shorter than a second side of the pair of sides located on a side opposite to the cooler side in the traveling direction of the vehicle.

4. The vehicle transformer according to claim 2 or 3, wherein

a plurality of surfaces that form portions of the bellows extending in the direction orthogonal to the traveling direction of the vehicle and that are folded over one another during contraction of the bellows each have a corrugated shape as seen in the direction orthogonal to the traveling direction of the vehicle.

5. The vehicle transformer according to any one of claims 1 to 4, wherein

the extending and contracting direction of the bellows is inclined toward the cooler with respect to the ceiling of the tank.

FIG.1

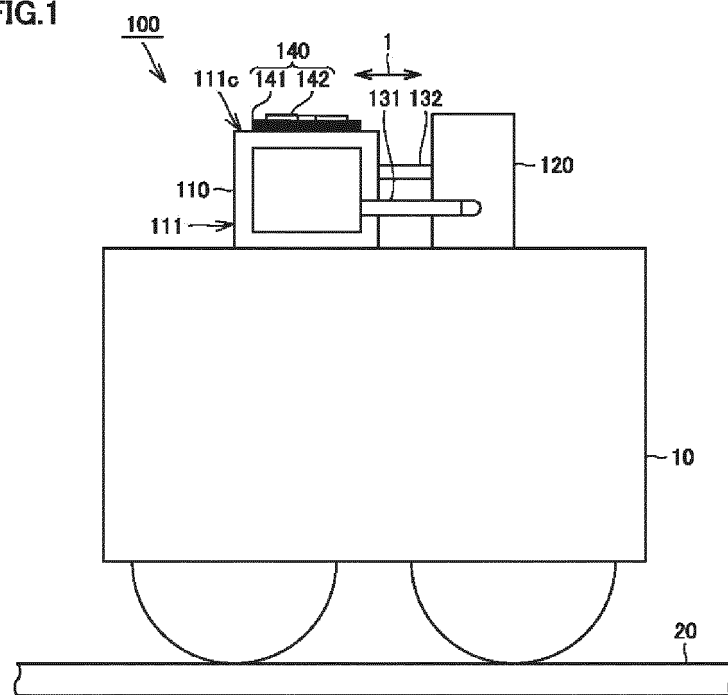


FIG.2

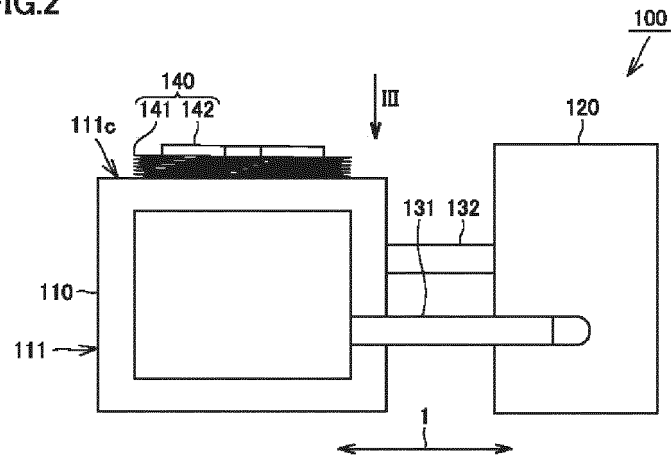


FIG.3

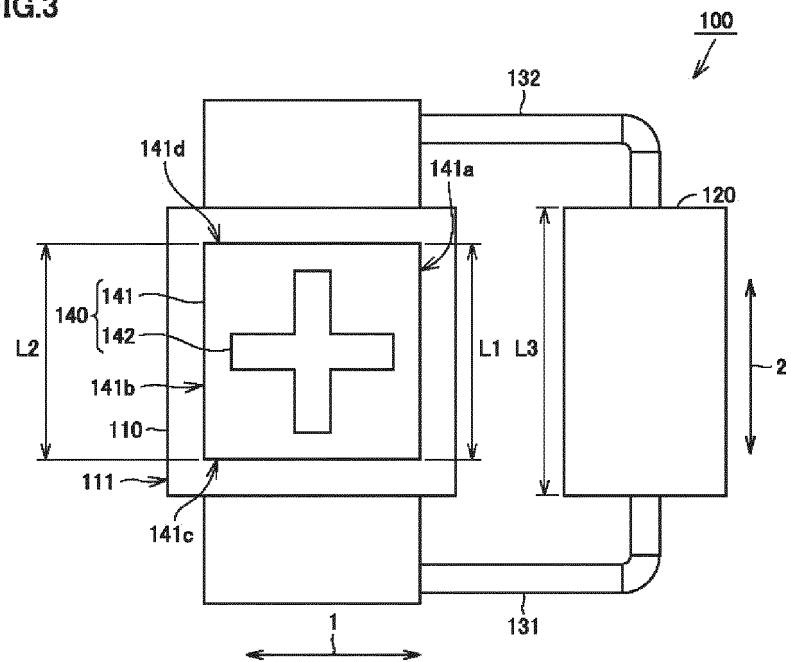


FIG.4

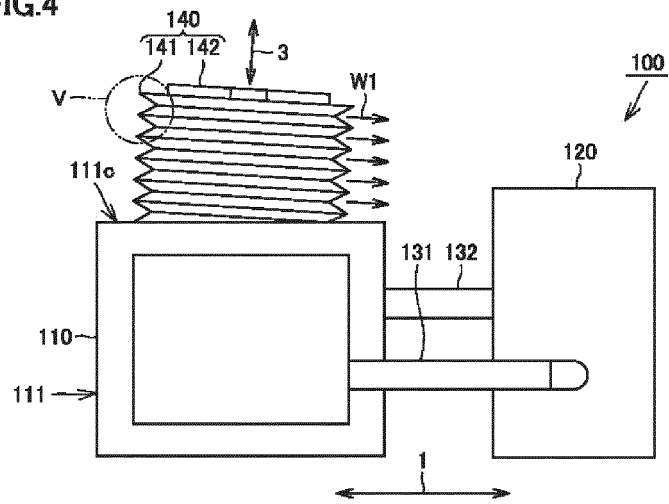


FIG.5

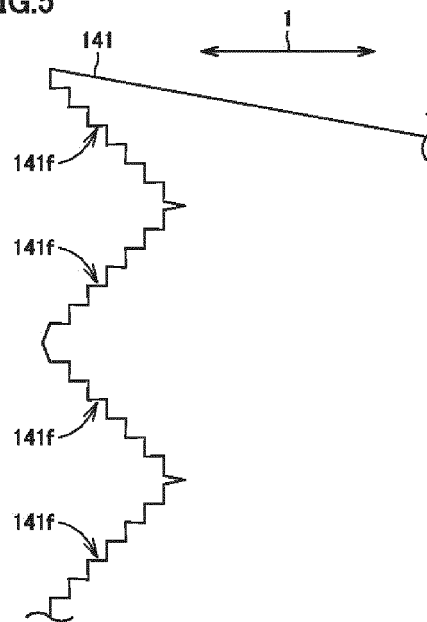


FIG.6

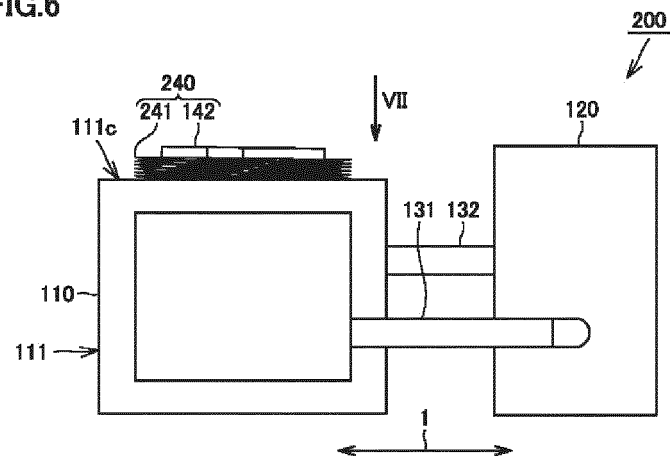


FIG.7

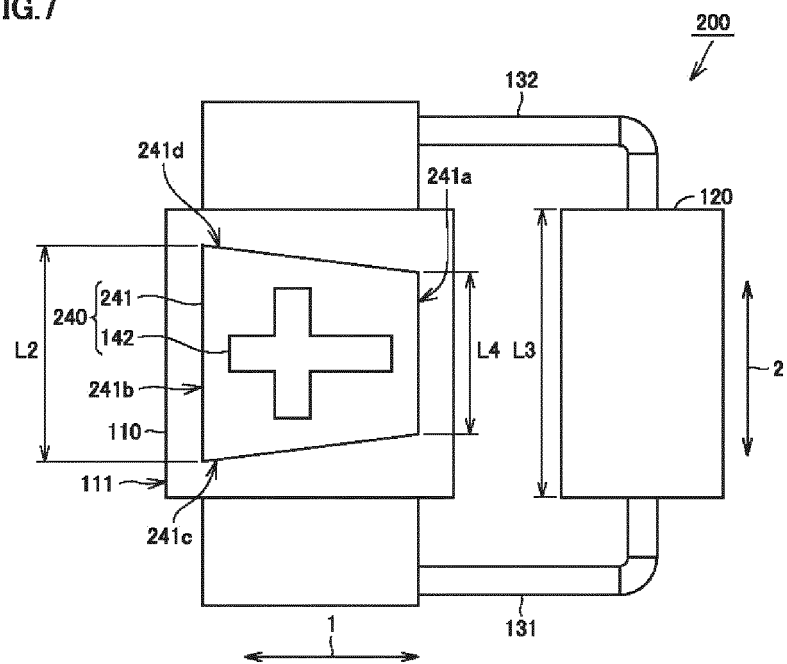
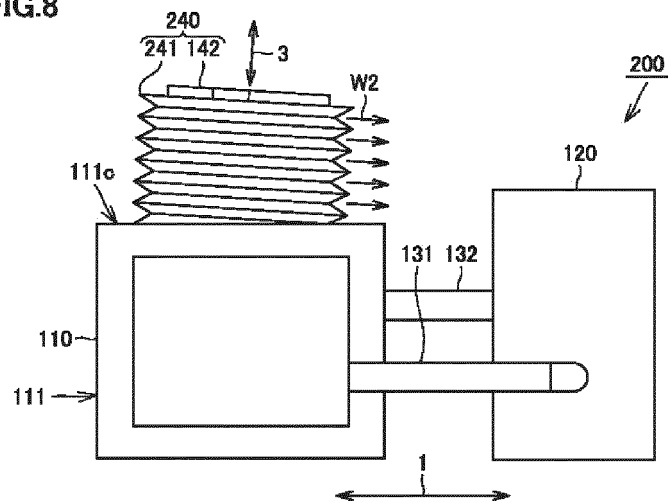


FIG.8



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/042266

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. H01F27/14 (2006.01) i, B61C17/00 (2006.01) i

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)

Int.Cl. H01F27/14, B61C17/00, H05K7/20

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 1971-2019

Registered utility model specifications of Japan 1996-2019

Published registered utility model applications of Japan 1994-2019

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.
Y A	WO 2016/103439 A1 (MITSUBISHI ELECTRIC CORPORATION) 30 June 2016, paragraphs [0014], [0015], [0067]-[0071], fig. 24-27 & EP 3239996 A1, paragraphs [0015], [0016], [0068]-[0072], fig. 24-27	1 2-5
Y A	JP 2018-37518 A (TOSHIBA INDUSTRIAL PRODUCTS & SYSTEMS CORP.) 08 March 2018, paragraphs [0009], [0023]-[0028], fig. 1, 3, 4 (Family: none)	1 2-5

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

* Special categories of cited documents:

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Date of the actual completion of the international search
28.01.2019Date of mailing of the international search report
05.02.2019Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/042266

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 14-4666 Y1 (SIEMENS-SCHUCKERTWERKE AKTIENGESELLSCHAFT) 04 April 1939, page 1, upper column, line 5 from the left to lower column, line 2 from the left, drawings (Family: none)	1 2-5

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2018037518 A [0002] [0003]