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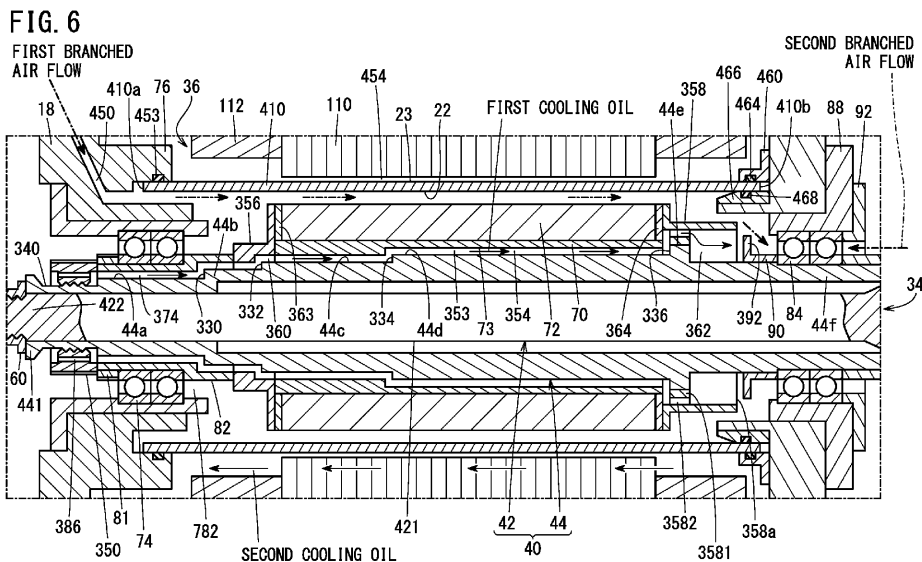
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(54) **ROTATING ELECTRIC MACHINE SYSTEM, AND COMBINED POWER SYSTEM EQUIPPED THEREWITH**

(57) A rotating electric machine system (10) includes a rotor (34) and a stator (36). A rotor internal oil passage (354) is formed in the interior of the rotor. The rotor is cooled by a first cooling oil serving as a lubricating oil that flows through a rotor internal oil passage. A housing internal oil passage (23) is formed in a rotating electric machine housing (14). The stator is cooled by a second

cooling oil serving as a lubricating oil that flows through the housing internal oil passage. A route by which the first cooling oil is supplied to the rotor internal oil passage, and a route by which the second cooling oil is supplied to the housing internal oil passage are different from each other.



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**Description**

## BACKGROUND OF THE INVENTION

## FIELD OF THE INVENTION

**[0001]** The present invention relates to a rotating electric machine system. Further, the present invention relates to a combined power system in which a rotating electric machine system and an internal combustion engine are integrally constructed.

## DESCRIPTION OF THE RELATED ART

**[0002]** The rotating electric machine includes a rotor having a rotating shaft, and a stator positioned on the outer circumference of the rotor. Permanent magnets are retained on the rotating shaft. When the rotating shaft rotates, an alternating magnetic field is formed by the permanent magnets and the electromagnetic coils in the stator. As a result, an induced current is generated in the electromagnetic coils. More specifically, in this case, the rotating electric machine functions as a generator.

**[0003]** When the induced current is continuously generated in the rotating electric machine, the rotating electric machine takes on heat. Further, when the rotating shaft is rotated at a high speed in a rotating electric machine that is small in scale, a fluid (primarily air) between the rotor and the stator becomes turbulent. As a result, wind losses become increased, and frictional resistance between the rotor and the stator increases. Due to such an occurrence as well, the temperature of the rotor and the stator rises.

**[0004]** In either case, the temperature of the electromagnetic coils increases. Under such circumstances, the conversion efficiency between the mechanical energy and the electrical energy is reduced. Further, the magnetic force of the electromagnetic coils is reduced. Along therewith, the output of the rotating electric machine is reduced. In order to avoid such a situation, the rotating electric machine may be cooled.

**[0005]** For example, in the technique disclosed in JP 2016-174443 A, the stator is cooled by cooling oil that is supplied to the interior of a rotating electric machine housing. In this case, a sleeve portion is provided between the rotor and the stator. A rotor chamber in which the rotor is accommodated is formed in the interior of the sleeve portion. A stator chamber in which the stator is accommodated is formed externally of the sleeve portion. Cooling oil is supplied to the stator chamber, and thereby the stator is cooled. In this instance, the rotating shaft of the rotor is supported in the rotating electric machine housing via bearings. The cooling oil also cools the bearings.

**[0006]** Moreover, the rotor is covered by a cover member. A location between the cover member and the sleeve portion is sealed by a seal member. Due to being sealed in this manner, the cooling oil is prevented from entering

into the rotor chamber.

**[0007]** The configuration described in JP 2016-174443 A cannot cool the rotor. Then, as described in JP 2007-159277 A, it is conceivable to supply compressed air, which has been cooled by an aftercooler (heat exchanger), to the rotor. Otherwise, as proposed in JP 2006-230098 A, it is conceivable that a portion of the lubricating oil of an internal combustion engine is supplied as a cooling oil to the interior of the rotating shaft.

## SUMMARY OF THE INVENTION

**[0008]** When the configuration described in JP 2006-230098 A is combined with the configuration described in JP 2016-174443 A, a cooling oil is supplied to the rotating shaft that is configured to rotate. More specifically, in this case, it is necessary for the cooling oil to be supplied to the stator chamber in the rotating electric machine housing, and to an oil path formed in the interior of the rotating shaft. That is, it is necessary to individually provide an oil route for supplying and recovering the cooling oil to and from the stator chamber, and an oil route for supplying and recovering the cooling oil to and from the oil path of the rotating shaft. As a result, the configuration of the rotating electric machine system becomes complicated. Further, along therewith, a concern arises in that the size and scale of the rotating electric machine system will increase.

**[0009]** The present invention has the object of solving the aforementioned problem.

**[0010]** According to one embodiment of the present invention, a rotating electric machine system is disclosed, which is equipped with a rotating electric machine provided with a rotor including a permanent magnet and a rotating shaft, and is equipped with a rotating electric machine housing in which the rotating shaft is rotatably supported, the rotor being provided with a rotor internal oil passage formed in an interior of the rotor, the rotating electric machine including a stator surrounding the permanent magnet from an outer circumference of the permanent magnet, the rotating electric machine housing including a first oil supply passage, a second oil supply passage, and a housing internal oil passage formed in an interior of the rotating electric machine housing and accommodating the stator, the rotating electric machine system comprising a first bearing and a second bearing that are interposed between the rotating electric machine housing and the rotating shaft, and an oil circulation supply device configured to circulate and supply a lubricating oil to the first bearing, the second bearing, the rotor internal oil passage, and the housing internal oil passage, wherein the oil circulation supply device includes a first oil supply line, a second oil supply line, a first oil recovery line, and a second oil recovery line, the oil circulation supply device is configured to supply the lubricating oil to the first bearing and the second bearing via the first oil supply line and the first oil supply passage, supply the lubricating oil toward the rotor internal oil passage via the

first oil supply line and the first oil supply passage, and supply the lubricating oil to the housing internal oil passage via the second oil supply line and the second oil supply passage, and the oil circulation supply device is configured to recover together, via the first oil recovery line, the lubricating oil supplied to the first bearing and the second bearing and the lubricating oil that has flowed through the rotor internal oil passage, and also recover via the second oil recovery line the lubricating oil that has flowed through the housing internal oil passage.

**[0011]** According to another embodiment of the present invention, a combined power system is provided, which is constituted to include the rotating electric machine system described above, and an internal combustion engine. In this instance, the internal combustion engine includes an output shaft configured to rotate integrally with the rotating shaft of the rotating electric machine system.

**[0012]** In the present invention, a portion of the lubricating oil supplied to the bearings is diverted and made to flow through the rotor internal oil passage. Based on the lubricating oil flowing in this manner, the rotor that constitutes the rotating electric machine is efficiently cooled by the lubricating oil. Further, from a route other than the above, the lubricating oil is supplied to the housing internal oil passage as a cooling oil. Since the stator is accommodated in the housing internal oil passage, the stator is efficiently cooled by the lubricating oil.

**[0013]** In this way, according to the present invention, the rotor and the stator are cooled simultaneously. Accordingly, a predetermined magnetic force is generated in an alternating magnetic field formed between the electromagnetic coils that make up the stator and the permanent magnet that makes up the rotor. In accordance with this feature, in the stator and the rotor, a decrease in the conversion efficiency between the mechanical energy and the electrical energy is suppressed. Therefore, the rotating electric machine is capable of maintaining a predetermined output. Further, by the rotor being made to rotate at a high speed, it is possible to cause the output to increase.

**[0014]** Also, in the present invention, the route of the lubricating oil supplied to the rotor, and the route of the lubricating oil supplied to the stator are separated. Therefore, the lubricating oil after cooling the rotor is not supplied to the stator. In the same manner, the lubricating oil after cooling the stator is not supplied to the rotor. For the aforementioned reasons, it is possible to cool efficiently the stator and the rotor.

**[0015]** In addition, the route of the lubricating oil that is supplied to the bearings, and the route of the lubricating oil that is supplied to the stator are separated. Accordingly, a situation is avoided in which the lubricating oil, which has become heated to a high temperature by taking on heat from the stator, is supplied to the bearings. Therefore, since the bearings are sufficiently lubricated and cooled, a situation is avoided in which seizure of the bearings takes place.

**[0016]** The above and other objects, features, and advantages of the present invention will become more apparent from the following description when taken in conjunction with the accompanying drawings, in which a preferred embodiment of the present invention is shown by way of illustrative example.

#### BRIEF DESCRIPTION OF THE DRAWINGS

10 **[0017]**

FIG. 1 is a schematic overall perspective view of a combined power system according to an embodiment of the present invention;

15 FIG. 2 is a schematic overall perspective view of a rotating electric machine system constituting part of the combined power system;

FIG. 3 is a schematic side cross-sectional view of the rotating electric machine system;

20 FIG. 4 is an enlarged view of principal components shown in FIG. 3;

FIG. 5 is an enlarged view of the principal components shown in FIG. 3, at a location that differs from that shown in FIG. 4;

25 FIG. 6 is a side cross-sectional view of principal components, showing an outer shaft that constitutes a rotating shaft, and constituent members provided on the outer shaft;

30 FIG. 7 is an enlarged side cross-sectional view of principal components, at a time when a rotor, a partition wall member, and a stator are viewed perpendicular to an axial direction of the rotating electric machine housing;

35 FIG. 8 is a schematic configuration diagram of an electrical current converter provided in a rotating electric machine housing;

40 FIG. 9 is a schematic perspective view of a second sub-housing that constitutes part of the rotating electric machine housing, and an inner housing in an engine housing;

FIG. 10 is a schematic side cross-sectional view of the rotating electric machine system, in a phase that differs from that shown in FIG. 3;

45 FIG. 11 is a schematic side cross-sectional view of the rotating electric machine system, showing a direction in which the lubricating oil (a second cooling oil) flows through a housing internal oil passage;

50 FIG. 12 is a schematic system diagram of an example in which there is schematically shown a lubricating oil flow passage in the rotating electric machine system;

FIG. 13 is a schematic side cross-sectional view of a gas turbine engine constituting part of the combined power system;

55 FIG. 14 is an enlarged view of principal components shown in FIG. 13;

FIG. 15 is a schematic side cross-sectional view of a case of using an externally provided compression

pump as a gas supplying device;

FIG. 16 is a schematic system diagram of an example in which there is schematically shown another example of the lubricating oil flow passage in the rotating electric machine system; and

FIG. 17 is a schematic side cross-sectional view of the rotating electric machine system in which lubricating oil flows through the housing internal oil passage in a direction opposite to that shown in FIG. 11.

#### DETAILED DESCRIPTION OF THE INVENTION

**[0018]** Hereinafter, the respective terms "left", "right", "lower", and "upper" refer specifically to the left, right, lower, and upper directions shown particularly in FIGS. 3 to 5, FIG. 13, and FIG. 14. However, these directions are provided for the sake of convenience in order to simplify the description and to facilitate understanding. In particular, the directions described in the specification are not limited to the directions when the combined power system is actually used.

**[0019]** FIG. 1 is a schematic overall perspective view of a combined power system 500 according to a present embodiment. The combined power system 500 is equipped with a rotating electric machine system 10, and a gas turbine engine 200. An axis extending in a longitudinal direction (axial direction) through a diametrical center of the rotating electric machine system 10 coincides with an axis extending in a longitudinal direction (axial direction) through a diametrical center of the gas turbine engine 200. Stated otherwise, the rotating electric machine system 10 and the gas turbine engine 200 are arranged on the same axis.

**[0020]** Hereinafter, the left end in the axial direction of each of the rotating electric machine system 10 and the gas turbine engine 200 may be referred to as a first end. Similarly, the right end in the axial direction of each of the rotating electric machine system 10 and the gas turbine engine 200 may be referred to as a second end. More specifically, in the rotating electric machine system 10, the left end part which is separated away from the gas turbine engine 200 is the first end. In the rotating electric machine system 10, the right end part which is in proximity to the gas turbine engine 200 is the second end. Further, in the gas turbine engine 200, the left end part which is in proximity to the rotating electric machine system 10 is the first end. In the gas turbine engine 200, the right end part which is separated away from the rotating electric machine system 10 is the second end. According to these definitions, in the illustrated example, the gas turbine engine 200 is disposed at the second end of the rotating electric machine system 10. The rotating electric machine system 10 is disposed at the first end of the gas turbine engine 200.

**[0021]** The combined power system 500 is used, for example, as a power source for providing propulsion in a flying object, a ship, an automobile, or the like. Suitable specific examples of the flying object include drones and

multi-copters. The combined power system 500, when mounted on a flying object, is used as a power drive source for rotationally urging, for example, a prop, a ducted fan, or the like. The combined power system 500, when mounted on a ship, is used as a screw rotational force generating device. The combined power system 500, when mounted on an automobile, is used as a power drive source for rotating a motor.

**[0022]** The combined power system 500 can also be used as an auxiliary power source in an aircraft, a ship, a building, or the like. Apart therefrom, it is also possible to utilize the combined power system 500 as gas turbine power generation equipment.

**[0023]** As will be discussed later, the gas turbine engine 200 is an internal combustion engine. Further, the gas turbine engine 200 serves as a gas supplying device that supplies compressed air (gas).

**[0024]** First, a description will be given concerning the rotating electric machine system 10. FIG. 2 is a schematic overall perspective view of the rotating electric machine system 10. FIG. 3 is a schematic side cross-sectional view of the rotating electric machine system 10. The rotating electric machine system 10 is equipped with a rotating electric machine 12 (for example, a generator), and a rotating electric machine housing 14 in which the rotating electric machine 12 is accommodated.

**[0025]** The rotating electric machine housing 14 includes a main housing 16, a first sub-housing 18, and a second sub-housing 20. The main housing 16 exhibits a generally cylindrical shape, and both a first end and a second end thereof are open ends. The first sub-housing 18 is connected to the first end (the left open end) of the main housing 16. The second sub-housing 20 is connected to the second end (the right open end) of the main housing 16. In accordance with the foregoing, the first end and the second end of the main housing 16 are closed.

**[0026]** The main housing 16 has a thick side wall that extends in a left-right direction. A hollow interior portion is formed in the main housing 16. Such a hollow interior portion is divided into a rotor chamber 22 and a stator chamber 23 by a partition wall member 410 which will be described later. The rotor chamber 22 is a chamber that is formed on an inner circumferential side (in the interior) of the partition wall member 410. The stator chamber 23 is a chamber that is formed on an outer circumferential side (externally) of the partition wall member 410.

**[0027]** A spiral shaped cooling jacket 24 is formed in the interior of a side wall of the main housing 16. A cooling medium flows through the cooling jacket 24. The cooling medium flows upstream through a first end, and flows downstream through a second end. In other words, the direction in which the cooling medium flows is a first direction from the first end toward the second end. The cooling medium advances while turning in a spiral shape along the cooling jacket 24. As a specific example of the cooling medium, there may be cited cooling water. In this case, the cooling jacket 24 is a water jacket.

**[0028]** A first casing 26 and a second casing 28 are provided in the vicinity of an edge of the first end on an outer surface (an outer wall) of the side wall of the main housing 16. The first casing 26 and the second casing 28 serve as one portion of the main housing 16. More specifically, the first casing 26 and the second casing 28 are disposed integrally with the main housing 16. As will be discussed later, the first casing 26 is a terminal casing. The second casing 28 is a measurement instrument casing.

**[0029]** As shown in FIG. 11, a lower contact chamber 290 and an upper terminal chamber 291 are formed in the interior of the first casing 26. The contact chamber 290 communicates with the stator chamber 23. An insertion port 292 that opens at an end surface of the first casing 26 facing toward the first end is formed in the contact chamber 290. The insertion port 292 is closed by a lid member 293.

**[0030]** A retaining member that retains a rotational parameter detector is connected to the first sub-housing 18. According to the present embodiment, as the rotational parameter detector, a resolver 132 is exemplified. Accordingly, hereinafter, the retaining member of the detector will be referred to as a "resolver holder 30". As will be discussed later, a cap cover 32 is connected via screws to the resolver holder 30.

**[0031]** The rotating electric machine 12 includes a rotor 34, and a stator 36 that surrounds an outer circumference of the rotor 34. Among these elements, the rotor 34 includes a rotating shaft 40. The partition wall member 410 is interposed between the rotor 34 and the stator 36 in a radial direction of the rotating shaft 40. Accordingly, the rotor 34 is positioned on the inner circumferential side of the partition wall member 410. Stated otherwise, the rotor 34 is accommodated in the rotor chamber 22. On the other hand, the stator 36 is positioned on the outer circumferential side of the partition wall member 410. Stated otherwise, the stator 36 is accommodated in the stator chamber 23.

**[0032]** The rotating shaft 40 includes an inner shaft 42, and a hollow cylindrical shaped outer shaft 44. Both ends of the outer shaft 44 are open ends. More specifically, the outer shaft 44 has a left open end 441 (refer to FIG. 4) and a right open end 442 (refer to FIG. 5). The inner shaft 42 is removably inserted in the interior of the outer shaft 44.

**[0033]** The inner shaft 42 is longer in comparison with the outer shaft 44. The inner shaft 42 includes a cylindrical columnar part 421, a left end part 422 (refer to FIG. 4), and a right end part 423 (refer to FIG. 5). The left end part 422 connects to the left side of the cylindrical columnar part 421. Accordingly, the left end part 422 is an end (a first end) of the inner shaft 42 that is separated away from the gas turbine engine 200. The right end part 423 connects to the right side of the cylindrical columnar part 421. Accordingly, the right end part 423 is an end (a second end) of the inner shaft 42 that is in proximity to the gas turbine engine 200. The diameter of the cylindrical

columnar part 421 is smaller than the diameter of the left end part 422 and the right end part 423. Further, the diameter of the right end part 423 is smaller than the diameter of the left end part 422.

**[0034]** One portion of the left end part 422 is exposed from the left open end 441 of the outer shaft 44. The portion exposed from the left open end 441 is a projecting distal end 46, which will be described later. Moreover, in the illustrated example, the right end part 423 of the inner shaft 42 and the right open end 442 of the outer shaft 44 are flush with each other. However, the right end part 423 may be positioned slightly in proximity to the second end relative to the right open end 442.

**[0035]** As shown in detail in FIG. 4, a first externally threaded portion 48, a flange portion 50, a stopper portion 52, and a second externally threaded portion 54 are provided sequentially in this order toward the right on the left end part 422 of the inner shaft 42. The outer diameters of the first externally threaded portion 48, the flange portion 50, the stopper portion 52, and the second externally threaded portion 54 become larger in this order. The outer diameter of the second externally threaded portion 54 is larger in comparison with the inner diameter of the outer shaft 44. Therefore, the right end of the second externally threaded portion 54 abuts against the edge of the left open end 441 of the outer shaft 44. Accordingly, in the inner shaft 42, a portion thereof on the left relative to the second externally threaded portion 54 is not inserted into the outer shaft 44.

**[0036]** A resolver rotor 56 is attached to the flange portion 50. Further, a small cap nut 58 is screw-engaged with the first externally threaded portion 48. A right end of the resolver rotor 56 is positioned by the stopper portion 52. A left end of the resolver rotor 56 is pressed by the small cap nut 58. In accordance with the foregoing, the resolver rotor 56 is positioned and fixed to the flange portion 50.

**[0037]** Further, a large cap nut 60 is screwed-engaged with the second externally threaded portion 54. A right end of the large cap nut 60 covers an outer circumferential wall of the left open end 441 of the outer shaft 44. In accordance with this feature, the left end part 422 of the inner shaft 42 is restrained by the left open end 441 of the outer shaft 44. Both the first externally threaded portion 48 and the second externally threaded portion 54 are so-called reverse threads. Accordingly, when screw-engaged, the small cap nut 58 and the large cap nut 60 are rotated counterclockwise. After being screw-engaged, it is preferable to partially deform the screw threads of the small cap nut 58 and the large cap nut 60. In accordance with this feature, the small cap nut 58 and the large cap nut 60 are prevented from becoming loosened.

**[0038]** As shown in FIG. 5, a connecting hole 62 is formed in the right end part 423 which is the second end of the inner shaft 42. The connecting hole 62 extends toward the left end part 422 which is the first end. A female threaded portion 64 is engraved on an inner circumfer-

ential wall of the connecting hole 62. The left end of an output shaft 204 is inserted into the connecting hole 62. The left end of the output shaft 204 is coupled to the inner shaft 42 by being screw-engaged with the female threaded portion 64. A compressor wheel 222 and a turbine wheel 224 (refer to FIG. 13) are retained on the output shaft 204.

**[0039]** Further, a first inner spline 66 is formed on the outer circumferential wall of the right open end 442 of the outer shaft 44. The first inner spline 66 extends in the axial direction (left-right direction) of the rotating electric machine system 10.

**[0040]** As shown in detail in FIG. 6, the outer shaft 44 includes in this order a first shaft portion 44a to a sixth shaft portion 44f in a direction from the first end to the second end. In the first shaft portion 44a to the sixth shaft portion 44f, the outer diameters (diameters) thereof differ from each other. Specifically, the outer diameter increases from the first shaft portion 44a toward the fifth shaft portion 44e. In particular, for example, the second shaft portion 44b is a portion that is larger in diameter than the first shaft portion 44a, and further, is a portion that is smaller in diameter than the third shaft portion 44c. Similarly, the third shaft portion 44c is a portion that is larger in diameter than the second shaft portion 44b, and further, is a portion that is smaller in diameter than the fourth shaft portion 44d. In this manner, from the first shaft portion 44a to the fifth shaft portion 44e, the outer shaft 44 changes from being a small diameter portion to a large diameter portion. In contrast thereto, the outer diameter of the sixth shaft portion 44f is smaller than the outer diameters of the third shaft portion 44c to the fifth shaft portion 44e.

**[0041]** A first stepped portion 330 is formed between the first shaft portion 44a and the second shaft portion 44b, based on a difference in the outer diameters (a diametrical difference) between both of the shaft portions 44a and 44b. A second stepped portion 332 is formed between the second shaft portion 44b and the third shaft portion 44c, based on a difference in the outer diameters between both of the shaft portions 44b and 44c. A third stepped portion 334 is formed between the third shaft portion 44c and the fourth shaft portion 44d, based on a difference in the outer diameters between both of the shaft portions 44c and 44d. A fourth stepped portion 336 is formed between the fourth shaft portion 44d and the fifth shaft portion 44e, based on a difference in the outer diameters between both of the shaft portions 44d and 44e.

**[0042]** FIG. 7 is a side cross-sectional view of the vicinity of the left open end 441 of the outer shaft 44 as viewed perpendicular to an axial direction. As shown in FIG. 7, an oil receiving concave portion 340 is formed in proximity to the first end of the first shaft portion 44a. The oil receiving concave portion 340 is an annular shaped concave portion formed on the outer surface of the first shaft portion 44a.

**[0043]** The rotating shaft 40 includes an oil guiding

member 350 which is made up from an annular shaped body. Specifically, concerning the oil guiding member 350, the oil guiding member 350 is positioned and fixed to the outer circumferential wall of the first shaft portion 44a. More specifically, a first threaded portion 348 is formed on the first shaft portion 44a, and a second threaded portion 352 is formed on the oil guiding member 350 (refer to FIG. 7). By the second threaded portion 352 being screw-engaged with the first threaded portion 348, the oil guiding member 350 is positioned and fixed to the first shaft portion 44a.

**[0044]** The oil guiding member 350 is positioned in facing relation to the oil receiving concave portion 340 that is formed in the rotating shaft 40 (the first shaft portion 44a of the outer shaft 44). An annular gap 385 that allows the lubricating oil to be received is formed between the opening of the oil guiding member 350 and the oil receiving concave portion 340. The annular gap 385 serves as an inlet of a rotor internal oil passage 354. Moreover, the outlet of the rotor internal oil passage 354 serves as an opening that faces toward the second end in a hole portion of a second magnet stopper 358.

**[0045]** A plurality of first oil delivery passages 386 are formed in the oil guiding member 350. The first oil delivery passages 386 extend in the axial direction of the rotating shaft 40 (refer to FIG. 7). Outlets of the plurality of the first oil delivery passages 386 connect to a flow through space 374 that is one part of the rotor internal oil passage 354. Stated otherwise, the first oil delivery passages 386 communicate with the rotor internal oil passage 354.

**[0046]** A plurality of individual upstream guide grooves 390 (first guide grooves) are formed in the outer circumferential wall of the oil guiding member 350. Two individual ones of the upstream guide grooves 390 that are adjacent to each other are separated, for example, by 60°.

**[0047]** A first outer stopper 81, which is one of the bearing stoppers, is provided at the second end of the first shaft portion 44a. A first inner stopper 82, which is another one of the bearing stoppers, is provided on the second shaft portion 44b. A first bearing 74 is sandwiched between the first outer stopper 81 and the first inner stopper 82.

**[0048]** As shown in FIG. 6, permanent magnets 72 are retained on the third shaft portion 44c to the fifth shaft portion 44e via a tubular member 70. The rotor 34 is constituted by including the rotating shaft 40, the tubular member 70, and the permanent magnets 72. An inner hole 73 that extends in the axial direction of the tubular member 70 is formed in the tubular member 70. The rotating shaft 40 is passed through the inner hole 73. Accordingly, in the radial direction of the rotating shaft 40, the tubular member 70 is interposed between the rotating shaft 40 and the permanent magnets 72. In the inner hole 73, the inner diameter thereof is formed to be larger at a portion thereof corresponding to the third stepped portion 334.

**[0049]** The tubular member 70 and the permanent magnets 72 are sandwiched between a first magnet stop-

per 356 and the second magnet stopper 358 in the axial direction of the rotating shaft 40. In accordance with this feature, the tubular member 70 is positioned on the third shaft portion 44c to the fifth shaft portion 44e. More specifically, a positional deviation (i.e., shifting in position) from the third shaft portion 44c to the fifth shaft portion 44e of the tubular member 70 and the permanent magnets 72 is prevented. In this manner, the first magnet stopper 356 and the second magnet stopper 358 serve to position the permanent magnets 72.

**[0050]** The first magnet stopper 356 straddles the second end of the second shaft portion 44b and the first end of the third shaft portion 44c. The second magnet stopper 358 covers the outer surface of the fifth shaft portion 44e. Moreover, a first ring body 363 is sandwiched between the first magnet stopper 356 and the permanent magnets 72. Similarly, a second ring body 364 is sandwiched between the permanent magnets 72 and the second magnet stopper 358. The first end and the second end of the tubular member 70 are each passed through respective through holes of the first ring body 363 and the second ring body 364.

**[0051]** An inward projecting member 3581 is provided on an inner circumferential wall of the hole portion of the second magnet stopper 358. The inward projecting member 3581 projects out in an annular shape inwardly in the radial direction of the hole portion. An inner circumferential wall of the inward projecting member 3581 contacts a top surface of the fourth stepped portion 336. A plurality of second oil delivery passages 3582 are formed in the inward projecting member 3581. The plurality of second oil delivery passages 3582 are arranged alongside one another in the circumferential direction of the inward projecting member 3581. Individual ones of the second oil delivery passages 3582 extend in the axial direction of the rotating shaft 40.

**[0052]** As shown in FIG. 3, a left end (a first end) of the rotating shaft 40 is rotatably supported in the first sub-housing 18 via the first bearing 74. The first bearing 74 is inserted between the outer shaft 44 and the first sub-housing 18. Specifically, as shown in FIG. 3 and FIG. 7, the first sub-housing 18 includes a cylindrical columnar shaped projecting member 76 that is projected out toward the main housing 16. A first insertion hole 78 is formed in the cylindrical columnar shaped projecting member 76. A first bearing holder 80 by which the first bearing 74 is retained is inserted into the first insertion hole 78. Accordingly, the first bearing 74 is arranged in the first insertion hole 78.

**[0053]** The first insertion hole 78 extends in the left-right direction. The left end of the first insertion hole 78 is separated farther away from the output shaft 204 than the right end of the first insertion hole 78 is. Hereinafter, the left end of the first insertion hole 78 may also be referred to as a "first distal end 781". On the other hand, the right end of the first insertion hole 78 is closer to the output shaft 204 than the left end (the first distal end 781) of the first insertion hole 78 is. Hereinafter, the right end

of the first insertion hole 78 may also be referred to as a "first proximal end 782".

**[0054]** As shown in FIG. 7, the first outer stopper 81 is provided at the first end of the first shaft portion 44a. The first outer stopper 81 is an annular shaped body, and a plurality of individual downstream guide grooves 368 (second guide grooves) are formed in the outer circumferential wall. Although it is preferable for the phases of the upstream guide grooves 390 and the downstream guide grooves 368 to coincide, even if they do not coincide, no particular problem arises.

**[0055]** The first inner stopper 82 is provided on the second shaft portion 44b. The first inner stopper 82 has a small diameter cylindrical portion 370 having a small outer diameter, and a large diameter cylindrical portion 372 having a large outer diameter. The first inner stopper 82 covers the outer surface of the second shaft portion 44b, in a manner so that the small diameter cylindrical portion 370 faces toward the first end, and further, the large diameter cylindrical portion 372 faces toward the second end.

**[0056]** In the foregoing description, the flow through space 374, which is of an annular shape, is formed between the first shaft portion 44a and the second shaft portion 44b, and the inner circumferential wall of the first inner stopper 82. A flow through space 360, which is of an annular shape, is also formed between the outer surfaces of the second shaft portion 44b and the third shaft portion 44c, and the inner circumferential wall of the hole portion of the first magnet stopper 356. A flow through space 353, which is of an annular shape, is also formed between the outer surfaces of the third shaft portion 44c to the fifth shaft portion 44e, and the inner wall of the inner hole 73 of the tubular member 70. A flow through space 362, which is of an annular shape, is also formed between the outer surface of the sixth shaft portion 44f, and the inner circumferential wall of the hole portion of the second magnet stopper 358. The rotor internal oil passage 354 is formed by the flow through spaces 374, 360, 353, and 362 being connected to each other. The flow through space 353 and the flow through space 362 are connected via the second oil delivery passages 3582.

**[0057]** The rotor internal oil passage 354 is a flow passage that extends in the axial direction of the rotating shaft 40, and for example, may be an annular space that extends partially in the axial direction. The rotor internal oil passage 354 extends from the first end to the second end of the permanent magnets 72 in the axial direction of the rotating shaft 40. The rotor internal oil passage 354 may be a groove or the like.

**[0058]** An end surface of the second end of the oil guiding member 350 abuts against an end surface of the first end of the small diameter cylindrical portion 370. An end surface of the first end of the first magnet stopper 356 abuts against an end surface of the second end of the large diameter cylindrical portion 372. Further, the first outer stopper 81 is positioned and fixed to the outer circumferential wall of the first end of the small diameter

cylindrical portion 370. The first bearing 74 is arranged on the outer circumference of the small diameter cylindrical portion 370, and further, is sandwiched between an end surface of the second end of the first outer stopper 81, and an end surface of the first end of the large diameter cylindrical portion 372.

**[0059]** The distal end of the left end part of the rotating shaft 40 passes through the first insertion hole 78 after having passed through an inner hole of the first bearing 74. The distal end of the left end part of the rotating shaft 40 is further exposed on an outer side (a hollow concave portion 118) of the cylindrical columnar shaped projecting member 76. Hereinafter, the portion of the rotating shaft 40 that is projected out from the left end of the first bearing 74 is referred to as a "projecting distal end 46". Within the left end part 422 of the inner shaft 42, the first externally threaded portion 48, the flange portion 50, the stopper portion 52, and the second externally threaded portion 54 are included on the projecting distal end 46 (refer to FIG. 4).

**[0060]** A second bearing 84 is provided on the sixth shaft portion 44f of the outer shaft 44. The second bearing 84 rotatably supports the right end (a second end) of the rotating shaft 40 on the second sub-housing 20. As shown in FIG. 5, the second bearing 84 is inserted between the outer shaft 44 and the second sub-housing 20 which exhibits a substantially disk shape.

**[0061]** The second sub-housing 20 is connected to the main housing 16 via non-illustrated bolts. The center of the second sub-housing 20 is in the form of a thick-walled cylindrical shaped portion. A second insertion hole 86 is formed in such a cylindrical shaped portion. The second insertion hole 86 extends in the left-right direction. The left end of the second insertion hole 86 is separated farther away from the output shaft 204 than the right end of the second insertion hole 86 is. Hereinafter, the left end of the second insertion hole 86 may also be referred to as a "second distal end 861". On the other hand, the right end of the second insertion hole 86 is closer to the output shaft 204 than the left end (the second distal end 861) of the second insertion hole 86 is. Hereinafter, the right end of the second insertion hole 86 may also be referred to as a "second proximal end 862".

**[0062]** A second bearing holder 88 by which the second bearing 84 is retained is inserted into the second insertion hole 86. Accordingly, the second bearing 84 is arranged in the second insertion hole 86. The second bearing 84 is sandwiched between a second inner stopper 90 positioned at the second distal end 861, and a second outer stopper 92 positioned at the second proximal end 862. Based on being sandwiched in this manner, the second bearing 84 is positioned and fixed to the sixth shaft portion 44f. In this manner, the second inner stopper 90 and the second outer stopper 92 serve as bearing stoppers.

**[0063]** The rotor 34 includes a disk portion 392 as shown in FIG. 6. The disk portion 392 is disposed at the first end of the second inner stopper 90, and is a protrud-

ing portion that protrudes outward in the radial direction of the rotating shaft 40 on the outer circumference of the rotating shaft 40. In the axial direction of the rotating shaft 40, the disk portion 392 is positioned between the permanent magnets 72 and the second bearing 84, and partially covers an opening 358a of a hole portion of the second magnet stopper 358. More specifically, the disk portion 392 is a shield member provided at an outlet (the outlet of the rotor internal oil passage 354) of the flow through space 362. The disk portion 392 is closer to the inner side (the first end) than the second bearing 84 is.

**[0064]** The disk portion 392 faces toward the second bearing 84 in the axial direction of the rotating shaft 40. Based on the fact that the disk portion 392 partially shields the outlet of the flow through space 362, the lubricating oil that is in contact with the second bearing 84 is separated away from the lubricating oil that has flowed out from the rotor internal oil passage 354.

**[0065]** Further, at the second distal end 861, a clearance is formed between the second inner stopper 90 and the second bearing holder 88. This clearance defines a third sub-branching passage 941.

**[0066]** As shown in FIG. 2 and FIG. 3, in the second sub-housing 20, a rectifying member 96 is connected to an end surface facing toward the gas turbine engine 200. The rectifying member 96 includes a base portion 98, a reduced diameter portion 100, and a top portion 102. The base portion 98 which faces toward the second sub-housing 20 has a large diameter and a thin cylindrical plate shape. The top portion 102 which faces toward the gas turbine engine 200 has a small diameter and a relatively long cylindrical plate shape. In the reduced diameter portion 100 between the base portion 98 and the top portion 102, the diameter thereof gradually becomes smaller. Accordingly, the rectifying member 96 is a mountain (chevron) shaped body or a bottomless cup shaped body. The outer surface of the reduced diameter portion 100 is a smooth surface with a small surface roughness.

**[0067]** In the base portion 98, inlets 104 are formed in an end surface thereof facing toward the second sub-housing 20. Further, the reduced diameter portion 100 is hollow. More specifically, a relay chamber 106 is formed in the interior of the reduced diameter portion 100. The inlets 104 serve as inlets for the compressed air to enter into the relay chamber 106.

**[0068]** An insertion hole 108 is formed in the top portion 102 in the left-right direction. A diameter (an opening diameter) of the insertion hole 108 is larger than the outer diameter of a portion of the second outer stopper 92 that extends along the rotating shaft 40. Therefore, a portion of the second outer stopper 92 that has entered into the insertion hole 108, and the outer circumferential wall thereof are separated away from the inner wall of the insertion hole 108. Stated otherwise, a clearance is formed between the outer circumferential wall of the second outer stopper 92 and the inner wall of the insertion hole 108. This clearance defines a fourth sub-branching passage 942. The relay chamber 106 becomes wider as



it comes closer to the insertion hole 108 and the fourth sub-branching passage 942.

**[0069]** Further, a diameter (opening diameter) of the insertion hole 108 is larger than the outer diameter of the relatively small left end (a small diameter cylindrical portion 242) of the compressor wheel 222. Therefore, the small diameter cylindrical portion 242 that has entered into the insertion hole 108 is also separated away from the inner wall of the insertion hole 108. Stated otherwise, a clearance is formed between the outer circumferential wall of the small diameter cylindrical portion 242 and the inner wall of the insertion hole 108. This clearance defines an outlet passage 943.

**[0070]** As shown in FIG. 3, the first insertion hole 78 and the third sub-branching passage 941 communicate with the rotor chamber 22.

**[0071]** The stator 36 constitutes the rotating electric machine 12 together with the aforementioned rotor 34. The stator 36 includes electromagnetic coils 110 and a plurality of insulating substrates 112. The electromagnetic coils 110 include three types of coils, including a U-phase coil, a V-phase coil, and a W-phase coil, and are wound around the insulating substrates 112. In the case that the rotating electric machine 12 is a generator, the rotating electric machine 12 is a so-called three-phase power source. The plurality of insulating substrates 112 are arranged in an annular shape. Due to being arranged in this manner, an inner hole is formed in the stator 36. The cylindrical columnar shaped projecting member 76 enters into a left opening of the inner hole of the stator 36.

**[0072]** As noted previously, the partition wall member 410 is interposed between the rotor 34 and the stator 36. As can be understood from FIG. 6, the partition wall member 410 is a cylindrical shaped body. Accordingly, the partition wall member 410 surrounds a major portion of the rotor 34 from the outer circumferential side. Consequently, the rotor chamber 22 is formed in the interior of the partition wall member 410. The rotor 34 is accommodated in the rotor chamber 22.

**[0073]** As will be discussed later, the compressed air, which is a gas, flows through the rotor chamber 22. In this instance, a clearance is formed between the outer circumferential wall of the cylindrical columnar shaped projecting member 76 and the insulating substrates 112. The compressed air flows through such a clearance. Stated otherwise, this clearance is one portion of a compressed air passage in the interior of the rotating electric machine housing 14.

**[0074]** Three individual starting passages 450 for the purpose of delivering the compressed air to the rotor chamber 22 are formed in the first sub-housing 18. In FIG. 3, an individual one of the three individual starting passages 450 is shown.

**[0075]** As it proceeds from a first end toward a second end of the first sub-housing 18, the one individual starting passage 450 is inclined from a radially outward portion toward a radially inward portion of the first sub-housing 18. A first end of the starting passage 450 is open at an

end surface facing toward the first end in the first sub-housing 18. Such an opening serves as an inlet for the compressed air into the interior of the rotating electric machine housing 14. A second end of the starting passage 450 opens toward a first end of the partition wall member 410. Such an opening serves as an inlet for the compressed air into the rotor chamber 22.

**[0076]** One portion of the compressed air flows from the starting passages 450 toward the first bearing 74. A remaining portion of the compressed air travels from the starting passages 450 via the rotor chamber 22, and flows toward the second bearing 84. In this manner, in the rotor chamber 22, the direction in which the compressed air flows is the first direction from the first end toward the second end.

**[0077]** A distal end at a second end of the cylindrical columnar shaped projecting member 76 enters between the inner hole of the stator 36 and the outer circumferential wall at the first end of the partition wall member 410. A first seal member 453 is provided at the distal end of the second end of the cylindrical columnar shaped projecting member 76. The first seal member 453 is an O-ring, and provides a seal between the distal end of the second end of the cylindrical columnar shaped projecting member 76, and the outer circumferential wall at the first end of the partition wall member 410. As shown in FIG. 4 and FIG. 6, the first sub-housing 18 and the like do not abut against a distal end surface 410a at the first end of the partition wall member 410.

**[0078]** On the other hand, a space is formed by the outer circumferential wall of the partition wall member 410 and the main housing 16. Such a space makes up the stator chamber 23. The stator 36 is accommodated in the stator chamber 23. The inner wall of the stator chamber 23 and the electromagnetic coils 110 are slightly separated away from each other. More specifically, a clearance is formed between the inner wall of the stator chamber 23 and the electromagnetic coils 110. Due to this clearance, the main housing 16 and the electromagnetic coils 110 are electrically insulated.

**[0079]** As will be described later, the lubricating oil flows through the stator chamber 23. More specifically, the stator chamber 23 makes up one portion of a housing internal oil passage formed in the interior of the rotating electric machine housing 14. In this instance, a clearance is also formed between the outer circumferential wall of the partition wall member 410 and the electromagnetic coils 110. Such a clearance is also one portion of the oil passage. Hereinafter, such an oil passage will be referred to as a "stator inner circumferential side oil passage 454". Moreover, the lubricating oil that flows through the stator chamber 23 (the housing internal oil passage) and the stator inner circumferential side oil passage 454 is a divided flow that is divided from the lubricating oil supplied to the first bearing 74 and the second bearing 84.

**[0080]** In the second sub-housing 20, an inner annular shaped projecting member 456 and an outer annular shaped projecting member 458 are provided concentri-

cally on a surface thereof facing toward the first end. The inner annular shaped projecting member 456 is positioned on the inner circumference of the outer annular shaped projecting member 458. An annular shaped concave portion 114 is formed between the inner annular shaped projecting member 456 and the outer annular shaped projecting member 458. The insulating substrates 112 that constitute the stator 36 are inserted into the annular shaped concave portion 114.

**[0081]** The inner annular shaped projecting member 456 is passed through a through hole of an annular shaped holder 460. A second end of the annular shaped holder 460 expands in the shape of a flange, and abuts an end surface of a first end of the annular shaped concave portion 114.

**[0082]** A first end of the annular shaped holder 460 extends toward the partition wall member 410. At the first end of the annular shaped holder 460, a second seal member 464 is provided on an inner surface facing toward the outer circumferential wall of the partition wall member 410. The second seal member 464 is an O-ring, and provides a seal between the inner circumferential wall at the first end of the annular shaped holder 460, and the outer circumferential wall at the second end of the partition wall member 410.

**[0083]** An annular shaped guide 466 is interposed between the inner annular shaped projecting member 456 and the inner circumferential wall at the second end of the partition wall member 410. A first end of the annular shaped guide 466 is a tapered portion 467 that reduces in diameter in a tapered shape as it progresses toward a first end. In the annular shaped guide 466, a third seal member 468 is provided on an outer surface thereof facing toward the inner circumferential wall of the partition wall member 410. The third seal member 468 is an O-ring, and provides a seal between an outer circumferential wall of the annular shaped guide 466, and the inner circumferential wall at the second end of the partition wall member 410. As shown in FIG. 5 and FIG. 6, the second sub-housing 20 and the like do not abut against a distal end surface 410b at the second end of the partition wall member 410.

**[0084]** Due to the presence of the first seal member 453, the second seal member 464, and the third seal member 468, the rotor chamber 22 and the stator chamber 23 become spaces that are independent from each other. In accordance with this feature, for example, the compressed air supplied to the rotor chamber 22 is prevented from leaking into the stator chamber 23. Further, the lubricating oil supplied to the stator chamber 23 is prevented from leaking into the rotor chamber 22.

**[0085]** The outer circumferential wall at the first end of the partition wall member 410 contacts the first sub-housing 18 via the first seal member 453. The second end of the partition wall member 410 is sandwiched between the annular shaped guide 466 and the annular shaped holder 460 via the second seal member 464 and the third seal member 468. The partition wall member 410 does

not come into abutment in particular with any other members. Further, in the partition wall member 410, no members thereof exist that are in contact with the distal end surface 410a of the first end and the distal end surface 410b of the second end. As can be understood from this feature, in the partition wall member 410, both of the distal end surfaces 410a and 410b in the axial direction are unconstrained surfaces that are not constrained by other members. Therefore, both end parts of the partition wall member 410 can be freely made to undergo thermal expansion in the axial direction of the partition wall member 410.

**[0086]** Moreover, although according to the present embodiment, both of the distal end surfaces 410a and 410b are non-constrained surfaces, some other members may be placed in contact with the distal end surface 410a or the distal end surface 410b.

**[0087]** In the case that the wall thickness T of the partition wall member 410 shown in FIG. 7 is large, the weight of the partition wall member 410 becomes greater, and the rotating electric machine 12 becomes enlarged in the radial direction. Further, the partition wall member 410 having such a large wall thickness T interrupts the alternating magnetic field between the permanent magnets 72 and the electromagnetic coils 110. In order to avoid such an inconvenience, it is preferable for the wall thickness T to be as small as possible. The wall thickness T, for example, is preferably on the order of 1 mm.

**[0088]** Accordingly, even though it is thin-walled, the partition wall member 410 should preferably be made of a material having sufficient strength and rigidity. As a suitable example of such a material, there may be cited ceramics. Insulating and nonmagnetic ceramics are particularly preferred, in order to avoid interrupting the alternating magnetic field between the rotor 34 and the stator 36. As detailed examples thereof, there may be cited aluminum nitride (AlN), silicon nitride (Si<sub>3</sub>N<sub>4</sub>), and alumina (Al<sub>2</sub>O<sub>3</sub>). Among these ceramics, alumina is particularly preferred because it is inexpensive.

**[0089]** As shown in FIG. 7, the separation distance between the permanent magnets 72 that constitute the rotor 34 and the inner circumferential wall of the partition wall member 410 is defined as an inner side separation distance D<sub>in</sub>. The separation distance between the outer circumferential wall of the partition wall member 410 and the electromagnetic coils 110 that constitute the stator 36 is defined as an outer side separation distance D<sub>out</sub>. When the inner side separation distance D<sub>in</sub> is smaller than the outer side separation distance D<sub>out</sub>, it becomes easy for turbulence to be generated in the compressed air that flows between the permanent magnets 72 and the partition wall member 410, and therefore, windage losses become greater. In addition, since the frictional resistance between the rotor 34 and the compressed air becomes greater, frictional heat generated in the permanent magnets 72 also increases.

**[0090]** In order to avoid the problems described above, according to the present embodiment, the inner side sep-

aration distance  $D_{in}$  is set to be greater than the outer side separation distance  $D_{out}$ . In particular, the following relational expression (inequality) is satisfied.

$$D_{in} > D_{out}$$

**[0091]** The value of  $D_{in}$  is preferably at least 2.5 times as great as the value of  $D_{out}$ . Although it is possible to set the value of  $D_{in}$  to be more than or equal to six times the value of  $D_{out}$ , in the case that the value of  $D_{in}$  is excessively large, the rotating electric machine 12 becomes excessively large in scale in the radial direction. In order to avoid this situation, in the case that the sum of  $D_{in}$  and  $D_{out}$  is maintained constant and the value  $D_{in}$  becomes excessively large, then since the value  $D_{out}$  becomes excessively small, it becomes difficult for the lubricating oil to flow through the stator inner circumferential side oil passage 454. Thus, it is preferable for the value of  $D_{in}$  to be set to approximately 3.5 times to approximately 4 times the value of  $D_{out}$ . To cite one example of a combination of  $D_{in}$  and  $D_{out}$ , the value of  $D_{in}$  lies within a range of from 1.1 mm to 2.1 mm, and the value of  $D_{out}$  lies within a range of from 0.3 mm to 0.5 mm.

**[0092]** As shown in FIG. 4, the first sub-housing 18 includes an annular shaped convex portion 116 that projects out in an annular shape. The hollow concave portion 118 is formed on an inner side of the annular shaped convex portion 116. The projecting distal end 46, which is one portion of the left end part 422 of the inner shaft 42, enters into the hollow concave portion 118.

**[0093]** The resolver holder 30 is provided on the annular shaped convex portion 116. The resolver holder 30 has a flange shaped stopper 120 that is projected out toward an outer side in the radial direction. The flange shaped stopper 120 is larger in diameter than an inner diameter of the annular shaped convex portion 116. Accordingly, the flange shaped stopper 120 abuts against the annular shaped convex portion 116. Due to abutting in this manner, the resolver holder 30 is positioned. In this state, the resolver holder 30 is connected to the first sub-housing 18, for example, via mounting bolts (not shown).

**[0094]** A small cylindrical portion 122 is provided in the resolver holder 30 on a left side of the flange shaped stopper 120. Further, a large cylindrical portion 124 is provided on a right side of the flange shaped stopper 120. The large cylindrical portion 124 is larger in diameter than the small cylindrical portion 122. A retaining hole 126 is formed in the resolver holder 30. A major portion of a resolver stator 130 is fitted into the retaining hole 126. Due to being fitted therein in this manner, the resolver stator 130 is retained by the resolver holder 30.

**[0095]** At a time when the large cylindrical portion 124 enters into the hollow concave portion 118 and the flange shaped stopper 120 comes into abutment against the annular shaped convex portion 116, the resolver rotor 56 is positioned in the inner hole of the resolver stator 130.

The resolver 132 is constituted by the resolver stator 130 and the resolver rotor 56. The resolver 132 serves as the rotational parameter detector. According to the present embodiment, the resolver 132 detects an angle of rotation of the inner shaft 42. Moreover, as noted previously, the resolver rotor 56 is retained by the flange portion 50 on the left end part 422 of the inner shaft 42.

**[0096]** An engagement hole 134 is formed in the flange shaped stopper 120. A transmission connector 136 is engaged with the engagement hole 134. The resolver stator 130 and the transmission connector 136 are electrically connected via a signal line 138. Moreover, a reception connector of a receiver (not shown) is inserted into the transmission connector 136. The resolver 132 and the receiver are electrically connected via the transmission connector 136 and the reception connector. The receiver receives signals emitted by the resolver 132.

**[0097]** A plurality of tab portions 140 (which are omitted from illustration in FIG. 1) are provided on the small cylindrical portion 122. An individual one of the tab portions 140 is shown in FIG. 3. Furthermore, the small cylindrical portion 122 is covered by the cap cover 32. The cap cover 32 closes a left opening of the small cylindrical portion 122, and in addition, shields the left end part 422 of the inner shaft 42. Moreover, it should be noted that the cap cover 32 is connected to the tab portions 140 via connecting bolts 142.

**[0098]** As noted previously, the first casing 26 and the second casing 28 are integrally provided on a side wall in proximity to the left end of the main housing 16. A U-phase terminal 1441, a V-phase terminal 1442, and a W-phase terminal 1443 are accommodated in the terminal chamber 291 of the first casing 26. The U-phase terminal 1441 is electrically connected to a U-phase coil within the electromagnetic coils 110. The V-phase terminal 1442 is electrically connected to a V-phase coil within the electromagnetic coils 110. The W-phase terminal 1443 is electrically connected to a W-phase coil within the electromagnetic coils 110. The U-phase terminal 1441, the V-phase terminal 1442, and the W-phase terminal 1443 are electric terminal portions to which an external device (an external load or an external power source) is electrically connected. Electrical power generated by the rotating electric machine 12 is supplied to the external device. As the external load, for example, there may be cited a non-illustrated motor. Further, as another external device, for example, there may be cited a battery 146 as shown in FIG. 8.

**[0099]** An electrical contact between the U-phase terminal 1441 and the U-phase coil is provided in the contact chamber 290 of the first casing 26. An electrical contact between the V-phase terminal 1442 and the V-phase coil is similarly provided in the contact chamber 290. An electrical contact between the W-phase terminal 1443 and the W-phase coil is similarly provided in the contact chamber 290. When describing the electrical contact between the V-phase terminal 1442 and the V-phase coil, as shown in FIG. 11, the V-phase terminal 1442 includes

a blocking convex portion 294. The blocking convex portion 294 closes and blocks a communication opening between the contact chamber 290 and the terminal chamber 291. Due to being blocked in this manner, the contact chamber 290 and the terminal chamber 291 become spaces that are independent from each other.

**[0100]** Terminal portions 295 of the V-phase terminal 1442 are provided on the blocking convex portion 294. The terminal portions 295 extend into the contact chamber 290. Further, terminal wires 110a, which are an end part of the V-phase coil, are led out to the contact chamber 290. Inside the contact chamber 290, the terminal portions 295 and the terminal wires 110a are connected via screws 296. In accordance with this feature, the V-phase terminal 1442 and the V-phase coil are electrically connected. Although not shown in particular, the U-phase terminal 1441 and the U-phase coil are similarly connected inside the contact chamber 290. In the same manner, the W-phase terminal 1443 and the W-phase coil are connected inside the contact chamber 290.

**[0101]** The second casing 28 is adjacent to the first casing 26. A thermistor 148, which serves as a temperature measurement device, is accommodated in the second casing 28. Although not illustrated in particular, measurement terminals of the thermistor 148 are connected to the electromagnetic coils 110 after having been drawn out from the second casing 28. A harness 149 that is connected to the thermistor 148 is drawn out from the second casing 28.

**[0102]** As shown in FIG. 1 and FIG. 2, an electrical current converter 150 is disposed on the outer circumferential wall of the main housing 16. The electrical current converter 150 is located closer to the gas turbine engine 200 than the first casing 26 is. As shown in FIG. 8, the electrical current converter 150 includes a conversion circuit 152, a capacitor 154, and a control circuit 156. The conversion circuit 152, the capacitor 154, and the control circuit 156 are accommodated inside an equipment case 158. The equipment case 158 is arranged, for example, on the outer circumferential wall of the main housing 16 at a location that does not interfere with a first hollow tube portion 1601, a second hollow tube portion 1602, and a third hollow tube portion 1603 (refer to FIG. 1).

**[0103]** The hollow interior portions of the first hollow tube portion 1601, the second hollow tube portion 1602, and the third hollow tube portion 1603 are compressed air flow passages through which the compressed air flows. More specifically, according to the present embodiment, three compressed air flow passages are formed in the rotating electric machine housing 14. The first hollow tube portion 1601 and the third hollow tube portion 1603, for example, are formed as hollow bulging portions that bulge out from the outer circumferential wall of the main housing 16.

**[0104]** In the first sub-housing 18, on an end surface facing toward the first end, distal ends of the three individual starting passages 450 are open respectively at the

first end. An individual one of the openings from among the three individual starting passages 450 is connected via a flexible tube 470a to the first hollow tube portion 1601. Another individual one of the openings from among the three individual starting passages 450 is connected via a flexible tube 470b to the second hollow tube portion 1602. Still another individual one of the openings from among the three individual starting passages 450 is connected via a flexible tube 470c to the third hollow tube portion 1603.

**[0105]** The conversion circuit 152 includes a power module 161. The conversion circuit 152 converts an AC current generated by the electromagnetic coils 110 into a DC current. At this time, the capacitor 154 temporarily stores the DC current converted by the conversion circuit 152 as an electric charge. The conversion circuit 152 also possesses a function of converting the DC current delivered from the battery 146 into an AC current. In this case, the capacitor 154 temporarily stores the DC current delivered from the battery 146 toward the electromagnetic coils 110 as an electric charge.

**[0106]** The control circuit 156 controls a current density or the like of the DC current that flows from the capacitor 154 toward the battery 146, or the DC current that flows in the opposite direction. Moreover, the DC current from the battery 146 is supplied to the motor, for example, via an AC-DC converter (neither of which are shown).

**[0107]** In the rotating electric machine system 10 which is configured in the manner described above, a compressed air flow passage, and a lubricating oil flow passage (a first oil supply passage and a second oil supply passage) are formed. First, a description will be given concerning the compressed air flow passage.

**[0108]** As shown in FIG. 9, in the second sub-housing 20, on an end surface thereof facing toward the gas turbine engine 200, an annular shaped collection flow passage 162 is formed therein as an annular concave portion. As will be discussed later, a portion of the compressed air generated by the gas turbine engine 200 flows through the collection flow passage 162. Three upstream communication holes 164 are formed in a bottom wall of the collection flow passage 162 (the annular concave portion). The upstream communication holes 164 serve as input ports for the compressed air.

**[0109]** Air relay passages 166 are provided as gas branching passages in the interior of the second sub-housing 20. The air relay passages 166 extend radially in a radial direction of the second sub-housing 20. The air relay passages 166 communicate on a radially outward side with the collection flow passage 162 via the upstream communication holes 164. Further, in the second sub-housing 20, three first downstream communication holes 1681 to 1683 are formed in an end surface facing toward the rotating electric machine 12. The first downstream communication holes 1681 to 1683 serve as first output ports of the air relay passages 166. A distribution passage is formed by the collection flow passage 162 and the air relay passages 166.

**[0110]** In the second sub-housing 20, three second downstream communication holes 1701 to 1703 are formed in an end surface facing toward the gas turbine engine 200. The second downstream communication holes 1701 to 1703 serve as second output ports of the air relay passages 166. The second downstream communication holes 1701 to 1703 are positioned more inward in a radial direction than the first downstream communication holes 1681 to 1683. Accordingly, the compressed air that has flowed through the air relay passages 166 is divided into compressed air (a first branched gas flow) that enters into the first downstream communication holes 1681 to 1683, and compressed air (a second branched gas flow) that enters into the second downstream communication holes 1701 to 1703. In this manner, the air relay passages 166 fulfill a role as branching passages.

**[0111]** As shown in FIG. 2, the first hollow tube portion 1601, the second hollow tube portion 1602, and the third hollow tube portion 1603 are provided on the outer surface of the side wall of the main housing 16. The first downstream communication holes 1681 to 1683, respectively, open individually toward the first hollow tube portion 1601 to the third hollow tube portion 1603. As can be understood from this feature, the air relay passages 166 place the collection flow passage 162 in communication with the hollow interiors of the first hollow tube portion 1601 to the third hollow tube portion 1603. As shown in FIG. 3, the first hollow tube portion 1601 to the third hollow tube portion 1603 are positioned radially outward of the cooling jacket 24 that is formed on the side wall interior of the main housing 16.

**[0112]** The first hollow tube portion 1601 to the third hollow tube portion 1603 extend in the axial direction of the main housing 16. More specifically, the first hollow tube portion 1601 to the third hollow tube portion 1603 extend from the second end that faces toward the gas turbine engine 200, and toward the first casing 26 (or the first end). As noted previously, the first hollow tube portion 1601 to the third hollow tube portion 1603 are connected respectively to the three individual starting passages 450 via the flexible tubes 470a to 470c. Accordingly, the compressed air that has flowed through the first hollow tube portion 1601 to the third hollow tube portion 1603 flows into the starting passages 450 via the flexible tubes 470a to 470c. As can be understood from this feature, the first hollow tube portion 1601 to the third hollow tube portion 1603 are gas supply passages for supplying the compressed air.

**[0113]** In the present embodiment, although a case is exemplified in which the first hollow tube portion 1601 to the third hollow tube portion 1603 are provided, the number of the hollow tube portions is appropriately determined in accordance with a flow rate or a flow velocity required for the curtain air to be formed from the compressed air. More specifically, the number of the hollow tube portions is not limited to being three. Further, in a similar manner, the cross-sectional area of the hollow

tube portions is appropriately determined in accordance with the flow rate or the flow velocity required for the curtain air.

**[0114]** The compressed air that has flowed into the starting passages 450 is thereafter divided into compressed air that is directed toward the first insertion hole 78, and compressed air that is directed toward the second insertion hole 86. Specifically, one portion of the compressed air flows through a clearance between the first sub-housing 18 and the rotor 34 and toward the first insertion hole 78. In this manner, the clearance between the first sub-housing 18 and the rotor 34 forms a first air branching passage L. On the other hand, a remaining portion of the compressed air primarily flows through a clearance between the outer walls of the permanent magnets 72 and the inner walls of the electromagnetic coils 110 and toward the second insertion hole 86. In this manner, the clearance between the outer walls of the permanent magnets 72 and the inner walls of the electromagnetic coils 110 forms a second air branching passage M.

**[0115]** The compressed air that has reached the first air branching passage L forms an air curtain which seals the lubricating oil supplied to the first bearing 74. Further, the compressed air that has reached the third sub-branching passage 941 (the second distal end 861 of the second insertion hole 86) from the second air branching passage M forms an air curtain which seals the lubricating oil supplied to the second bearing 84. In this manner, the compressed air that has flowed through the starting passages 450 functions as the curtain air.

**[0116]** As shown in FIG. 5, the three individual inlets 104 are formed in the base portion 98 of the rectifying member 96. An individual one of the inlets is shown in FIG. 5. An individual one of the inlets 104 connects to the second downstream communication hole 1701 (not shown). Another individual one of the inlets 104 connects to the second downstream communication hole 1702 (not shown). Further, another individual one of the inlets 104 connects to the second downstream communication hole 1703 (not shown). Accordingly, the compressed air output from the second downstream communication holes 1701 to 1703 enters into the relay chamber 106 of the reduced diameter portion 100 of the rectifying member 96 via the inlets 104.

**[0117]** The relay chamber 106 connects to the insertion hole 108 that is formed in the top portion 102. In this instance, the relay chamber 106 becomes wider as it comes closer to the insertion hole 108 and the fourth sub-branching passage 942. Therefore, as the compressed air flows through the relay chamber 106, the pressure of the curtain air decreases.

**[0118]** The outlet of the relay chamber 106 faces toward the small diameter cylindrical portion 242 of the compressor wheel 222. Accordingly, the compressed air that has entered into the relay chamber 106 comes into contact with the small diameter cylindrical portion 242 of the compressor wheel 222. Thereafter, the compressed air is divided into compressed air that is directed toward

the fourth sub-branching passage 942, and compressed air that is directed toward the outlet passage 943. As a result, the pressure of the compressed air that flows along the fourth sub-branching passage 942 and toward the second proximal end 862 of the second insertion hole 86 is reduced.

**[0119]** The compressed air that has reached the second proximal end 862 of the second insertion hole 86 from the fourth sub-branching passage 942 forms an air curtain which seals the lubricating oil supplied to the second bearing 84. Further, the compressed air that has flowed into the outlet passage 943 is discharged in an inward direction from a first end (an open end) in a shroud case 220. The compressed air is drawn back again to the compressor wheel 222.

**[0120]** As shown in FIG. 3, an exhaust passage 172 (a gas exhaust passage) is formed in the main housing 16. The compressed air that has reached the first air branching passage L and the compressed air that has reached the second air branching passage M are discharged to the exterior of the main housing 16 through the exhaust passage 172.

**[0121]** Next, a description will be given concerning the lubricating oil flow passage. FIG. 10 and FIG. 11 are schematic side cross-sectional views of the rotating electric machine system 10. Moreover, in FIG. 10, a phase is shown that differs from the phase shown in FIG. 3. A lubricating oil passage having a first oil supply passage, a first oil recovery passage, a second oil supply passage, and a second oil recovery passage is formed in the rotating electric machine housing 14.

**[0122]** The first oil supply passage includes an input passage 174, a main oil passage 176, a first auxiliary oil passage 180, and a second auxiliary oil passage 181. Among these elements, the input passage 174 is formed at a position closer to the first end than a center in the axial direction of the main housing 16. The input passage 174 extends in the radial direction of the main housing 16, and communicates with the main oil passage 176. The main oil passage 176 is formed on the outer circumference of the cooling jacket 24, and extends in the axial direction of the main housing 16. At a border with a connecting location with the input passage 174, the main oil passage 176 branches into a first oil branching passage N directed toward the first sub-housing 18, and a second oil branching passage R directed toward the second sub-housing 20.

**[0123]** In the first sub-housing 18, a first inflow hole 178 is formed at a location in facing relation to the first oil branching passage N. Furthermore, in the interior of the first sub-housing 18, the first auxiliary oil passage 180, which faces toward a radially inward direction of the first sub-housing 18, is formed. The first auxiliary oil passage 180 bends at two locations until reaching the first bearing holder 80.

**[0124]** The second auxiliary oil passage 181 branches off from the first auxiliary oil passage 180. In this instance, as shown in FIG. 7 and FIG. 10, the first sub-housing 18

includes a protruding end part 400 that projects outward toward the oil guiding member 350. A distal end of the second auxiliary oil passage 181 extends to the interior of the protruding end part 400. The outlet of the second auxiliary oil passage 181 is slightly curved. The outlet of the second auxiliary oil passage 181 discharges the lubricating oil toward the annular gap 385 of the rotor 34.

**[0125]** A first oil supply hole 182 that communicates with the first auxiliary oil passage 180 is formed in the first bearing holder 80. An outlet of the first oil supply hole 182 is formed at the first distal end 781 of the first insertion hole 78. Accordingly, the lubricating oil that flows from the main oil passage 176 into the first auxiliary oil passage 180 flows from the first oil supply hole 182 through the first distal end 781 of the first insertion hole 78, and comes into contact with the first bearing 74.

**[0126]** As shown in FIG. 3, a first drain passage 184 which is one part of the first oil recovery passage is formed in the first sub-housing 18. The first drain passage 184 discharges the lubricating oil that has come into contact with the first bearing 74 from the hollow concave portion 118 formed by the annular shaped convex portion 116 of the first sub-housing 18, and the resolver holder 30. The lubricating oil discharged from the first drain passage 184 is recovered by a gas-liquid separation device 302 (to be described later). In this manner, the first drain passage 184 serves as a first oil pathway that guides the lubricating oil to the gas-liquid separation device 302.

**[0127]** Three individual ones of the first oil branch passages N, three individual ones of the first inflow holes 178, three individual ones of the first auxiliary oil passages 180, and three individual ones of the first oil supply holes 182 are formed. Similarly, three individual ones of the second oil branching passages R are formed. In FIG. 10, an individual one of each of the first oil branching passages N, the first inflow holes 178, the first auxiliary oil passages 180, the first oil supply holes 182, and the second oil branching passages R are shown.

**[0128]** As noted previously, the outlet of the second auxiliary oil passage 181 is slightly curved. In accordance with this feature, the outlet of the second auxiliary oil passage 181 faces toward the annular gap 385 between the oil guiding member 350 and the outer surface of the first shaft portion 44a of the outer shaft 44. Accordingly, one portion of the lubricating oil, which was diverted from the first auxiliary oil passage 180 into the second auxiliary oil passage 181, is supplied from the outlet of the second auxiliary oil passage 181 toward the oil receiving concave portion 340. The lubricating oil moves from the oil receiving concave portion 340 toward the annular gap 385 formed between the rotating shaft 40 and the oil guiding member 350. The lubricating oil which has entered into the annular gap 385 passes through the first oil delivery passages 386, and flows therethrough in order of the flow through space 374, the flow through space 360, the flow through space 353, the second oil delivery passages 3582, and the flow through space 362. More specifically, the lubricating oil flows through the rotor internal oil pas-

sage 354.

**[0129]** An opening of the hole portion of the second magnet stopper 358 (the outlet of the rotor internal oil passage 354) is covered by the disk portion 392 of the second inner stopper 90. Therefore, the lubricating oil that has flowed out from the rotor internal oil passage 354 comes into contact with the disk portion 392. Due to coming into contact therewith, a situation is avoided in which the lubricating oil flows toward the second bearing 84.

**[0130]** As shown in FIG. 9, a first drain hole 198, a second drain hole 197, and a second drain passage 196 are formed in the second sub-housing 20. The lubricating oil, which has flowed out from the rotor internal oil passage 354 and come into contact with the disk portion 392, passes through the first drain hole 198 and flows into the second drain passage 196. On the other hand, the lubricating oil, which has come into contact with the second bearing 84, passes through the second drain hole 197 and flows into the second drain passage 196. In this manner, the second drain passage 196 serves as a second oil pathway that guides the lubricating oil to the gas-liquid separation device 302 (refer to FIG. 12). Further, the first drain hole 198, the second drain hole 197, and the second drain passage 196 make up another part of the first oil recovery passage, and serve to discharge the lubricating oil that is recovered by the gas-liquid separation device 302.

**[0131]** As shown in FIG. 9, in the second sub-housing 20, three individual oil receiving holes 186 open on an end surface facing toward the rotating electric machine system 10. The oil receiving holes 186 are closer to the outer side in the radial direction than the first downstream communication holes 1681 to 1683 are. The oil receiving holes 186 serve as inlets for the lubricating oil.

**[0132]** Three individual third auxiliary oil passages 188 are provided in the interior of the second sub-housing 20. The third auxiliary oil passages 188 extend radially in a radial direction of the second sub-housing 20. However, the third auxiliary oil passages 188 are formed at a phase that differs from the phase of the air relay passages 166. Further, in the second sub-housing 20, three individual oil outflow holes 190 are formed in an end surface facing toward the gas turbine engine 200. Hollow pin portions 193 of an oil distributor 192 are fitted into the oil outflow holes 190.

**[0133]** A first guide passage 1941 and a second guide passage 1942 are formed in the interior of the oil distributor 192. The lubricating oil that has passed through the third auxiliary oil passages 188 is divided into lubricating oil that flows through the first guide passage 1941, and lubricating oil that flows through the second guide passage 1942. The outlet of the first guide passage 1941 is positioned at the second proximal end 862 of the second insertion hole 86. Accordingly, the lubricating oil that has flowed out from the first guide passage 1941 comes into contact with the second bearing 84 from the second proximal end 862. The aforementioned feature forms another

part of the first oil supply passage.

**[0134]** The second guide passage 1942 branches off from midway along the first guide passage 1941. A second oil supply hole 195, which is formed in the second bearing holder 88, continues to the outlet of the second guide passage 1942. Accordingly, the lubricating oil that has passed through the second guide passage 1942 flows out from the second oil supply hole 195 and comes into contact with the second bearing 84.

**[0135]** As shown in FIG. 10, a space formed by the rectifying member 96 and the second outer stopper 92 communicates with the second drain passage 196 via the second drain hole 197. Accordingly, the lubricating oil, which has entered into the space, passes through the second drain hole 197 and flows into the second drain passage 196.

**[0136]** The gas-liquid separation device 302 shown in FIG. 12 includes a first oil supply line 304, a first oil recovery line 305, an exhaust line 306, a second oil supply line 310, and a second oil recovery line 312. The first oil recovery line 305 includes a first relay pipe 3001, a second relay pipe 3002, and a third relay pipe 3003. The first drain passage 184 is connected via the first relay pipe 3001 to the gas-liquid separation device 302. The second drain passage 196 is connected via the second relay pipe 3002 to the gas-liquid separation device 302. The exhaust passage 172 is connected via the third relay pipe 3003 to the gas-liquid separation device 302. Further, the first oil supply line 304 is connected to the input passage 174, which is maximally upstream of the first oil supply passage.

**[0137]** As can be understood from this feature, the gas-liquid separation device 302 recovers the compressed air and the lubricating oil that have flowed through the interior of the rotating electric machine housing 14, and resupplies them to the interior of the rotating electric machine housing 14. In this manner, the gas-liquid separation device 302 constitutes an oil circulation supply device. Between the first oil supply line 304 and the first oil recovery line 305, a circulation pump 308 which constitutes the oil circulation supply device is provided. The circulation pump 308 is also positioned between the second oil supply line 310 and the second oil recovery line 312.

**[0138]** As will be discussed later, compressed air is contained in the lubricating oil that has flowed out from the first drain passage 184 and the second drain passage 196. Stated otherwise, the lubricating oil flowing from the first oil recovery line 305 into the gas-liquid separation device 302 is a gas-liquid mixture. In the gas-liquid separation device 302, the gas-liquid mixture is separated into the lubricating oil and air. The lubricating oil is temporarily stored in a tank 318. Thereafter, the lubricating oil is drawn in from the tank 318 by the circulation pump 308, passes through the first oil supply line 304, and is resupplied to the input passage 174. On the other hand, the air is discharged to the atmosphere via the exhaust line 306.

**[0139]** The rotating electric machine housing 14 includes an input pipe portion 314 serving as the second oil supply passage, and an output pipe portion 316 serving as the second oil recovery passage. The input pipe portion 314 is provided in proximity to the second end of the main housing 16. The output pipe portion 316 is provided on a side portion of the first casing 26. The input pipe portion 314 and the output pipe portion 316 are each hollow portions having internal passages therein. The internal passage of the input pipe portion 314 communicates with the stator chamber 23, and the internal passage of the output pipe portion 316 communicates with the contact chamber 290 of the first casing 26 (refer to FIG. 11).

**[0140]** The second oil supply line 310, for example, branches off from the first oil recovery line 305 and is connected to the input pipe portion 314. Accordingly, one portion of the lubricating oil that is stored in the tank 318 is supplied to the stator chamber 23 via the second oil supply line 310 and the input pipe portion 314. In the stator chamber 23, the lubricating oil flows, for example, through the stator inner circumferential side oil passage 454. The lubricating oil may also pass through slots in the stator 36, or alternatively, through gaps or the like in the electromagnetic coils 110.

**[0141]** In the stator chamber 23, the direction in which the compressed air flows is the second direction from the second end toward the first end. Consequently, the lubricating oil sufficiently flows through both the first end and the second end of the electromagnetic coils 110. As noted previously, the stator chamber 23 communicates with the contact chamber 290 of the first casing 26. Accordingly, the lubricating oil flows into the contact chamber 290 of the first casing 26. In this instance, the second oil recovery line 312 is connected to the output pipe portion 316. Accordingly, the lubricating oil inside the contact chamber 290 is recovered in the gas-liquid separation device 302 via the output pipe portion 316 and the second oil recovery line 312.

**[0142]** Next, a description will be given concerning the gas turbine engine 200. As shown in FIG. 13, the gas turbine engine 200 comprises an engine housing 202, and the output shaft 204 that rotates inside the engine housing 202. The engine housing 202 includes an inner housing 2021 and an outer housing 2022. The inner housing 2021 is connected to the second sub-housing 20 of the rotating electric machine system 10. The outer housing 2022 is connected to the inner housing 2021. The outer housing 2022 forms a housing main body.

**[0143]** As shown in FIG. 1 and FIG. 9, the inner housing 2021 includes a first annular portion 206, a second annular portion 208, and a plurality of individual leg members 210. The first annular portion 206 is connected to the second sub-housing 20. The diameter of the second annular portion 208 is larger than the diameter of the first annular portion 206. The leg members 210 connect the first annular portion 206 and the second annular portion 208. In the illustrated example, the number of the leg

members 210 is six. However, the number of the leg members 210 is determined in accordance with the necessary coupling strength required between the gas turbine engine 200 and the rotating electric machine system 10. Stated otherwise, the number of the leg members 210 is not limited to being six as in the illustrated example.

**[0144]** A cylindrically shaped cover member 212 projects out toward the rotating electric machine system 10 from a central opening of the second annular portion 208. Right ends of the leg members 210 continue to both sides of the cylindrically shaped cover member 212. An air intake space 214 is formed between the leg members 210.

**[0145]** As shown in FIG. 9 and FIG. 13, air bleed passages 216 are individually formed in the interior of the six individual leg members 210. In the leg members 210, inlets of the air bleed passages 216 are individually formed at connected locations thereof with the cylindrically shaped cover member 212. In the first annular portion 206, outlets of the air bleed passages 216 are individually formed on an end surface facing toward the second sub-housing 20. All of the outlets of the air bleed passages 216 are positioned on the circumference of a virtual circle. Accordingly, all of the outlets of the air bleed passages 216 are superimposed on the collection flow passage 162 which is formed in an annular shape. More specifically, all of the plurality of air bleed passages 216 are in communication with the collection flow passage 162. In this manner, the compressed air from the plurality of air bleed passages 216 flows in and is gathered in the collection flow passage 162.

**[0146]** Air vent holes 217 are formed in the leg members 210. The air vent holes 217 extend linearly from an inner wall to an outer wall of the cylindrically shaped cover member 212. The air vent holes 217 are also capable of extending from an inner wall of the cylindrically shaped cover member 212 to the outer walls of the leg members 210. The number of the air vent holes 217 may be one individual air vent hole or a plurality of individual air vent holes. Further, formation of the air vent holes 217 is not strictly essential.

**[0147]** As shown in FIG. 13, an annular shaped engaging concave portion 218 is formed on a right end surface of the second annular portion 208. The shroud case 220 and a diffuser 226 are positioned and fixed in place by the engaging concave portion 218 (to be described later).

**[0148]** As shown in FIG. 13, the gas turbine engine 200 is further equipped with the shroud case 220, the compressor wheel 222, the turbine wheel 224, the diffuser 226, a combustor 228, and a nozzle 230.

**[0149]** The shroud case 220 is a hollow body, and is of a larger scale than the rectifying member 96. A small diameter left end of the shroud case 220 faces toward the rectifying member 96. A large diameter right end of the shroud case 220 is inserted into the cylindrically shaped cover member 212 in the inner housing 2021. The shroud case 220 gradually decreases in diameter from the right end toward the left end, however, the distal



end of the left end thereof is curved so as to expand toward an outer side in the radial direction.

**[0150]** The left end of the shroud case 220 is exposed to the air intake space 214. The top portion 102 of the rectifying member 96 enters into the interior of the shroud case 220 at the left end thereof. An annular shaped closing flange portion 232 is provided on a curved side circumferential wall in the shroud case 220. An outer edge of the closing flange portion 232 abuts against the inner walls of the cylindrically shaped cover member 212 and the leg members 210.

**[0151]** In the side wall of the shroud case 220, an air bleed port 234 is formed between the closing flange portion 232 and a first engaging convex portion 238. The air bleed port 234 extends from the inner surface to the outer surface of the side wall of the shroud case 220. The air bleed port 234 serves as an inlet to a chamber 236 when the compressed air enters into the chamber 236.

**[0152]** The chamber 236 is interposed between the air bleed port 234 and the air bleed passages 216. More specifically, the chamber 236 allows the air bleed port 234 and the air bleed passages 216 to communicate with each other. Further, the chamber 236 is open to the atmosphere through the air vent holes 217.

**[0153]** From the right end of the shroud case 220, the first engaging convex portion 238 projects out toward the second annular portion 208. The first engaging convex portion 238 engages with the engaging concave portion 218 of the second annular portion 208. Due to such engagement and the outer edge of the closing flange portion 232 coming into abutment against the inner walls of the cylindrically shaped cover member 212 and the leg members 210, the shroud case 220 is positioned and fixed in place in the inner housing 2021. Simultaneously, the chamber 236 is formed, which is surrounded by the leg members 210, the cylindrically shaped cover member 212, the second annular portion 208, and the closing flange portion 232, the side circumferential wall, and the first engaging convex portion 238 of the shroud case 220. The chamber 236 exhibits an annular shape which surrounds the shroud case 220.

**[0154]** The compressor wheel 222 and the turbine wheel 224 are capable of rotating integrally together with the rotating shaft 40 and the output shaft 204. More specifically, as shown in detail in FIG. 5, the compressor wheel 222 includes the small diameter cylindrical portion 242 at the left end thereof. The small diameter cylindrical portion 242 enters into the insertion hole 108 that is formed in the rectifying member 96. A first outer spline 239 is formed on the inner wall of the small diameter cylindrical portion 242. The first outer spline 239 is enmeshed with the first inner spline 66 that is formed on the right open end 442 of the outer shaft 44.

**[0155]** The right open end 442 of the outer shaft 44 is press-fitted into a hollow interior of the small diameter cylindrical portion 242. Therefore, the inner circumferential wall of the left opening of the small diameter cylindrical portion 242 presses the outer circumferential wall of the

right open end 442 of the outer shaft 44 radially inward. Due to the enmeshment and press-fitting described above, the compressor wheel 222 is connected to the outer shaft 44 (the rotating shaft 40).

**[0156]** A through hole 240 that extends in the left-right direction is formed in a diametrical center of the compressor wheel 222. In the through hole 240, a second outer spline 246 is engraved into the inner wall of the left end thereof. Further, in the through hole 240, a hole diameter of a location contiguous with the hollow interior of the small diameter cylindrical portion 242 is slightly smaller than that of other locations. Therefore, in the compressor wheel 222, an inner flange portion 248 is provided in proximity to an opening on the side of the small diameter cylindrical portion 242 of the through hole 240. At the portion where the inner flange portion 248 is provided, the hole diameter (diameter) of the through hole 240 is smallest.

**[0157]** The output shaft 204 provided on the turbine wheel 224 is inserted into the through hole 240. The distal end of the left end of the output shaft 204 extends out substantially to the same position as the distal end of the left end of the small diameter cylindrical portion 242 of the compressor wheel 222. As noted previously, the outer circumferential wall of the right open end 442 of the outer shaft 44 is press-fitted into the hollow interior of the small diameter cylindrical portion 242. Therefore, the left end of the output shaft 204, which is projected out from the through hole 240, enters into the connecting hole 62 of the rotating shaft 40. A male threaded portion 252 is engraved on the left end of the output shaft 204. The male threaded portion 252 is screw-engaged with the female threaded portion 64 that is formed on the inner wall of the connecting hole 62. Due to such screw-engagement, the rotating shaft 40 and the output shaft 204 are connected.

**[0158]** A second inner spline 254 is formed in proximity to the left end of the output shaft 204. The second inner spline 254 is enmeshed with the second outer spline 246 that is formed on the inner circumferential wall of the through hole 240. Further, a left end part of the output shaft 204 is press-fitted into the inner flange portion 248.

**[0159]** As shown in FIG. 13, a ring member 256 is interposed between the compressor wheel 222 and the turbine wheel 224. The ring member 256, for example, is made up from a heat resistant metal material such as a nickel-based alloy or the like.

**[0160]** As shown in FIG. 14, the ring member 256 is formed with a fitting hole 258 therein that extends from the compressor wheel 222 toward the turbine wheel 224. Further, a plurality of (for example, three) labyrinth forming convex portions 264 are formed on the outer circumferential wall of the ring member 256. The labyrinth forming convex portions 264 project outward in the radial direction of the ring member 256, and in addition, extend in the circumferential direction of the outer circumferential wall. As will be discussed later, the labyrinth forming convex portions 264 prevent a combusted fuel (an exhaust

gas) generated in the combustor 228 from flowing back into the compressor wheel 222.

**[0161]** In the compressor wheel 222, an annular shaped projecting member 268 projects out from the right end surface that faces toward the turbine wheel 224. At a time when a left end surface of the ring member 256 is seated on a right end surface of the compressor wheel 222, the annular shaped projecting member 268 is fitted into the fitting hole 258. On the other hand, in the turbine wheel 224, the output shaft 204 extends out from a left end surface thereof that faces toward the compressor wheel 222. Further, a fitting convex portion 270 surrounding the output shaft 204 is formed to project out on the left end surface. At a time when a right end surface of the ring member 256 is seated on the left end surface of the turbine wheel 224, the top surface of the fitting convex portion 270 is fitted into the fitting hole 258. In accordance with the foregoing, the respective parts of the compressor wheel 222 and the turbine wheel 224 are fitted into the fitting hole 258. In such a state, the ring member 256 is sandwiched between the compressor wheel 222 and the turbine wheel 224.

**[0162]** The labyrinth forming convex portions 264 are surrounded by an intermediate plate 266 in the hollow interior of the outer housing 2022 (refer to FIG. 13). The labyrinth forming convex portions 264 are inserted into a hole portion 272 that is formed in the intermediate plate 266. A labyrinth flow passage is formed by the inner wall of the hole portion 272 and the labyrinth forming convex portions 264 that abut against the inner wall. Compressed air generated by the compressor wheel 222 reaches the labyrinth forming convex portions 264 via a rear surface of the compressor wheel 222. On the other hand, the combustion gas reaches the labyrinth forming convex portions 264 from the turbine wheel 224. Since the pressure of the compressed air is higher in comparison with the pressure of the combustion gas, it is possible to prevent the combustion gas from passing through the labyrinth forming convex portions 264 and flowing into the space surrounding the compressor wheel 222.

**[0163]** As shown in FIG. 13, within the hollow interior of the outer housing 2022, respective portions of the shroud case 220 and the compressor wheel 222, as well as the intermediate plate 266 are surrounded by the diffuser 226. A second engaging convex portion 273 is formed on the left end of the diffuser 226. The second engaging convex portion 273 is engaged with the engaging concave portion 218 together with the first engaging convex portion 238 of the shroud case 220. Due to such engagement, the diffuser 226 is positioned and fixed in place in the inner housing 2021.

**[0164]** Within the hollow interior of the outer housing 2022, the turbine wheel 224 is surrounded by the nozzle 230, and further, the nozzle 230 is surrounded by the combustor 228. An annular shaped combustion air flow passage 274 is formed between the combustor 228 and the outer housing 2022. The combustion air flow passage 274 is a passage through which the combustion air flows.

A fuel supply nozzle 275 is positioned and fixed to a right end surface of the outer housing 2022. The fuel supply nozzle 275 supplies fuel to the combustor 228.

**[0165]** Relay holes 276 in order to place the combustion air flow passage 274 and the interior of the combustor 228 in communication with each other are formed in the combustor 228. As will be discussed later, the combustion air that is compressed by the compressor wheel 222 reaches the interior of the combustor 228 via the diffuser 226, the combustion air flow passage 274, and the relay holes 276. Non-illustrated fine holes are also formed in the combustor 228. Air discharged from the fine holes forms an air curtain that serves to cool the interior of the combustor 228.

**[0166]** The nozzle 230 includes a portion that surrounds the largest diameter portion of the turbine wheel 224. A non-illustrated delivery hole is formed in this portion for the purpose of supplying the fuel, which has undergone combustion together with the combustion air, to the turbine wheel 224. Moreover, it should be noted that, hereinafter, the fuel that has undergone combustion may also be referred to as a "combusted fuel". The term "combusted fuel" is synonymous with the term "combustion gas" or the "exhaust gas after combustion".

**[0167]** An exhaust port 280 opens at the right end of the outer housing 2022 and the nozzle 230. After having traveled through the delivery hole and into the nozzle 230, by the rotating turbine wheel 224, the combusted fuel is blown out to the exterior of the outer housing 2022 through the exhaust port 280. Moreover, although not shown in particular, an exhaust pipe through which the combusted fuel is discharged is provided in the exhaust port 280.

**[0168]** The rotating electric machine system 10 and the combined power system 500 according to the present embodiment are basically configured in the manner described above. Next, a description will be given concerning the advantageous effects of the rotating electric machine system 10 and the combined power system 500.

**[0169]** When the rotating electric machine system 10 is assembled, the partition wall member 410 is inserted between the rotor 34 and the stator 36. For example, the second end of the partition wall member 410 is inserted into a clearance between the rotor 34 and the stator 36 at the first end. The partition wall member 410 is pressed inwardly in a manner so that the second end faces toward the second sub-housing 20. At this time, the inner circumferential wall of the second end comes into sliding contact with the outer circumferential wall of the tapered portion 467. In accordance with this feature, the second end of the partition wall member 410 is guided by the annular shaped guide 466. By the second end of the partition wall member 410 being pressed inwardly further toward the second sub-housing 20, the second end is sandwiched between the annular shaped guide 466 and the annular shaped holder 460. In this manner, by the annular shaped guide 466 being provided inside the rotating electric machine housing 14, it becomes easy to

guide the partition wall member 410 to the annular shaped holder 460.

**[0170]** Initially, a DC current is supplied from the battery 146. The conversion circuit 152 of the electrical current converter 150 shown in FIG. 2 and FIG. 8 converts such a DC current into an AC current. The AC current is supplied to the electromagnetic coils 110 (the U-phase coil, the V-phase coil, and the W-phase coil) via the U-phase terminal 1441, the V-phase terminal 1442, and the W-phase terminal 1443. By the AC current flowing through the electromagnetic coils 110, an alternating magnetic field is generated in the stator 36. Therefore, an attractive force and a repulsive force act alternately between the electromagnetic coils 110 and the permanent magnets 72 of the rotor 34. As a result, the rotating shaft 40 begins to rotate. Alternatively, the rotating shaft 40 may be rotated by a well-known type of starter (not shown).

**[0171]** In this instance, as shown in FIG. 5, the first inner spline 66 is formed on the outer circumferential wall of the right open end 442 of the outer shaft 44, and the first outer spline 239 is formed on the inner wall of the small diameter cylindrical portion 242 of the compressor wheel 222. The first inner spline 66 and the first outer spline 239 mesh with one another. Further, the second inner spline 254 is formed on the output shaft 204, and the second outer spline 246 is formed on the inner wall of the through hole 240 of the compressor wheel 222. The second inner spline 254 and the second outer spline 246 mesh with one another. Therefore, a rotational torque of the rotating shaft 40 is rapidly transmitted to the output shaft 204 via the compressor wheel 222.

**[0172]** More specifically, when the rotating shaft 40 begins to rotate, the output shaft 204 also starts rotating integrally together with the rotating shaft 40. Along therewith, the compressor wheel 222 and the turbine wheel 224, which are supported by the output shaft 204, rotate integrally together with the output shaft 204. In the foregoing manner, by the first inner spline 66 and the first outer spline 239 being meshed, and by the second inner spline 254 and the second outer spline 246 being meshed, the rotational torque of the rotating shaft 40 can be sufficiently transmitted to the output shaft 204.

**[0173]** In addition, the right end part of the rotating shaft 40 is press-fitted into the hollow interior of the small diameter cylindrical portion 242 of the compressor wheel 222. Further, the left end part of the output shaft 204 is press-fitted into the inner flange portion 248 of the compressor wheel 222. Therefore, the axis of the rotating shaft 40 and the axis of the output shaft 204 coincide precisely. In accordance with this feature, the output shaft 204 is sufficiently prevented from rotating in an eccentric manner, or rotating while being subjected to vibrations.

**[0174]** Additionally, as shown in FIG. 14, the ring member 256 is interposed between the compressor wheel 222 and the turbine wheel 224. The annular shaped projecting member 268 on the right end surface of the compressor wheel 222, and the fitting convex portion 270 on the

left end surface of the turbine wheel 224 are fitted into the fitting hole 258 of the ring member 256. These fittings also contribute to suppressing eccentric rotation (vibration) of the output shaft 204. Accordingly, there is no need to provide a mechanism for suppressing vibration. Further, there is no need to increase the diameter of the output shaft 204. Consequently, it is possible to reduce the size and scale of the combined power system 500.

**[0175]** Furthermore, a frictional force is generated between the right end surface of the compressor wheel 222 and the left end surface of the ring member 256. A frictional force is also generated between the right end surface of the ring member 256 and the left end surface of the turbine wheel 224. Due to such frictional forces, the compressor wheel 222, the ring member 256, and the turbine wheel 224 are kept in close contact with each other. Accordingly, a situation is avoided in which both of the wheels 222 and 224 give rise to rotational misalignment.

**[0176]** Further still, when the combined power system 500 is assembled, due to the above-described fitting, the compressor wheel 222 and the turbine wheel 224 are positioned (centered) with respect to the output shaft 204. In this manner, the ring member 256 is preferably disposed between both of the wheels 222 and 224, and both of the wheels 222 and 224 are partially fitted individually into the fitting hole 258 of the ring member 256. In accordance with this feature, it becomes easy to center the compressor wheel 222 and the turbine wheel 224 with respect to the output shaft 204.

**[0177]** Due to the above-described rotation, as shown in FIG. 13, atmospheric air is drawn into the shroud case 220 through the air intake space 214 formed between the leg members 210 of the inner housing 2021. In this instance, the rectifying member 96 is positioned at the diametrical center of the inner housing 2021. As noted previously, the rectifying member 96 exhibits a mountain (chevron) shape that becomes smaller in diameter following along the shroud case 220. In addition, the surface of the reduced diameter portion 100 is smooth. Therefore, the atmospheric air that is drawn in is rectified by the rectifying member 96 in a manner so as to flow toward the shroud case 220. Since the right end of the rectifying member 96 enters from the left end opening of the shroud case 220, the atmospheric air is efficiently introduced into the shroud case 220. In this manner, by the rectifying member 96 being shaped in the manner described above, and in addition, by the top portion 102 being made to enter into the shroud case 220, the atmospheric air can be efficiently collected by the shroud case 220.

**[0178]** The atmospheric air that is drawn into the shroud case 220 flows between the compressor wheel 222 and the shroud case 220. From the fact that, in comparison with the left opening of the shroud case 220, the space between the compressor wheel 222 and the shroud case 220 is sufficiently narrow, when flowing therethrough, the atmospheric air is compressed. Stated otherwise, the compressed air is generated.

**[0179]** The air bleed port 234 is formed in the shroud case 220. Therefore, one portion of the compressed air flows into the chamber 236 from the air bleed port 234. Stated otherwise, the compressed air is diverted. The chamber 236 is formed in an annular shape, and includes a larger volume in comparison with the volume of the air bleed port 234. Therefore, the compressed air that has flowed into the chamber 236 is temporarily accumulated and retained in the chamber 236.

**[0180]** From the fact that the plurality of the individual air bleed passages 216 are formed, the compressed air is distributed from the chamber 236 to each of the air bleed passages 216. In this case, the curtain air itself that is distributed may differ in pressure. However, according to the present embodiment, the compressed air (the curtain air) that has passed through the air bleed port 234 flows into the single individual chamber 236 that is formed in an annular shape. Consequently, the pressure of the curtain air inside the chamber 236 is uniform. Stated otherwise, the pressure of the curtain air is equalized. In this manner, the chamber 236 serves as a pressure regulation chamber that regulates the pressure of the curtain air to be substantially constant.

**[0181]** The curtain air that has flowed in from the air bleed port 234, as has been discussed previously, makes up a portion of the compressed air, and is high in pressure. In this instance, since the volume of the chamber 236 is larger than the volume of the air bleed port 234, the curtain air spreads out as it flows into the chamber 236. Therefore, the pressure of the curtain air is lowered. As can be understood from this feature, the chamber 236 also serves in a dual manner as a buffer chamber that causes the pressure of the compressed air to be reduced.

**[0182]** In addition to the air bleed passages 216, the air vent holes 217 are formed in the inner housing 2021. Compressed air that excessively flows thereinto is released to the exterior (the atmosphere) of the gas turbine engine 200 through the air vent holes 217. Therefore, an excessive rise in the pressure of the curtain air inside the chamber 236 is avoided. More specifically, due to the air vent holes 217, the pressure inside the chamber 236 can be easily adjusted.

**[0183]** Inside the chamber 236, the inlets of the air bleed passages 216 which are formed individually open into each of the six individual leg members 210. Therefore, next, the curtain air inside the chamber 236 flows individually through the six air bleed passages 216, and in accordance therewith, travels toward the second sub-housing 20. As noted previously, at this point in time, the pressure of the curtain air is substantially constant.

**[0184]** As shown in FIG. 9, the outlets of all of the six individual air bleed passages 216 overlap with the collection flow passage 162. Accordingly, the curtain air that has flowed through the six individual air bleed passages 216 flows in and is collected in the collection flow passage 162, and in addition, spreads out in an annular shape along the collection flow passage 162. In this process, the pressure of the curtain air is made more uniform.

**[0185]** Furthermore, the curtain air flows individually from the collection flow passage 162 into the three individual upstream communication holes 164, and individually flows along the three individual air relay passages 166. Thereafter, a portion of the curtain air is discharged from the first downstream communication holes 1681 to 1683. Further, a remaining portion of the curtain air is discharged from the second downstream communication holes 1701 to 1703. Hereinafter, the curtain air that is exhausted from the first downstream communication holes 1681 to 1683 will be referred to as a "first branched air flow". The curtain air that is discharged from the second downstream communication holes 1701 to 1703 will be referred to as a "second branched air flow".

**[0186]** A description will now be given concerning a route of the first branched air flow. The first downstream communication hole 1681 communicates with the hollow interior of the first hollow tube portion 1601. The first downstream communication hole 1682 communicates with the hollow interior of the second hollow tube portion 1602. The first downstream communication hole 1683 communicates with the hollow interior of the third hollow tube portion 1603. Accordingly, the first branched air flow flows through the first hollow tube portion 1601 to the third hollow tube portion 1603 shown in FIG. 1, etc., and flows from the second end to the first end of the rotating electric machine housing 14. More specifically, prior to the first branched air flow entering into the rotor chamber 22 inside the rotating electric machine housing 14, the direction in which the first branched air flows is the second direction.

**[0187]** The first hollow tube portion 1601 to the third hollow tube portion 1603 are positioned on an outer circumferential portion of the cooling jacket 24. The cooling medium is allowed to flow in advance through the cooling jacket 24. Accordingly, the heat of a first branched air flow is sufficiently conducted to the cooling medium as the first branched air flow flows along the first hollow tube portion 1601 to the third hollow tube portion 1603. Consequently, the first branched air flow becomes a relatively low temperature. More specifically, according to the present embodiment, in accordance with the cooling jacket 24 that serves in order to cool the rotating electric machine 12, the electrical current converter 150, and the like, the temperature of the first branched air flow can also be lowered.

**[0188]** For the reasons mentioned above, in the gas turbine engine 200 or the rotating electric machine system 10, there is no need to separately provide cooling equipment in order to cool the curtain air. Accordingly, it is possible to reduce the size and scale of the combined power system 500.

**[0189]** The first branched air flow that has flowed through the first hollow tube portion 1601 to the third hollow tube portion 1603 flows into three individual starting passages 450 via the flexible tubes 470a to 470c. The first branched air flow further flows through the starting passages 450, and flows into the rotor chamber 22 that

is formed inwardly in the radial direction of the partition wall member 410.

**[0190]** Thereafter, one portion of the first branched air flow flows toward the first insertion hole 78 via the first air branching passage L inside the rotor chamber 22. Further, a remaining portion of the first branched air flow flows via the second air branching passage M inside the rotor chamber 22, passes along the clearance between the outer walls of the permanent magnets 72 and the inner circumferential wall of the partition wall member 410, and flows toward the second insertion hole 86. In this manner, the first branched air flow is divided into compressed air that flows toward the first insertion hole 78 at the left end (the first end), and compressed air that flows toward the second insertion hole 86 at the right end (the second end).

**[0191]** The one portion of the first branched air flow flows through the clearance between the outer walls of the permanent magnets 72 and the inner circumferential wall of the partition wall member 410, and thereby cools the rotor 34. In the rotor chamber 22, the direction in which the first branched air flow flows is the first direction from the first end toward the second end. In this instance, as noted previously, the first branched air flow is sufficiently reduced in temperature by the cooling jacket 24. Accordingly, the rotor 34 is efficiently cooled.

**[0192]** Further, according to the present embodiment, the rotating electric machine 12 is cooled using the compressed air that is generated by the gas turbine engine 200. Accordingly, it is not necessary to supply the cooling air to the rotor chamber 22 in order to cool the rotor 34. Consequently, while cooling of the rotor 34 is achieved, it is possible to simplify the configuration of the combined power system 500.

**[0193]** As shown in FIG. 7, the inner side separation distance  $D_{in}$  between the permanent magnets 72 and the inner circumferential wall of the partition wall member 410 is larger than the outer side separation distance  $D_{out}$  between the outer circumferential wall of the partition wall member 410 and the electromagnetic coils 110. Preferably, the value of  $D_{in}$  is roughly 3.5 times to roughly 4 times the value of  $D_{out}$ . Consequently, generation of turbulence in the compressed air that flows between the permanent magnets 72 and the partition wall member 410 is suppressed. Moreover, generation of a large amount of frictional heat in the permanent magnets 72 is also suppressed.

**[0194]** One portion of the first branched air flow that has flowed toward the first insertion hole 78 reaches the first proximal end 782 of the first insertion hole 78. In the first proximal end 782, the one portion of the first branched air flow becomes an air curtain for the first bearing 74. On the other hand, the remaining portion of the first branched air flow that has flowed toward the second insertion hole 86 passes through the third sub-branching passage 941 and reaches the second distal end 861 of the second insertion hole 86. In the second distal end 861, the remaining portion of the first branched air flow

becomes an air curtain for the second bearing 84.

**[0195]** An excessive amount of the first branched air flow is recovered in the gas-liquid separation device 302 (the oil circulation supply device) via the exhaust passage 172 and the third relay pipe 3003.

**[0196]** A description will now be given concerning a route of the second branched air flow. The second downstream communication holes 1701 to 1703 individually overlap with the three individual inlets 104 that are formed in the base portion 98 of the rectifying member 96. Accordingly, the second branched air flow flows into the relay chamber 106 (the hollow interior of the rectifying member 96) through the inlets 104.

**[0197]** As noted previously, the outlet of the relay chamber 106 opens at a position that faces toward the small diameter cylindrical portion 242 of the compressor wheel 222. Accordingly, the second branched air flow that has flowed into the relay chamber 106 comes into contact with the small diameter cylindrical portion 242. Thereafter, one portion of the second branched air flow flows toward the fourth sub-branching passage 942. The remaining portion of the second branched air flow flows toward the outlet passage 943.

**[0198]** The one portion of the second branched air flow reaches the second proximal end 862 of the second insertion hole 86 via the fourth sub-branching passage 942. In the second proximal end 862, the one portion of the second branched air flow becomes an air curtain for the second bearing 84. In this manner, the second bearing 84 is sandwiched between the remaining portion of the second branched air flow that has reached the second proximal end 862, and the portion of the first branched air flow that has reached the second distal end 861.

**[0199]** The remaining portion of the second branched air flow passes through the outlet passage 943 and is discharged into the interior of the left end of the shroud case 220. At the left end opening of the shroud case 220, the air is drawn in as noted previously. Accordingly, the remaining portion of the second branched air flow is compressed by the compressor wheel 222 along with the drawn in atmospheric air.

**[0200]** As noted previously, due to the chamber 236 provided between the inner housing 2021 and the shroud case 220, the pressure of the curtain air is equalized. Accordingly, the occurrence of a pressure distribution in the curtain air is avoided. Further, the occurrence of surging in the curtain air is also avoided. Therefore, while the pressure of the curtain air is maintained substantially constant, it is possible to supply the curtain air circumferentially around the first bearing 74 and the second bearing 84.

**[0201]** As noted previously, the relay chamber 106 becomes wider as it comes closer to the fourth sub-branching passage 942. In addition, the second branched air flow that has flowed out from the relay chamber 106 is divided into a portion that is directed toward the fourth sub-branching passage 942, and a remaining portion that is directed toward the outlet passage 943. Accordingly,

the pressure of the second branched air flow that has reached the second proximal end 862 is less than the pressure of the second branched air flow prior to entering into the relay chamber 106. As a result, the pressure of the first branched air flow that has reached the second distal end 861, and the pressure of the second branched air flow that has reached the second proximal end 862 are in balance.

**[0202]** Next, a description will be given concerning the lubricating oil passage. One portion of the lubricating oil is supplied as a lubricating agent to the first bearing 74 and the second bearing 84. A remaining portion of the lubricating oil is supplied to the rotating shaft 40 and the stator 36 as cooling oil for cooling the rotating electric machine 12.

**[0203]** The lubricating oil is drawn out into the first oil supply line 304 by the circulation pump 308 from the tank 318 shown in FIG. 12. After having flowed through the first oil supply line 304, a major portion of the lubricating oil is supplied to the input passage 174 that is formed in the main housing 16. The lubricating oil flows from the input passage 174 into the main oil passage 176. The main oil passage 176 branches into the first oil branching passage N directed toward the first sub-housing 18, and the second oil branching passage R directed toward the second sub-housing 20. Accordingly, the lubricating oil is divided into lubricating oil that flows along the first oil branching passage N, and lubricating oil that flows along the second oil branching passage R.

**[0204]** One portion of the lubricating oil that has flowed through the first oil branching passage N flows into the first auxiliary oil passage 180 via the first inflow holes 178 that are formed in the first sub-housing 18. One portion of the lubricating oil that flows through the first auxiliary oil passage 180 further flows from the first auxiliary oil passage 180 into the second auxiliary oil passage 181. Hereinafter, the lubricating oil that flows along the first auxiliary oil passage 180 and is discharged from the outlet of the first auxiliary oil passage 180 will be referred to as a "first branched oil flow". The lubricating oil that flows along the second auxiliary oil passage 181 and is discharged from the outlet of the second auxiliary oil passage 181 will be referred to as a "first cooling oil". The lubricating oil that flows along the second oil branching passage R will be referred to as a "second branched oil flow".

**[0205]** The first branched oil flow discharged from the outlet of the first auxiliary oil passage 180 is supplied to the first distal end 781 of the first insertion hole 78 via the first oil supply hole 182 that is formed in the first bearing holder 80. At this time, the first branched oil flow is guided to the upstream guide grooves 390 of the oil guiding member 350, and to the downstream guide grooves 368 that are formed in the first outer stopper 81, and flows toward the first bearing 74. The first branched oil flow enters into the inner hole of the first bearing 74, and thereby lubricates the first bearing 74.

**[0206]** The first branched oil flow that has flowed from

the first distal end 781 to the first proximal end 782 is blocked by the first branched air flow (the air curtain) that has reached the first proximal end 782. Accordingly, a situation is avoided in which the first branched oil flow flows toward the first air branching passage L. Therefore, a situation is also avoided in which the first branched oil flow enters into the rotor chamber 22. In accordance with this feature, it is possible to avoid a situation in which the permanent magnets 72 in particular become contaminated by the first branched oil flow.

**[0207]** A surplus amount of the first branched oil flow flows into the hollow concave portion 118. The first drain passage 184 communicates with the hollow concave portion 118. Accordingly, the first branched oil flow inside the hollow concave portion 118 is collected in the gas-liquid separation device 302 via the first drain passage 184.

**[0208]** The second branched oil flow that has flowed through the second oil branching passage R flows into the third auxiliary oil passages 188 via the oil receiving holes 186 formed in the second sub-housing 20. The second branched oil flow that has flowed through the third auxiliary oil passages 188 is diverted into the first guide passage 1941 and the second guide passage 1942 that are formed in the interior of the oil distributor 192. One portion of the second branched oil flow that has flowed out from the outlet of the first guide passage 1941 is supplied to the second proximal end 862 of the second insertion hole 86. A remaining portion of the second branched oil flow that has passed through the second guide passage 1942 is supplied to the second bearing 84 via the second oil supply hole 195 that is formed in the second bearing holder 88. The second branched oil flow enters into the inner hole of the second bearing 84, and thereby lubricates the second bearing 84.

**[0209]** The second branched oil flow that has entered into the inner hole of the second bearing 84 is surrounded by the first branched air flow supplied to the second distal end 861, and the second branched air flow supplied to the second proximal end 862. In the manner described above, the pressure of the first branched air flow supplied to the second distal end 861, and the pressure of the second branched air flow supplied to the second proximal end 862 are in balance. Accordingly, a situation is avoided in which the second branched oil flow flows toward the third sub-branching passage 941 or the fourth sub-branching passage 942. Therefore, a situation is avoided in which the second branched oil flow infiltrates between the rotating shaft 40 and the electromagnetic coils 110. Further, a situation is avoided in which the second branched oil flow infiltrates into the relay chamber 106 of the rectifying member 96. Consequently, it is possible to avoid a situation in which the permanent magnets 72 in particular and the rectifying member 96 become contaminated by the second branched oil flow.

**[0210]** As noted previously, the pressure of the curtain air is adjusted to be substantially constant. Accordingly, an air curtain of a predetermined pressure is continuously

formed circumferentially around the first bearing 74 and the second bearing 84. Therefore, leakage of the lubricating oil from the first bearing 74 and the second bearing 84 is prevented.

**[0211]** A surplus amount of the second branched oil flow flows into the space formed by the rectifying member 96 and the second outer stopper 92. The second drain hole 197 and the second drain passage 196 are formed in the second sub-housing 20. The second branched oil flow, which has flowed into the space, is collected in the gas-liquid separation device 302 via the second drain hole 197 and the second drain passage 196.

**[0212]** As noted previously, the first branched oil flow lubricates the first bearing 74, and the second branched oil flow lubricates the second bearing 84. Consequently, generation of seizure in the first bearing 74 and the second bearing 84 is suppressed.

**[0213]** A description will be given concerning the passage of the first cooling oil that has flowed through the second auxiliary oil passage 181. As noted previously, the outlet of the second auxiliary oil passage 181 faces toward the annular gap 385 formed between the oil guiding member 350, and the outer surface of the first shaft portion 44a in the outer shaft 44 (refer to FIG. 7). Accordingly, as shown in FIG. 7, the first cooling oil is discharged toward the annular gap 385 from the outlet of the second auxiliary oil passage 181.

**[0214]** At this point in time, the rotating shaft 40 begins to rotate. Accordingly, due to the action of a centrifugal force, the lubricating oil that has entered into the oil receiving concave portion 340 moves to an annular groove 384 that is positioned on the outer circumference of the oil receiving concave portion 340. Since the oil receiving concave portion 340 and the annular groove 384 possess sufficient capacity, it is possible to temporarily store a predetermined amount of the cooling oil in the first oil receiving concave portion 340 and the annular groove 384.

**[0215]** The annular groove 384 communicates with the rotor internal oil passage 354 via the first oil delivery passages 386 that are formed in the oil guiding member 350. Accordingly, the first cooling oil flows into the rotor internal oil passage 354 via the first oil delivery passages 386. Furthermore, the first cooling oil flows through the rotor internal oil passage 354 and toward the first drain hole 198.

**[0216]** In such a flow through process, the first cooling oil passes over the first stepped portion 330, the second stepped portion 332, the third stepped portion 334, and the fourth stepped portion 336 (refer to FIG. 6). Therefore, as the first cooling oil moves from the upstream side to the downstream side in the direction through which the first cooling oil flows, the first cooling oil smoothly moves outward in the radial direction of the rotating shaft 40. In this manner, as the first cooling oil passes over the first stepped portion 330, the second stepped portion 332, the third stepped portion 334, and the fourth stepped portion 336, the first cooling oil flows in a direction other than

the axial direction of the rotating shaft 40.

**[0217]** Since the rotating shaft 40 is rotated, a centrifugal force acts on the first cooling oil that flows through the rotor internal oil passage 354. Due to the centrifugal force, there is a tendency for the first cooling oil to approach the outer side in the radial direction of the rotating shaft 40. In this instance, as noted previously, on the outer shaft 44 that makes up the rotating shaft 40, the first stepped portion 330, the second stepped portion 332, the third stepped portion 334, and the fourth stepped portion 336 are provided. Due to these direction change-over portions, the first cooling oil moves outward in the radial direction of the rotating shaft 40.

**[0218]** A force that is directed outward in the radial direction of the rotating shaft 40, and a force that is directed in the axial direction of the rotating shaft 40 act on the first cooling oil that flows through the rotor internal oil passage 354. Accordingly, it is easy for the first cooling oil to flow in the direction in which the resultant force of these two forces is directed. Consequently, the first cooling oil is prevented from being unevenly distributed, for example, on the inner circumferential wall of the inner hole 73 of the tubular member 70. Therefore, it is possible to avoid a situation in which flowing through of the first cooling oil is impeded due to such an uneven distribution. More specifically, irrespective of the centrifugal force that acts on the first cooling oil, the first cooling oil can be made to smoothly flow in the axial direction of the rotating shaft 40.

**[0219]** The first cooling oil, while flowing through the rotor internal oil passage 354, comes into contact with the outer surface of the outer shaft 44. As a result thereof, the outer shaft 44 is cooled. At the same time, the first cooling oil comes into contact with the inner circumferential wall of the inner hole 73 of the tubular member 70. Along therewith, the tubular member 70 and the permanent magnets 72 are cooled. In accordance with the foregoing, an excessive rise in the temperature of the rotor 34 is suppressed.

**[0220]** More specifically, a rise in the temperature of the permanent magnets 72 is suppressed based on them being cooled by the first branched air flow and the first cooling oil. Therefore, a situation is avoided in which the temperature of the permanent magnets 72 reaches the Curie temperature. Therefore, a reduction in the magnetic force of the permanent magnets 72 can be suppressed.

**[0221]** The first cooling oil that has flowed out from the outlet (the flow through space 362) of the rotor internal oil passage 354 comes into contact with the disk portion 392. As shown in FIG. 10, the first cooling oil passes through the first drain hole 198 that is formed in the second sub-housing 20, and flows into the second drain passage 196. In the second drain passage 196, the first cooling oil merges with the second branched oil flow, and thereafter, is collected in the gas-liquid separation device 302.

**[0222]** As can be understood from this feature, by the disk portion 392, movement of the first cooling oil toward

the second bearing 84 is suppressed. Accordingly, even in the case that dust or debris or the like becomes mixed within the first cooling oil, a situation is avoided in which such dust or debris or the like reaches the second bearing 84. Further, contact of the first cooling oil, the temperature of which has risen by flowing through the rotor internal oil passage 354, with the second bearing 84 is also suppressed. Accordingly, a situation is avoided in which the temperature of the second bearing 84 rises excessively.

**[0223]** One portion of the lubricating oil that is drawn out from the tank 318 flows into the second oil supply line 310 that is branched off from the first oil supply line 304. Hereinafter, the lubricating oil that flows through the second oil supply line 310 will be referred to as a "second cooling oil".

**[0224]** The second cooling oil reaches the input pipe portion 314 after having flowed through the second oil supply line 310. Since the input pipe portion 314 is formed in proximity to the second end in the outer circumferential wall of the main housing 16, the second cooling oil flows into the second end side of the stator chamber 23. Due to the discharge force of the circulation pump 308, the second cooling oil flows through from the second end toward the first end of the stator chamber 23. More specifically, in the stator chamber 23, the direction in which the second cooling oil flows is the second direction from the second end toward the first end.

**[0225]** In the stator chamber 23, which is the housing internal oil passage, the second cooling oil, for example, flows through the stator inner circumferential side oil passage 454. Alternatively, the second cooling oil flows through gaps between the electromagnetic coils 110 in the stator 36. Alternatively, the second cooling oil flows through inner holes (gaps between the insulating substrates 112) of the stator 36. Consequently, by the second cooling oil coming into contact with the stator 36, the stator 36 is efficiently cooled.

**[0226]** In the foregoing manner, in the present embodiment, the rotor 34 is cooled by the first cooling oil and the first branched air flow. In addition, the stator 36 is cooled by the second cooling oil. Accordingly, the rotating electric machine 12 is sufficiently cooled. As a result, a predetermined magnetic force is generated in the alternating magnetic field that is formed between the permanent magnets 72 and the electromagnetic coils 110. Consequently, the rotating electric machine 12 maintains a predetermined output. Further, by the rotor 34 being made to rotate at a high speed, it is possible to increase the output.

**[0227]** In the rotating electric machine housing 14, the direction in which the first branched air flow flows through the rotor chamber 22 having a maximal inward circumference is the first direction. In the rotating electric machine housing 14, the direction in which the cooling medium flows through the cooling jacket 24 having a maximal outward circumference is also the first direction. In contrast thereto, the direction in which the second cooling oil flows through the stator chamber 23, which is posi-

tioned between the rotor chamber 22 and the cooling jacket 24, is the second direction. In this manner, the direction in which the fluids that flow inwardly in the radial direction of the rotating electric machine housing 14, and the direction in which the fluid that flows outwardly in the radial direction of the rotating electric machine housing 14 are opposite to each other.

**[0228]** Accordingly, for example, a situation can be avoided in which the first branched air flow that has become high in temperature after having flowed through the rotor chamber 22, and the second cooling oil that has become high in temperature after having flowed through the stator chamber 23 overlap one another in the radial direction of the rotating electric machine housing 14. More specifically, at the first end or the second end of the rotating electric machine housing 14, the first branched air flow which is high in temperature, and the second cooling oil which is high in temperature do not converge. Consequently, at the first end or the second end of the rotating electric machine housing 14, insufficient cooling of the rotor 34 and the stator 36 is prevented.

**[0229]** Further, a situation can be avoided in which the second cooling air flow that has become high in temperature after having flowed through the stator chamber 23, and the cooling medium that has become high in temperature after having flowed through the cooling jacket 24 overlap one another in the radial direction of the rotating electric machine housing 14. More specifically, at the first end or the second end of the rotating electric machine housing 14, the second cooling oil which is high in temperature, and the cooling medium which is high in temperature do not converge. Consequently, at the first end or the second end of the rotating electric machine housing 14, insufficient cooling of the compressed air that flows through the first hollow tube portion 1601 to the third hollow tube portion 1603 is prevented. In addition, at the first or second end of the rotating electric machine housing 14, insufficient cooling of the rotating electric machine 12 by the cooling medium that flows through the cooling jacket 24 is prevented.

**[0230]** The second cooling oil that has flowed through the stator chamber 23 (the housing internal oil passage) flows from the first end of the stator chamber 23 into the contact chamber 290 of the first casing 26. As can be understood from this feature, the contact chamber 290 is positioned downstream relative to the stator chamber 23 in the direction in which the second cooling oil flows. Moreover, the contact chamber 290 and the terminal chamber 291 are separated from each other by the blocking convex portion 294 in the manner described above. Accordingly, the second cooling oil does not flow from the contact chamber 290 into the terminal chamber 291.

**[0231]** The second cooling oil inside the contact chamber 290 comes into contact with the terminal portions 295, the terminal wires 110a, and the screws 296. Consequently, the electrical contact between the U-phase terminal 1441 and the U-phase coil is cooled. For the same reason, the electrical contact between the V-phase



terminal 1442 and the V-phase coil is also cooled. The electrical contact between the W-phase terminal 1443 and the W-phase coil is also cooled.

**[0232]** The second cooling oil inside the contact chamber 290 flows into the second oil recovery line 312 via the output pipe portion 316. The lubricating oil that has flowed through the second oil recovery line 312 is recovered in the gas-liquid separation device 302 shown in FIG. 12.

**[0233]** In the foregoing manner, the gas-liquid separation device 302 recovers the first branched air flow and the second branched air flow (the curtain air), the first branched oil flow, the second branched oil flow, the first cooling oil, and the second cooling oil (the lubricating oil). In this instance, inside the rotating electric machine housing 14, the first branched oil flow and the second branched oil flow are blocked by the air curtain. Therefore, the lubricating oil is contained in the curtain air that is exhausted from the exhaust passage 172. More specifically, the curtain air exhausted from the exhaust passage 172 is substantially a gas-liquid mixture.

**[0234]** According to the present embodiment, the gas-liquid separation device 302 is included in the oil circulation supply device. Accordingly, the gas-liquid mixture is separated into the air and the lubricating oil. The air passes through the exhaust line 306 that is provided in the gas-liquid separation device 302, and is released to the atmosphere. On the other hand, the lubricating oil is temporarily stored in the tank 318. The lubricating oil inside the tank 318 is drawn out from the gas-liquid separation device 302 by the circulation pump 308. Furthermore, in accordance with the foregoing description, the lubricating oil passes through the first oil supply line 304, and is resupplied from the gas-liquid separation device 302 to the first bearing 74, the second bearing 84, and the rotor internal oil passage 354. While the rotating shaft 40 rotates, the first bearing 74, the second bearing 84, and the rotor 34 are cooled by the lubricating oil.

**[0235]** In the foregoing manner, by separating the gas-liquid mixture into the lubricating oil and the air in the gas-liquid separation device 302, the occurrence of so-called air entrainment in the first oil supply line 304 and the circulation pump 308 is avoided. Accordingly, the lubricating oil is capable of being resupplied at an appropriate discharge pressure or flow rate to the first bearing 74 and the second bearing 84. Therefore, the first bearing 74 and the second bearing 84 are sufficiently lubricated. As a result, generation of seizure in the first bearing 74 and the second bearing 84 can be suppressed.

**[0236]** In the foregoing manner, the curtain air (the first branched air flow and the second branched air flow) prevents the lubricating oil from scattering from the first bearing 74 and the second bearing 84. Thereafter, the curtain air is discharged to the exterior of the rotating electric machine housing 14 in the manner described above. Therefore, even in the case that the lubricating oil leaks out from the first bearing 74 or the second bearing 84, the leaked out lubricating oil is accompanied by the cur-

tain air and is discharged to the exterior of the rotating electric machine housing 14. Therefore, it is possible to avoid a situation in which the leaked out lubricating oil flows toward the rotor 34. Further, it is possible to avoid a situation in which the leaked out lubricating oil remains inside the rotor 34.

**[0237]** As has been described above, the pressure of the curtain air that is continuously supplied to the rotating electric machine housing 14 is substantially constant. Therefore, it is possible to continuously prevent the aforementioned scattering of the lubricating oil from occurring. Further, even in the case that leakage of the lubricating oil has occurred, the leaked out lubricating oil can be continuously discharged to the exterior of the rotating electric machine housing 14.

**[0238]** The compressed air that has passed between the shroud case 220 and the compressor wheel 222 without entering into the air bleed port 234 becomes the combustion air. As shown in FIG. 13, the combustion air enters into the diffuser 226. The combustion air flows out from an outlet hole that is formed in a wall portion of the diffuser 226, and into the combustion air flow passage 274 formed between the combustor 228 and the outer housing 2022. Furthermore, the combustion air flows into the combustion chamber (the hollow interior of the combustor 228) through the relay holes 276 and the fine holes that are formed in the combustor 228, and a clearance formed between the combustor 228 and the fuel supply nozzle 275.

**[0239]** The combustor 228 is placed in a state of being heated beforehand. Accordingly, the combustion chamber is also at a high temperature. Fuel is supplied from the fuel supply nozzle 275 to the high temperature combustion chamber. The fuel undergoes combustion together with the combustion air, and results in a high temperature combusted fuel. At a time when the combusted fuel is supplied into the nozzle 230 from the delivery hole, the combusted fuel expands inside the nozzle 230. Consequently, the turbine wheel 224 begins to rotate at a high speed.

**[0240]** The output shaft 204 retains the turbine wheel 224.

Further, the compressor wheel 222 is also provided on the output shaft 204. Accordingly, accompanying the turbine wheel 224 being rotated at a high speed, the output shaft 204 and the compressor wheel 222 rotate together at a high speed. Simultaneously, the rotating shaft 40 also rotates at a high speed. Moreover, the combusted fuel is discharged to the exterior of the outer housing 2022 through a non-illustrated exhaust pipe provided in the exhaust port 280.

**[0241]** The ring member 256, which is interposed between the compressor wheel 222 and the turbine wheel 224, also serves as a sealing member for sealing the space between both of the wheels 222 and 224. In addition, as shown in FIG. 14, the plurality of the individual labyrinth forming convex portions 264 are formed on the outer circumferential wall of the ring member 256. The

labyrinth forming convex portions 264 abut against the inner wall of the hole portion 272 formed in the intermediate plate 266. The compressed air generated by the compressor wheel 222 reaches the labyrinth forming convex portions 264 via the rear surface of the compressor wheel 222. Further, the combustion gas reaches the labyrinth forming convex portions 264 from the turbine wheel 224. As discussed above, the pressure of the compressed air is higher in comparison with the pressure of the combustion gas. Therefore, an occurrence is suppressed in which the combustion gas passes through the labyrinth forming convex portions 264 and flows into the compressor wheel 222. For the reasons mentioned above, a situation is avoided in which the combusted fuel, for example, enters into the through hole 240 from between both of the wheels 222 and 224.

**[0242]** As shown in FIG. 13, when the output shaft 204 begins to rotate at a high speed, the supply of electrical current from the battery 146 (refer to FIG. 8) to the electromagnetic coils 110 is halted. However, since the turbine wheel 224 is already rotating at a high speed in the manner described above, the rotating shaft 40 rotates at a high speed integrally together with the turbine wheel 224 and the output shaft 204. At this time as well, for the same reasons as mentioned above, a sufficient rotational torque is transmitted from the output shaft 204 with respect to the rotating shaft 40.

**[0243]** As shown in FIG. 3, the direction of rotation of the output shaft 204 and the rotating shaft 40 is preferably opposite to the direction of rotation when the small cap nut 58, the large cap nut 60, and the male threaded portion 252 are screwed together. This is because, in this case, a situation is avoided in which the small cap nut 58, the large cap nut 60, and the male threaded portion 252 become loosened during rotation of the rotating shaft 40. Moreover, it should be noted that the small cap nut 58, the large cap nut 60, or the male threaded portion 252 may also be provided with a mechanism in order to prevent loosening thereof.

**[0244]** Since the rotating shaft 40 retains the permanent magnets 72, the AC current is generated in the electromagnetic coils 110 that surround the permanent magnets 72. Via the U-phase terminal 1441, the V-phase terminal 1442, and the W-phase terminal 1443, the AC current is delivered to the electrical current converter 150 shown in FIG. 1 and FIG. 8. The conversion circuit 152 of the electrical current converter 150 converts such an AC current into a DC current. At a time when the control circuit 156 of the electrical current converter 150 has determined that the output of an external load (for example, a motor) which is electrically connected to the battery 146 has decreased, the DC current is supplied to the battery 146 (refer to FIG. 8) via the capacitor 154. Consequently, charging is carried out on the battery 146.

**[0245]** In this process, within the electrical current converter 150, in particular, the conversion circuit 152 and the capacitor 154 become heated. However, according to the present embodiment, the conversion circuit 152

and the capacitor 154 inside the equipment case 158 are in proximity to the cooling jacket 24. Therefore, the heat of the conversion circuit 152 and the capacitor 154 is rapidly conducted to the cooling medium inside the cooling jacket 24. Consequently, a situation is avoided in which the conversion circuit 152 and the capacitor 154 become excessively high in heat.

**[0246]** Accompanying the electrical current flowing therethrough, the electromagnetic coils 110 generate heat. In this instance, in the stator 36, the second cooling oil comes into contact therewith as described above. Therefore, the stator 36 is cooled by the second cooling oil. Further, the cooling medium flows through the cooling jacket 24 that is provided in the main housing 16. The rotating electric machine 12 is rapidly cooled by the cooling medium. Due to this feature as well, the alternating magnetic field that is formed between the permanent magnets 72 and the electromagnetic coils 110 can be made to develop a predetermined magnetic force.

**[0247]** According to the present embodiment, the rotating electric machine housing 14 (the main housing 16) in which the rotating electric machine 12 is accommodated, and the first casing 26 in which the U-phase terminal 1441, the V-phase terminal 1442, and the W-phase terminal 1443 are accommodated are separately provided. Therefore, the influence of heat generated in the stator 36 inside the main housing 16 is less likely to affect the U-phase terminal 1441, the V-phase terminal 1442, and the W-phase terminal 1443 inside the first casing 26. Moreover, accompanying the electrical current being supplied thereto, the electrical contacts between the U-phase terminal 1441 and the U-phase coil, between the V-phase terminal 1442 and the V-phase coil, and between the W-phase terminal 1443 and the W-phase coil also generate heat. However, the electrical contacts are rapidly cooled by the second cooling oil that has flowed into the contact chamber 290.

**[0248]** In this manner, from the fact that the electric terminal portions (the U-phase terminal 1441, the V-phase terminal 1442, and the W-phase terminal 1443), the electromagnetic coils 110, the permanent magnets 72, and the like are cooled, a situation may be avoided in which the output control and the like of the rotating electric machine system 10 are affected by heat. Further, it is possible to prevent the magnetization of the electromagnetic coils 110, the permanent magnets 72, and the like from deteriorating due to heat. As a result, the reliability of the rotating electric machine system 10 is improved.

**[0249]** Furthermore, from the fact that the main housing 16 in which the rotating electric machine 12 is accommodated, and the first casing 26 in which the U-phase terminal 1441, the V-phase terminal 1442, and the W-phase terminal 1443 are accommodated are individually provided, the rotating electric machine 12 and the electric terminal portions are separated away from each other. Therefore, the U-phase terminal 1441, the V-phase terminal 1442, and the W-phase terminal 1443 are less likely

to be affected by the influence of vibrations generated accompanying the rotation of the rotor 34. Stated otherwise, the U-phase terminal 1441, the V-phase terminal 1442, and the W-phase terminal 1443 are protected from vibrations. Further, as noted previously, in the first bearing 74 and the second bearing 84, generation of seizure therein is suppressed by the lubricating oil. Accordingly, the rotating electric machine system 10 is superior in terms of durability.

**[0250]** Since the rotating electric machine 12 takes on heat, such heat travels to the partition wall member 410. Therefore, the partition wall member 410 undergoes thermal expansion. In this instance, both of the end surfaces in the axial direction of the partition wall member 410 are non-contact surfaces that are not in contact with any other member. Stated otherwise, in the partition wall member 410, both of the distal end surfaces 410a and 410b in the axial direction are unconstrained surfaces that are not constrained by other members. Accordingly, both end parts of the partition wall member 410 can be freely expanded in the axial direction of the partition wall member 410 based on thermal expansion. Therefore, a situation is avoided in which both ends of the partition wall member 410 which have undergone thermal expansion receive a compressive stress from other members.

**[0251]** The partition wall member 410 has a comparatively low strength because it is thin-walled. Further, in the case that the material of the partition wall member 410 is a ceramic, it becomes brittle. However, as noted previously, at a time when the partition wall member 410 is subjected to thermal expansion, a situation is avoided in which the partition wall member 410 receives a compressive stress. Accordingly, even in the case that the partition wall member 410 is constituted by a highly brittle material, any concern that the partition wall member 410 may become damaged due to thermal expansion can be dispensed with.

**[0252]** The angle of rotation (the rotational parameter) of the rotating shaft 40 is detected by the resolver 132 while the rotating shaft 40 is undergoing rotation. Specifically, the resolver rotor 56 that is externally fitted onto the left end part 422 of the inner shaft 42 rotates together integrally with the rotating shaft 40. Consequently, electrical signals generated in the resolver stator 130 are transmitted to the receiver via the transmission connector 136. The receiver, which has received and read the electrical signals, calculates the angle of rotation of the rotating shaft 40 on the basis of the electrical signals. The receiver delivers the calculation result to a non-illustrated control device or the like. The control device or the like obtains the rotational speed by way of a calculation based on the angle of rotation.

**[0253]** In the rotating shaft 40, the resolver 132 is disposed on the projecting distal end 46 that is exposed from the rotating electric machine housing 14. Accordingly, it is less likely for the resolver 132 to be influenced by heat generated in the electromagnetic coils 110 of the stator 36 inside the rotating electric machine housing 14.

Further, the resolver 132 is also less likely to be affected by vibrations generated accompanying the rotation of the rotor 34. In addition, the first bearing 74 and the second bearing 84 that support the rotating shaft 40 are provided inside the rotating electric machine housing 14. Accordingly, due to the rotating electric machine housing 14, vibrations of the first bearing 74 and the second bearing 84 are suppressed. This feature as well makes it unlikely for the influence of such vibrations to reach the resolver 132.

**[0254]** In the foregoing manner, according to the present embodiment, transmission of heat and vibrations and the like to the resolver 132 are suppressed. Consequently, the detection result of the angle of rotation determined by the resolver 132 becomes accurate. Further, the useful lifetime of the resolver 132 is lengthened.

**[0255]** Cases may occur in which the resolver 132 is replaced by another resolver having a larger inner diameter and outer diameter. In the case that one solid rotating shaft is used as the rotating shaft, it is necessary to replace the rotating shaft with a large diameter solid rotating shaft, at a time when the resolver is replaced with a resolver having a large inner diameter and an outer diameter. At this time, it is not easy for such a large diameter solid rotating shaft to be passed through the first bearing 74 and the second bearing 84.

**[0256]** According to the present embodiment, the outer shaft 44 and the inner shaft 42 constitute the rotating shaft 40. Further, the outer shaft 44 passes through the first bearing 74 and the second bearing 84, and in addition, in the inner shaft 42, the resolver rotor 56 is disposed on the portion thereof that is exposed from the outer shaft 44. Therefore, at the time when the resolver 132 is replaced with another resolver having a larger inner diameter and outer diameter, the inner shaft 42 can be replaced with an inner shaft the left end part 422 of which is formed with a larger diameter. As can be understood from this feature, according to the present embodiment, by replacing the inner shaft 42, it is possible to support resolvers having various inner diameters and outer diameters.

**[0257]** According to the present embodiment, the third sub-branching passage 941 and the fourth sub-branching passage 942 are provided. Alternatively, the first air branching passage L may branch off into a first sub-branching passage and a second sub-branching passage. In this case, the one portion of the first branched air flow is supplied from the first sub-branching passage to the first distal end 781, and the remaining portion of the first branched air flow is supplied from the second sub-branching passage to the first proximal end 782. Alternatively, the first air branching passage L may be branched off into the first sub-branching passage and the second sub-branching passage, and in addition, the third sub-branching passage 941 and the fourth sub-branching passage 942 may be provided.

**[0258]** In the gas turbine engine 200, the compressor wheel 222 and the turbine wheel 224 can also be ar-

ranged in a reverse order to that shown in FIG. 13. In this case, the through hole 240 is formed in the turbine wheel 224, and the output shaft 204 is provided in the compressor wheel 222. Apart therefrom, the compressor wheel 222 and the turbine wheel 224 may be of a centrifugal type or an axial flow type. If the compressor wheel 222 and the turbine wheel 224 are arranged on the same axis, a combination of a multi-stage compressor wheel and a multi-stage turbine wheel, which is a combination of a centrifugal type and an axial flow type, may be used.

**[0259]** In FIG. 3, the rotating electric machine 12 that makes up the rotating electric machine system 10 may be a motor that rotates the rotating shaft 40 by supplying an electrical current to the electromagnetic coils 110. In this case, the U-phase terminal 1441, the V-phase terminal 1442, and the W-phase terminal 1443 serve as electric terminal portions that receive the electrical power from the battery 146.

**[0260]** It is also possible to disconnect the rotating electric machine system 10 from the gas turbine engine 200, and for it to be used independently. In a case in which it is necessary to supply the compressed air to the rotating electric machine system 10, as shown in FIG. 15, a compression pump 320 may be provided externally of the rotating electric machine housing 14, and the compression pump 320 may be used as an air supplying device.

**[0261]** In this case, for example, the compression pump 320 is connected to at least one of the flexible tubes 470a to 470c. In this case, the compressed air supplied from the compression pump 320 flows into the at least one of the flexible tubes 470a to 470c. Also, a communication hole 324, which is continuous with the upstream communication holes 164, is formed in the second sub-housing 20. The communication hole 324 is closed with a plug 326. In this state, the compression pump 320 compresses the air or the like, whereby the compressed air is obtained. The compressed air is supplied to the first hollow tube portion 1601 to the third hollow tube portion 1603.

**[0262]** Furthermore, in the above-described embodiment, although the first cooling oil is made to flow through in a direction from the first bearing 74 toward the second bearing 84, conversely to this feature, the first cooling oil may be made to flow through in a direction from the second bearing 84 toward the first bearing 74. In this case, the second auxiliary oil passage 181 branches off from the third auxiliary oil passages 188. Further, it is preferable for the outer diameter of the outer shaft 44 to become greater in diameter from the second bearing 84 toward the first bearing 74. The disk portion 392 is provided at the second end of the first inner stopper 82.

**[0263]** As shown in FIG. 16, a second circulation pump 412 can also be provided. In this case, in the first oil supply line 304, a branching line 414 is provided more upstream than the tank 318. The branching line 414 may also be disposed more downstream than the tank 318. The second circulation pump 412 is interposed between the branching line 414 and the second oil supply line 310.

**[0264]** In accordance with such a configuration, one portion of the lubricating oil that has flowed out of the gas-liquid separation device 302 is drawn out by the second circulation pump 412 and flows into the branching line 414. The lubricating oil (the second cooling oil) in the branching line 414 flows through the second oil supply line 310, the input pipe portion 314, the stator chamber 23, the output pipe portion 316, and the second oil recovery line 312, and then is returned to the gas-liquid separation device 302. Thereafter, such a circulating supply is repeated.

**[0265]** In the interior of the rotating electric machine housing 14, a device or a member does not exist to which the second cooling oil and the compressed air are simultaneously supplied. Accordingly, there is no particular need for the second cooling oil to be returned to the gas-liquid separation device 302. Thus, a bypass line 416 may be provided that connects the second oil recovery line 312 and the second oil supply line 310. In accordance with such a configuration, the second cooling oil flows into the branching line 414 via the bypass line 416. The second cooling oil further flows through the second oil supply line 310, the input pipe portion 314, the stator chamber 23, the output pipe portion 316, and the second oil recovery line 312, and flows again into the bypass line 416.

**[0266]** As shown in FIG. 17, it is also possible for the second cooling oil to flow in a direction opposite to that shown in FIG. 11. In this case, the second cooling oil is input to the stator chamber 23 (the housing internal oil passage) from the output pipe portion 316, and the second cooling oil is output from the stator chamber 23 to the input pipe portion 314. The second cooling oil flows through the stator chamber 23 from the first bearing 74 toward the second bearing 84. More specifically, in this case, the direction in which the second cooling oil flows in the housing internal oil passage is the first direction.

**[0267]** As described above, in the present embodiment, the rotating electric machine system (10) is disclosed, which is equipped with the rotating electric machine (12) provided with the rotor (34) including the permanent magnet (72) and the rotating shaft (40), and is equipped with the rotating electric machine housing (14) in which the rotating shaft is rotatably supported, the rotor being provided with the rotor internal oil passage (354) formed in the interior of the rotor, the rotating electric machine including the stator (36) surrounding the permanent magnet from the outer circumference of the permanent magnet, the rotating electric machine housing including the first oil supply passage, the second oil supply passage (314), and the housing internal oil passage (23) formed in an interior of the rotating electric machine housing and accommodating the stator, the rotating electric machine system including the first bearing (74) and the second bearing (84) that are interposed between the rotating electric machine housing and the rotating shaft, and the oil circulation supply device configured to circulate and supply the lubricating oil to the first bearing, the

second bearing, the rotor internal oil passage, and the housing internal oil passage, wherein the oil circulation supply device includes the first oil supply line (304), the second oil supply line (310), the first oil recovery line (305), and the second oil recovery line (312), the oil circulation supply device is configured to supply the lubricating oil to the first bearing and the second bearing via the first oil supply line and the first oil supply passage, supply the lubricating oil toward the rotor internal oil passage via the first oil supply line and the first oil supply passage, and supply the lubricating oil to the housing internal oil passage via the second oil supply line and the second oil supply passage, and the oil circulation supply device is configured to recover together, via the first oil recovery line, the lubricating oil supplied to the first bearing and the second bearing and the lubricating oil that has flowed through the rotor internal oil passage, and also recover via the second oil recovery line the lubricating oil that has flowed through the housing internal oil passage.

**[0268]** In the rotating electric machine system, a portion of the lubricating oil supplied to the bearings is diverted and made to flow through the rotor internal oil passage. Based on the lubricating oil flowing in this manner, the rotor that constitutes the rotating electric machine is efficiently cooled by the lubricating oil. Further, from a route other than the above, the lubricating oil is supplied to the housing internal oil passage as a cooling oil. Since the stator is accommodated in the housing internal oil passage, the stator is efficiently cooled by the lubricating oil.

**[0269]** In this way, according to the present invention, the rotor and the stator are cooled simultaneously. Accordingly, a predetermined magnetic force is generated in an alternating magnetic field formed between the electromagnetic coils that make up the stator and the permanent magnet that makes up the rotor. In accordance with this feature, in the stator and the rotor, the power generation efficiency becomes high, and a decrease in the conversion efficiency between the mechanical energy and the electrical energy is suppressed. Therefore, by the rotor being made to rotate at a high speed, it is possible to increase the amount of generated electrical power while suppressing the generation of heat.

**[0270]** Also, in the present invention, the route of the lubricating oil supplied to the rotor, and the route of the lubricating oil supplied to the stator are separated. Therefore, the lubricating oil after cooling the rotor is prevented from being supplied to the stator. In the same manner, the lubricating oil after cooling the stator is prevented from being supplied to the rotor. For the aforementioned reasons, it is possible to cool efficiently the stator and the rotor.

**[0271]** In addition, the route of the lubricating oil that is supplied to the bearings, and the route of the lubricating oil that is supplied to the stator are separated. Accordingly, a situation is avoided in which the lubricating oil, which has become heated to a high temperature by taking

on heat from the stator, is supplied to the bearings. Therefore, since the bearings are sufficiently lubricated and cooled, a situation is avoided in which seizure of the bearings takes place.

5 **[0272]** The present embodiment discloses the rotating electric machine system, which may further include the cylindrically shaped partition wall member (410) interposed between the rotor and the stator in the radial direction of the rotating shaft, wherein the partition wall member may partition the interior of the rotating electric machine housing into the rotor chamber (22) in which the rotor is accommodated, and the stator chamber (23) in which the stator is accommodated, and the stator chamber is the housing internal oil passage.

10 **[0273]** In this case, the interior of the rotating electric machine housing is partitioned by the partition wall member into the rotor chamber and the stator chamber. By using the stator chamber as the housing internal oil passage through which the lubricating oil flows, the lubricating oil is prevented from entering into the rotor chamber. As a result, in particular, the permanent magnet is prevented from becoming contaminated by the lubricating oil.

15 **[0274]** The present embodiment discloses the rotating electric machine system in which the partition wall member may be made of a ceramic.

20 **[0275]** Such a ceramic is a material that generally exhibits high strength, an insulating property, and resistance to heat. Therefore, even in the case that the partition wall member is formed to be thin-walled, the strength and the insulating property of the partition wall member are ensured, and stability with respect to heat is exhibited. Consequently, the partition wall member exhibits sufficient durability. Further, even if the partition wall member which is made of a ceramic is interposed between the rotor and the stator, there is almost no interruption in the alternating magnetic field.

25 **[0276]** The present embodiment discloses the rotating electric machine system, wherein the rotor may include the tubular member (70) interposed between the rotating shaft and the permanent magnet in the radial direction of the rotating shaft, and at least the portion of the rotor internal oil passage may be formed between the outer surface of the rotating shaft, and the inner circumferential wall of the tubular member.

30 **[0277]** In accordance with such features, one portion of the rotor internal oil passage can be formed easily.

35 **[0278]** The present embodiment discloses the rotating electric machine system, in which the first oil supply passage may include the first auxiliary oil passage (180) facing toward the first bearing, and the second auxiliary oil passage (181) facing toward the rotating shaft, and the second auxiliary oil passage may branch off from the first auxiliary oil passage.

40 **[0279]** In accordance with such a configuration, a portion from the lubricating oil directing toward the first bearing can be diverted. More specifically, it is easy for the portion of the lubricating oil to be diverted, and be made

to flow through the rotor internal oil passage as the cooling oil. Therefore, in this case, it is easy for the portion of the lubricating oil to be diverted, and be made to flow through the rotor internal oil passage as the cooling oil for cooling the rotor.

**[0280]** The present embodiment discloses the rotating electric machine system, in which the rotating electric machine housing may further include the first oil pathway (184) configured to guide the lubricating oil supplied to the first bearing from the first oil supply passage, to the oil circulation supply device, and the second oil pathway (196) configured to guide the lubricating oil supplied to the second bearing from the first oil supply passage, and the lubricating oil that has flowed through the rotor internal oil passage, to the oil circulation supply device.

**[0281]** In accordance with such a configuration, after having recovered the lubricating oil supplied to the first bearing and the second bearing, and the lubricating oil that has cooled the stator, the lubricating oil can be easily resupplied to the first bearing, the second bearing, and the housing internal oil passage.

**[0282]** The present embodiment discloses the rotating electric machine system, wherein the lubricating oil flowing through the rotor internal oil passage may flow in the first direction from the first bearing toward the second bearing, and the lubricating oil flowing through the housing internal oil passage may flow in the second direction from the second bearing to the first bearing.

**[0283]** In accordance with such a configuration, a situation can be avoided in which the lubricating oil (first cooling oil) that has become high in temperature resulting from the cooling of the rotor and the lubricating oil (second cooling oil) that has become high in temperature resulting from the cooling of the stator do not converge in the vicinity of the first bearing or in the vicinity of the second bearing. Accordingly, a portion in the vicinity of the first bearing in each of the stator and the rotor, and a portion in the vicinity of the second bearing in each of the stator and the rotor are efficiently cooled.

**[0284]** The present embodiment discloses the rotating electric machine system, which may further include the gas supplying device (200) configured to supply the gas to the first bearing and the second bearing, wherein the rotating electric machine housing may further include the gas supplying passages (1601 to 1603) configured to supply the gas supplied from the gas supplying device to the first bearing and the second bearing, and the gas discharge passage (172) configured to discharge the gas from the first bearing and the second bearing, and the oil circulation supply device may be configured to recover the gas that has flowed through the gas discharge passage.

**[0285]** The gas supplied to the first bearing and the second bearing forms a gas curtain. Such a gas curtain seals the lubricating oil that was supplied to the first bearing and the second bearing. More specifically, the lubricating oil supplied to the first bearing and the second bearing is blocked by the gas curtain. Accordingly, the

lubricating oil is prevented from scattering circumferentially around the first bearing or the second bearing. Consequently, for example, a situation is avoided in which the rotating shaft or the like becomes contaminated by the lubricating oil.

**[0286]** Further, since the oil circulation supply device recovers the gas and the lubricating oil together, there is no need for the gas and the lubricating oil to be recovered separately. Accordingly, it is also unnecessary to provide a gas recovery device in the rotating electric machine system. Therefore, a situation is avoided in which the configuration of the rotating electric machine system becomes complex.

**[0287]** The present embodiment discloses the rotating electric machine system, in which the oil circulation supply device may include the gas-liquid separation device (302) configured to separate the gas and the lubricating oil.

**[0288]** Since the gas-liquid separation device separates the gas and the lubricating oil, even though the gas and the lubricating oil are recovered together, only the lubricating oil is capable of being resupplied to the first oil supply line and the second oil supply line. More specifically, in this case, it is easy to circulate and supply the lubricating oil to the first bearing, the second bearing, the rotor internal oil passage, and the housing internal oil passage.

**[0289]** The present embodiment discloses the combined power system (500) that includes the aforementioned rotating electric machine system (10), and the internal combustion engine (200) including the output shaft (204) configured to rotate integrally with the rotating shaft (40).

**[0290]** In accordance with such features, the combined power system can be constituted in which the rotating electric machine system and the internal combustion engine are integrally combined. In this case, even though the rotor and the stator in the rotating electric machine system are cooled in the manner described above, it is possible to avoid a situation in which the rotating electric machine system becomes complex or large in scale. Therefore, it is possible to avoid a situation in which the combined power system becomes complicated or large in scale. Further, it is possible to avoid a situation in which the weight of the combined power system becomes large.

**[0291]** A rotating electric machine system (10) includes a rotor (34) and a stator (36). A rotor internal oil passage (354) is formed in the interior of the rotor. The rotor is cooled by a first cooling oil serving as a lubricating oil that flows through a rotor internal oil passage. A housing internal oil passage (23) is formed in a rotating electric machine housing (14). The stator is cooled by a second cooling oil serving as a lubricating oil that flows through the housing internal oil passage. A route by which the first cooling oil is supplied to the rotor internal oil passage, and a route by which the second cooling oil is supplied to the housing internal oil passage are different from each other.

## Claims

1. A rotating electric machine system (10) that is equipped with a rotating electric machine (12) provided with a rotor (34) including a permanent magnet (72) and a rotating shaft (40), and is equipped with a rotating electric machine housing (14) in which the rotating shaft is rotatably supported,
- the rotor being provided with a rotor internal oil passage (354) formed in an interior of the rotor, the rotating electric machine including a stator (36) surrounding the permanent magnet from an outer circumference of the permanent magnet, the rotating electric machine housing including a first oil supply passage, a second oil supply passage (314), and a housing internal oil passage (23) formed in an interior of the rotating electric machine housing and accommodating the stator,
- the rotating electric machine system comprising: a first bearing (74) and a second bearing (84) that are interposed between the rotating electric machine housing and the rotating shaft; and an oil circulation supply device configured to circulate and supply a lubricating oil to the first bearing, the second bearing, the rotor internal oil passage, and the housing internal oil passage,
- wherein the oil circulation supply device includes a first oil supply line (304), a second oil supply line (310), a first oil recovery line (305), and a second oil recovery line (312);
- the oil circulation supply device is configured to supply the lubricating oil to the first bearing and the second bearing via the first oil supply line and the first oil supply passage, supply the lubricating oil toward the rotor internal oil passage via the first oil supply line and the first oil supply passage, and supply the lubricating oil to the housing internal oil passage via the second oil supply line and the second oil supply passage; and
- the oil circulation supply device is configured to recover together, via the first oil recovery line, the lubricating oil supplied to the first bearing and the second bearing and the lubricating oil that has flowed through the rotor internal oil passage, and also recover via the second oil recovery line the lubricating oil that has flowed through the housing internal oil passage.
2. The rotating electric machine system according to claim 1, further comprising a cylindrically shaped partition wall member (410) interposed between the rotor and the stator in a radial direction of the rotating shaft,
- wherein the partition wall member partitions the interior of the rotating electric machine housing into a rotor chamber (22) in which the rotor is accommodated, and a stator chamber (23) in which the stator is accommodated; and the stator chamber is the housing internal oil passage.
3. The rotating electric machine system according to claim 2, wherein the partition wall member is made of a ceramic.
4. The rotating electric machine system according to claim 1, wherein the rotor includes a tubular member (70) interposed between the rotating shaft and the permanent magnet in a radial direction of the rotating shaft, and at least a portion of the rotor internal oil passage is formed between an outer surface of the rotating shaft and an inner circumferential wall of the tubular member.
5. The rotating electric machine system according to any one of claims 1 to 4, wherein the first oil supply passage includes a first auxiliary oil passage (180) facing toward the first bearing, and a second auxiliary oil passage (181) facing toward the rotating shaft, and the second auxiliary oil passage branches off from the first auxiliary oil passage.
6. The rotating electric machine system according to claim 5, wherein the rotating electric machine housing further includes:
- a first oil pathway (184) configured to guide the lubricating oil supplied to the first bearing from the first oil supply passage, to the oil circulation supply device; and
- a second oil pathway (196) configured to guide the lubricating oil supplied to the second bearing from the first oil supply passage, and the lubricating oil that has flowed through the rotor internal oil passage, to the oil circulation supply device.
7. The rotating electric machine system according to any one of claims 1 to 6, wherein the lubricating oil flowing through the rotor internal oil passage flows in a first direction from the first bearing toward the second bearing, and the lubricating oil flowing through the housing internal oil passage flows in a second direction from the second bearing to the first bearing.
8. The rotating electric machine system according to any one of claims 1 to 7, further comprising a gas supplying device (200) configured to supply a gas to the first bearing and the second bearing,

wherein the rotating electric machine housing further includes gas supplying passages (1601 to 1603) configured to supply the gas supplied from the gas supplying device to the first bearing and the second bearing, and a gas discharge passage (172) configured to discharge the gas from the first bearing and the second bearing; and  
the oil circulation supply device is configured to recover the gas that has flowed through the gas discharge passage.

9. The rotating electric machine system according to claim 8, wherein the oil circulation supply device includes a gas-liquid separation device (302) configured to separate the gas and the lubricating oil.
10. A combined power system (500) comprising the rotating electric machine system (10) according to claim 1, and an internal combustion engine (200) including an output shaft (204) configured to rotate integrally with the rotating shaft (40).

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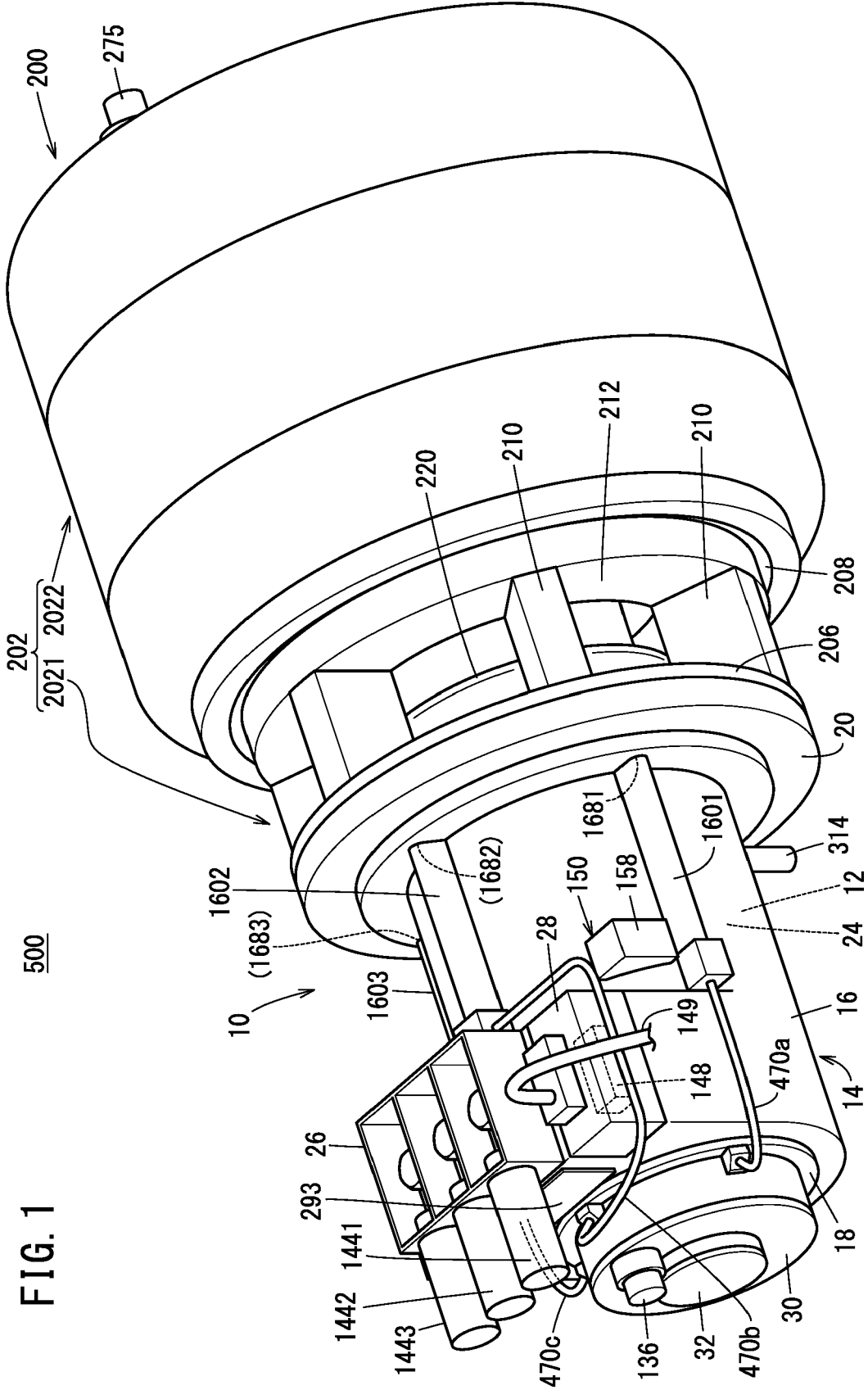


FIG. 1

500

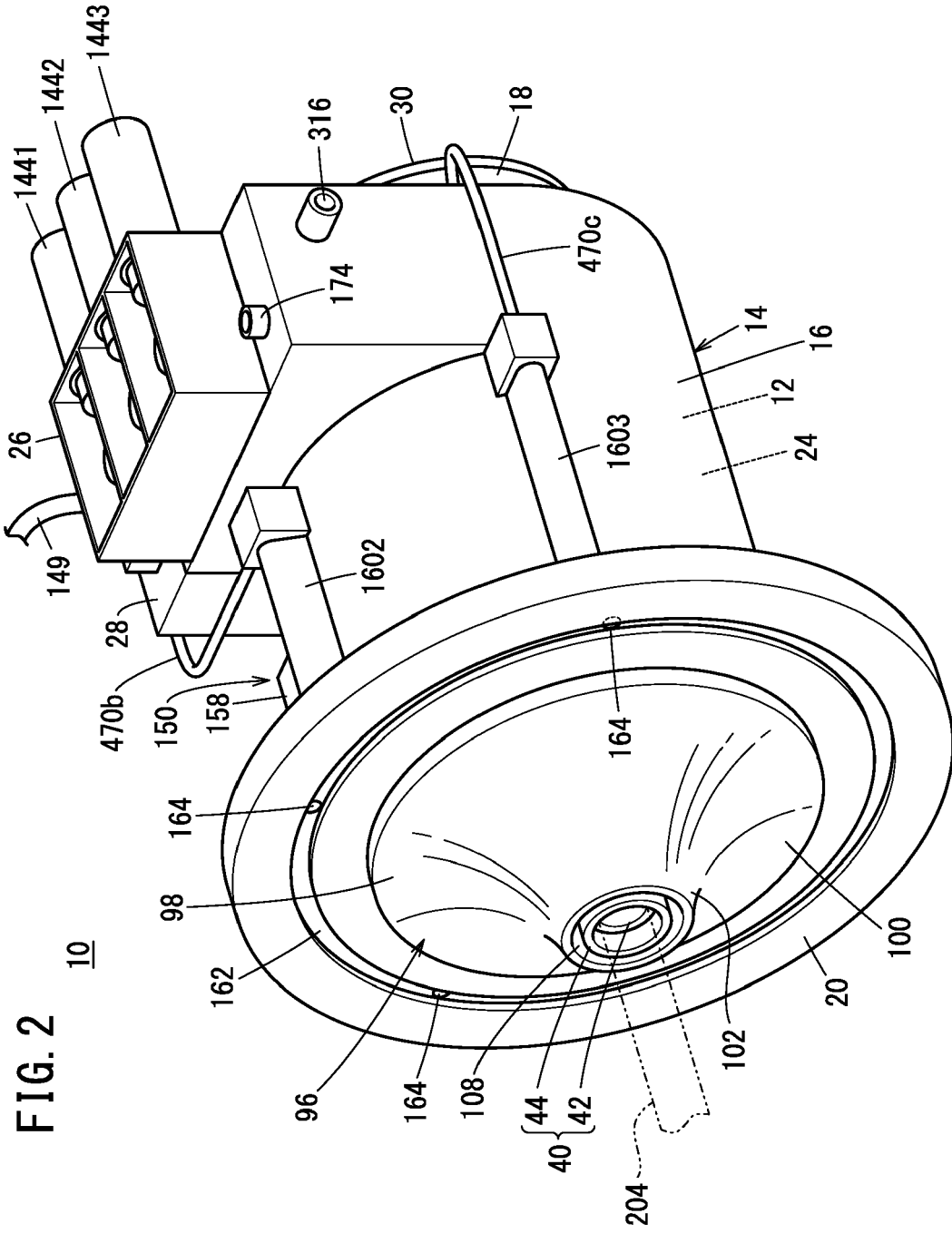
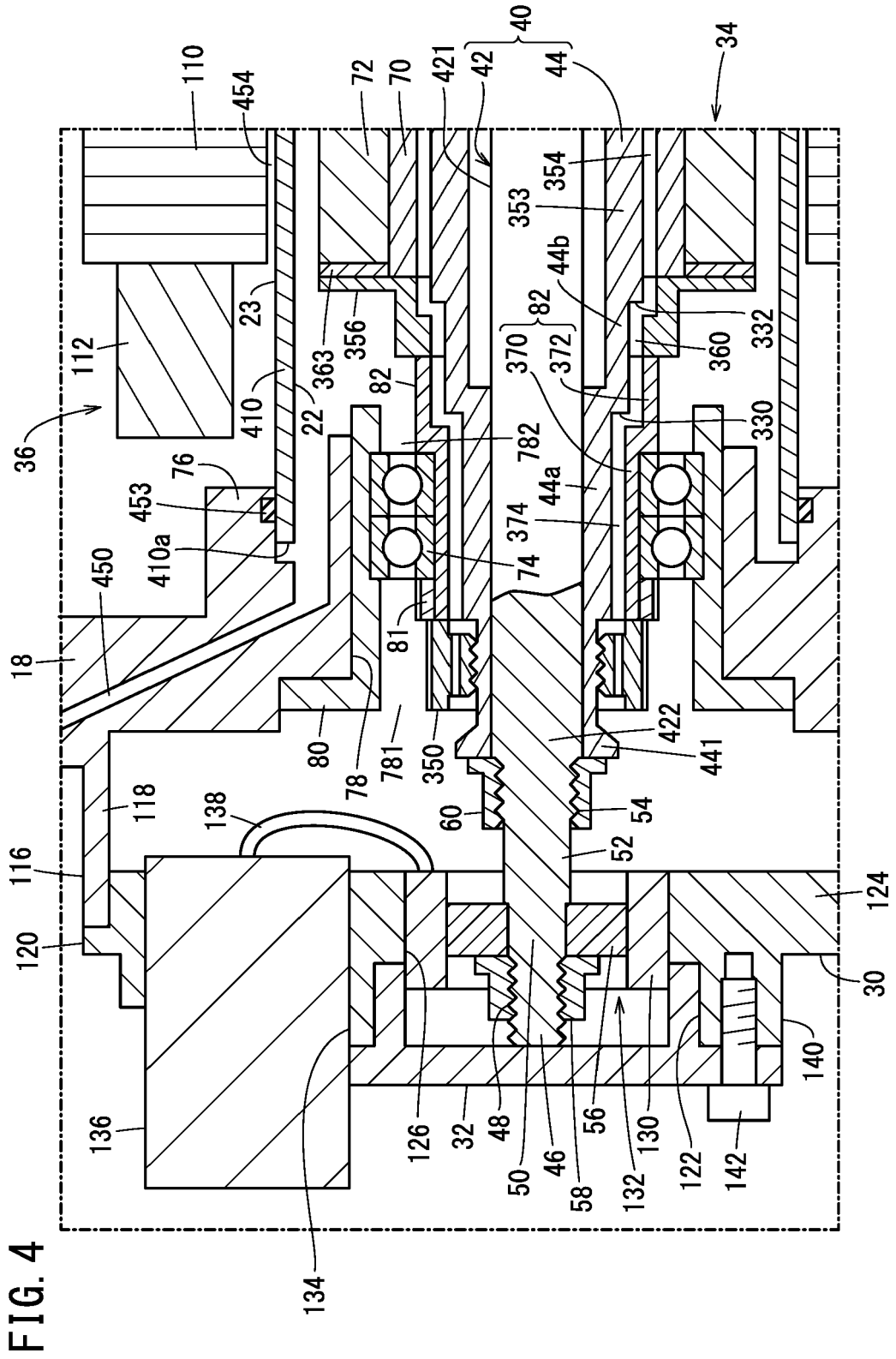


FIG. 2





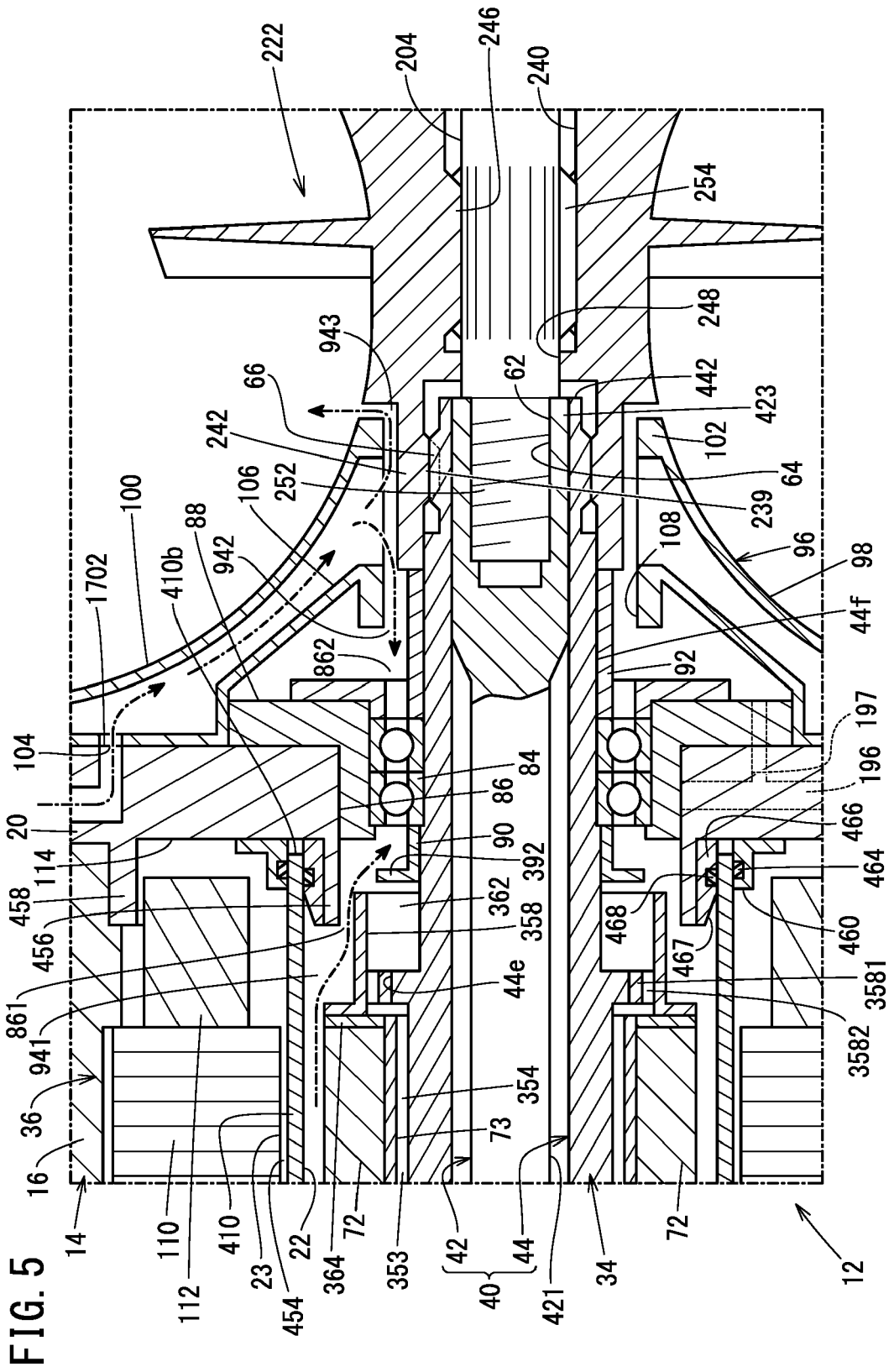


FIG. 5

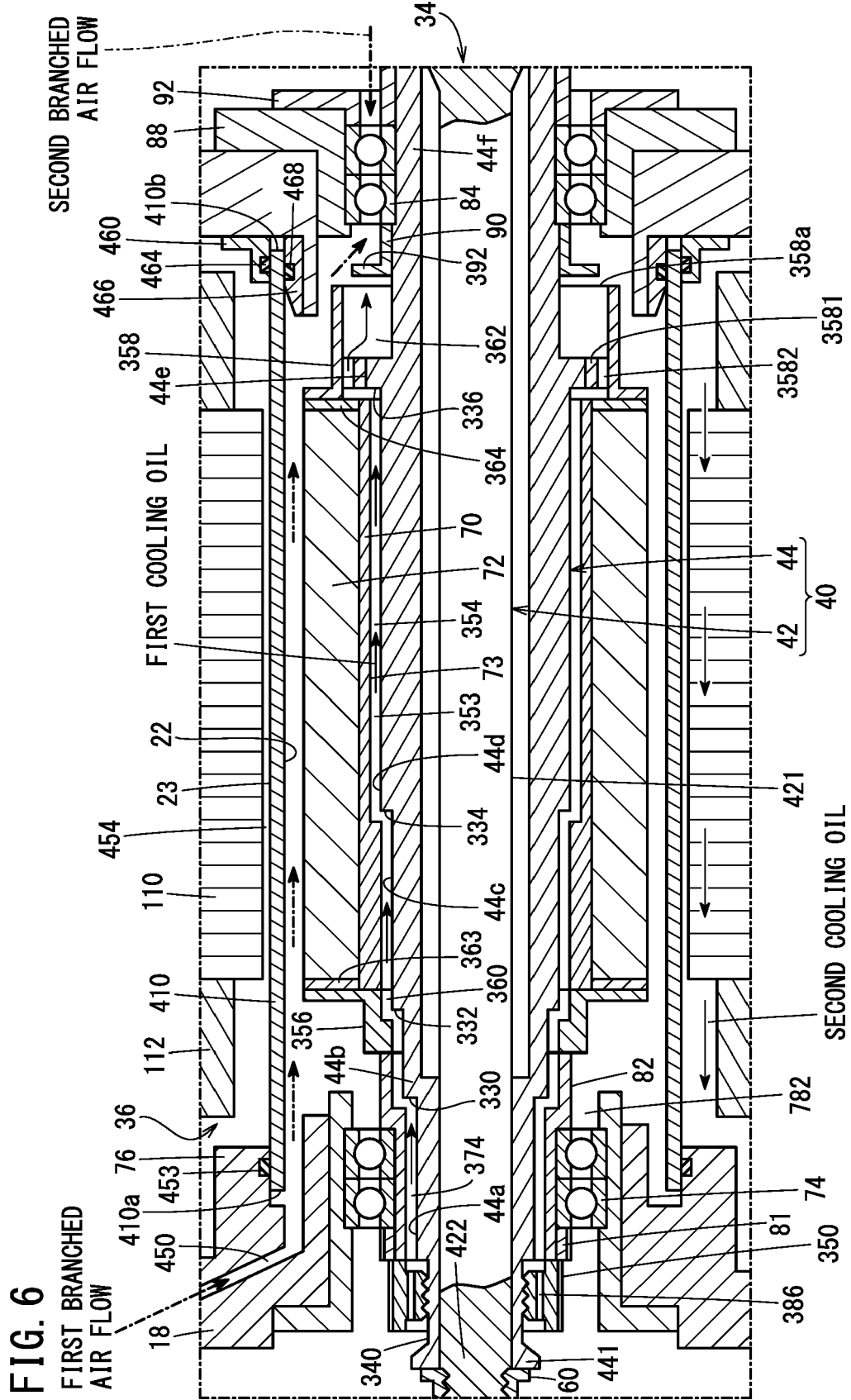


FIG. 6

FIRST BRANCHED AIR FLOW

SECOND BRANCHED AIR FLOW

FIRST COOLING OIL

SECOND COOLING OIL



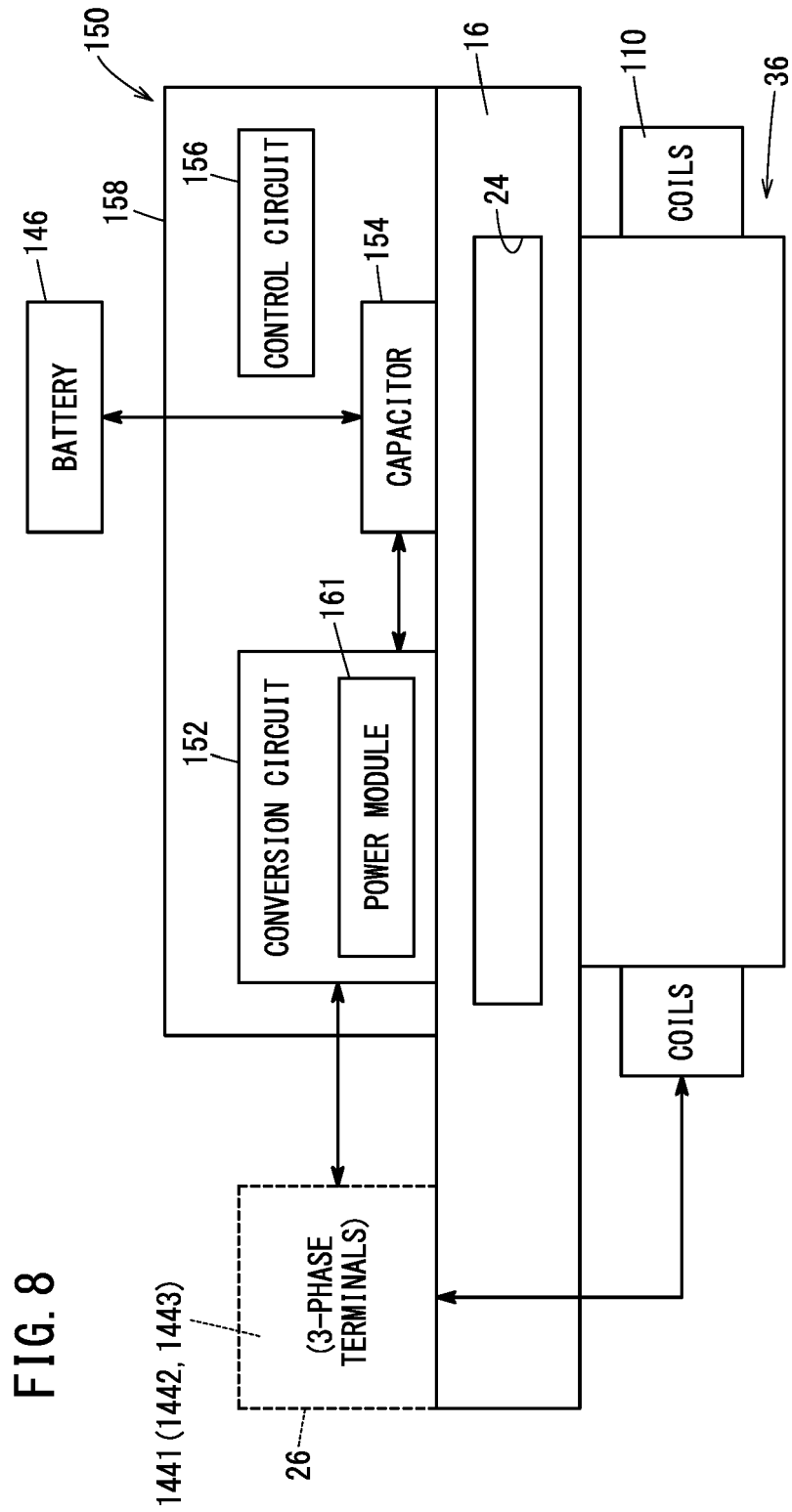


FIG. 8



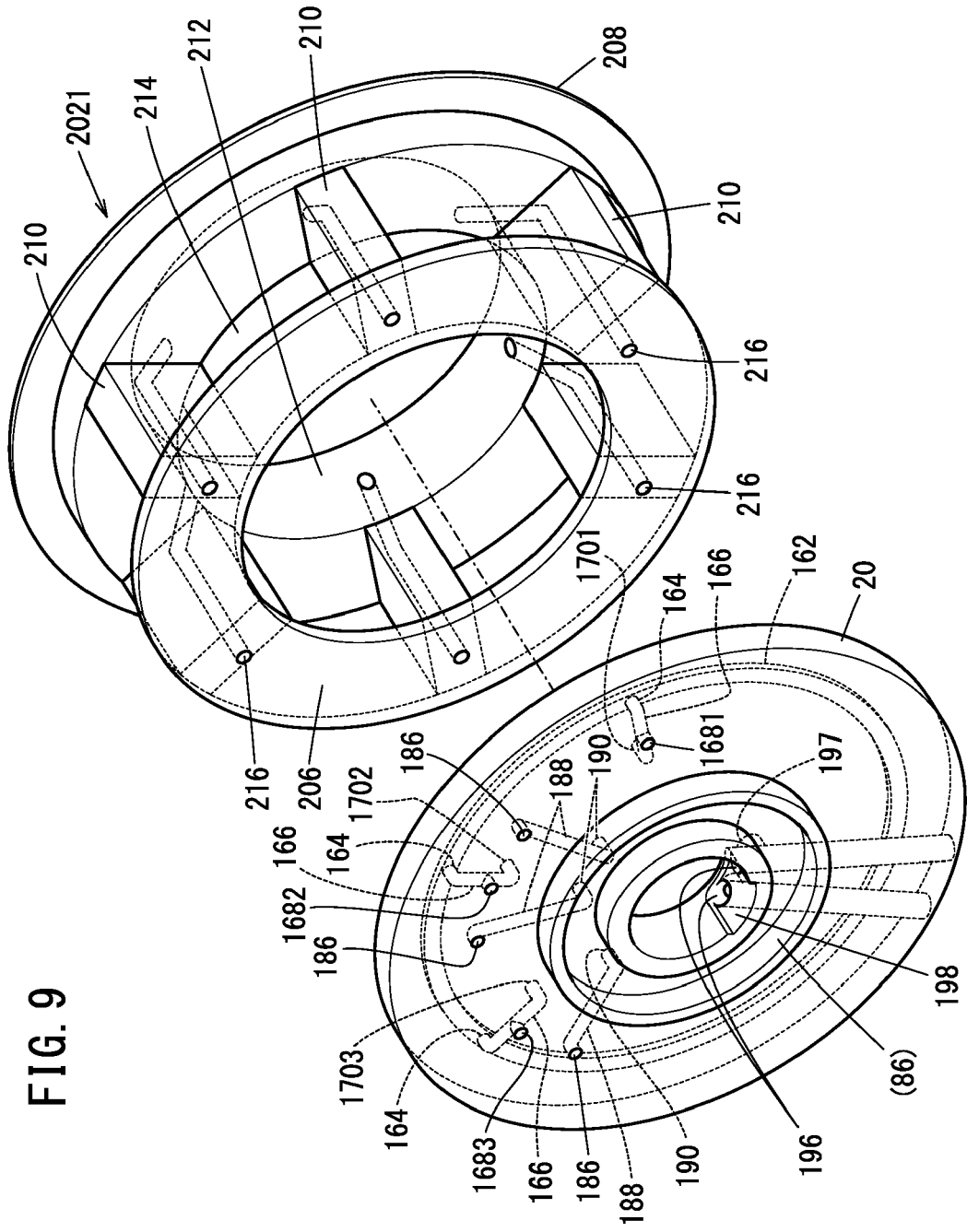


FIG. 9

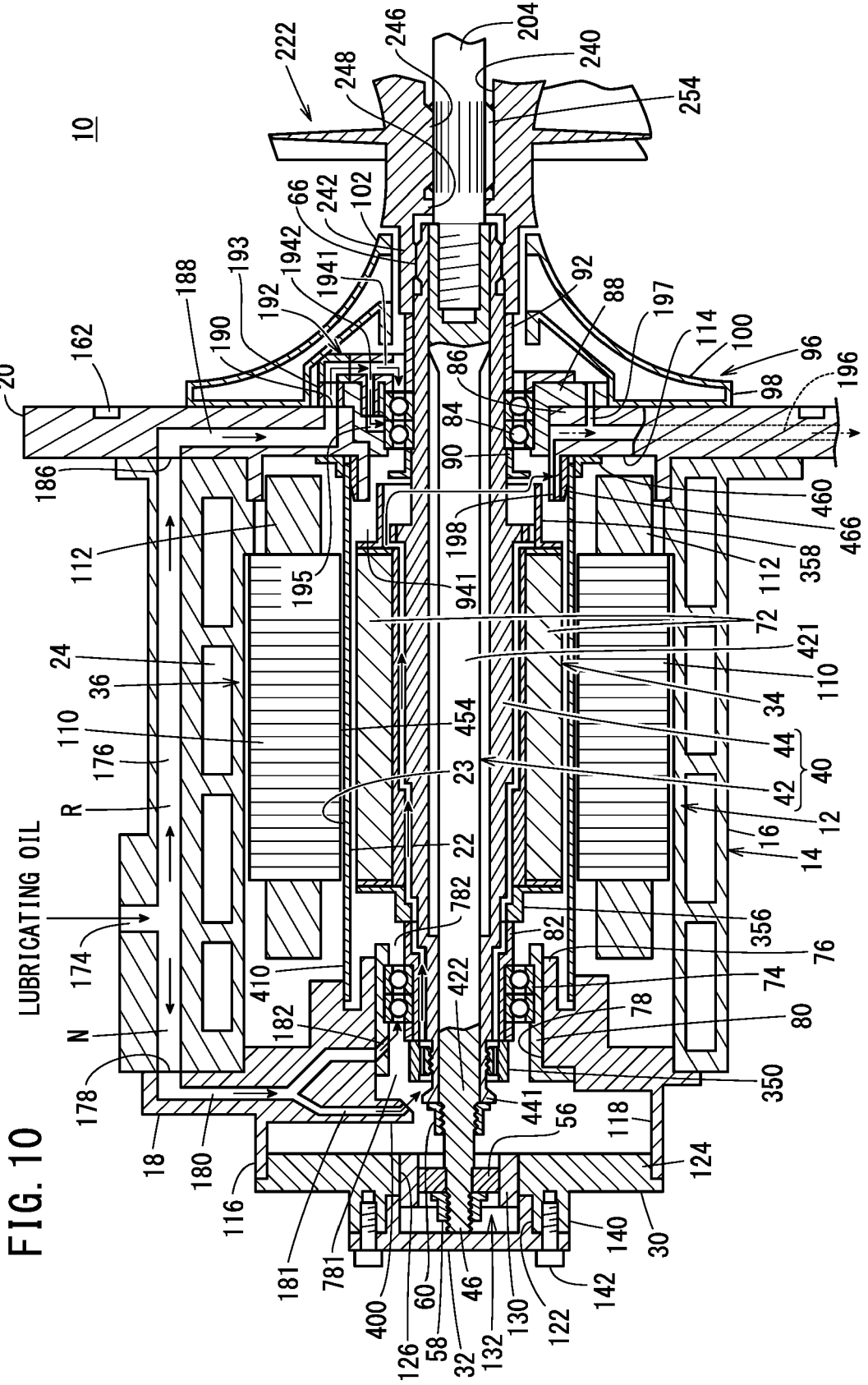


FIG. 10

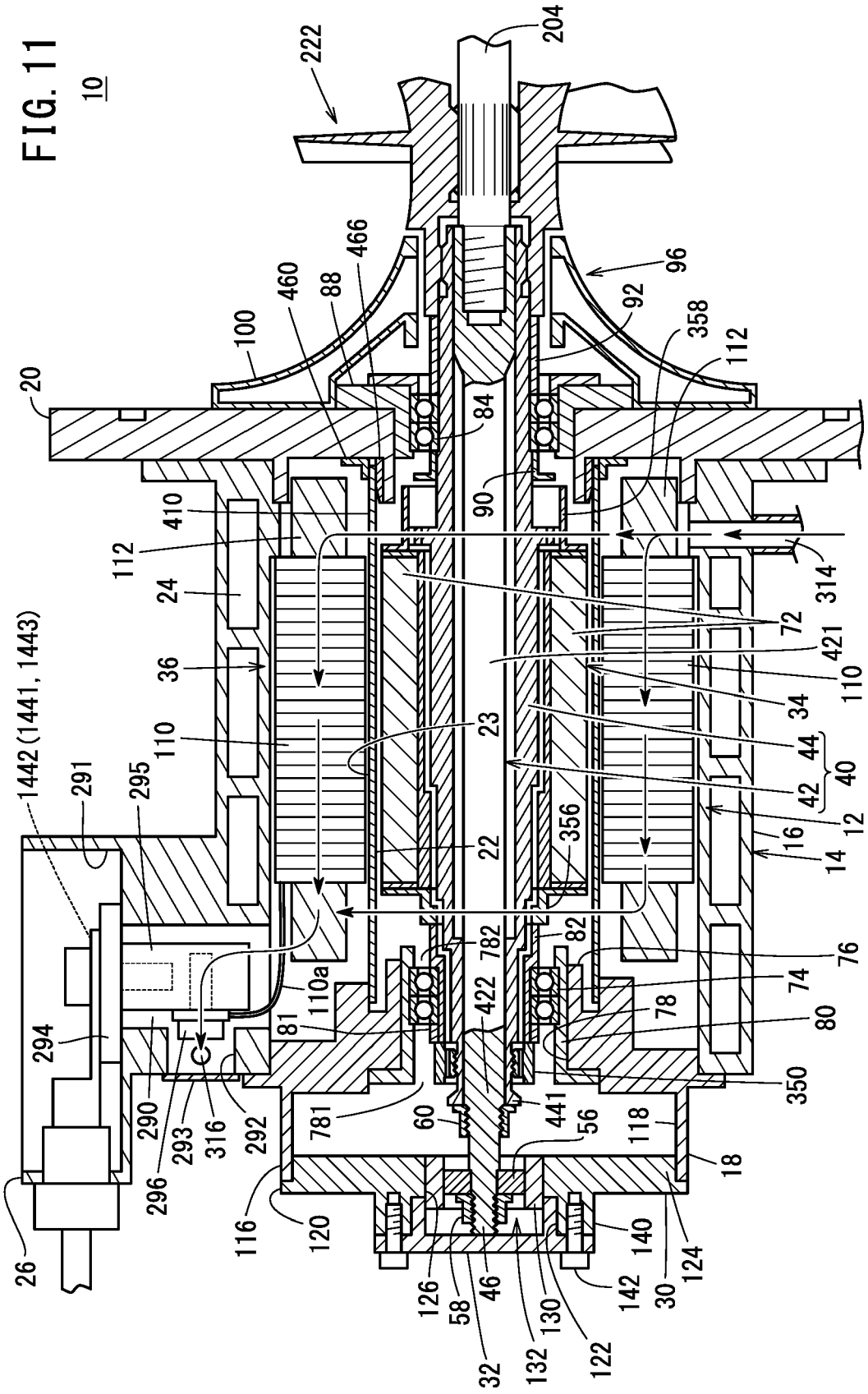
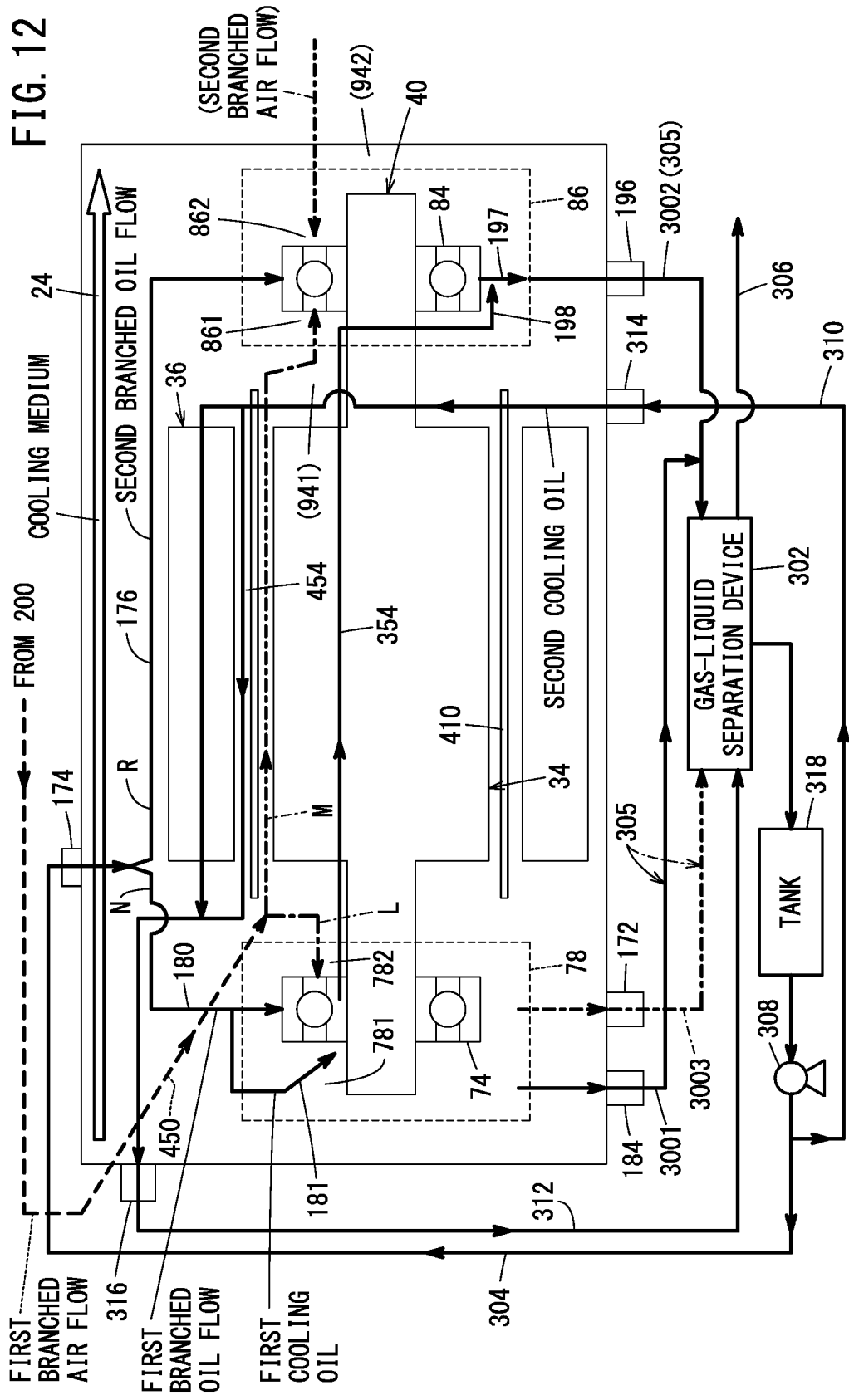
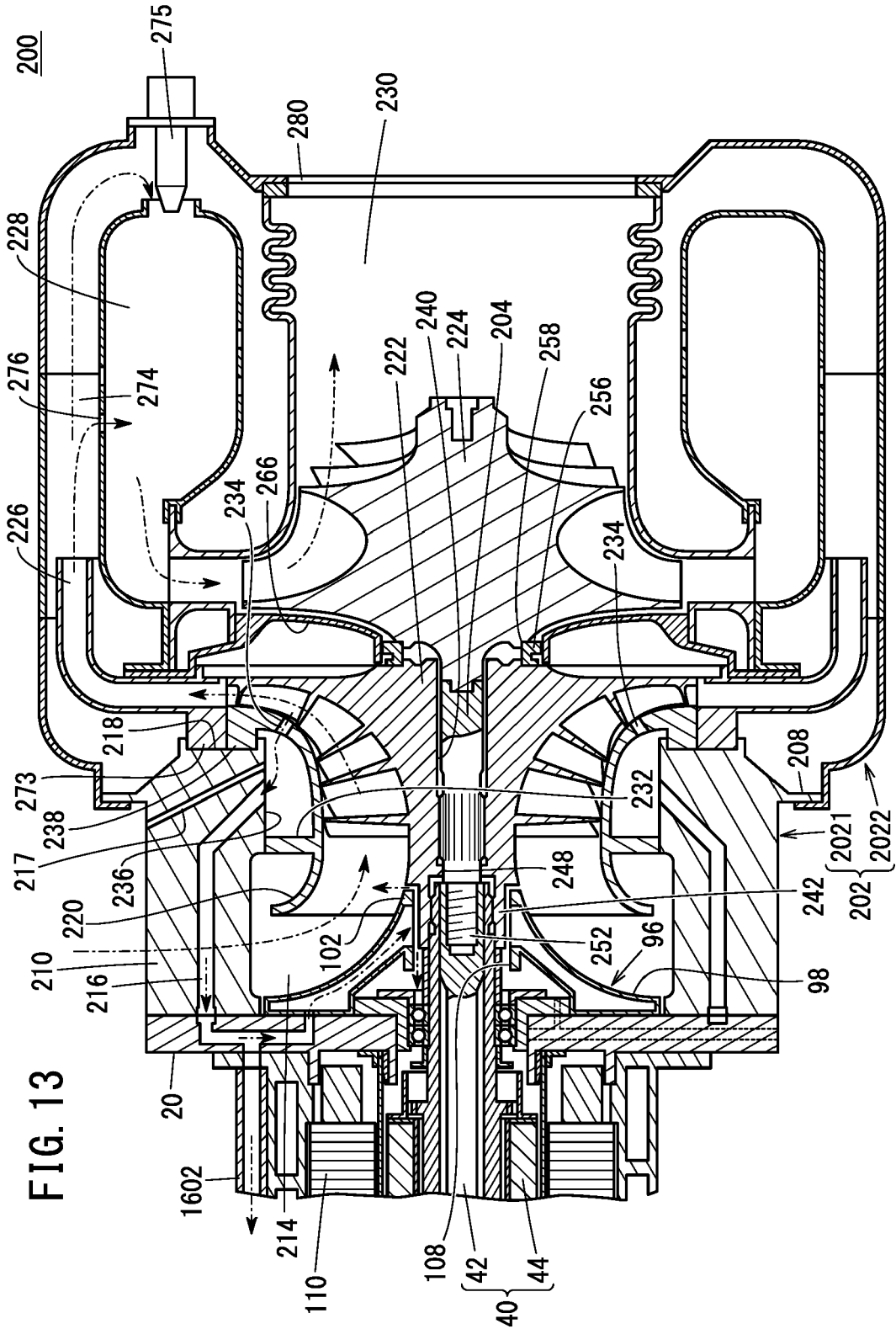


FIG. 11

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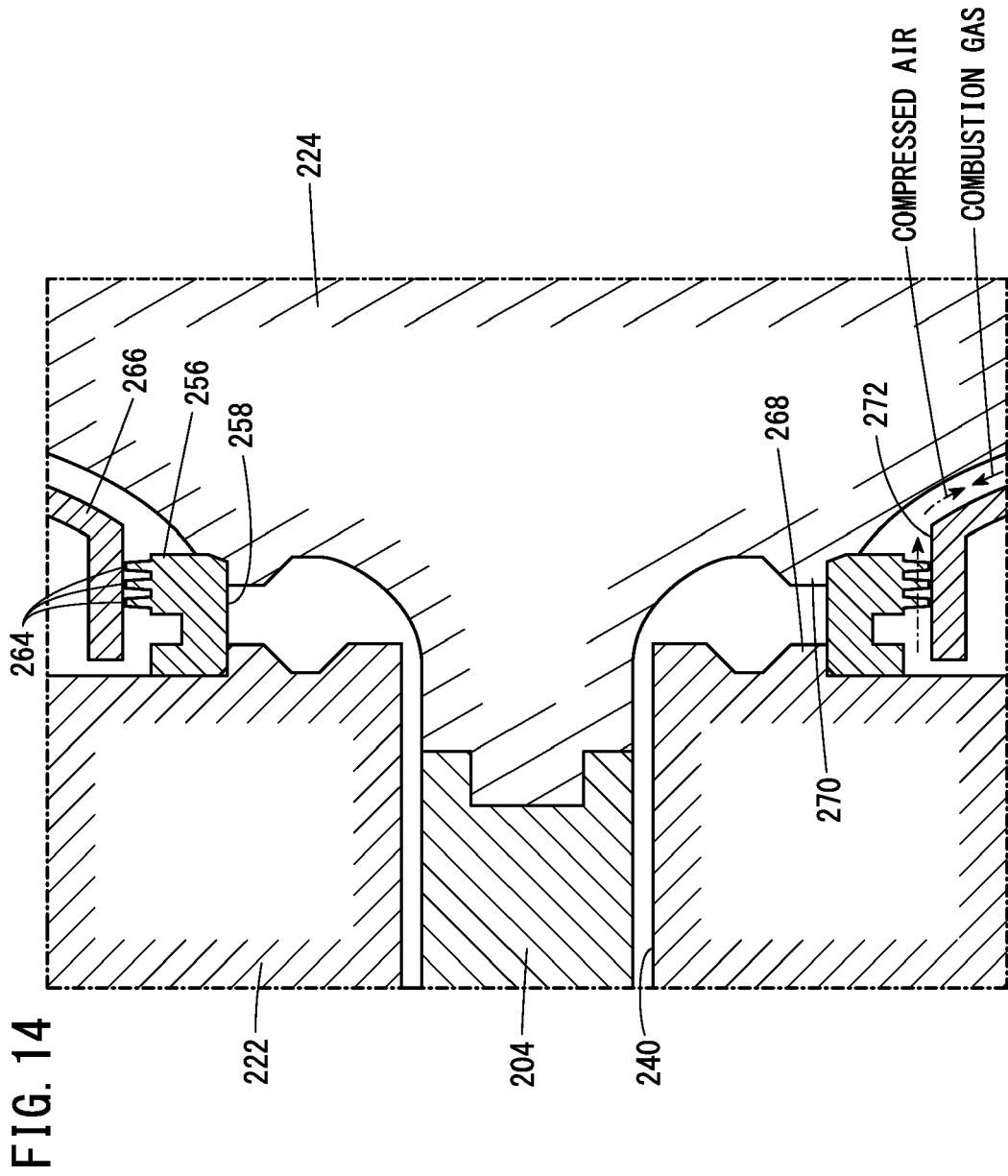
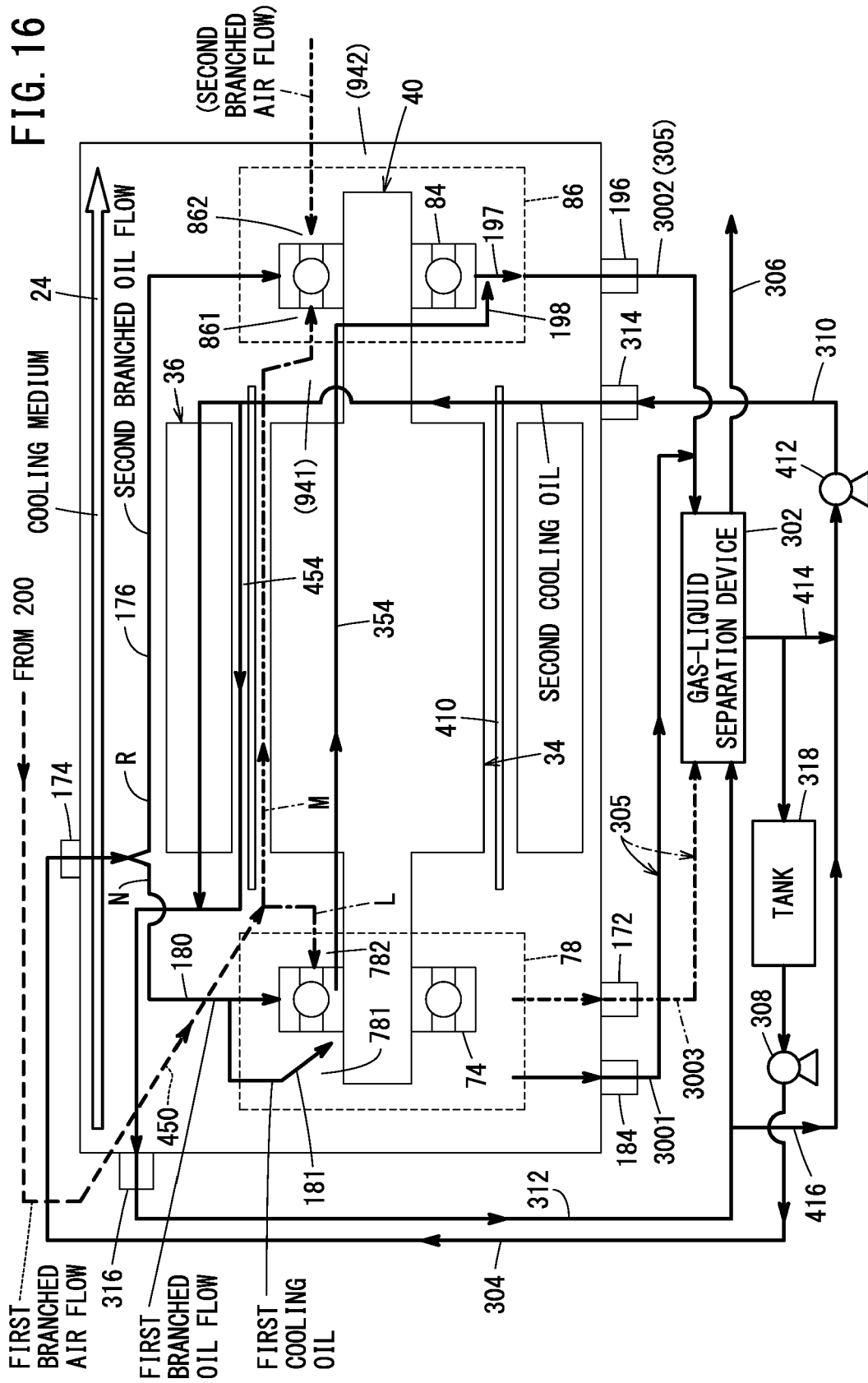




FIG. 16





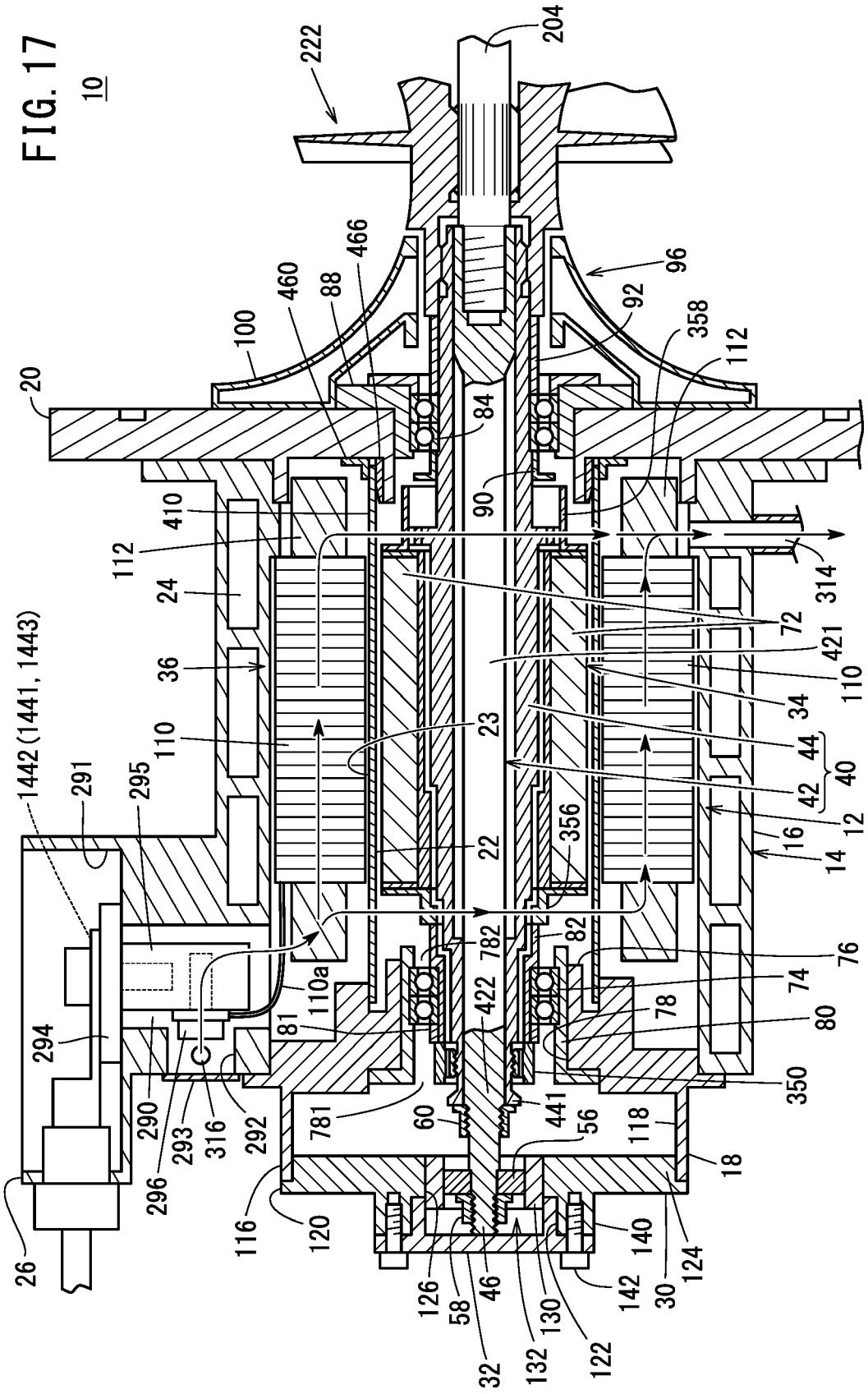


FIG. 17

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EUROPEAN SEARCH REPORT

Application Number  
EP 23 19 0610

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