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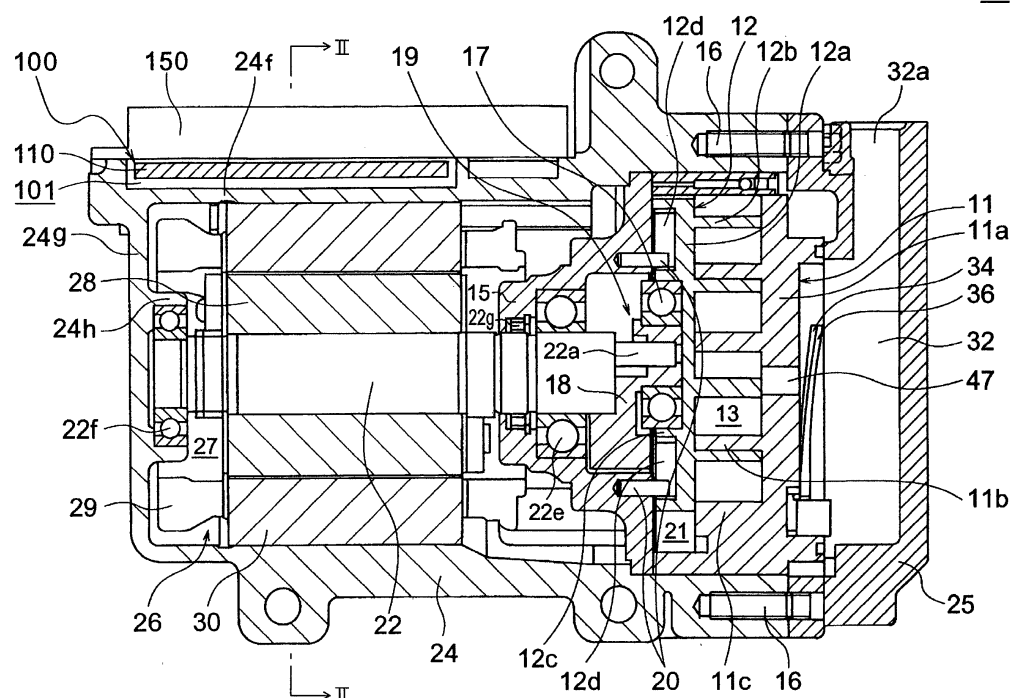
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80336 München (DE)**(54) **Electric compressor with inverter**

(57) An electric compressor (10) is equipped with a motor chamber (27) provided in a suction pressure region. The motor chamber (27) is adjacent to an inverter accommodation chamber (101) with a first housing (24) therebetween, and a cooling hole (130) extending from the motor chamber (27) toward the inverter accommo-

modation chamber (101) is formed through the first housing (24). The cooling hole (130) is a through-hole passing through the first housing (24). A cooling medium in the motor chamber (27) flows into the cooling hole (130) and comes into contact with a heat transfer plate (110), thereby cooling the heat transfer plate (110) directly.

FIG. 1**10**

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to an electric compressor, and more particularly, to an inverter for driving an electric motor.

2. Description of the Related Art

[0002] Electric compressors having a compression mechanism portion equipped with an electric motor for driving the compression mechanism portion, and also with an inverter for controlling and driving the electric motor are known. In this kind of electric compressor, the inverter is accommodated and fixed in an inverter accommodation chamber. In some cases, this kind of electric compressor is constructed so that respective members of the inverter are irremovably fixed in position. For example, JP 2004-197688 A discloses such an electric compressor.

[0003] However, in the inverter of such a conventional electric compressor as disclosed in JP 2004-197688 A, there is a problem in that efficiency of cooling electronic components included in the inverter, especially the switching elements is relatively low.

[0004] Therefore, temperature protection is required and hence constructional complication is caused when, for example, switching elements with low heatresisting temperatures are used. Alternatively, high cost and constructional enlargement are caused when switching elements with high heatresisting temperatures are used.

SUMMARY OF THE INVENTION

[0005] The present invention has been made to solve the above-mentioned problem, and it is therefore an object of the present invention to provide an electric compressor that can enhance the efficiency of cooling electronic components of an inverter assembly.

[0006] In order to achieve the above-mentioned object, according to the present invention, there is provided an electric compressor including: a compression mechanism portion for sucking in fluid from a suction pressure region; an electric motor for driving the compression mechanism portion; a motor chamber provided in the suction pressure region, for accommodating the electric motor; an inverter assembly for converting a direct current into a polyphase alternating current to supply the converted current to the electric motor and for controlling rotational frequency of the electric motor; and an inverter accommodation chamber for accommodating the inverter assembly, wherein the inverter assembly is provided with a substrate having an electric circuit, electronic components connected to the substrate, and a base for supporting the substrate, the inverter assembly removably

fixed in the inverter accommodation chamber, the motor chamber and the inverter accommodation chamber are adjacent to each other with a housing therebetween, the housing having formed therethrough a through-hole extending from the motor chamber toward the inverter accommodation chamber, the through-hole being in contact at one end thereof with the base, with the motor chamber and the inverter accommodation chamber being sealed from each other around the through-hole.

[0007] With this electric compressor, a cooling medium in the motor chamber located in the suction pressure region, namely on a low-temperature side, flows into the through-hole, passes through the housing, and comes into contact with the base. Thus, the base is directly cooled around the through-hole. The base functions as a heat transfer plate, and further cools the electronic components.

[0008] The electronic components include a switching element, and the through-hole may be provided in the vicinity of the switching element.

[0009] By adopting this construction, the switching element tends to reach a higher temperature than the other elements constituting the electronic components. Therefore, when the switching element can thus be cooled in a pinpoint manner, the electronic components can be cooled as a whole more efficiently.

[0010] The inverter assembly may further be equipped with the base for supporting the substrate, and the base may be in contact with one end of the through-hole.

[0011] By adopting this construction, the base serving as the heat transfer plate can also be utilized as a constructional element for sealing the motor chamber and the inverter accommodation chamber from each other. As a result, constructional simplification is achieved.

[0012] According to the present invention, the cooling medium in the suction pressure region flows through a cooling hole and comes into contact with the heat transfer plate of the inverter assembly, thereby cooling the heat transfer plate directly. Therefore, the efficiency of cooling the electronic components of the inverter assembly can be enhanced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] In the accompanying drawings:

FIG. 1 is a diagram showing a construction of an electric compressor according to a first embodiment of the present invention; and

FIG. 2 is a diagram showing a construction of an inverter assembly included in the electric compressor of Fig. 1 and the periphery thereof.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0014] An embodiment of the present invention will be

described hereinafter with reference to the accompanying drawings.

First Embodiment

[0015] FIG. 1 shows an electric compressor 10 according to the first embodiment of the present invention.

[0016] The electric compressor 10 is provided with a first housing 24 and a second housing 25. The first housing 24 and the second housing 25 are fixed to each other by bolts 16. An inner surface of the first housing 24 is generally in the shape of a bottomed cylinder including a cylindrical portion 24f and a bottom portion 24g. The bottom portion 24g is provided with a cylindrical shaft support portion 24h.

[0017] In FIG. 1, the right side of the figure, namely the second housing 25 side, is defined as the front, and the left side of the figure, namely the bottom portion 24g side of the first housing 24, is defined as the rear.

[0018] The electric compressor 10 is equipped with a fixed scroll 11, a rotary scroll 12, and a compression chamber 13 formed by the fixed scroll 11 and the rotary scroll 12. The fixed scroll 11 has a disc-shaped fixed base 11a, a spiral fixed lap 11b provided upright on the fixed base 11a, and a fixed lap outermost wall 11c. A discharge port 47 is formed through the center of the fixed base 11a.

[0019] In the electric compressor 10, a compression mechanism portion is composed of the fixed scroll 11, the rotary scroll 12, and the compression chamber 13. The compression mechanism portion sucks in fluid from a suction pressure region, compresses the fluid, and discharges the fluid to a discharge pressure region. It should be noted herein that the suction pressure region is a region through which the fluid sucked in from outside the electric compressor 10 flows before flowing into the compression chamber 13, and that the discharge pressure region is a region through which the fluid compressed in the compression chamber 13 flows before flowing out of the electric compressor 10.

[0020] The rotary scroll 12 is composed of a disc-shaped rotary base 12a, and a spiral rotary lap 12b provided upright on the rotary base 12a. A holding portion 12c, which is in the shape of a bottomed cylinder, for holding a ball bearing 17, is provided at a center of a back side of the rotary base 12a.

[0021] The electric compressor 10 is further equipped with a drive crank mechanism 19 for rotating the rotary scroll 12 (rotational movement), and pins 20 for preventing the rotary scroll 12 from spinning. The pins 20, which are mounted on a shaft support member 15, are provided so as to freely engage with an annular recess portion 12d of the rotary scroll 12.

[0022] The drive crank mechanism 19 is composed of the holding portion 12c, a crank pin 22a of a drive shaft 22, and the ball bearing 17 for bearing the crank pin 22a via a bush 18.

[0023] The drive shaft 22 penetrates the center of an electric motor 26. The electric motor 26, which drives the

compression mechanism portion, is a three-phase synchronous motor equipped with the drive shaft 22, a rotor 28 fitted on the drive shaft 22, and a stator 30 provided on an outer peripheral side of the rotor 28 and having a coil 29 wound therearound.

[0024] By making a part of the first housing 24 concave, an inverter accommodation chamber 101 is provided in an outer surface of the first housing 24 on a rear side thereof. The electric compressor 10 includes an inverter assembly 100 accommodated in the inverter accommodation chamber 101. A detailed construction of the inverter assembly 100 will be described later with reference to FIG. 2. In FIG. 1, only a heat transfer plate 110 is illustrated for the sake of simplification.

[0025] The inverter assembly 100 is electrically connected to the electric motor 26 via a hermetic terminal 122 (which will be described later with reference to FIG. 2) provided in the first housing 24.

[0026] The inverter assembly 100 converts a direct-current power supplied from the outside into a polyphase alternating-current power to supply the converted poly-phase alternating-current power to the electric motor 26, and controls the rotational frequency of the electric motor 26.

[0027] A cover 150 is mounted onto the first housing 24 so as to cover the inverter assembly 100. The cover 150 isolates the inverter accommodation chamber 101 from the outside. It should be noted herein that the cover 150 constitutes an outer wall of the electric compressor 10. That is, the cover 150, the first housing 24, and the second housing 25 isolate the inside of the electric compressor 10 from the outside. The inverter accommodation chamber 101 is formed with an outer wall thereof constituted by the cover 150 and the first housing 24.

[0028] When the electric compressor 10 is in use, the electric compressor 10 is disposed such that a viewing direction from the drive shaft 22 toward the inverter assembly 100 coincides with an upward direction in FIG. 1. That is, the inverter assembly 100 is disposed above the first housing 24.

[0029] The drive shaft 22 is supported, at an end thereof on the drive crank mechanism 19 side, by the shaft support member 15 via a ball bearing 22e, and at a rear end thereof by the shaft support portion 24h of the first housing 24 via a ball bearing 22f. A seal 22g, which is provided behind the ball bearing 22e, seals a gap between the drive shaft 22 and the shaft support member 15.

[0030] A fluid as a cooling medium flows through a space covered by the first housing 24 and the second housing 25 described above. In this space, a motor chamber 27 is defined by the first housing 24 and the shaft support member 15, and a crank chamber 21 is defined by the first housing 24, the second housing 25, and the shaft support member 15. The motor chamber 27 and the crank chamber 21 communicate with each other through a channel (not shown).

[0031] It should be noted herein that, as shown in

FIGS. 1 and 2, the motor chamber 27 and the inverter accommodation chamber 101 are adjacent to each other with the first housing 24 therebetween.

[0032] A discharge chamber 32, which is defined by the fixed scroll 11 and the second housing 25, is provided on the other side of the compression chamber 13 with respect to the discharge port 47. The cooling medium compressed in the compression chamber 13 is discharged to the discharge chamber 32 via the discharge port 47. A reed valve 34 and a retainer 36 are provided in the discharge chamber 32 to prevent the cooling medium from flowing backward, namely, from the discharge chamber 32 toward the discharge port 47. The discharge chamber 32 has an external opening 32a communicating with the outside. The inside and outside of the electric compressor 10 communicate with each other through the external opening 32a.

[0033] In the electric compressor 10 constructed as described above, the cooling medium flows from the outside into the motor chamber 27 via an intake port (not shown). The cooling medium further flows from the motor chamber 27 into the crank chamber 21 and the compression chamber 13, which communicates with the crank chamber 21, via an intake channel (not shown). In the compression chamber 13, the cooling medium is compressed through rotation of the rotary scroll 12 resulting from rotation of the drive shaft 22. The compressed cooling medium flows from the discharge port 47 into the discharge chamber 32 and then is discharged to the outside via the external opening 32a.

[0034] FIG. 2 shows the construction of the inverter assembly 100 according to the first embodiment of the present invention and the periphery thereof.

[0035] FIG. 2 is a partial sectional view taken along the line II-II of FIG. 1.

[0036] The cover 150 and the first housing 24 sandwich a gasket 120 therebetween, so the inverter accommodation chamber 101 is isolated from the outside. The gasket 120 is a plate-shaped member composed of a core as an iron plate and a rubber material surrounding the core.

[0037] The inverter assembly 100 includes a substrate 112 having an electric circuit, and the heat transfer plate 110 as a base for supporting the substrate 112. The heat transfer plate 110, which is made of a material exhibiting relatively high thermal conductivity, for example, aluminum, serves as an intermediary for transferring heat between the motor chamber 27 and the inverter accommodation chamber 101. The substrate 112 is fixed to the heat transfer plate 110 by screws 128.

[0038] The cover 150, the heat transfer plate 110, and the first housing 24 are fastened together and fixed by screws 118. Accordingly, the heat transfer plate 110 is mounted to the first housing 24 in a close contact state. The screws 118 are provided at positions different from the section of FIG. 2, so those regions which are fastened together are not visible in FIG. 2. For the sake of explanation, only screw heads of the screws 118 are illustrated

in FIG. 2.

[0039] The inverter assembly 100 also includes, as electronic components, a capacitor 114, a coil 16, the hermetic terminal 122, insulated gate bipolar transistors (IGBT's) 124 and 125 as switching elements, and a varistor (not shown).

[0040] The capacitor 114 is designed as, for example, an electrolytic capacitor, and has leads 114a. The leads 114a are soldered on the substrate 112 to electrically connect the capacitor 114 to the electric circuit of the substrate 112. The capacitor 114 is fixed to the substrate 112 by the leads 114a and solder (not shown) around the leads 114a, and glued and fixed to the heat transfer plate 110 by a resinous adhesive 114b.

[0041] The coil 116 has leads 116a. The leads 116a are soldered to the substrate 112 to electrically connect the coil 116 to the electric circuit of the substrate 112. The coil 116 is fixed to the substrate 112 by the leads 116a and solder (not shown) around the leads 116a. Further, the coil 116 is glued and fixed to the heat transfer plate 110 by a resinous adhesive 116b.

[0042] The IGBT's 124 and 125 have leads 124a and 125a, respectively. The leads 124a and 125a are soldered to the substrate 112 to electrically connect the IGBT's 124 and 125 to the electric circuit of the substrate 112, respectively. The IGBT's 124 and 125 are fixed to the heat transfer plate 110 by screws 126 and 127, respectively.

[0043] The hermetic terminal 122 has leads 122a. The leads 122a are soldered to the substrate 112 to electrically connect the hermetic terminal 122 to the electric circuit of the substrate 112. The hermetic terminal 122 is fixed to the heat transfer plate 110. Although not shown, the hermetic terminal 122 electrically connects the inverter assembly 100 to the electric motor 26 (see FIG. 1) in the first housing 24, and isolates the inverter accommodation chamber 101 from the motor chamber 27, namely, a space in which the electric motor 26 is accommodated, in an airtight manner.

[0044] In this manner, the substrate 112, the capacitor 114, and the coil 116 are supported by the heat transfer plate 110 and the inverter assembly 100 is assembled. As described above, the heat transfer plate 110 is fixed to the first housing 24 by the screws 118. The inverter assembly 100 is thereby fixed to the first housing 24. The fixing is removable screwing by the screws 118.

[0045] A cooling medium channel including at least part of the motor chamber 27 is formed between the first housing 24 and the stator 30 (see FIG. 1), and the cooling medium flows through the cooling medium channel. The cooling medium cools the heat transfer plate 110 through the first housing 24, thereby cooling the inverter assembly 100. The cooling medium also cools the electric motor 26 through the stator 30.

[0046] The cooling medium channel is a low pressure-side channel of the electric compressor 10. In other words, the motor chamber 27 is provided in the suction pressure region of the electric compressor 10.

[0047] A cooling hole 130 extending from the motor chamber 27 toward the inverter accommodation chamber 101 is formed so as to pass through the first housing 24 immediately below the IGBT 125. The cooling hole 130 is a through-hole penetrating the first housing 24. An upper end opening 130a of the cooling hole 130 is in contact with the heat transfer plate 110, so the heat transfer plate 110 is in contact with the cooling medium in the suction pressure region. The cooling hole 130 is in the shape of, for example, a hollow cylinder, but may be in another shape.

[0048] A sealing structure for sealing the motor chamber 27 and the inverter accommodation chamber 101 from each other is provided around the cooling hole 130. In the example of FIG. 2, an O-ring groove 130b is provided around the upper end opening 130a of the cooling hole 130, and an O-ring 130c as a sealing member is disposed in the O-ring groove 130b. The O-ring 130c, which is sandwiched by the first housing 24 and the heat transfer plate 110, isolates the motor chamber 27 and the inverter accommodation chamber 101 from each other around the cooling hole 130.

[0049] In assembling the electric compressor 10, the inverter assembly 100 is first assembled so as to be integrated as one body. The assembly may be carried out in any sequence. For example, the respective electronic components are first mounted on the heat transfer plate 110, the substrate 112 is then fixed to the heat transfer plate 110 by the screws 128, and the respective electronic components are connected to the substrate 112.

[0050] After having been assembled, the inverter assembly 100 is incorporated into the electric compressor 10. The incorporation is carried out by fastening and fixing the cover 150, the heat transfer plate 110, and the first housing 24 together by the screws 118.

[0051] It should be noted herein that, as described above, gel is not encapsulated in the inverter accommodation chamber 101. Therefore, by removing the screws 118, the heat transfer plate 110 is released from the first housing 24, so the inverter assembly 100 can be removed. That is, the integral-type inverter assembly 100 is a cartridge-type assembly designed to be removable in the electric compressor 10.

[0052] With this electric compressor 10 constructed as described above, the cooling medium in the suction pressure region of the electric compressor 10, namely, on the low-temperature side thereof flows from the motor chamber 27 through the cooling hole 130 and comes into contact with the heat transfer plate 110 at the upper end 130a thereof. Thus, the heat transfer plate 110 is directly cooled around the cooling hole 130. The cooling hole 130 is formed immediately below the IGBT 125, so the cooling medium in the cooling hole 130 efficiently cools the IGBT 125 through the heat transfer plate 110. Thus, the electric compressor 10 can improve the performance of cooling the IGBT 125 and the inverter assembly 100 including the IGBT 125.

[0053] Due to the enhancement of the cooling efficiency,

the IGBT 125 can be kept at a lower temperature, so the heatresisting temperature required of the IGBT 125 can be lowered. Thus, switching elements that are smaller in size or lower in cost can be adopted.

[0054] Further, temperature protection is not required even in the case where switching elements with a low heatresisting temperature are used. Therefore, the inverter assembly 100 can be used in a wider operational range, namely, in wider varieties of operational states.

[0055] The cooling medium directly cools the heat transfer plate 110 without the intermediary of the first housing 24, so cooling efficiency can be enhanced compared to that with a construction in which the cooling medium cools the heat transfer plate 110 indirectly through the first housing 24.

[0056] In the electric compressor 10, there is no gel encapsulated in the inverter accommodation chamber 101, and the inverter assembly 100 is removable, so maintenance can be carried out more easily than with a conventional construction in which an inverter assembly is irremovably fixed. Thus, cooling efficiency can be enhanced as described above while facilitating maintenance.

[0057] In some conventional constructions, fins or the like are formed to cool the inverter. In such constructions, the shape of a casting mold for forming the fins or the like is complicated, so it is difficult to carry out maintenance of the casting mold. In the electric compressor 10 according to this embodiment, the cooling hole 130 can be formed by forming the through-hole through the first housing 24. Therefore, a casting mold having a relatively simple shape can be used, so it is easier to carry out the maintenance.

[0058] In the aforementioned first embodiment of the present invention, referring to the example of FIG. 2, the cooling hole 130 is located immediately below the IGBT 125. However, the cooling hole 130 does not have to be located immediately below the IGBT 125. For example, the cooling hole 130 may be located below or close to the IGBT 125. In addition, the cooling hole 130 may be provided anywhere as long as the efficiency of cooling the IGBT 125 is enhanced.

[0059] Further, the cooling hole 130 may also be designed to not cool the IGBT 125 but to cool at least one of the electronic components, for example, the capacitor 114 or the coil 116. In this case, the cooling hole 130 may be provided immediately below or close to the capacitor 114 or the coil 116, or at such a position that the efficiency of cooling the capacitor 114 or the coil 116 is enhanced. In such a construction as well, the inverter assembly 100 including the electronic components can be efficiently cooled as in the case of the construction shown in FIG. 2.

[0060] In the example of FIG. 2, only the single cooling hole 130 is provided for the IGBT 125. However, a cooling hole 130 may be provided for each of a plurality of elements. For example, a cooling hole may be provided for each of the IGBT's 124 and 125, and a cooling hole may be provided for each of the other electronic components.

Further, a plurality of cooling holes 130 may be provided for each of the electronic components.

[0061] The electric compressor 10 is exemplified as a scroll-type compressor. However, the type of the electric compressor 10 may be changed as long as the electric compressor 10 is equipped with a compression mechanism portion for compressing a fluid.

[0062] An electric compressor (10) is equipped with a motor chamber (27) provided in a suction pressure region. The motor chamber (27) is adjacent to an inverter accommodation chamber (101) with a first housing (24) therebetween, and a cooling hole (130) extending from the motor chamber (27) toward the inverter accommodation chamber (101) is formed through the first housing (24). The cooling hole (130) is a through-hole passing through the first housing (24). A cooling medium in the motor chamber (27) flows into the cooling hole (130) and comes into contact with a heat transfer plate (110), thereby cooling the heat transfer plate (110) directly.

(130a) thereof with the base (110); and the motor chamber (27) and the inverter accommodation chamber (101) are sealed from each other around the through-hole (130).

2. The electric compressor according to claim 1, **characterized in that** the motor chamber (27) and the inverter accommodation chamber (101) are sealed from each other using an O-ring (130c).

3. The electric compressor according to claim 1 or 2, **characterized in that:**

the electronic components (114,116,124,125) include a switching element (124,125); and the through-hole (130) is provided in a vicinity of the switching element (124,125).

Claims

1. An electric compressor comprising:

a compression mechanism portion for sucking in fluid from a suction pressure region;
an electric motor (26) for driving the compression mechanism portion;
a motor chamber (27) provided in the suction pressure region for accommodating the electric motor (26);
an inverter assembly (100) for converting a direct current into a polyphase alternating current to supply the converted current to the electric motor (26) and for controlling rotational frequency of the electric motor (26); and
an inverter accommodation chamber (101) for accommodating the inverter assembly(100), wherein
the inverter assembly (100) is provided with a substrate (112) having an electric circuit, electronic components (114, 116, 124, 125) connected to the substrate (112), and a base (110) for supporting the substrate (112), the inverter assembly (100) removably fixed in the inverter accommodation chamber (101),
the motor chamber (27) and the inverter accommodation chamber (101) are adjacent to each other with a housing (24) therebetween,

characterized in that:

the housing (24) has formed therethrough a through-hole (130) extending from the motor chamber (27) toward the inverter accommodation chamber (101);
the through-hole (130) is in contact at one end

FIG. 1

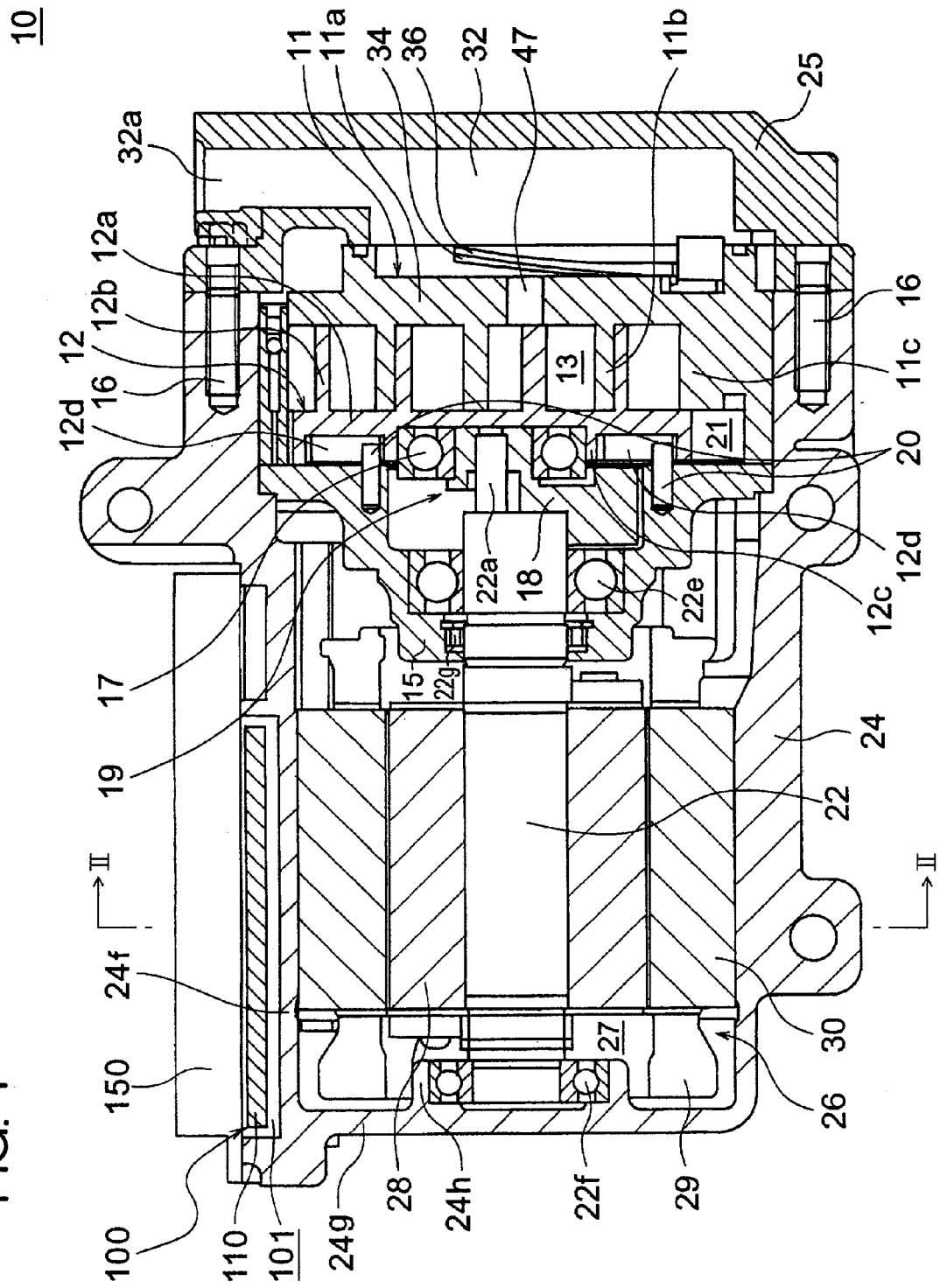
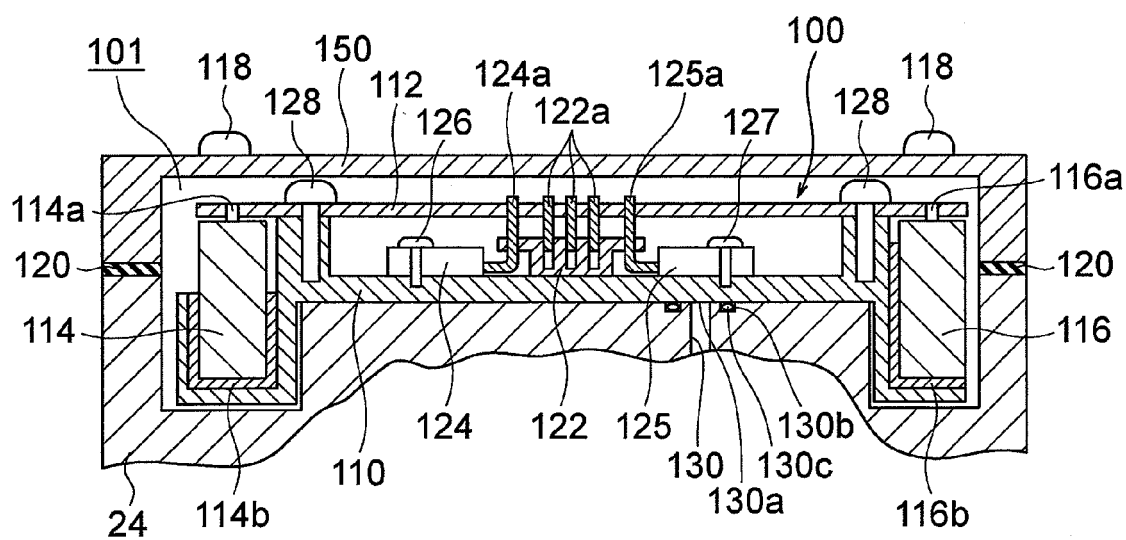


FIG. 2





European Patent
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EUROPEAN SEARCH REPORT

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Place of search The Hague		Date of completion of the search 29 April 2008	Examiner Lequeux, Frédéric
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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