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(54) ROTARY MACHINE

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USPC ........................................................... **310/58**

(57) **ABSTRACT**

A rotary machine capable of preventing leakage of a coolant and simply and efficiently cooling a rotor is provided. A motor **1** has a rotor **20** made by laminating magnetic steel sheets, a stator **30** arranged around the rotor **20**, a rotary shaft **10** passed through a central part of the rotor **20**, and an annular sleeve **27** arranged between the rotary shaft **10** and the rotor **20**. On an outer circumferential face of the rotary shaft **10**, a groove **12** serving as a coolant flow path for guiding a coolant is formed. The groove **12** may be formed only on the outer circumferential face of the rotary shaft **10**, or only on an inner circumferential face of the sleeve **27**, or on both the outer circumferential face of the rotary shaft **10** and the inner circumferential face of the sleeve **27**.

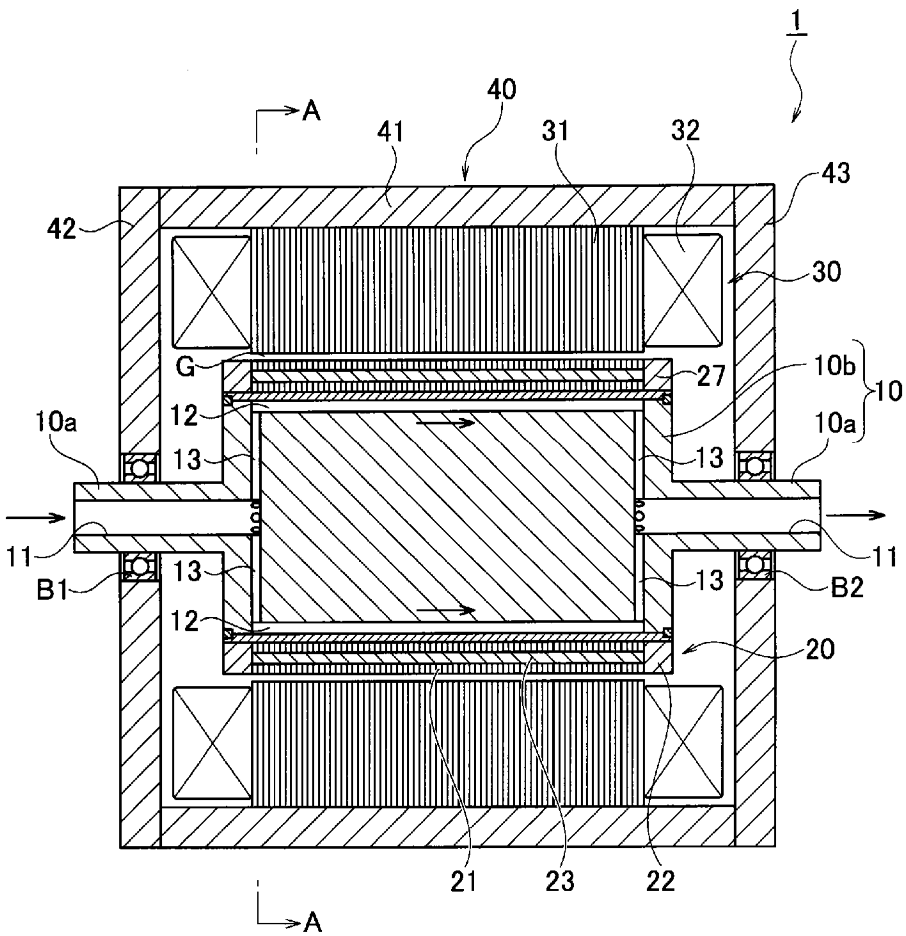


FIG. 1

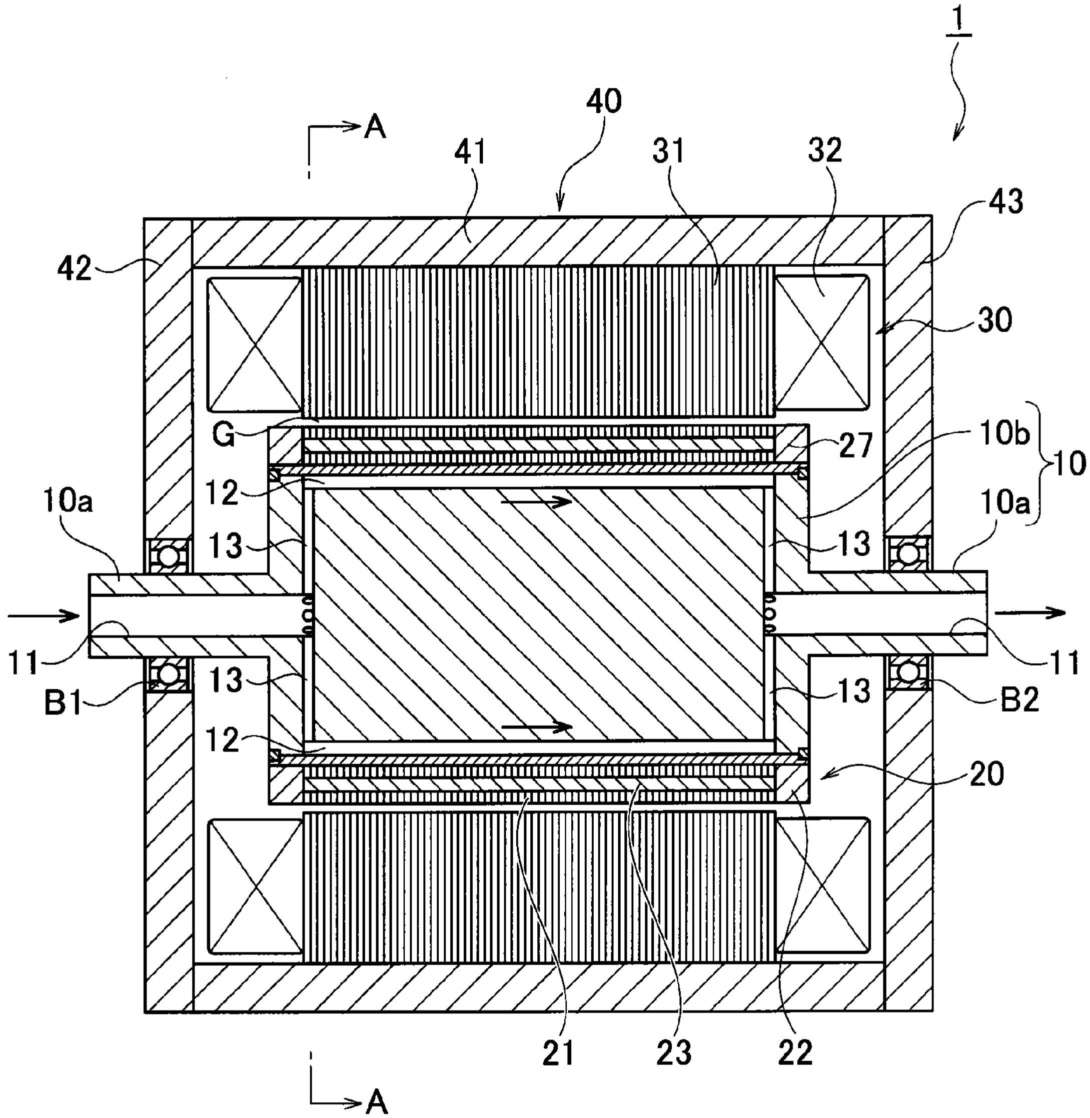

1
40
A
41
31
32
43
42
30
G
27
10b
10
12
10a
10a
13
13
11
11
13
13
B1
B2
12
20
21
23
22
A

FIG. 2

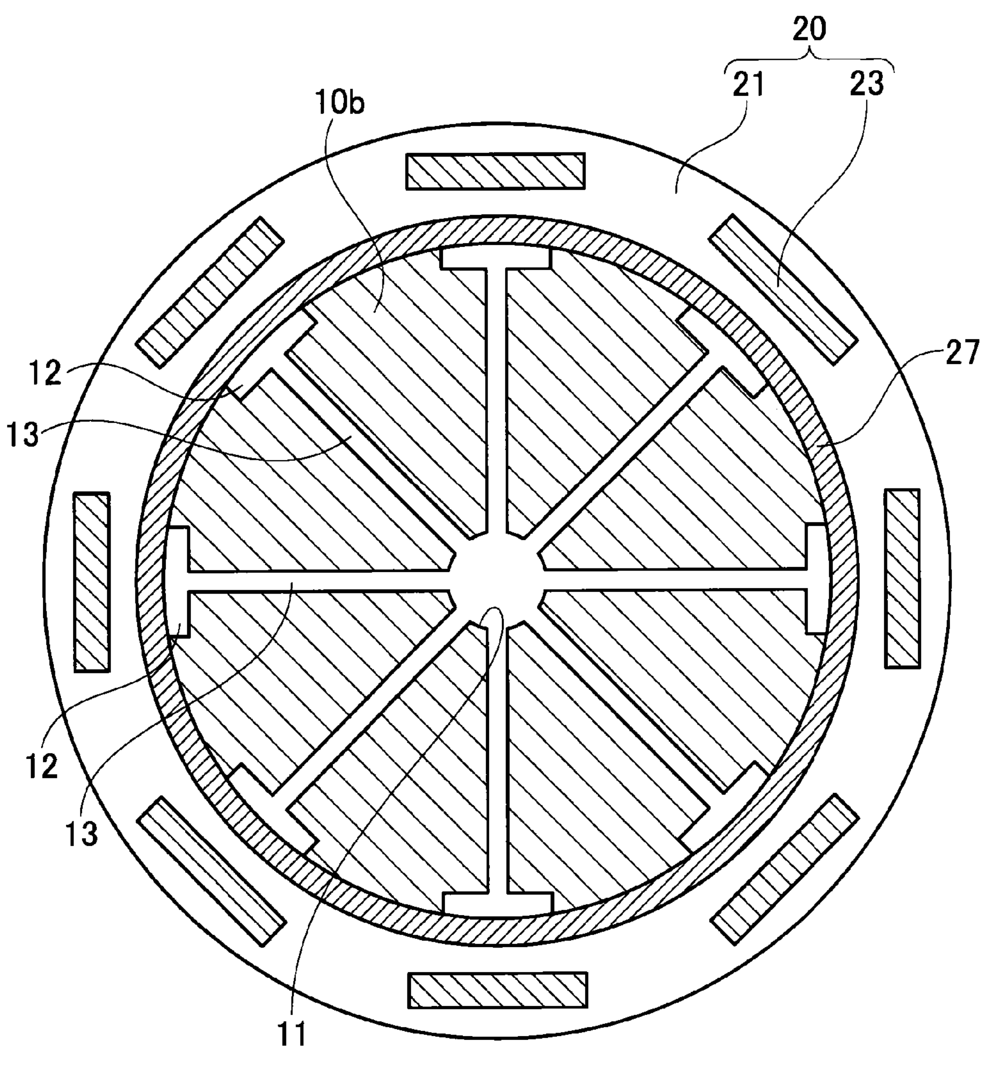
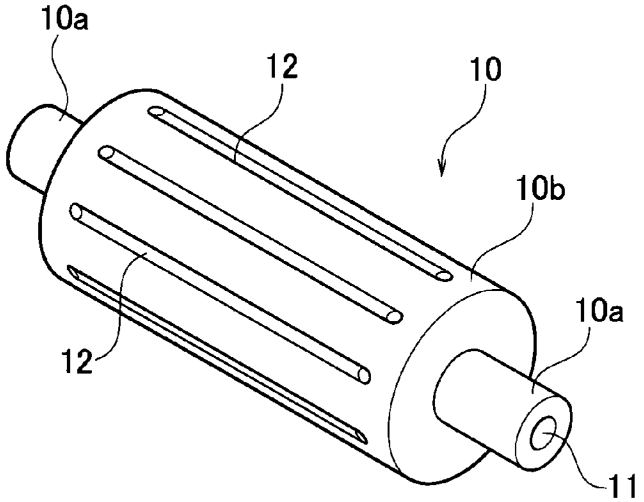
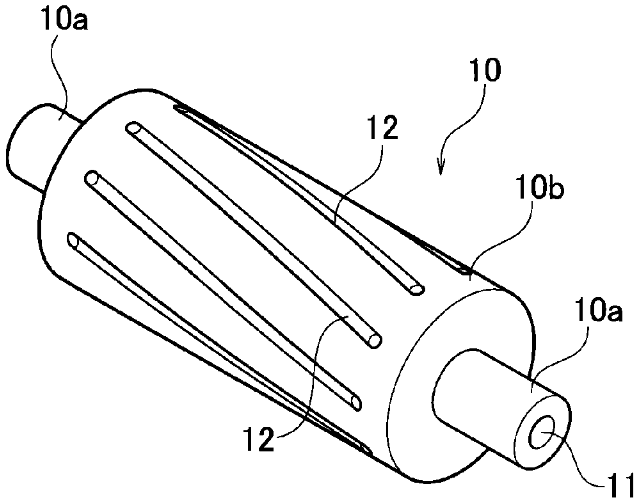


FIG. 3

(a)


10a
12
10
10b
12
10a
11

(b)


10a
12
10
10b
10a
12
11

(c)

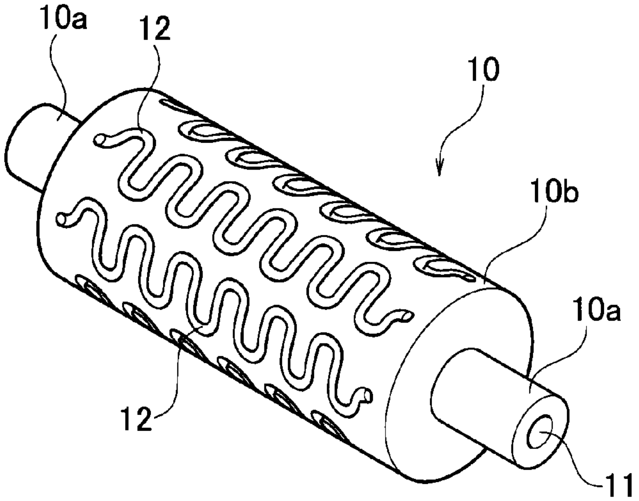
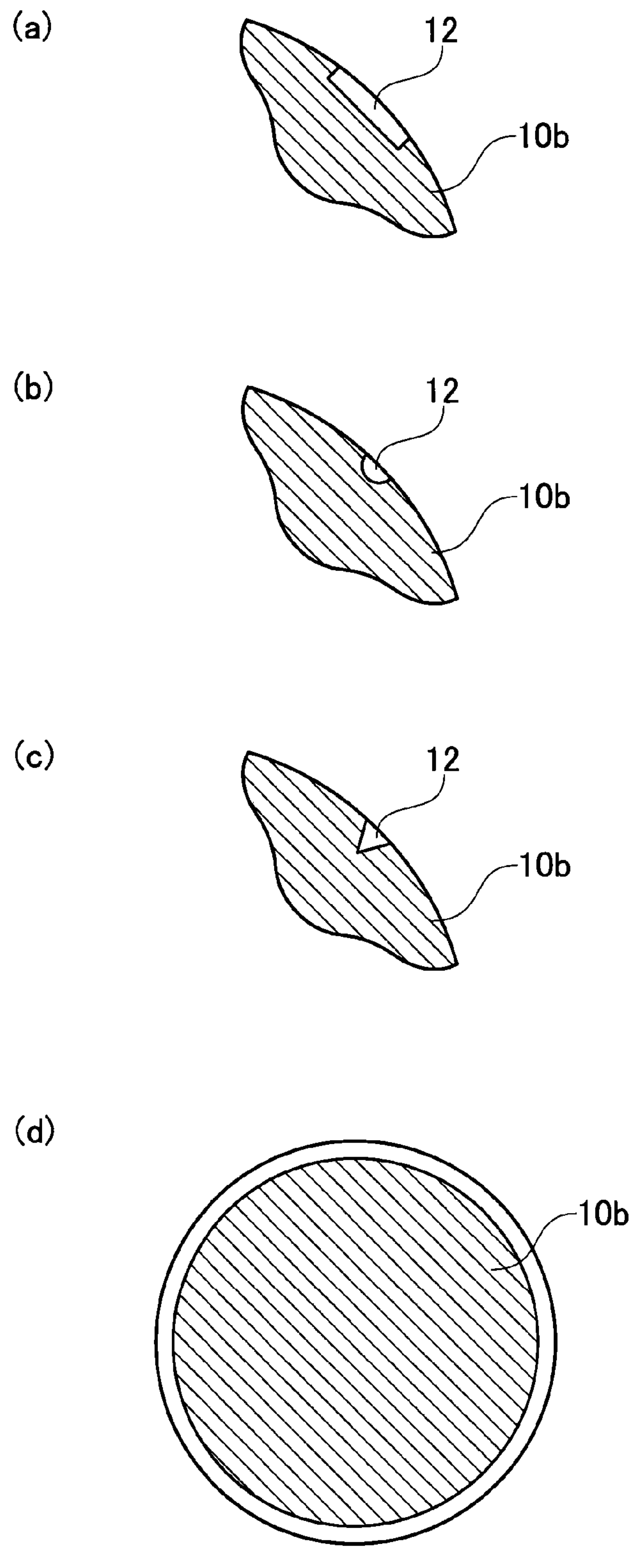

10a
12
10
10b
10a
12
11

FIG. 4



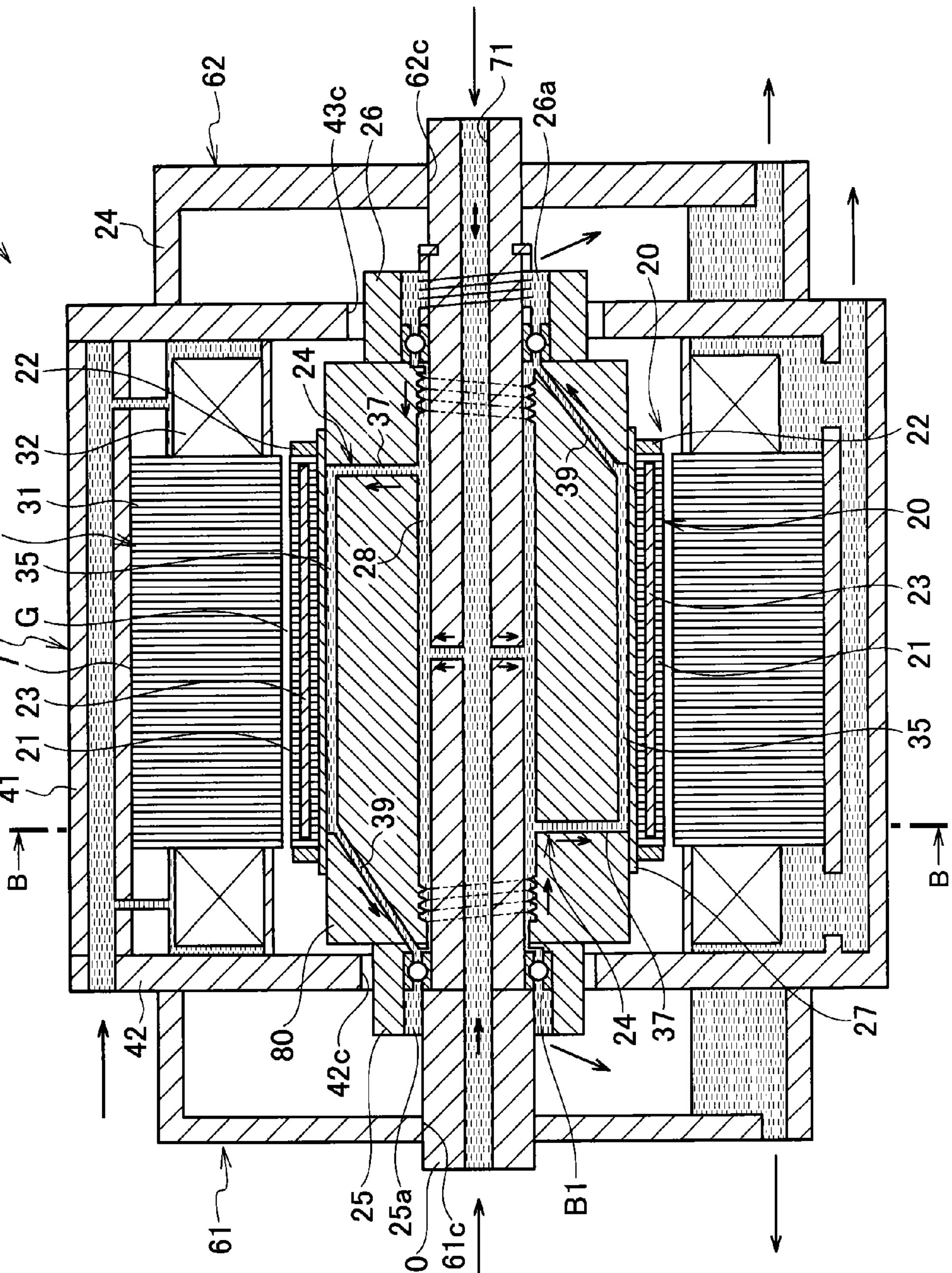

2
62
62c
71
43c
26
26a
24
20
22
32
31
30
35
G
40
7
23
21
41
37
39
28
B
B1
42
42c
80
25
25a
70
61c
61
27

FIG. 5

FIG. 6

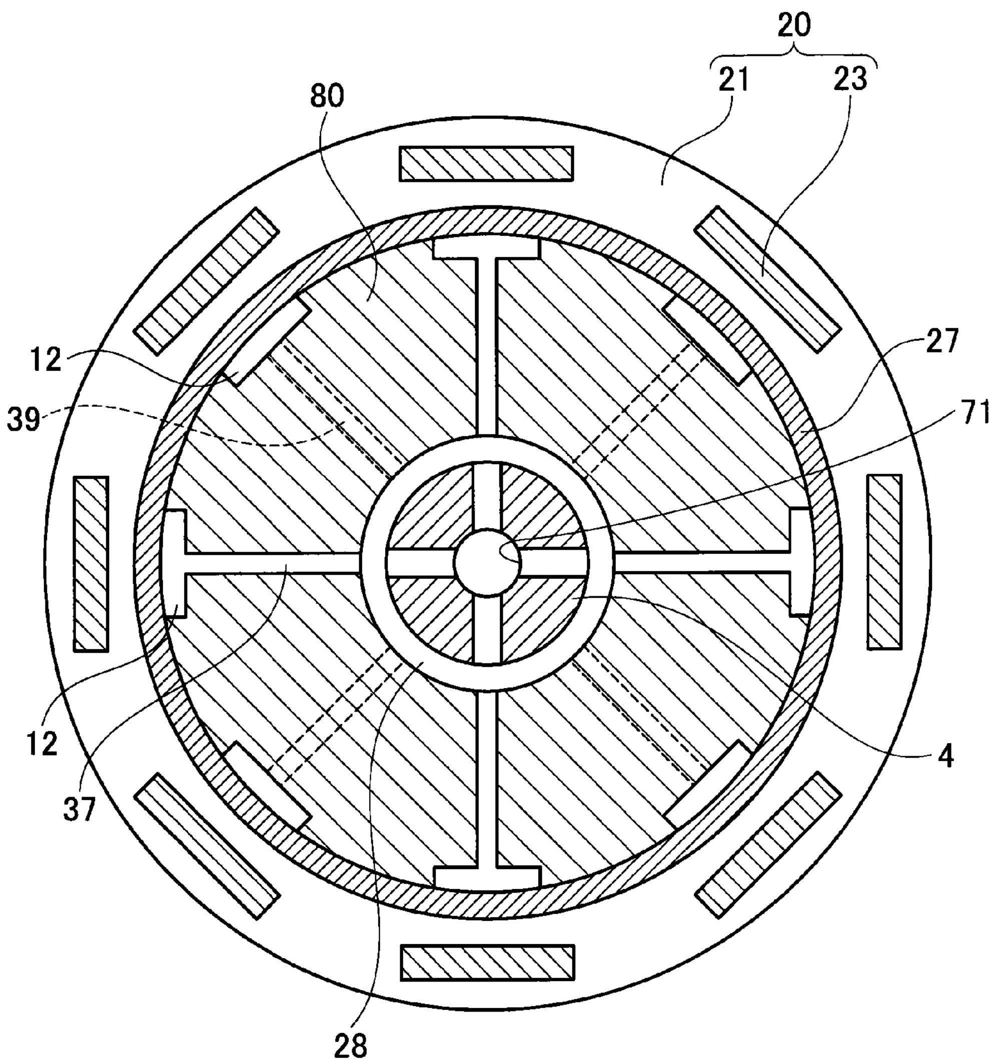


FIG.7

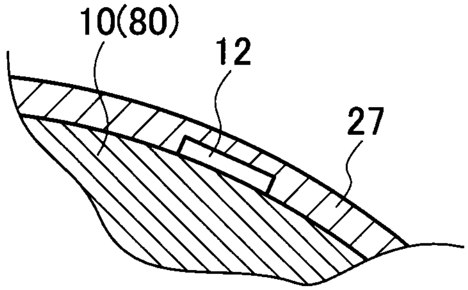



FIG. 8

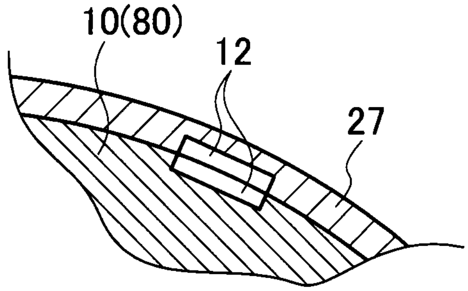


FIG. 9

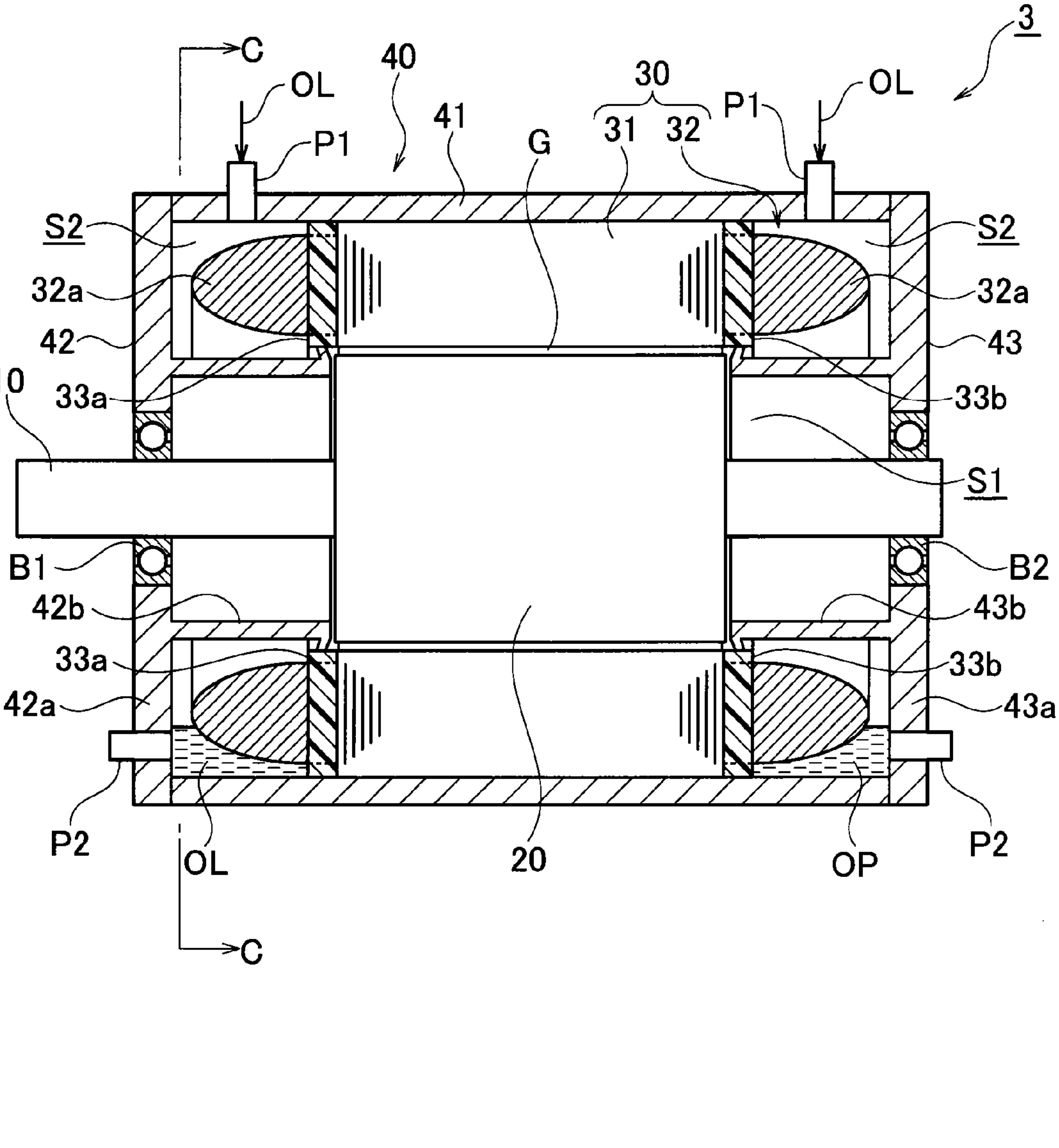

3
C
OL
40
30
P1
OL
41
31
32
P1
G
S2
S2
32a
32a
42
43
10
33a
33b
S1
B1
B2
42b
43b
33a
33b
42a
43a
P2
OL
20
OP
P2
C

FIG. 10

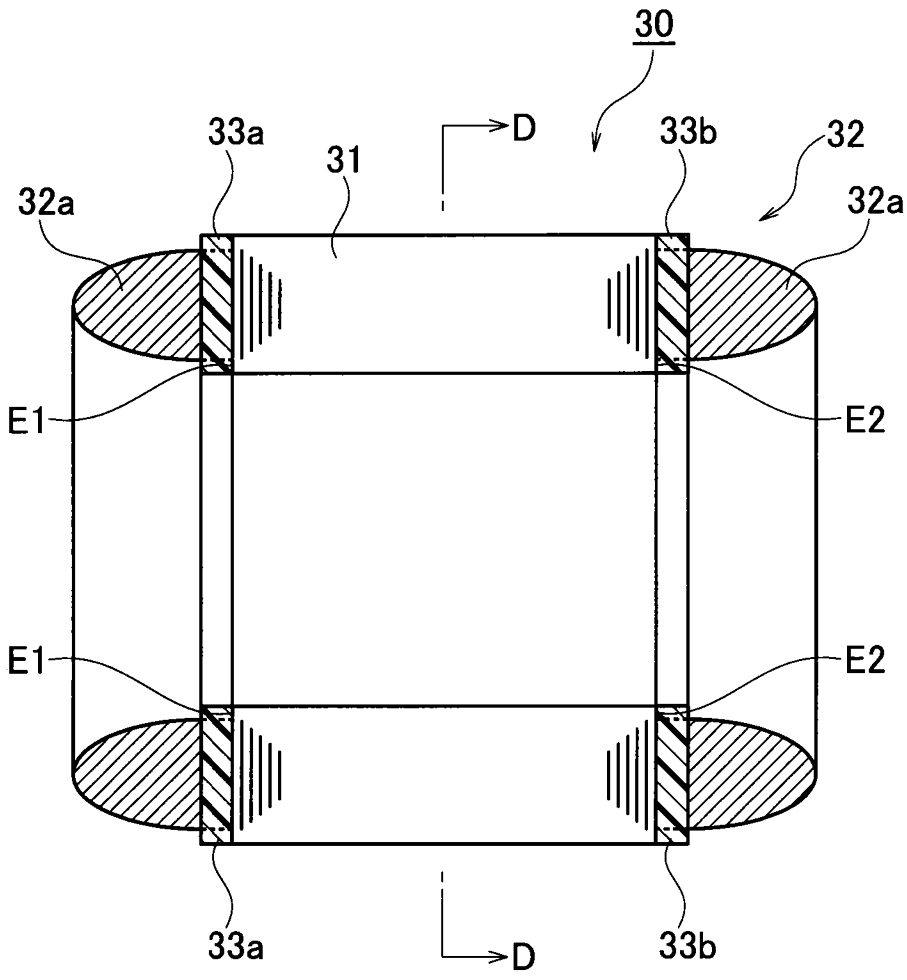


FIG. 11

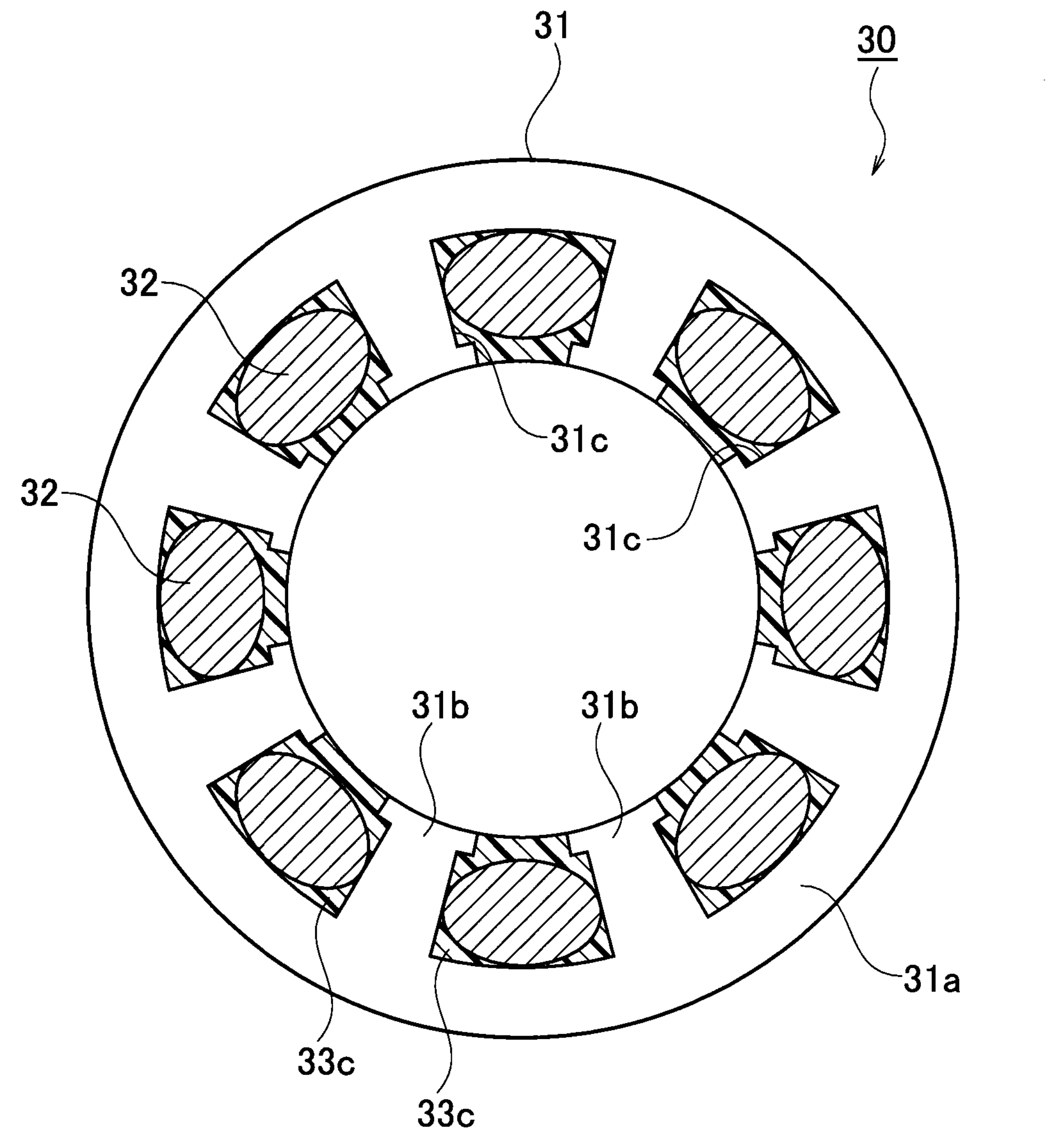


FIG. 12

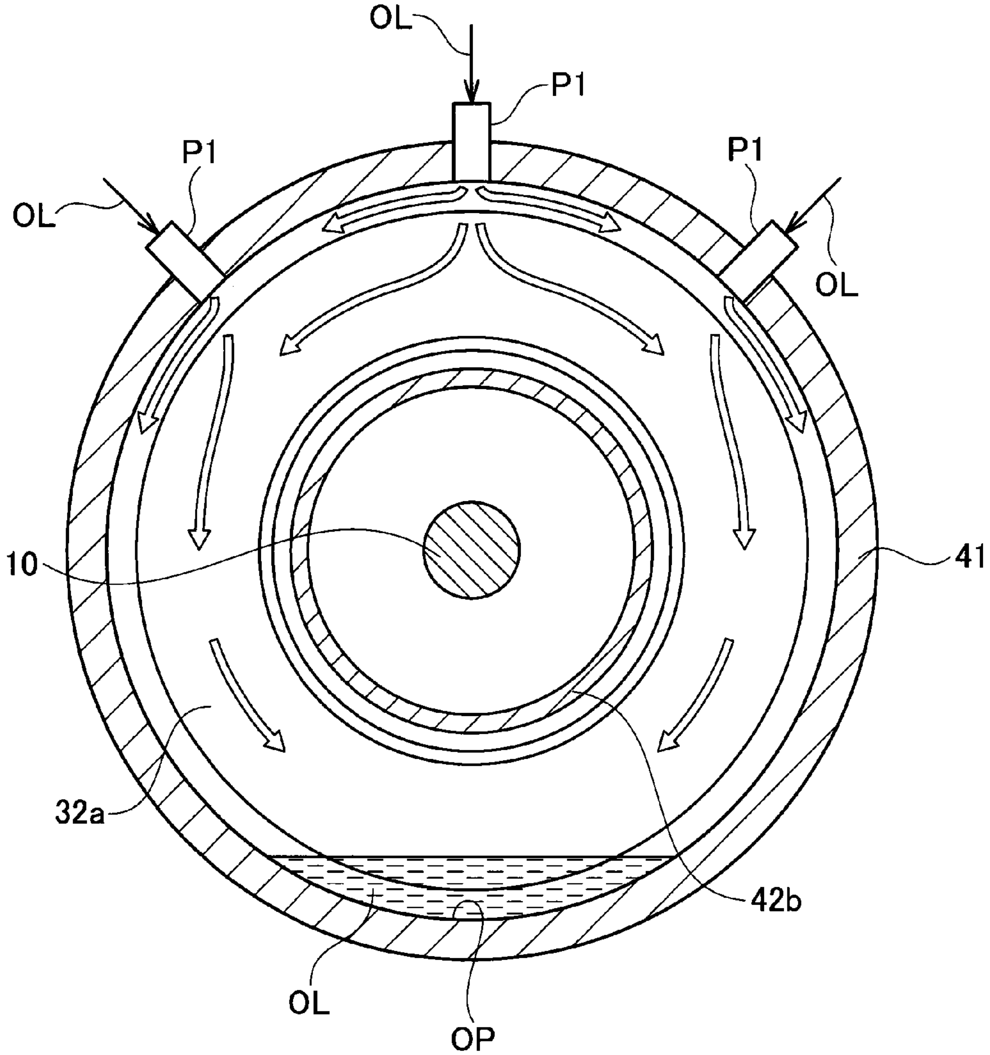


FIG. 13

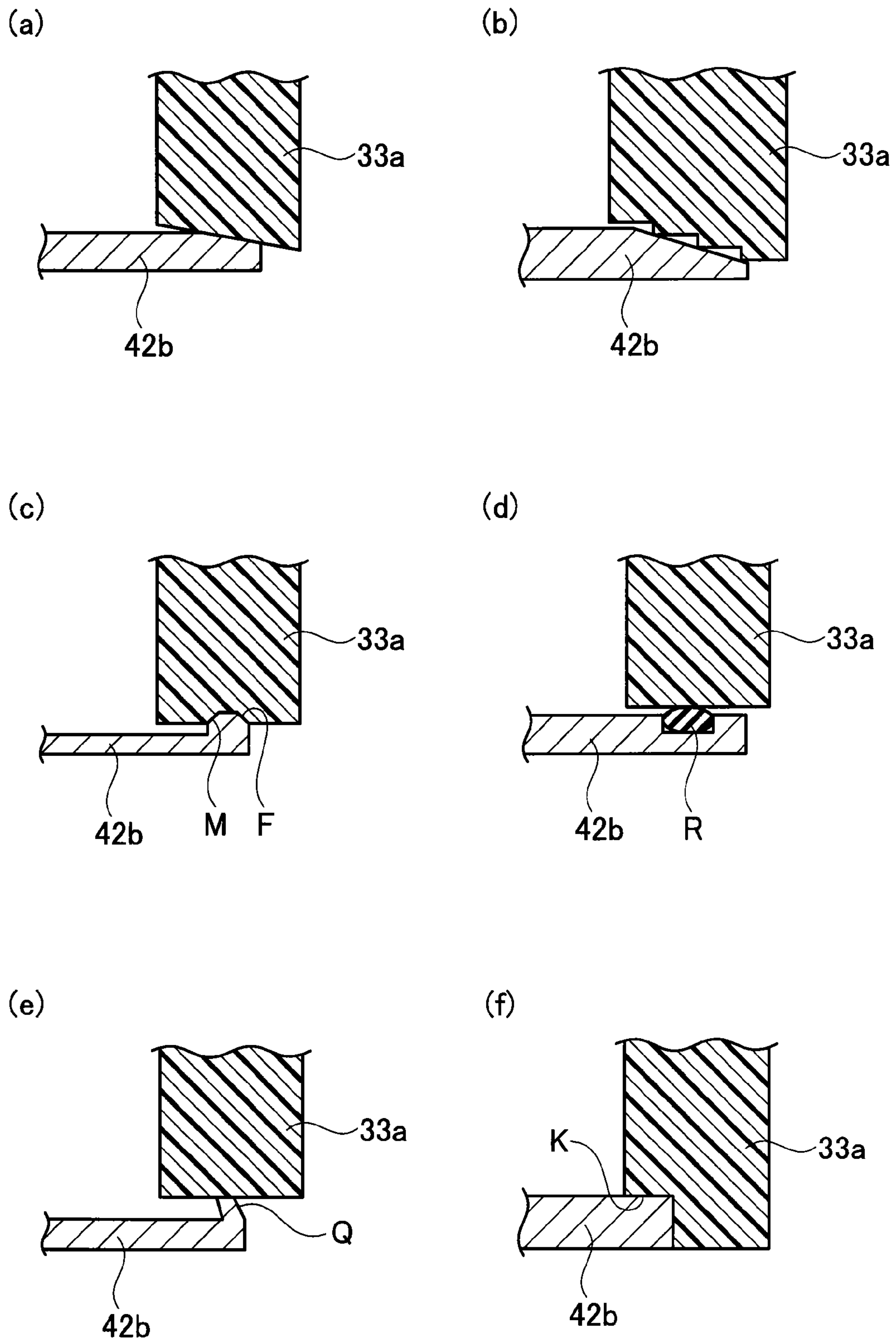
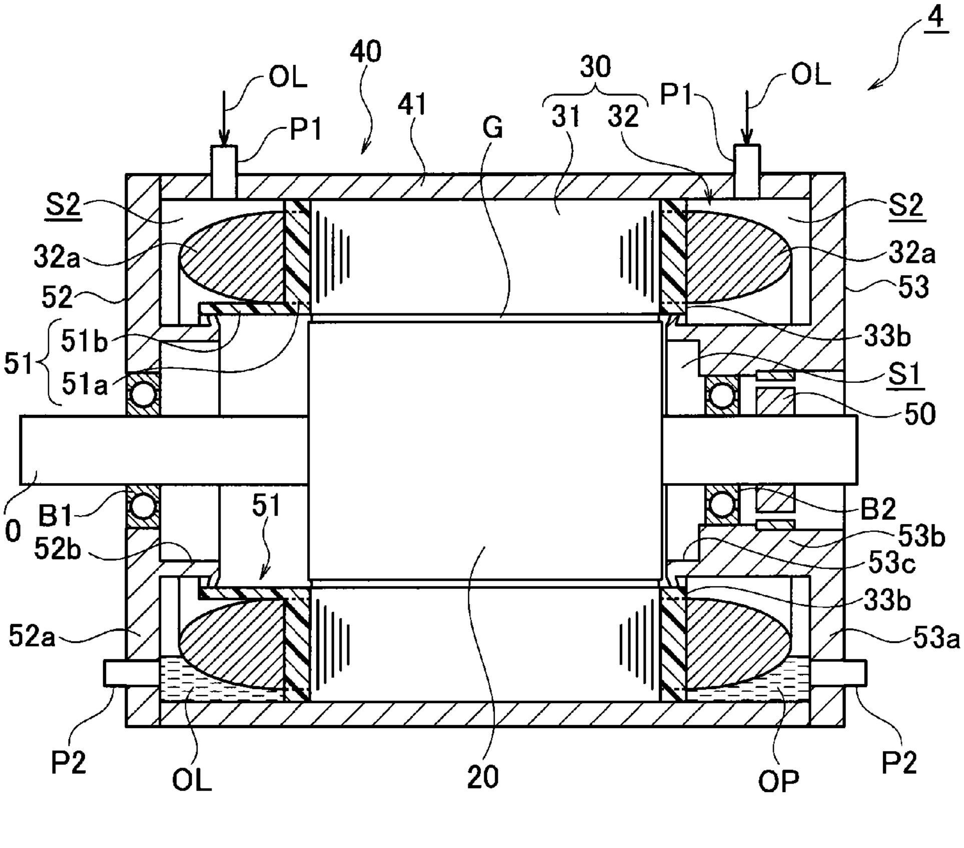


FIG. 14


4
40
30
OL
P1
41
G
31
32
S2
32a
52
53
51b
51
51a
33b
S1
50
10
B1
52b
B2
53b
53c
52a
53a
P2
OL
20
OP

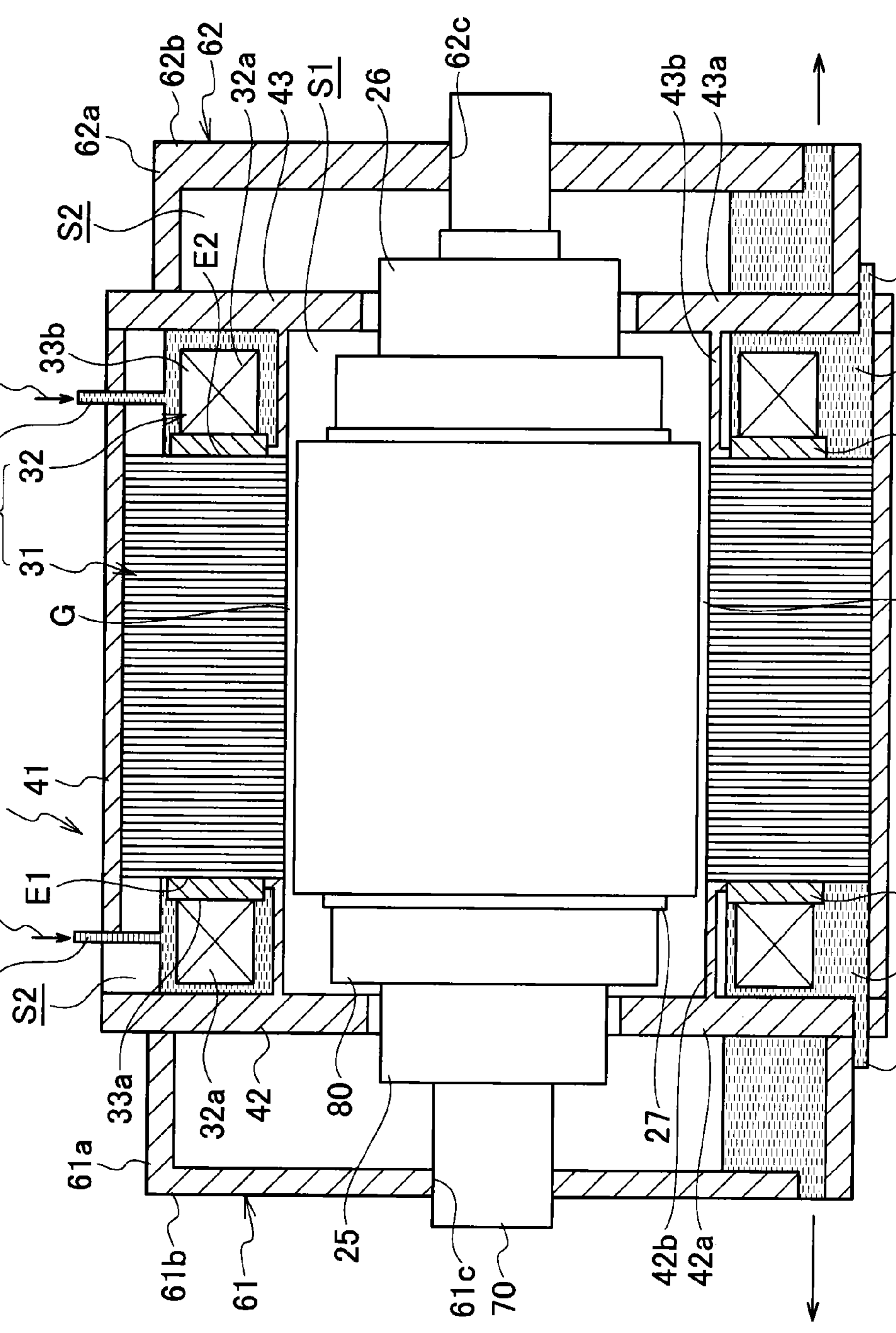

5
62a
62b
62
32a
43
S1
26
62c
43b
43a
S2
E2
P2
33b
P1
OL
OP
32
30
31
G
20
41
40
D
E1
33a
42
80
27
25
61a
61b
61
61c
70
42b
42a

FIG. 15

# ROTARY MACHINE

## TECHNICAL FIELD

**[0001]** The present invention relates to a rotary machine employing a coolant to cool a motor.

## BACKGROUND ART

**[0002]** Cooling a rotary machine used for an electric vehicle and the like with the use of a coolant is useful to efficiently generate driving force (torque) by use of electric power. As an example of such a cooling technique for a rotary machine, there is a technique of cooling a rotor incorporating permanent magnets with a coolant. Related arts are disclosed in Japanese Unexamined Patent Application Publications No. 2002-345188, No. 2010-220340, and No. 2010-252544 and Japanese Patent Publication No. 4469670.

## CITATION LIST

### Patent Literature

**[0003]** Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2002-345188

**[0004]** Patent Literature 2: Japanese Unexamined Patent Application Publication No. 2010-220340

**[0005]** Patent Literature 3: Japanese Unexamined Patent Application Publication No. 2010-252544

**[0006]** Patent Literature 4: Japanese Patent Publication No. 4469670

## SUMMARY OF INVENTION

### Problem to be Solved by Invention

**[0007]** In connection with using a coolant to cool a rotor incorporating permanent magnets of a rotary machine, the present inventors have studied the structural details of the rotary machine to further improve cooling efficiency. During the studying process, it has been found that further suppressing a mechanical loss of the rotary machine has a room for improvement in connection with a structure for cooling the rotor that incorporates permanent magnets with a coolant. The present invention has been made in consideration of this issue and an object of the present invention is to provide a rotary machine that converts electric power into torque, or torque into electric power at higher efficiency.

### Means to Solve Problem

**[0008]** An aspect of the present invention provides a rotary machine including a rotor made by laminating magnetic steel sheets; a stator arranged around the rotor; a rotary body passed through a central part of the rotor; an annular sleeve member arranged between the rotary body and the rotor; and a recess formed on at least one of an outer circumferential face of the rotary body and an inner circumferential face of the sleeve member and serving as a coolant flow path to guide a coolant.

### Effects of Invention

**[0009]** According to the rotary machine of the present invention, a mold member is formed at each end of a stator core, to cover a base part of a coil end part. A partition member is attached in contact with the mold member, to separate a first space accommodating the rotor from a second space accommodating the coil end part. Accordingly, there is provided an effect of realizing efficient cooling without increasing costs or deteriorating performance.

## BRIEF DESCRIPTION OF DRAWINGS

**[0010]** FIG. **1** is a sectional side view illustrating the structure of a motor, i.e., a rotary machine according to a first embodiment of the present invention.

**[0011]** FIG. **2** is a sectional view taken along a line A-A of FIG. **1** as seen from an arrowed direction.

**[0012]** FIG. **3** is a perspective view of a rotary shaft of the motor, i.e., the rotary machine according to the first embodiment of the present invention.

**[0013]** FIG. **4** is a view illustrating grooves formed on the rotary shaft of the motor, i.e., the rotary machine according to the first embodiment of the present invention.

**[0014]** FIG. **5** is a sectional side view illustrating the structure of a motor, i.e., a rotary machine according to a second embodiment of the present invention.

**[0015]** FIG. **6** is a sectional view taken along a line B-B of FIG. **5** as seen from an arrowed direction;

**[0016]** FIG. **7** is a sectional view illustrating a sectional shape of a groove formed on a sleeve of FIG. **1** or **5**.

**[0017]** FIG. **8** is a sectional view illustrating a sectional shape of a groove formed on the rotary body and sleeve of FIG. **1** or **5**.

**[0018]** FIG. **9** is a sectional side view illustrating the structure of a motor, i.e., a rotary machine according to a third embodiment of the present invention.

**[0019]** FIG. **10** is a sectional side view illustrating a stator extracted from the rotary machine according to the third embodiment of the present invention.

**[0020]** FIG. **11** is a sectional view taken along a line D-D of FIG. **10** as seen from an arrowed direction.

**[0021]** FIG. **12** is a sectional view taken along a line C-C of FIG. **9** as seen from an arrowed direction.

**[0022]** FIG. **13** is a view illustrating sealing methods for a partition member according to the third embodiment of the present invention.

**[0023]** FIG. **14** is a sectional side view illustrating the structure of a motor, i.e., a rotary machine according to a fourth embodiment of the present invention.

**[0024]** FIG. **15** is a sectional side view illustrating the structure of a motor, i.e., a rotary machine according to a fifth embodiment of the present invention.

## MODE OF IMPLEMENTING INVENTION

**[0025]** Rotary machines according to embodiments of the present invention will be explained in detail with reference to the drawings. In the embodiments mentioned below, the rotary machines each are, as an example, a motor (an electric motor) driven and rotated with an externally supplied current (such as a three-phase AC current).

### First Embodiment

**[0026]** FIG. **1** is a sectional side view illustrating the structure of a motor, i.e., a rotary machine according to the first embodiment of the present invention. FIG. **2** is a sectional view taken along a line A-A of FIG. **1** as seen from an arrowed direction.

**[0027]** As illustrated in FIG. **1**, the motor **1** has a rotary shaft **10**, a rotor (rotator) **20**, a sleeve (sleeve member) **27**, a stator (stationary element) **30**, and a housing **40**. An externally supplied current creates electromagnetic force between the rotor **20** and the stator **30**, to rotate the rotor **20**, thereby rotationally driving the rotary shaft **10**. In the following explanation, a left-right direction of FIG. **1** in which the rotary shaft **10** extends is referred to as "axial direction".

**[0028]** The rotary shaft **10** is a shaft member to transmit torque of the rotor **20** to the outside and includes a first shaft part (first rotary body part) **10***a* and a second shaft part (second rotary body part) **10***b*. The first shaft part **10***a* has a cylindrical shape and extends leftward in the axial direction from a central part of a left side face of the second shaft part **10***b* and rightward in the axial direction from a central part of a right side face of the second shaft part **10***b*. The second shaft part **10***b* has a cylindrical shape having a larger diameter than the first shaft part **10***a*.

**[0029]** In the rotary shaft **10**, the second shaft part **10***b* is passed through a central part of the rotor **20**, and together with the sleeve **27**, is fixed to the rotor **20**. A first side of the first shaft part **10***a* leftward protrudes from the housing **40** and a second side of the first shaft part **10***a* rightward protrudes from the housing **40**. The first shaft part **10***a* is freely rotatably supported with bearings B**1** and B**2** arranged in the housing **40**. Accordingly, the rotary shaft **10**, rotor **20**, and sleeve **27** integrally rotate around a rotation axis of the rotary shaft **10**. The bearings B**1** and B**2** are, for example, antifriction bearings such as angular ball bearings.

**[0030]** Inside the first shaft part **10***a* of the rotary shaft **10**, a coolant flow path (first flow path) **11** is formed along a center axis up to the inside of the second shaft part **10***b*. On an outer circumferential face of the second shaft part **10***b* of the rotary shaft **10**, a groove (recess) **12** is formed as a coolant flow path to guide a coolant (such as cooling oil) to cool permanent magnets **23** arranged in the rotor **20**. As illustrated in FIG. **2**, this embodiment forms eight grooves **12** each having a rectangular sectional shape at regular intervals in a circumferential direction of the second shaft part **10***b*.

**[0031]** FIG. **3** is a perspective view of the rotary shaft of the motor **1**, i.e., the rotary machine according to the embodiment. As illustrated in FIG. **3**(*a*), the grooves **12** are linearly formed in the axial direction on the second shaft part **10***b* of the rotary shaft **10**. The grooves **12** are formed not to reach each axial end of the second shaft part **10***b* but they are formed to extend from the vicinity of one axial end of the second shaft part **10***b* up to the vicinity of the other axial end thereof. This is to at most prevent the coolant supplied to the grooves **12** serving as coolant flow paths from leaking outside through a gap between the rotary shaft **10** (second shaft part **10***b*) and the sleeve **27**.

**[0032]** The grooves **12** formed on the outer circumferential face of the rotary shaft **10** may be spiral in the axial direction as illustrated in FIG. **3**(*b*), or may be winding in the axial direction as illustrated in FIG. **3**(*c*). When the grooves **12** are spiral as illustrated in FIG. **3**(*b*), a circumferential temperature distribution of the rotor **20** will be equalized compared with the linearly formed grooves illustrated in FIG. **3**(*a*). When the grooves **12** are winding as illustrated in FIG. **3**(*c*), the cooling efficiency of the rotor **20** will improve compared with the linearly formed grooves **12** illustrated in FIG. **3**(*a*).

**[0033]** FIG. **4** is a view illustrating sectional shapes of grooves formed on the rotary shaft of the motor **1**, i.e., the rotary machine according to the embodiment. As illustrated in FIG. **4**(*a*), the embodiment forms the grooves each into a rectangular sectional shape on the outer circumferential face of the second shaft part **10***b* of the rotary shaft **10**. The sectional shape of each groove **12** may be an arc shape (a convex arc oriented toward the rotation axis) as illustrated in FIG. **4**(*b*), or a triangular shape (with one vertex oriented toward the rotation axis) as illustrated in FIG. **4**(*c*).

**[0034]** Instead of arranging the plurality of thin and long axial grooves **12** in the circumferential direction of the second shaft part **10***b* as illustrated in FIGS. **4**(*a*) to **4**(*c*), the outer circumferential face of the second shaft part **10***b* may generally be recessed as illustrated in FIG. **4**(*d*). Namely, the outer circumferential face of the second shaft part **10***b* except axial ends thereof may generally be hollowed to form a recess. Such a recess may be realized by forming, for example, a countless number of the linear grooves **12** of FIG. **4**(*a*) in the circumferential direction.

**[0035]** Inside the second shaft part **10***b* of the rotary shaft **10**, a communicating flow path (second flow path) **13** is formed to connect the coolant flow path **11** formed in the first shaft part **10***a* to each groove **12** formed on the outer circumferential face of the second shaft part **10***b*. As illustrated in FIG. **2**, the communicating flow paths **13** are formed to extend from the coolant flow path **11** toward the grooves **12** in diametral directions of the second shaft part **10***b* (more precisely, in different eight directions).

**[0036]** As illustrated in FIG. **2**, the rotary shaft **10** is positioned in a rotation direction of the rotor **20** so that the grooves **12** formed on the outer circumferential face of the second shaft part **10***b* come nearest to the permanent magnets **23** of the rotor **20**, respectively. This is to increase the cooling efficiency of the rotor **20** by bringing the grooves **12** serving as the coolant flow paths for guiding the coolant closest to the permanent magnets **23** as heat generating sources.

**[0037]** The rotor **20** has a rotor core **21**, end rings **22**, and the permanent magnets **23**, is attached together with the sleeve **27** to the rotary shaft **10**, and is rotatable around the rotation axis of the rotary shaft **10**. As illustrated in FIG. **1**, the rotor core **21** is made by laminating magnetic steel sheets made of magnetic material with an adhesive and is an annular member with the rotary shaft **10** being passed through a central part of the rotor core **21**.

**[0038]** The permanent magnet **23** is, for example, a rectangular parallelepiped magnet extending in the axial direction and is inserted into an insertion hole formed in the rotor core **21**. The permanent magnets **23** are arranged at regular intervals along an outer circumferential face of the rotor core **21**. According to the example illustrated in FIG. **2**, eight permanent magnets **23** each having a rectangular sectional shape are arranged at regular intervals in a circumferential direction of the rotor core **21**. Alternating magnetic fields along the outer circumferential face of the rotor core **21** is formed by way of this arrangements.

**[0039]** The end ring **22** is arranged at each axial side (in the laminated direction of the magnetic steel sheets) of the rotor core **21**. The end rings **22** are annular members that axially hold the rotor core **21** from each side. An axial length of the rotor core **21** is set so that the length of the rotor core **21** including the end rings **22** arranged at each axial side of the rotor core **21** is equal to an axial length of the second shaft part **10***b* of the rotary shaft **10**.

**[0040]** The sleeve **27** is an annular member arranged between the second shaft part **10***b* of the rotary shaft **10** and the rotor **20** and is made of, for example, the same material as the rotary shaft **10**. An axial length of the sleeve **27** is set to be equal to an axial length of the second shaft part **10***b* of the rotary shaft **10**. The sleeve **27** is fitted to the outer circumferential face of the second axial part **10***b* of the rotary shaft **10** by, for example, shrinkage fitting. When the sleeve **27** is fitted to the outer circumferential face of the second shaft part **10***b* of the rotary shaft **10**, the grooves **12** form coolant flow paths between the rotary shaft **10** and the sleeve **27**.

**[0041]** The coolant guided into the grooves **12** serving as the coolant flow paths flows between the rotary shaft **10** (the second shaft part **10***b*) and the sleeve **27**. Even if the rotor **20** is rotated at a high speed under a condition that the bonding strength of the adhesive that adheres the magnetic steel sheets of the rotor core **21** together decreases due to a temperature increase of the motor **1**, this configuration prevents the coolant guided into the grooves **12** serving as the coolant flow paths from leaking. The rotor core **21** mentioned above is fitted to the outer circumferential face of the sleeve **27** by, for example, shrinkage fitting.

**[0042]** Since the sleeve **27** is fitted to the outer circumferential face of the second shaft part **10***b* by, for example, shrinkage fitting, the coolant guided into the grooves **12** almost causes no leakage. There will be leakage if the pressure of the coolant guided into the grooves **12** is high. To deal with this, at each axial end, the sleeve **27** is soldered or welded to the second shaft part **10***b* of the rotary shaft **10**, or a sealing material such as an O-ring is arranged between the sleeve **27** and the second shaft part **10***b* of the rotary shaft **10**, to seal the location.

**[0043]** The stator **30** has a stator core **31** and a coil **32** and is fixed to an inner circumferential face of a body member **41** forming part of the housing **40**, to surround the rotor **20** in the rotation direction of the rotary shaft **10**. According to a current externally supplied to the coil **32**, the stator **30** forms a rotating magnetic field in the circumferential direction of the rotor **20**. Like the rotor core of the rotor **20**, the stator core **31** is an annular member formed by laminating a plurality of magnetic steel sheets made of magnetic material. The rotor **20** is arranged on an inner circumferential side of the stator core **31**. An inner diameter of the stator core **31** is so set to form an annular gap (an air gap G illustrated in FIG. **1**) having preset dimensions between the inner circumferential face of the stator core **31** and the outer circumferential face of the rotor **20**.

**[0044]** The coil **32** is inserted into a slot (not illustrated) formed in the stator core **31**, to form magnetic poles according to an externally supplied current. The coil **32** includes a first coil to which a U-phase current of three-phase AC is supplied, a second coil to which a V-phase current is supplied, and a third coil to which a W-phase current is supplied. These first to third coils are sequentially arranged in the circumferential direction of the stator core **31**. When a three-phase AC current is supplied to the coil **32**, a rotating magnetic field is formed along the inner circumferential face of the stator core **31**. As illustrated in FIG. **1**, the coil **32** is attached to the stator core **31** so that a coil end part protrudes from each end of the stator core **31**.

**[0045]** The housing **40** includes the body member **41**, a left sidewall member **42**, and a right sidewall member **43**, accommodates part of the rotary shaft **10**, the rotor **20**, the sleeve **27**, and the stator **30**, and forms an external shape of the motor **1**. The body member **41** is made of iron alloy and the like and is a cylindrical member with each axial end being open. To the inner circumferential face of the body member **41**, the above-mentioned stator **27** is fixed. The left sidewall member **42** is a disk-shaped member, has a fitting hole for the bearing B**1** at a central part thereof, and is attached to a left end of the body member **41**. The right sidewall member **43** is a disk-shaped member, has a fitting hole for the bearing B**2** at a central part thereof, and is attached to a right end of the body member **41**.

**[0046]** Operation of the motor **1** with the above-mentioned structure will briefly be explained. When an external three-phase AC current is supplied to the motor **1**, each phase current of the three-phase AC current passes through the coil **32** (first to third coils) arranged in the stator **30**, to form a rotating magnetic field in the rotation direction of the rotor **20** according to the supplied current. The rotor core **21** with alternating magnetic fields formed along the outer circumference thereof interacts with the rotating magnetic field, to create attractive force and repulsive force. This results in rotating the rotor **20** to rotate the rotary shaft **10**, rotor **20**, and sleeve **27** together, thereby transmitting torque of the rotary shaft **10** to the outside.

**[0047]** When the motor **1** is driven, a pump (not illustrated) supplies a coolant to the coolant flow path **11** at a first side of the first shaft part **10***a* of the rotary shaft **10**. The coolant supplied to the coolant flow path **11** is guided through the communicating flow paths **13** at a first end side (left side) of the second shaft part **10***b* to the grooves **12** formed on the outer circumferential face of the second shaft part **10***b*. Between the rotary shaft **10** and the sleeve **27**, the grooves **12** form coolant flow paths. Accordingly, the coolant guided into the grooves **12** cools the permanent magnets **23**. These coolant flow paths are formed to be nearest to the permanent magnets **23** arranged in the rotor **20**, and therefore, the rotor core **21** and permanent magnets **23** are efficiently cooled. The coolant passed through the grooves **12** serving as the coolant flow paths is guided through the communicating flow paths **13** at a second end side (right side) of the second shaft part **10***b* to the coolant flow path **11** at a second side of the first shaft part **10***a* and is discharged outside.

**[0048]** As mentioned above, this embodiment forms the grooves serving as coolant flow paths on the outer circumferential face of the rotary shaft **10** and arranges the annular sleeve **27** between the rotary shaft **10** on which the grooves **12** are formed and the rotor **20**, so that a coolant guided into the grooves **12** passes between the rotary shaft **10** and the sleeve **27**. Even if the rotor **20** is rotated at a high speed under a condition that the bonding strength of the adhesive fixing the magnetic steel sheets of the rotor core **21** together decreases due to a temperature increase of the motor **1**, the embodiment prevents the coolant guided into the grooves **12** from leaking.

**[0049]** This embodiment forms the grooves **12** on the outer circumferential face of the second shaft part **10***b* of the rotary shaft **10** that is larger in diameter than the first shaft part **10***a* and arranges the sleeve **27** between the second shaft part **10***b* on which the grooves **12** are formed and the rotor **20**, thereby positioning the coolant flow paths closest to the permanent magnets **23**. Accordingly, the rotor **20** including the permanent magnets **23** is simply and efficiently cooled.

**[0050]** The number, length, and shape (including sectional shape) of the grooves **12** formed on the rotary shaft **10** are not limited to those of the above-mentioned embodiment.

**[0051]** The rotation-direction (circumferential-direction) arrangements and positional relationships of the grooves **12** formed on the rotary shaft **10** and the permanent magnets **23** arranged in the rotor **20** are not limited to those of the above-mentioned embodiment. These arrangements and positional relationships are optional.

**[0052]** Although the above-mentioned embodiment has explained, as an example, the rotary shaft **10** that has the first shaft part **10***a* and second shaft part **10***b* that are integrated into one body, the present invention is applicable to a rotary shaft made of a first shaft part **10***a* and second shaft part **10***b* that are discrete members. For example, the rotary shaft **10** may be made of a cylindrical shaft member whose outer diameter is similar to that of the first shaft part **10***a* and a cylindrical auxiliary member that has an outer diameter similar to that of the second shaft part **10***b* and an inner diameter similar to that of the first shaft part **10***a* and is fixed to the cylindrical shaft member.

Second Embodiment

**[0053]** FIG. **5** is a sectional side view illustrating the structure of a motor, i.e., a rotary machine according to the second embodiment of the present invention. The motor **1** of the first embodiment illustrated in FIGS. **1** to **4** is of an inner ring rotating type that turns the rotor **20** together with the rotary shaft **10**. On the other hand, the motor **2** of the second embodiment illustrated in FIG. **5** is of an outer ring rotating type that turns a rotor **20** around a fixed center shaft **70**.

**[0054]** The motor **2** of this embodiment attaches outer housings **61** and **62** to left and right outer sides of a housing **40** as illustrated in FIG. **5**. Fitting holes **61***c* and **62***c* of the outer housings **61** and **62** fixedly support ends of the center shaft **70**. With bearings B**1** and B**2**, the center shaft **70** rotatably supports a cylindrical rotary body **80** (second rotary body part) that forms part of the rotor **20**. On an outer circumferential face of the rotary body **80**, a sleeve **27** is attached, and on an outer circumferential face of the sleeve **27**, the rotor **20** is attached.

**[0055]** Inside the center shaft **70**, a rotor oil introducing flow path **71** is formed to open at each end of the center shaft **70**. To the rotor oil introducing flow path **71**, an oil supply unit such as an oil pump (not illustrated) supplies oil for cooling the rotor **20**.

**[0056]** To end faces of the rotary body **80**, rotary support members **25** and **26** (first rotary body part) are attached with their center axes being positionally aligned to each other. The rotary support members **25** and **26** are inserted into openings **42***c* and **43***c* formed at centers of left sidewall member **42** and right sidewall member **43** of the housing **40** with proper gaps interposed between them, are axially outwardly protruded from the left and right sidewall members **42** and **43**, respectively, and are rotatably supported by the center shaft **70** through the bearings B**1** and B**2**. The rotary support members **25** and **26** form part of the rotor **20**.

**[0057]** The rotary support members **25** and **26** have paths to connect an oil flow path **24** and inner spaces of the bearings B**1** and B**2** to each other. These paths guide oil from the oil flow path **24** through the inner spaces of the bearings B**1** and B**2** to the open sides of the rotary support members **25** and **26**.

**[0058]** The rotary support members **25** and **26** form, with respect to the center shaft **70**, annular gaps **25***a* and **26***a* (first flow path) for guiding oil in the axial direction of the center shaft **70**. The rotary body **80** has a larger diameter than the rotary support members **25** and **26**.

**[0059]** Between an inner circumferential face of the rotary body **80** and an outer circumferential face of the center shaft **70**, an annular gap **28** is formed. The gap **28** communicates with the rotor oil introducing flow path **71** opened to the outer circumferential face of the center shaft **70** and the oil flow path **24** of the rotary body **80**.

**[0060]** The oil flow path **24** includes a gap flow path **35** extending along the outer circumferential face of the rotary body **80** in the axial direction of the rotary body **80** and an inlet flow path **37** and an outlet flow path **39** that extend in a diametral direction of the rotary body **80** and connect both ends of the gap flow path **35** to the gap **28**.

**[0061]** A plurality of the oil flow paths **24** are arranged in a circumferential direction for permanent magnets **23**, respectively. Namely, as illustrated in FIG. **6**, the oil flow paths **24** are formed in the vicinities of the permanent magnets **23** on the outer circumferential face of the rotary body **80**. The oil flow paths **24** formed in the circumferential direction of the rotary body **80** alternate the flowing directions of oil passing therethrough.

**[0062]** On the outer circumferential face of the rotary body **80**, grooves (recesses) **12** are formed to form the gap flow paths **35** with respect to the inner circumferential face of the sleeve **27**. According to this embodiment, eight grooves **12** each having a rectangular sectional shape are formed at regular intervals in the circumferential direction of the rotary body **80** as illustrated in FIG. **6**.

**[0063]** As illustrated in FIG. **6**, the rotary body **80** is positioned in a rotation direction of a rotor core **21** so that the grooves **12** formed on the outer circumferential face of the rotary body **80** come closest to the permanent magnets **23** of the rotor core **21**, respectively. This is to improve the cooling efficiency of the rotor **20** by way of bringing the grooves **12** forming the gap flow paths **35** of the oil flow paths **24** for guiding oil as close to the permanent magnets **23**, i.e., heat generating sources as possible.

**[0064]** The rotor **20** has the rotor core **21**, the permanent magnets **23**, and end rings **22**, is attached together with the sleeve **27** to the rotary body **80**, and is rotatable with the rotary body **80** around the center shaft **70**. As illustrated in FIG. **5**, the rotor core **21** is made by laminating magnetic steel sheets made of magnetic material with an adhesive and is an annular member with the rotary body **80** and sleeve **27** being passed through a central part of the rotor core **21**.

**[0065]** The end ring **22** is arranged at each axial side (in the laminated direction of the magnetic steel sheets) of the rotor core **21**. The end rings **22** are annular members that axially hold the rotor core **21** from each side. An axial length of the rotor core **21** is set so that the length of the rotor core **21** including the end rings **22** arranged at each axial side of the rotor core **21** is equal to an axial length of the rotary body **80**.

**[0066]** The sleeve **27** is an annular member arranged between the rotary body **80** and the rotor **20** and is made of, for example, the same material as the center shaft **70** and rotary body **80**. An axial length of the sleeve **27** is set to be equal to an axial length of the rotary body **80** and is fitted to the outer circumferential face of the rotary body **80** by, for example, shrinkage fitting. When the sleeve **27** is fitted to the outer circumferential face of the rotary body **80**, the grooves **12** form the gap flow paths **35** between the rotary body **80** and the sleeve **27**.

**[0067]** The oil guided into the grooves **12** forming part of the oil flow paths **24** flows between the rotary body **80** and the sleeve **27**. Even if the rotor **20** is rotated at a high speed under a condition that the bonding strength of the adhesive that adheres the magnetic steel sheets of the rotor core **21** together decreases due to a temperature increase of the motor **2**, this configuration prevents the oil guided into the grooves **12** forming part of the oil flow paths **24** from leaking. The rotor core **21** mentioned above is fitted to the outer circumferential face of the sleeve **27** by, for example, shrinkage fitting.

**[0068]** Since the sleeve **27** is fitted to the outer circumferential face of the rotary body **80** by, for example, shrinkage fitting, the oil guided into the grooves **12** almost causes no leakage. There will be leakage if the pressure of the oil guided into the grooves **12** is high. To deal with this, at each axial end, the sleeve **27** is soldered or welded to the rotary body **80**, or a sealing material such as an O-ring is arranged between the sleeve **27** and the rotary body **80**, to seal the location.

**[0069]** Operation of the motor **2** with the above-mentioned structure will briefly be explained. When the motor **2** is driven, a pump (not illustrated) supplies oil from an end opening of the center shaft **70** into the oil introducing flow path **71**. The introduced oil flows from the oil introducing flow path **71** to the gap **28** on the outer circumferential side of the center shaft **70**, passes the gap **28** in an axial outward direction, and flows into the oil flow paths **24**.

**[0070]** The oil flowed into the oil flow paths **24** is guided into the grooves **12** formed on the outer circumferential face of the rotary body **80**. Between the rotary body **80** and the sleeve **27**, the grooves **12** form the gap flow paths **35**, and therefore, the oil guided into the grooves **12** cools the permanent magnets **23**. The grooves **12** are arranged to be closest to the permanent magnets **23** incorporated in the rotor core **21**, and therefore, the rotor core **21** and permanent magnets **23** are efficiently cooled.

**[0071]** The oil passing through the gap flow paths **34** formed by the grooves **12** passes through the oil flow paths **24** and the internal spaces of the bearings B**1** and B**2** and reaches the openings of the rotary support members **25** and **26**. Thereafter, the oil passes through the gaps **25***a* and **26***a* between the rotary support members **25** and **26** and the center shaft **70** and is discharged into spaces between the left sidewall member **42** and right sidewall member **43** of the housing **40** and the left sidewall member **61***b* and right sidewall member **62***b* of the outer housings **61** and **62**.

**[0072]** As mentioned above, this embodiment forms the grooves **12** on the outer circumferential face of the rotary body **80** of the rotor **20** to form the gap flow paths **35** of the oil flow paths **24**, and between the rotary body **80** on which the grooves **12** are formed and the rotor core **21**, arranges the annular sleeve **27**, so that the oil introduced into the grooves **12** may pass between the rotary body **80** and the sleeve **27**. Even if the rotor **20** is rotated at a high speed under a condition that the bonding strength of the adhesive that adheres the magnetic steel sheets of the rotor core **21** together decreases due to a temperature increase of the motor **2**, this configuration prevents the coolant guided into the grooves **12** from leaking.

**[0073]** This embodiment forms the grooves **12** on the outer circumferential face of the rotary body **80** that is larger in diameter than the rotary support members **25** and **26** and arranges the sleeve **27** between the rotary body **80** on which the grooves **12** are formed and the rotor core **21**, thereby positioning the gap flow paths **35** closest to the permanent magnets **23**. Accordingly, the rotor **20** incorporating the permanent magnets **23** is simply and efficiently cooled.

**[0074]** The number, length, and shape (including sectional shape) of the grooves **12** formed on the rotary body **80** are not limited to those mentioned above. The rotation-direction (circumferential-direction) arrangements and positional relationships of the grooves **12** formed on the outer circumferential face of the rotary body **80** and the permanent magnets **23** arranged in the rotor core **21** are not limited to those mentioned above. These arrangements and positional relationships are optional.

**[0075]** Although the above-mentioned embodiment integrates the rotary support members **25** and **26** and the rotary body **80** into one body, the rotary support members **25** and **26** and the rotary body **80** may be discrete members.

**[0076]** According to the first embodiment of FIGS. **1** to **4**, the grooves **12** that are recesses to form coolant flow paths are formed on the outer circumferential face of the rotary shaft **10**. According to the second embodiment of FIGS. **5** and **6**, the grooves **12** that are recesses to form the gap flow paths **35** of the oil flow paths **24** are formed on the outer circumferential face of the rotary body **80**. The grooves **12** may be formed on the inner circumferential face of the sleeve **27** as illustrated in FIG. **7**, or may be formed on the outer circumferential face of the rotary shaft **10** (rotary body **80**) and the inner circumferential face of the sleeve **27**.

## Third Embodiment

**[0077]** A motor **3** according to the third embodiment illustrated in FIGS. **9** to **13** uses oil as a coolant to cool a stator **30**, which is the same as the stator of the motor **1** of the first embodiment. In FIG. **9**, the internal structures of a rotary shaft **10** and rotor **20** are omitted. The details of the structure of the motor **3** according to the third embodiment will be explained.

**[0078]** The stator **30** has a stator core **31** and a coil **32** and is fixed to an inner circumferential face of a body member **41** forming part of a housing **40**, to surround the rotor **20** in a rotation direction of the rotary shaft **10**. According to a current externally supplied to the coil **32**, the stator forms a rotating magnetic field in a circumferential direction of the rotor **20**. FIG. **10** is a sectional side view illustrating the stator **30** extracted from the motor **3**. FIG. **11** is a sectional view taken along a line D-D of FIG. **10** and seen from an arrowed direction.

**[0079]** As illustrated in FIG. **11**, the stator core **31** has an annular yoke **31***a* and teeth **31***b* that are arranged in a circumferential direction of the yoke **31***a* and protrude toward a center axis of the yoke **31***a*. A clearance between the adjacent teeth **31***b* is a slot **31***c* into which the coil **32** is inserted. To avoid complication, FIG. **11** illustrates the stator core **31** having eight teeth **31***b* and eight slots **31***c*. These numbers may optionally be set.

**[0080]** The teeth **31***b* of the stator core **31** function as magnetic poles when three-phase AC is supplied to the coils **32** in the slots **31***c*. The stator core **31** is arranged around the rotor **20** so that the teeth **31***b* protrude toward a rotation axis of the rotary shaft **10**. In this arrangement, a protrusion amount of the teeth **31***b* is set so that a gap between the teeth **31***b* and the rotor core forms an air gap G.

**[0081]** The coils **32** are inserted in the slots **31***c* formed in the stator core **31**. The coils **32** are attached to the stator core **31** so that coil end parts **32***a* protrude from each end of the stator core **31**. Namely, as illustrated in FIG. **10**, the coil end parts **32***a* leftward protrude from a left end E**1** of the stator core **31** and the coil end parts **32***a* protrude from a right end E**2** of the stator core **31**. Every coil **32** is attached to the stator core **31** as mentioned above, and therefore, the coil end parts **32***a* are circularly arranged along the ends E**1** and E**2** of the stator core **31** as illustrated in FIG. **10**.

**[0082]** The ends E**1** and E**2** of the stator core **31** are provided with annular mold members **33***a* and **33***b* that extend along the ends E**1** and E**2** to cover base parts of the coil end parts **32***a*. The reason why the mold members **33***a* and **33***b* cover only the base parts of the coil end parts **32***a* instead of entirely covering the coil end parts **32***a* is to realize cooling with cooling oil OL and prevent the cooling oil from entering the air gap G between the rotor **20** and the stator **30**.

**[0083]** Namely, covering only the base parts of the coil end parts **32***a* with the mold members **33***a* and **33***b* and exposing the remaining parts thereof realize that the cooling oil OL is directly poured onto the exposed parts of the coil end parts **32***a*, to efficiently cool the stator **30** (coils **32**). As will be explained later in detail, front ends of partition parts **42***b* and **43***b* that are part of left sidewall member **42** and right sidewall member **43** of the housing **40** are sealed with the mold members **33***a* and **33***b*, to separate a space S**1** (first space) accommodating the rotor **20** from a space S**2** (second space) accommodating the coil end parts **32***a*, thereby preventing the oil from entering the air gap G.

**[0084]** The thickness of the mold members **33***a* and **33***b* is determined in consideration of a sealing degree and cooling efficiency. If the front ends of the partition parts **42***b* and **43***b* are not sealed, the oil will enter the air gap G. Accordingly, the thickness of the mold members **33***a* and **33***b* must be sufficient at least to seal the front ends of the partition parts **42***b* and **43***b*. As the thickness of the mold members **33***a* and **33***b* increases, the exposed part of the coil end parts **32***a* reduces to lower the cooling efficiency with oil. Accordingly, the thickness of the mold members **33***a* and **33***b* must be smaller than a thickness capable of securing a necessary cooling efficiency. The thickness of the mold members **33***a* and **33***b* is, for example, about 50% of the protruding amount of the coil end part **32***a*, preferably, about 20 to 30% of the protruding amount of the coil end part **32***a*.

**[0085]** As illustrated in FIG. **11**, the inside of the stator core **31** is provided with a mold member **33***c*, which is similar to the mold members **33***a* and **33***b*, to bury an inner gap of each slot **31***c* formed in the stator core **31**. The mold member **33***c* is arranged to fix the coil **32** inserted in the slot **31***c* so as to prevent the coil **32** from vibrating in the slot **31***c* and improve the cooling efficiency of the coil **32**.

**[0086]** When a current is applied, the coil **32** becomes a heat generating source, and therefore, the mold members **33***a* and **33***b* covering the base parts of the coil end parts **32***a* and the mold member **33***c* fixing each coil **32** in each slot **31***c* are required to have a high thermal conductivity. It is preferable to form the mold members **33***a*, **33***b*, and **33***c* with thermally conductive resin mixed with thermally conductive fillers having an insulating characteristic, such as silicon oxide (SiO2) and aluminum oxide (Al2O3).

**[0087]** The mold members **33***a* and **33***b* and the mold member **33***c* may be made of material having the same thermal conductivity, or materials having different thermal conductivities. Each coil **32** attached to the stator core **31** has a higher wire concentration (wires that form the coil **32**) at part inserted in the slot **31***c* and a front end of the coil end part **32***a* and a lower wire concentration at the base of the coil end part **32***a*. Heat resistance is higher at the part where the wire concentration is low (the base of the coil end part **32***a*) than at the part where the wire concentration is high (the inside of the slot **31***c* and the front end of the coil end part **32***a*). Accordingly, it is preferable to form the mold members **33***a* and **33***b* with a material whose thermal conductivity is higher than that of a material used to form the mold member **33***c*.

**[0088]** In connection with the mold resin **33***a* and **33***b* formed at the ends E**1** and E**2** of the stator core **31**, a viscosity when forming them may be given priority to a thermal conductivity after forming them. In this case, the mold resin **33***a* and **33***b* may be formed with a material that has a lower thermal conductivity and viscosity than those of a material used to form the mold member **33***c*. Such a material is required when the material for the mold member **33***c* is insufficient to fill gaps at the base part of the coil end part **32***a* (gaps among the wires that form the coil **32**).

**[0089]** In consideration of a functional difference between the mold members **33***a* and **33***b* and the mold member **33***c*, the mold members **33***a* and **33***b* and the mold member **33***c* may be formed from different materials. The mold members **33***a* and **33***b* are used to seal the front ends of the partition parts **42***b* and **43***b*, and therefore, they may be formed with a material having resiliency after the material hardens. On the other hand, the mold member **33***c* must surely fix the coil **32** in the slot **31***c*, and therefore, it may be formed from a material that increases hardness after the material hardens.

**[0090]** As illustrated in FIG. **9**, vertically above the body member **41** of the housing **40**, an oil supply port P**1** (coolant supply port) is arranged to guide externally supplied cooling oil OL to the coil end parts **32***a* arranged inside the housing **40**. The oil supply port P**1** is arranged at a plurality of locations in the rotation direction of the rotary shaft **10** above an exposed part (a part not covered with the mold member **33***a*) of each coil end part **32***a* leftward protruding from the end E**1** of the stator core **31** and above an exposed part (a part not covered with the mold member **33***b*) of each coil end part **32***a* rightward protruding from the end E**2** of the stator core **31**.

**[0091]** FIG. **12** is a sectional view taken along a line C-C of FIG. **9** and seen in an arrowed direction. As illustrated in FIG. **12**, the oil supply ports P**1** are arranged above the exposed parts of the coil end parts **32***a* at three locations in the rotation direction of the rotary shaft **10**. The oil supply ports P**1** are arranged at intervals of, for example, 20 to 70° in the rotation direction of the rotary shaft **10**. Oil supplied from the oil supply ports P**1** drops on different parts of the coil end parts **32***a* and flows downward along the exposed parts of the coil end parts **32***a* as indicated with arrows in FIG. **12**. The bottom of the body member **41** is an oil pool OP where the oil downwardly moved along the exposed parts of the coil end parts **32***a* is temporarily kept.

**[0092]** Compared with dropping the oil OL only from one oil supply port P**1**, arranging the oil supply ports P**1** at three locations in the rotation direction of the rotary shaft **10** and dropping the oil OL from these oil supply ports P**1** are able to spread the oil OL over the whole of the exposed parts of the coil end parts **32***a*, thereby improving cooling efficiency. Although the example illustrated in FIG. **12** forms the oil supply ports P**1** at three locations in the rotation direction of the rotary shaft **10**, the oil supply ports P**1** may be formed at two locations or more than four locations in the rotation direction of the rotary shaft **10** according to the size of the motor and the like. It is not always necessary to linearly arrange the oil supply ports P**1** in the rotation direction of the rotary shaft **10**. They may be axially shifted from one another.

**[0093]** As illustrated in FIG. **9**, the left sidewall member **42** has a disk-shaped bottom plate part **42***a* and the cylindrical partition part (partition member) **42***b*. In the left sidewall member **42**, the bottom plate part **42***a* is attached to a left end of the body member **41** so that the partition part **42***b* is arranged inside the body member **41**. The bottom plate part **42***a* that forms part of the left sidewall member **42** has, at a central part thereof, a hole to fit the bearing B**1**. At an outer peripheral part of the bottom plate part **42***a*, an oil discharge port P**2** is arranged to discharge the oil OL from the oil pool OP to the outside.

**[0094]** The partition part **42***b* that forms part of the left sidewall member **42** has an outer diameter substantially equal to an inner diameter of the stator core **31** (the mold member **33***a*). A front end of the partition part **42***b* is in contact with the mold member **33***a*, to separate the space S**1** in which the rotor **20** is arranged from the space S**2** in which the coil end parts **32***a* are arranged on the left side of the stator core **31**. Namely, the front end of the partition part **42***b* is sealed with the mold member **33***a*, to separate the spaces S**1** and S**2** from each other.

**[0095]** Similar to the left sidewall member **42**, the right sidewall member **43** has a disk-shaped bottom plate part **43***a* and the cylindrical partition part (partition member) **43***b*. In the right sidewall member **43**, the bottom plate part **43***a* is attached to a right end of the body member **41** so that the partition part **43***b* is arranged inside the body member **41**. The bottom plate part **43***a* that forms part of the right sidewall member **43** has, at a central part thereof, a hole to fit the bearing B**2**. At an outer peripheral part of the bottom plate part **43***a*, an oil discharge port P**2** is arranged to discharge the oil OL from the oil pool OP to the outside.

**[0096]** The partition part **43***b* that forms part of the right sidewall member **43** has an outer diameter substantially equal to the inner diameter of the stator core **31** (the mold member **33***b*). A front end of the partition part **43***b* is in contact with the mold member **33***b*, to separate the space S**1** in which the rotor **20** is arranged from the space S**2** in which the coil end parts **32***a* are arranged on the right side of the stator core **31**. Namely, the front end of the partition part **43***b* is sealed with the mold member **33***b*, to separate the spaces S**1** and S**2** from each other.

**[0097]** FIG. **13** is a view illustrating sealing methods for the partition member according to the embodiment. As mentioned above, the partition parts **42***b* and **43***b* of the left sidewall member **42** and right sidewall member **43** are sealed with their front ends being in contact with the mold members **33***a* and **33***b*. There will be various methods (sealing methods) of bringing the front ends of the partition parts **42***b* and **43***b* in contact with the mold members **33***a* and **33***b*, as illustrated in FIG. **13**. Methods of sealing the partition part **42***b* with the mold member **33***a* will be explained. These method are also applicable to seal the partition part **43***b* with the mold member **33***b*.

**[0098]** The sealing method illustrated in FIG. **13**(*a*) tapers an outer circumferential face of the front end of the partition part **42***b* and an inner circumferential face of the mold member **33***a* and wholly fits the front end of the partition part **42***b* to the inner circumferential face of the mold member **33***a*, thereby increasing a contact area between the partition part **42***b* and the mold member **33***a*. The sealing method illustrated in FIG. **13**(*b*) tapers the outer circumferential face of the front end of the partition part **42***b* and forms steps in the inner circumferential face of the mold member **33***a* and wholly fits the front end of the partition part **42***b* to the inner circumferential face of the mold member **33***a*, thereby increasing contact locations between the partition part **42***b* and the mold member **33***a*.

**[0099]** The sealing method illustrated in FIG. **13**(*c*) forms a flange F at the front end of the partition part **42***b* and a groove M on the inner circumferential face of the mold member **33***a* and fits the whole of the flange F formed at the front end of the partition part **42***b* to the groove M formed in the inner circumferential face of the mold member **33***a*, thereby improving a sealing degree between the partition part **42***b* and the mold member **33***a*. The sealing method illustrated in FIG. **13**(*d*) forms a groove at the front end of the partition part **42***b*, arranges an O-ring R in the groove, and brings the whole of the O-ring R arranged at the front end of the partition part **42***b* in contact with the inner circumferential face of the mold member **33***a*, thereby improving a sealing degree between the partition part **42***b* and the mold member **33***a*.

**[0100]** The sealing method illustrated in FIG. **13**(*e*) forms a protrusion Q entirely along the outer circumferential face of the front end of the partition part **42***b* and wholly brings the protrusion Q in contact with the inner circumferential face of the mold member **33***a*, thereby improving a sealing degree between the partition part **42***b* and the mold member **33***a*. The sealing method illustrated in FIG. **13**(*f*) forms a notch K in the inner circumferential face of the mold member **33***a* and wholly fits the front end of the partition part **42***b* to the notch K formed in the mold member **33***a*, thereby improving a sealing degree between the partition part **42***b* and the mold member **33***a*.

**[0101]** Operation of the motor **3** with the above-mentioned configuration will briefly be explained. When the motor **3** is driven, a pump or the like (not illustrated) supplies cooling oil OL to the oil supply ports P**1** and the oil drops onto a plurality of locations of the exposed parts of the coil end parts **32***a* arranged in the space S**2**. The oil OL dropped on the coil end parts **32***a* downwardly moves along the exposed parts of the coil end parts **32***a* as indicated with arrows in FIG. **12**. Since the oil OL drops onto the plurality of locations of the coil end parts **32***a*, the oil OL wholly spreads over the coil end parts **32***a* arranged along the ends of the stator core **31**, thereby efficiently cooling the coil end parts **32***a*.

**[0102]** The partition part **42***b* of the left sidewall member **42** is sealed with the mold member **33***a* and the partition part **43***b* of the right sidewall member **43** is sealed with the mold member **33***b*, so that, on both the left and right sides of the stator core **31**, the space S**1** in which the rotor **20** is arranged is separated from the space S**2** in which the coil end parts **32***a* are arranged. This prevents the oil OL supplied from the oil supply ports P**1** into the space S**2** from entering the air gap G.

**[0103]** As mentioned above, this embodiment forms the mold members **33***a* and **33***b* at both ends of the stator core **31**, to cover the base parts of the coil end parts **32***a* and arranges the partition parts **42***b* and **43***b* in contact with the mold members **33***a* and **33***b*, respectively, to separate the space S**1** in which the rotor **20** is arranged from the space S**2** in which the coil end parts **32***a* are arranged. This realizes efficient cooling without increasing costs or deteriorating performance.

## Fourth Embodiment

**[0104]** FIG. **14** is a sectional side view illustrating the structure of a motor **4**, i.e., a rotary machine according to the fourth embodiment of the present invention. The motor **4** of this embodiment illustrated in FIG. **14** differs from the motor **3** illustrated in FIG. **9** in that it attaches a resolver **50** to a rotary shaft **10**, arranges a mold member **51** instead of the mold member **33***a*, and employs left sidewall member **52** and right sidewall member **53** instead of the left sidewall member **42** and right sidewall member **43**.

**[0105]** The resolver **50** is a sensor to detect a rotation angle of the rotary shaft **10**, and in the example illustrated in FIG.

14, is arranged on a right side of a bearing B2. The mold member 51 is formed to have an asymmetric shape with respect to a mold member 33*b* formed on a right side of a stator core 31 in connection with the axial direction of the rotary shaft 10. More precisely, the mold member 51 has an annular part 51*a* formed in an annular shape along an end (end E1) of the stator core 31 to cover base parts of coil end parts 32*a* and a cylindrical protrusion 51*b* leftward protruding from the annular part 51*a*. The annular part 51*a* has the same shape as the mold member 33*a* illustrated in FIG. 9.

**[0106]** Similar to the left sidewall member 42 illustrated in FIG. 9, the left sidewall member 52 is a member having a disk-shaped bottom plate part 52*a* and a cylindrical partition part (partition member) 52*b*. The partition part 52*b* of the left sidewall member 52 is shorter in the axial direction than the partition part 42*b* of the left sidewall member 42. This is because the above-mentioned mold member 51 has the cylindrical protrusion 51*b* leftward protruding from the annular part 51*a*, and therefore, the partition part 52*b* is able to be in contact with the mold member 51 without extended up to the annular part 51*a* of the mold member 51.

**[0107]** The right sidewall member 53 has a disk-shaped bottom plate part 53*a*, a cylindrical support part 53*b*, and a cylindrical partition part (partition member) 53*c*. The support part 53*b* supports, with its inner circumferential face, part of the bearing B2 and resolver 50. The partition part 53*c* is similar to the partition part 43*b* illustrated in FIG. 9 but is shorter in the axial direction than the partition part 43*b* by the portion of the support part 53*b*. In this way, the motor 4 of this embodiment has the resolver 50, and for this, the mold members 33*b* and 51 have asymmetrical shapes and the left sidewall member 52 and right sidewall member 53 have asymmetrical shapes.

**[0108]** According to this embodiment, the mold member 51 and mold member 33*b* are formed at ends of the stator core 31 to cover the base parts of the coil end parts 32*a*. The partition parts 52*b* and 53*c* are in contact with the mold members 51 and 33*b*, to separate a space S1 in which a rotor 20 is arranged from a space S2 in which the coil end parts 32*a* are arranged. Like the first embodiment, this embodiment is capable of carrying out efficient cooling without increasing costs or deteriorating performance.

### Fifth Embodiment

**[0109]** A motor 5 according to the fifth embodiment illustrated in FIG. 15 employs oil as a coolant to cool the stator 30 of the motor 2 of the second embodiment. In FIG. 15, the internal structures of a rotary shaft 10 and rotor 20 are omitted. The structure of the motor 5 according to the fifth embodiment will be explained in detail.

**[0110]** In the motor 5 of this embodiment, a first end of a center shaft 70 is fixedly supported with an outer housing 61 that is on the left side of FIG. 15. The outer housing 61 has a body member 61*a* fixed to a left sidewall member 42 of a housing 40 and a left sidewall member 61*b* that closes a side of the body member 61*a* opposite to the housing 40. At the center of the left sidewall member 61*b*, a fitting hole 61*c* is formed to fix an outwardly protruding first end of the center shaft 70.

**[0111]** Similarly, a second end of the center shaft 70 is fixedly supported with an outer housing 62 that is on the right side of FIG. 15. The outer housing 62 has a body member 62*a* fixed to a right sidewall member 43 of the housing 40 and a right sidewall member 62*b* that closes a side of the body member 62*a* opposite to the housing 40. At the center of the right sidewall member 62*b*, a fitting hole 62*c* is formed to fix an outwardly protruding second end of the center shaft 70.

**[0112]** According to this embodiment, the motor 5 is of an outer ring rotating type with the rotor 20 rotating around the center shaft 70. Mold members 33*a* and 33*b* are formed at both ends of a stator core 31 to cover base parts of coil end parts 32*a*. Partition parts 42*b* and 43*b* are in contact with the mold members 33*a* and 33*b*, respectively, to separate a space S1 in which the rotor 20 is arranged from a space S2 in which the coil end parts 32*a* are arranged. Similar to the fourth embodiment, this embodiment is capable of carrying out efficient cooling without increasing costs or deteriorating performance.

### INDUSTRIAL APPLICABILITY

**[0113]** The present invention is applicable not only to motors of electric vehicles but also generally and widely to rotary machines that convert electric power into torque, or rotary machines such as generators that convert torque into electric power.

### EXPLANATION OF REFERENCE NUMERALS

**[0114]** 1, 2, 3, 4, 5: Motor
**[0115]** 10: Rotary shaft (Rotor shaft)
**[0116]** 10*a*: First shaft part (First rotary body part)
**[0117]** 10*b*: Second shaft part (Second rotary body part)
**[0118]** 11: Coolant flow path
**[0119]** 12: Groove
**[0120]** 13: Communicating flow path
**[0121]** 20: Rotor
**[0122]** 21: Rotor core
**[0123]** 23: Permanent magnet
**[0124]** 24: Oil flow path (Coolant flow path, Second flow path)
**[0125]** 25, 26: Rotary support member (First rotary body part)
**[0126]** 25*a*, 26*a*: Gap (First flow path)
**[0127]** 27: Sleeve (Sleeve member)
**[0128]** 30: Stator
**[0129]** 31: Stator core
**[0130]** 32: Coil
**[0131]** 32*a*: Coil end part
**[0132]** 33*a*, 33*b*: Mold member
**[0133]** 33*c*: Mold member
**[0134]** 42*b*, 43*b*: Partition part (Partition member)
**[0135]** 51: Mold member
**[0136]** 51*a*: Annular part
**[0137]** 51*b*: Protrusion
**[0138]** 52*b*, 53*c*: Partition part (Partition member)
**[0139]** 70: Center shaft (Rotor shaft)
**[0140]** 80: Rotary body (Second rotary body part)
**[0141]** P1: Oil supply port (Coolant supply port)
**[0142]** S1: First space
**[0143]** S2: Second space

1. A rotary machine comprising:
a rotor made by laminating magnetic steel sheets;
a stator arranged around the rotor;
a rotary body passed through a central part of the rotor;
an annular sleeve member arranged between the rotary body and the rotor; and

a recess formed on at least one of an outer circumferential face of the rotary body and an inner circumferential face of the sleeve member and serving as a coolant flow path to guide a coolant.

**2**. The rotary machine as set forth in claim **1**, wherein

the rotary body includes

a first rotary body part having a first flow path to guide the coolant in an axial direction of the rotary body and

a second rotary body part that has a larger diameter than the first rotary body part and incorporates a second flow path to connect the first flow path and the coolant flow path to each other.

**3**. The rotary machine as set forth in claim **2**, wherein

the recess is formed on an outer circumferential face of the second rotary body part.

**4**. The rotary machine as set forth in claim **1**, wherein

the recess is a groove having a linear, spiral, or winding shape formed in the axial direction of the rotary body.

**5**. The rotary machine as set forth in claim **4**, wherein the recess has a rectangular, arc, or triangular sectional shape.

**6**. The rotary machine as set forth in claim **1**, wherein

the recess is formed in the same number as the number of permanent magnets arranged in the rotor.

**7**. The rotary machine as set forth in claim **6**, wherein

the rotary body and sleeve member are positioned in a rotation direction of the rotor so that the recesses come closest to the permanent magnets, respectively.

**8**. The rotary machine as set forth in claim **1**, wherein

the sleeve member is sealed with respect to the rotary body at each axial end of the rotary body.

**9**. The rotary machine as set forth in claim **1**, wherein

the stator has a stator core and a coil attached to the stator core with a coil end part protruding from each end of the stator core and the rotary machine further comprises:

a mold member formed at each end of the stator core, to cover a base part of the coil end part; and

a partition member attached in contact with the mold member, to separate a first space in which the rotor is arranged from a second space in which the coil end part is arranged.

**10**. The rotary machine as set forth in claim **9**, further comprising

a mold member arranged inside the stator core, to fill a gap in a slot that is formed in the stator core to accommodate the coil,

the mold member formed at each end of the stator core and the mold member arranged inside the stator core being made of different materials having different thermal conductivities.

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