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(71) Applicant: **Tokuden Co., Ltd.**
Kyoto-shi
Kyoto
607-8345 (JP)

(72) Inventors:
- **OZORA, Kentaro**
  Kyoto, 607-8345 (JP)
- **OKAMOTO, Kozo**
  Kyoto, 607-8345 (JP)
- **KITANO, Takatsugu**
  Kyoto, 607-8345 (JP)

(74) Representative: **Horn Kleimann Waitzhofer Patentanwälte PartG mbB**
Ganghoferstraße 29a
80339 München (DE)

(54) INDUCTION HEATED ROLL APPARATUS

(57) The present invention can not only increase the rotation speed of a roller body (5) but also reduce the size of a single-sided support induction heated roll apparatus (100) and offer the torque and the capacity of the motor required for the single-sided support induction heated roll apparatus (100). The single-sided support induction heated roll apparatus (100) includes a stationary shaft (2), a roller body (5), an induction heater (6), and an axial gap motor (7). The stationary shaft (2) includes one side supported by a machine base (20). The roller body (5) has a cylindrical shape and is rotatably supported by the stationary shaft (2) with a bearing (3, 4) interposed therebetween. The induction heater (6) is provided inside the roller body (5) and allows the roller body (5) to inductively generate heat. The axial gap motor (7) is provided between the machine base (20) and the roller body (5) and rotates the roller body (5) with respect to the stationary shaft (2).

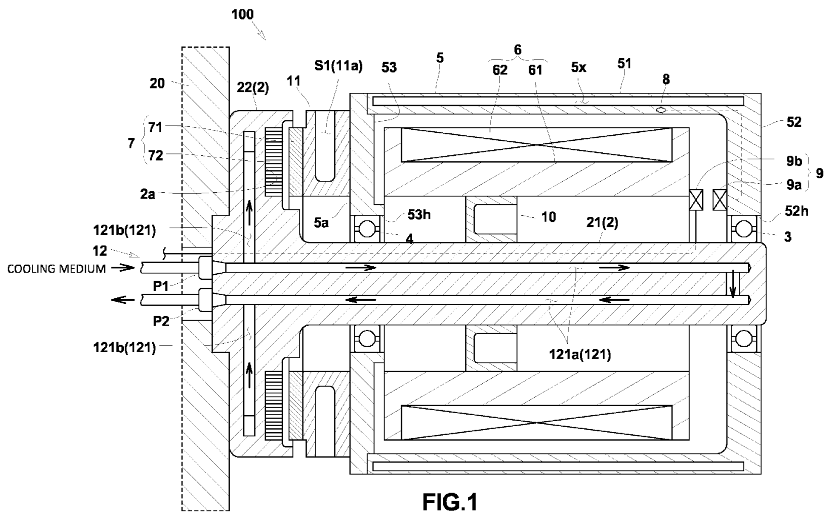

FIG.1

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Description

TECHNICAL FIELD

[0001] The present invention relates to an induction heated roll apparatus.

BACKGROUND ART

[0002] In a process for producing synthetic fibers such as nylon and polyester, a spin-draw process is performed. In the spin-draw process, molecular orientation is aligned by heating after spinning and by stretching in the length direction to improve characteristics such as tensile strength and elastic modulus.

[0003] In the spin-draw process, a plurality of single-sided support induction heated roll apparatuses have been used. The synthetic fibers are heated, and stretched by a rotation speed difference between the induction heated roll apparatuses.

[0004] As disclosed in JP 2009-163968 A, the single-sided support induction heated roll apparatus includes a roller body including a shaft fitting portion at a bottom central portion, and a magnetic flux generation mechanism including a cylindrical iron core and an induction coil, both of which are disposed inside the roller body. The roller body is supported only on one end of the roll by fitting and connecting a tip of a rotary shaft of a motor to the shaft fitting portion of the roller body, and the roller body is rotated by the motor.

[0005] Specifically, in the induction heated roll apparatus described above, a cylindrical portion supporting the magnetic flux generation mechanism is provided inside the roller body. The rotary shaft of the motor is supported by a rolling bearing on an inner peripheral surface of the cylindrical portion.

[0006] However, with the configuration in which the rotary shaft of the motor is supported by the rolling bearing, the roller body cannot be rotated at a speed higher than the critical speed of the rotation shaft. The critical speed corresponds to the resonance frequency determined by the mass of members constituting the rotation system and the rigidity determined by the materials of the members.

[0007] As a countermeasure against this, the size of the rolling bearing is increased to increase the outer diameter of the rotating shaft, making it possible to increase the rigidity of the rotary shaft to increase the critical speed. On the other hand, as the size of the rolling bearing increases, the allowable maximum rotation speed of the bearing itself decreases. As described above, a known problem is that the critical speed is specified and the maximum rotation speed of the roller body is determined as a result of the conflict between the rigidity of the rotary shaft and the size of the rolling bearing.

[0008] As disclosed in JP H06-111920 A, another configuration has been also conceived as follows: a motor stator is fitted and fixed to the inner diameter side of the hot roller rotor and the heater coil, and a motor rotor disposed facing the motor stator and a shaft to which the motor rotor is fixed are provided. The shaft is connected to the hot roller rotor. The shaft is rotatably supported by a cover connected to a hot roller boss portion provided with a heater coil, with a bearing interposed between the shaft and the cover.

[0009] With this configuration, the area required for installing the induction heated roll apparatus can be reduced. However, the configuration is unchanged in terms of being restricted by the critical speed of the shaft, and the arrangement of the motor stator and the motor rotor is limited to within a range of the inner diameter of the heater coil. This makes it difficult to provide a motor that offers the requisite rotational torque and capacity. On the other hand, if the outer diameter of the hot roller rotor is increased to increase the inner diameter of the heater coil, the weight and the moment of inertia of the hot roller rotor increase as a result. Accordingly, a contradiction arises that a larger motor is required.

CITATION LIST

PATENT LITERATURES

[0010]

JP 2009-163968 A
JP H06-111920 A

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0011] The present invention has been made to solve the above problems. A main object of the present invention is to not only increase the rotation speed of the roller body but also reduce the size of the single-sided support induction heated roll apparatus and offer the torque and the capacity of the motor required for the single-sided support induction heated roll apparatus.

Solution to Problem

[0012] That is, an induction heated roll apparatus according to the present invention is characterized by including a stationary shaft including one side supported by a machine base; a roller body having a cylindrical shape and rotatably supported by the stationary shaft with a bearing interposed between the roller body and the stationary shaft; an induction heater provided inside the roller body and configured to allow the roller body to inductively generate heat; and an axial gap motor provided between the machine base and the roller body and configured to rotate the roller body with respect to the stationary shaft.

[0013] With such a configuration, the single-sided support induction heated roll apparatus is not restricted by the critical speed due to the configuration not using the rotary shaft, making it easy to increase the rotation speed of the roller body. Since the axial gap motor is used, the size of the single-sided support induction heated roll apparatus can be reduced and the area required for installation can be greatly reduced to save space, as compared with the induction heated roll apparatus using the radial gap motor in the related art. The rotor and the stator of the axial gap motor can be increased to the same or similar dimension as the outer diameter of the roller body. Accordingly, the torque and the capacity of the motor required for the single-sided support induction heated roll apparatus can be obtained. In addition, since the axial gap motor is provided outside the roller body, the dimension in the axial direction of the induction heater provided inside the roller body can be increased as much as possible.

[0014] As a specific embodiment of the axial gap motor, conceivably, the axial gap motor includes a rotor having a disk shape, the rotor provided on a machine base-side end surface of the roller body, the machine base-side end surface facing toward the machine base, and the rotor including a plurality of permanent magnets disposed around a rotation axis of the roller body, and a stator having a disk shape, the stator provided to face the machine base-side end surface at the machine base or the stationary shaft and including a plurality of magnetic poles each facing the rotor in a rotation axis direction of the roller body.

[0015] To prevent breakage of the bearing by cooling of the bearing, a cooling medium flow path through which a cooling medium flows is desirably formed inside the stationary shaft.

[0016] To cool not only the bearing but also the stator, the cooling medium flow path desirably cools the bearing and the stator.

[0017] As a specific embodiment of the stationary shaft, the stationary shaft desirably includes: a support shaft portion supporting the roller body, and a fixed flange portion formed at a proximal end of the support shaft portion and fixed to the machine base, and the stator is provided at the fixed flange portion.

[0018] As a specific embodiment for cooling the bearing and the stator, desirably, a bearing cooling flow path configured to cool the bearing is formed inside the support shaft portion, and a stator cooling flow path configured to cool the stator is formed inside the fixed flange portion.

[0019] To cool the axial gap motor while ensuring lubrication and cooling of the bearing, desirably, the cooling medium flow path allows a cooling medium containing a lubricating oil to flow, is open on an outer peripheral surface of the stationary shaft, and supplies the cooling medium in a mist state to the bearing and the axial gap motor.

[0020] To reduce heat transfer from the roller body to be inductively heated to the rotor and prevent the rotor from being excessively heated, a heat insulating layer is desirably formed between the machine base-side end surface of the roller body and the rotor.

[0021] As a specific embodiment of forming the heat insulating layer, desirably, the rotor is fixed to the machine base-side end surface by a fixing member having an annular shape, and the fixing member forms the heat insulating layer. By forming the heat insulating layer by the fixing member in this manner, the apparatus configuration for heat insulation can be simplified.

[0022] Desirably, the fixing member includes a recessed groove that is open on an entire circumference of an outer peripheral surface of the fixing member, and the recessed groove forms the heat insulating layer. With this configuration, the back surface side of the rotor can be proactively air-cooled.

[0023] Desirably, a cooling medium flow path through which a cooling medium flows is formed inside the stationary shaft, the cooling medium flow path is open on an outer peripheral surface of the stationary shaft and supplies the cooling medium to the axial gap motor, and an internal flow path is formed inside the fixing member, and the cooling medium flows through the internal flow path from an inner side toward an outer side in a radial direction. With this configuration, since the internal flow path through which the cooling medium flows is formed in the fixing member, the heat insulation performance of the fixing member can be improved, and the rotor can be proactively cooled.

[0024] Desirably, a cooling medium flow path through which a cooling medium flows is formed inside the stationary shaft, the cooling medium flow path is open on an outer peripheral surface of the stationary shaft and supplies the cooling medium to the axial gap motor, and a flow path is formed between the plurality of permanent magnets adjacent to each other in the rotor, and the cooling medium flows through the flow path from an inner side toward an outer side in a radial direction. With this configuration, since the flow path through which the cooling medium flows is formed between the permanent magnets adjacent to each other in the rotor, the permanent magnets of the rotor can be proactively cooled. Advantageous Effects of Invention

[0025] According to the present invention configured as described above, not only can the rotation speed of the roller body be increased, but also the size of the induction heated roll apparatus can be reduced as well as the torque and the capacity of the motor required for the induction heated roll apparatus can be obtained.

BRIEF DESCRIPTION OF DRAWINGS

[0026]

Fig. 1 is a sectional view schematically illustrating a configuration of a single-sided support induction heated roll apparatus according to an embodiment of the present invention.

Fig. 2 is a sectional view schematically illustrating a configuration of a single-sided support induction heated roll apparatus according to a modified embodiment.

Fig. 3 is a sectional view schematically illustrating a configuration of a single-sided support induction heated roll apparatus according to another modified embodiment.

Fig. 4 is a sectional view schematically illustrating a configuration of a single-sided support induction heated roll apparatus according to still another modified embodiment.

Figs. 5A1 to 5B2 are sectional views of a fixing member, including Figs. 5A1 and 5A2 that illustrate Configuration Example 1, and Figs. 5B1 and 5B2 that illustrate Configuration Example 2, in which Fig. 5A1 is a sectional view along an axial direction, Fig. 5A2 is a sectional view orthogonal to the axial direction, Fig. 5B1 is a sectional view along the axial direction, and Fig. 5B2 is a sectional view orthogonal to the axial direction.

Fig. 6 is a sectional view schematically illustrating a configuration of a single-sided support induction heated roll apparatus according to yet another modified embodiment.

Figs. 7A to 7C are views each schematically illustrating the configuration of a single-sided support induction heated roll apparatus according to a further modified embodiment, including Fig. 7A being a partial sectional view, Fig. 7B being a perspective view of a rotor, and Fig. 7C being a schematic view illustrating a flow of a cooling medium.

DESCRIPTION OF EMBODIMENTS

Embodiment of Present Invention

[0027] Hereinafter, an embodiment of a single-sided support induction heated roll apparatus 100 according to the present invention will be described with reference to the drawings.

[0028] The single-sided support induction heated roll apparatus 100 is used, for example, in a heat treatment process of a sheet material such as a plastic film, paper, cloth, nonwoven fabric, synthetic fiber, or metal foil, or a continuous material such as a web material or a wire (yarn) material.

[0029] As illustrated in Fig. 1, the single-sided support induction heated roll apparatus 100 according to the present embodiment includes a stationary shaft 2, a roller body 5, an induction heater 6, and an axial gap motor 7. The stationary shaft 2 is supported only on one end of the shaft by a machine base 20. The roller body 5 has a cylindrical shape and is rotatably supported by the stationary shaft 2 with bearings 3 and 4 interposed therebetween. The induction heater 6 is provided inside the roller body 5 and allows the roller body 5 to inductively generate heat. The axial gap motor 7 is provided between the machine base 20 and the roller body 5 and rotates the roller body 5 with respect to the stationary shaft 2.

Stationary Shaft 2

[0030] One end portion of the stationary shaft 2 is fixed to the fixed machine base 20, whereby the stationary shaft 2 is supported only on one end of the shaft. The stationary shaft 2 includes a support shaft portion 21 and a fixed flange portion 22. The support shaft portion 21 has a substantially columnar shape and rotatably supports the roller body 5 with the bearings 3 and 4 interposed therebetween. The fixed flange portion 22 is formed at a proximal end of the support shaft portion 21 and fixed to the machine base 20.

[0031] The bearings 3 and 4 are rolling bearings. Materials such as chromium bearing steel, stainless steel, and ceramics can be appropriately selected in accordance with the temperature of the bearing portion. The lubricant used for the bearings 3 and 4 can also be appropriately selected from heat-resistant grease, heat-resistant oil, solid lubricant, and the like in accordance with the temperature of the bearing portion. Instead of the rolling bearing, a non-contact magnetic bearing may be used.

Roller Body 5

[0032] The roller body 5 includes a cylindrical portion 51 having a cylindrical shape, a first disk portion 52, and a second disk portion 53. The first disk portion 52 is provided so as to close one end opening in the axial direction of the cylindrical portion 51. The second disk portion 53 is provided so as to close the other end opening in the axial direction of the cylindrical portion 51. A plurality of jacket chambers 5x are formed in the thickness of the cylindrical portion 51 along the axial direction. A gas-liquid two-phase heating medium is enclosed in the jacket chamber 5x.

[0033] Insertion holes 52h and 53h into which the stationary shaft 2 is inserted are formed at the first disk portion 52 and the second disk portion 53 of the roller body 5. The rolling bearing 3 of an outer-ring rotation type is provided between the insertion hole 52h of the first disk portion 52 and the stationary shaft 2. The rolling bearing 4 of an outer-ring rotation type is provided between the insertion hole 53h of the second disk portion 53 and the stationary shaft 2. One of the first disk portion 52 and the second disk portion 53 may be integrally formed with the cylindrical portion 51.

[0034] In addition, a temperature sensor 8 for detecting the temperature of the cylindrical portion 51 is provided in the thickness of the cylindrical portion 51 of the roller body 5. The temperature sensor 8 is connected to a detection signal transmitter 9 provided at the roller body 5, and a detection signal of the temperature sensor 8 is transmitted to an external temperature control device (not illustrated) by the detection signal transmitter 9.

[0035] The temperature control device controls a power supply circuit (not illustrated) described later to control the temperature of the roller body 5. The detection signal transmitter 9 may use, for example, a near field communication system, or may be an electromagnetic induction type or an optical type including a sender 9a and a receiver 9b. In the detection signal transmitter 9 in Fig. 1, the sender 9a is provided at the first disk portion 52, and the receiver 9b is provided at the cylindrical iron core 61.

Induction Heater 6

[0036] The induction heater 6 is provided inside the roller body 5. The induction heater 6 includes a cylindrical iron core 61 having a cylindrical shape and an induction coil 62 wound around an outer peripheral surface of the cylindrical iron core 61. The stationary shaft 2 is inserted into the cylindrical iron core 61 of the induction heater 6. The induction heater 6 is attached and fixed to the stationary shaft 2 by an attachment member 10.

[0037] A power supply circuit (not illustrated) for applying an alternating-current (AC) voltage of a commercial frequency (50 Hz or 60 Hz) or the like is connected to a lead wire (not illustrated) connected to the induction coil 62.

[0038] When an AC voltage is applied to the induction coil 62 by the induction heater 6, an alternating magnetic flux is generated. The alternating magnetic flux passes through a side peripheral wall (cylindrical portion 51) of the roller body 5. This passage generates an induced current in the cylindrical portion 51 of the roller body 5. The induced current causes the cylindrical portion 51 of the roller body 5 to generate Joule heat.

Axial Gap Motor 7

[0039] The axial gap motor 7 rotates the roller body 5 with respect to the stationary shaft 2. The axial gap motor 7 is provided on the machine base 20 side outside the roller body 5.

[0040] Specifically, the axial gap motor 7 includes a rotor 71 and a stator 72. The rotor 71 has a disk shape and is fixed to the roller body 5. The stator 72 has a disk shape and is fixed to the fixed flange portion 22 of the stationary shaft 2.

[0041] The rotor 71 includes a plurality of permanent magnets disposed at equal intervals around the rotation axis of the roller body 5. The rotor 71 according to the present embodiment is fixed to a machine base-side end surface 5a in the rotation axis direction of the roller body 5. The machine base-side end surface 5a according to the present embodiment includes the outer end surface of the second disk portion 53 of the roller body 5.

[0042] Here, a heat insulating layer S1 is formed between the machine base-side end surface 5a of the roller body 5 and the back surface of the rotor 71 (the surface opposite to the machine base 20), throughout the circumferential direction around the rotation axis. Specifically, the rotor 71 is fixed to the machine base-side end surface 5a by a fixing member 11 having an annular shape. The fixing member 11 forms the heat insulating layer S1. Specifically, at the fixing member 11, a recessed groove 11a is formed. The recessed groove 11a is open on the entire circumference of the outer peripheral surface of the fixing member 11. The recessed groove 11a is formed at a position further inside than a half position of the rotor 71 in the radial direction of the fixing member 11. With this configuration, the fixing member 11 has a substantially U-shaped section. The recessed groove 11a forms the heat insulating layer S1. The thick portion itself of the fixing member 11 also functions as a heat insulating layer.

[0043] The stator 72 includes a plurality of magnetic poles each facing the rotor 71 in the rotation axis direction of the roller body 5. The plurality of magnetic poles are also disposed at equal intervals around the rotation axis of the roller body 5, similarly to the plurality of permanent magnets. The stator 72 according to the present embodiment is provided on the facing surface 2a facing the machine base-side end surface 5a of the roller body 5. The facing surface 2a includes a surface of the fixed flange portion 22 of the stationary shaft 2. The surface of the fixed flange portion 22 faces the machine base-side end surface 5a.

[0044] In the axial gap motor 7, by supplying AC power to the stator 72, rotational torque is generated between the rotor 71 and the stator 72, and the roller body 5 rotates at a predetermined rotation speed.

Cooler 12 for Bearings 3 and 4 and Axial Gap Motor 7

[0045] The single-sided support induction heated roll apparatus 100 according to the present embodiment further includes a cooler 12 for cooling the bearings 3 and 4 and the axial gap motor 7.

[0046] The cooler 12 includes a cooling medium flow path 121 and a cooling medium supply source (not illustrated) such as a pump that supplies the cooling medium to the cooling medium flow path 121. The cooling medium flow path 121 is formed inside the stationary shaft 2 and a cooling medium flows through the cooling medium flow path 121. As the cooling medium, for example, water or air can be used.

[0047] The cooling medium flow path 121 is formed to cool the bearings 3 and 4 and the stator 72 of the axial gap motor 7. Specifically, the cooling medium flow path 121 includes a bearing cooling flow path 121a and a stator cooling flow path 121b. The bearing cooling flow path 121a is formed inside the support shaft portion 21 and is for cooling the bearings 3 and 4. The stator cooling flow path 121b is formed inside the fixed flange portion 22 and is for cooling the stator 72.

[0048] The bearing cooling flow path 121a communicates with an input port P1 and an output port P2, both of which are provided at the proximal end of the stationary shaft 2. The bearing cooling flow path 121a is a reciprocating path formed inside the support shaft portion 21 along the axial direction. The bearing cooling flow path 121a extends to or near the bearing 3 on the free end side in the axial direction of the support shaft portion 21.

[0049] The stator cooling flow path 121b includes an annular flow path formed inside the fixed flange portion 22 along the circumferential direction of the stator 72 at a portion facing the stator 72. The stator cooling flow path 121b according to the present embodiment is formed to be branched from the bearing cooling flow path 121a, and communicates with the input port P1 and the output port P2. The stator cooling flow path 121b may be formed independently of the bearing cooling flow path 121a inside the stationary shaft 2.

Effects of Present Embodiment

[0050] The induction heated roll apparatus 100 configured as described above is not restricted by the critical speed due to the configuration not using the rotary shaft, making it easy to increase the rotation speed of the roller body 5. Since the axial gap motor 7 is used, the size of the single-sided support induction heated roll apparatus 100 can be reduced and the area required for installation can be greatly reduced to save space, as compared with the radial gap motor in the related art. The rotor 71 and the stator 72 of the axial gap motor 7 can be increased to the same or similar dimension as the outer diameter of the roller body 5. Accordingly, the torque and the capacity of the motor required for the single-sided support induction heated roll apparatus 100 can be obtained. In addition, since the axial gap motor 7 is provided outside the roller body 5, the dimension in the axial direction of the induction heater 6 provided inside the roller body 5 can be increased as much as possible.

[0051] The recessed groove 11a is formed at the fixing member 11 for fixing the rotor 71, and whereby the recessed groove 11a forms the heat insulating layer S1. Thus, heat transfer from the roller body 5 inductively heated to the rotor 71 can be reduced, and the rotor 71 can be prevented from being excessively heated. Furthermore, the back surface side of the rotor 71 can be proactively air-cooled.

Other Embodiments

[0052] The present invention is not limited to the above embodiment, and the following aspects may be adopted.

[0053] In the embodiment described above, the stator 72 of the axial gap motor 7 is provided at the fixed flange portion 22 of the stationary shaft 2. Alternatively, as illustrated in Fig. 2, the stator 72 may be provided, for example, at a member different from the machine base 20 or from the stationary shaft 2 provided at the machine base 20 (not illustrated).

[0054] The cooler 12 may directly supply a cooling medium containing a lubricating oil to the bearings 3 and 4 and the axial gap motor 7. In this case, conceivably, as illustrated in Fig. 3, the cooling medium flow path 121 allows the cooling medium containing a lubricating oil to flow, is open on the outer peripheral surface of the stationary shaft 2 (support shaft portion 21), and leads out the mist-like cooling medium from vents 121x. Here, forming the vents 121x of the cooling medium flow path 121 into a nozzle shape makes it possible to lead out a mist-like cooling medium. The vents 121x are respectively formed toward the bearings 3 and 4. The mist-like cooling mediums led out from the vents 121x of the cooling medium flow path 121 are respectively sprayed to the bearings 3 and 4. The mist-like cooling medium sprayed to the bearing 4 on the machine base side passes between the rotor 71 and the stator 72 of the axial gap motor 7 to cool the rotor 71 and the stator 72, and then is discharged to the outside.

[0055] As illustrated in Fig. 4, the cooling medium flow path 121 through which the cooling medium flows may be formed inside the stationary shaft 2. The cooling medium flow path 121 may be open at a position, which is closer to the machine base 20 than the bearing 4 is, on the outer peripheral surface of the stationary shaft 2, thereby supplying the cooling medium (e.g., air) to the axial gap motor 7. Here, the fixing member 11 fixing the rotor 71 to the roller body 5 serves as the heat insulating layer S1. An internal flow path 11R through which the cooling medium flows from the inner side to the outer side in the radial direction is formed inside the fixing member 11. The cooling medium flow path 121 is open on the outer peripheral surface of the stationary shaft 2 such that the opening faces the inner peripheral surface of the fixing member 11 in the radial direction. With such a configuration, the cooling medium supplied from the cooling medium flow path 121 cools the bearing 4 on the machine base side, and then passes through the internal flow path 11R by the centrifugal force accompanying the rotation and by the supply pressure of the cooling medium. As a result, the rotor 71 is cooled. Some of the cooling medium passes between the rotor 71 and the stator 72 to cool the rotor 71 and the stator 72, and then is discharged to the outside.

[0056] Here, a configuration example of the fixing member 11 including the internal flow path 11R is illustrated in Fig. 5. In Configuration Example 1, as illustrated in Figs. 5A1 and 5A2, the fixing member 11 includes one plate member having an annular shape. The internal flow path 11R is formed from the inner side toward the outer side in the radial direction in the thickness of the plate member. The internal flow path 11R may be a linear flow path or may be a curved flow path. In Configuration Example 2, as illustrated in Figs. 5B1 and 5B2, the fixing member 11 includes two annular plate members 11a and 11b overlapping with each other with a plurality of spacer members 11c interposed therebetween. The internal flow path 11R is formed between the plate members 11a and

11b by the plurality of spacer members 11c. In this configuration, the rotor 71 is fixed to one plate member 11a, and the other plate member 11b is fixed to the roller body 5.

[0057] As illustrated in Fig. 6, the fixing member 11 fixing the rotor 71 to the roller body 5 may include the recessed groove 11a that is open on the entire circumference of the inner peripheral surface. The recessed groove 11a forms the heat insulating layer S1. Further, the cooling medium flow path 121 through which the cooling medium flows may be formed inside the stationary shaft 2. The cooling medium flow path 121 may be open at a position, which is closer to the machine base 20 than the bearing 4 is, on the outer peripheral surface of the stationary shaft 2, thereby supplying the cooling medium (e.g., air) to the axial gap motor 7. Here, one or a plurality of through holes 11h are formed at a bottom wall (outer peripheral wall) of the recessed groove 11a of the fixing member 11. The recessed groove 11a and the through hole(s) 11h constitute the internal flow path 11R. The cooling medium flow path 121 is open on the outer peripheral surface of the stationary shaft 2 such that the opening faces the recessed groove 11a of the fixing member 11 in a radial direction. With such a configuration, the cooling medium supplied from the cooling medium flow path 121 cools the bearing 4 on the machine base side, then flows in the recessed groove 11a by the centrifugal force accompanying the rotation and by the supply pressure of the cooling medium, and discharged from the through hole(s) 11h to the outside. As a result, the rotor 71 is cooled. Some of the cooling medium passes between the rotor 71 and the stator 72 to cool the rotor 71 and the stator 72, and then is discharged to the outside.

[0058] As illustrated in Fig. 7, a flow path 71R through which the cooling medium flows from the inner side to the outer side in the radial direction may be formed between the permanent magnets 712 adjacent to each other in the rotor 71. Here, the rotor 71 includes a base member 711 and permanent magnets 712. The base member 711 is a magnetic body and has an annular shape. The permanent magnets 71m are provided intermittently on the base member 711 with N and S magnetic poles alternately disposed. The base member 711 may have a function as the heat insulating layer S1. A fixing member 11 may be provided between the base member 711 and the roller body 5. Further, the cooling medium flow path 121 through which the cooling medium flows may be formed inside the stationary shaft 2. The cooling medium flow path 121 may be open at a position, which is closer to the machine base 20 than the bearing 4 is, on the outer peripheral surface of the stationary shaft 2, thereby supplying the cooling medium (e.g., air) to the axial gap motor 7. Here, the cooling medium flow path 121 is open on the outer peripheral surface of the stationary shaft 2 such that the opening faces the permanent magnets 712 in a radial direction. With such a configuration, the cooling medium supplied from the cooling medium flow path 121 cools the bearing 4 on the machine base side, and then passes through the flow paths 71R between the permanent magnets 712 by the centrifugal force accompanying the rotation and by the supply pressure of the cooling medium. The cooling medium passes between the rotor 71 and the stator 72. As a result, the rotor 71 is cooled.

[0059] In each of the embodiments described above, a magnetic shield portion may be provided between the axial gap motor 7 and the induction heater 6. In Figs. 1 and 2, the magnetic shield portion may be configured such that the second disk portion 53 or the fixing member 11 has a magnetic shield function, or a magnetic shield member is separately provided. With this configuration, mutual magnetic interference between the axial gap motor 7 and the induction heater 6 disposed in series can be prevented. In addition, using an involute iron core is also conceivable as a measure against occurrence of magnetic flux leakage at an iron core. The involute iron core is an iron core in which magnetic steel plates each having a substantially involute shape in section are stacked in a cylindrical shape, and has low magnetic resistance.

[0060] When the spin-draw process is carried out using a plurality of the induction heated roll apparatuses, a rotatable portion may be provided on the stationary shaft 2 in order to give a mutual tilt angle (Nelson angle) for ensuring stable travel on a predetermined yarn path between the plurality of induction heated roll apparatuses.

[0061] In addition, the present invention is not limited to the embodiments described above, and it goes without saying that various modifications can be made without departing from the spirit of the present invention.

REFERENCE SIGNS LIST

[0062]

100	Single-sided support induction heated roll apparatus
20	Machine base
2	Stationary shaft
21	Support shaft portion
22	Fixed flange portion
3, 4	Bearing
5	Roller body
5a	Machine base-side end surface
6	Induction heater
7	Axial gap motor
71	Rotor
72	Stator
11	Fixing member
11a	Recessed groove
S1	Heat insulating layer
121	Cooling medium flow path
121a	Bearing cooling flow path
121b	Stator cooling flow path
11R	Internal flow path

71R Flow path

Claims

1. A single-sided support induction heated roll apparatus (100) **characterized by**:

   a stationary shaft (2) including one side supported by a machine base (20);
   a roller body (5) having a cylindrical shape and rotatably supported by the stationary shaft (2) with a bearing (3, 4) interposed between the roller body (5) and the stationary shaft (2);
   an induction heater (6) provided inside the roller body (5) and configured to allow the roller body (5) to inductively generate heat; and
   an axial gap motor (7) provided between the machine base (20) and the roller body (5) and configured to rotate the roller body (5) with respect to the stationary shaft (2).

2. The single-sided support induction heated roll apparatus (100) according to claim 1, **characterized in that**
   the axial gap motor (7) includes

   a rotor (71) having a disk shape, the rotor (71) provided on a machine base-side end surface (5a) of the roller body (5), the machine base-side end surface (5a) facing toward the machine base (20), and the rotor (71) including a plurality of permanent magnets (71m) disposed around a rotation axis of the roller body (5), and
   a stator (72) having a disk shape, the stator (72) provided to face the machine base-side end surface (5a) at the machine base (20) or the stationary shaft (2) and including a plurality of magnetic poles each facing the rotor (71) in a rotation axis direction of the roller body (5).

3. The single-sided support induction heated roll apparatus (100) according to claim 2, **characterized in that** a cooling medium flow path (121) through which a cooling medium flows is formed inside the stationary shaft (2).

4. The single-sided support induction heated roll apparatus (100) according to claim 3, **characterized in that** the cooling medium flow path (121) cools the bearing (3, 4) and a stator (72).

5. The single-sided support induction heated roll apparatus (100) according to claim 2, **characterized in that**

   the stationary shaft (2) includes:

   a support shaft portion (21) supporting the roller body (5), and
   a fixed flange portion (22) formed at a proximal end of the support shaft portion (21) and fixed to the machine base (20), and

   the stator (72) is provided at the fixed flange portion (22).

6. The single-sided support induction heated roll apparatus (100) according to claim 5, **characterized in that**

   a bearing cooling flow path (121a) configured to cool the bearing (3, 4) is formed inside the support shaft portion (21), and
   a stator cooling flow path (121b) configured to cool the stator (72) is formed inside the fixed flange portion (22).

7. The single-sided support induction heated roll apparatus (100) according to claim 4, **characterized in that** the cooling medium flow path (121) allows a cooling medium containing a lubricating oil to flow, is open on an outer peripheral surface of the stationary shaft (2), and supplies the cooling medium in a mist state to the bearing (3, 4) and the axial gap motor (7).

8. The single-sided support induction heated roll apparatus (100) according to claim 2, **characterized in that** a heat insulating layer (S1) is formed between the machine base-side end surface (5a) of the roller body (5) and the rotor (71).

9. The single-sided support induction heated roll apparatus (100) according to claim 8, **characterized in that**

   the rotor (71) is fixed to the machine base-side end surface (5a) by a fixing member (11) having an annular shape, and
   the fixing member (11) forms the heat insulating layer (S1).

10. The single-sided support induction heated roll apparatus (100) according to claim 9, **characterized in that**

    the fixing member (11) includes a recessed groove (11a) that is open on an entire circumference of an outer peripheral surface of the fixing member (11), and
    the recessed groove (11a) forms the heat insulating layer (S1).

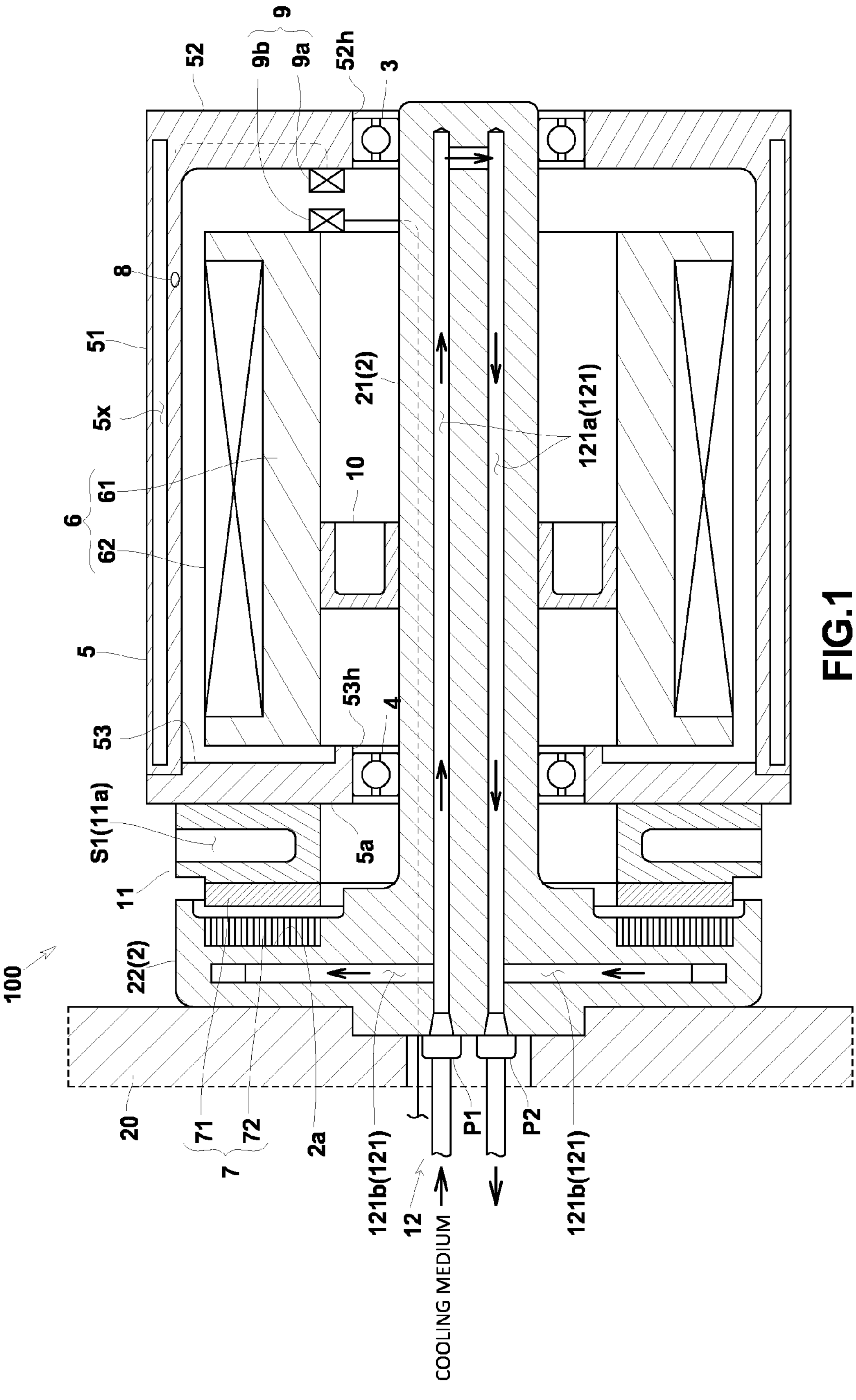
11. The single-sided support induction heated roll apparatus (100) according to claim 9 or 10, **characterized**

in that

a cooling medium flow path (121) through which a cooling medium flows is formed inside the stationary shaft (2),
the cooling medium flow path (121) is open on an outer peripheral surface of the stationary shaft (2) and supplies the cooling medium to the axial gap motor (7), and
an internal flow path (11R) is formed inside the fixing member (11), and the cooling medium flows through the internal flow path (11R) from an inner side toward an outer side in a radial direction.

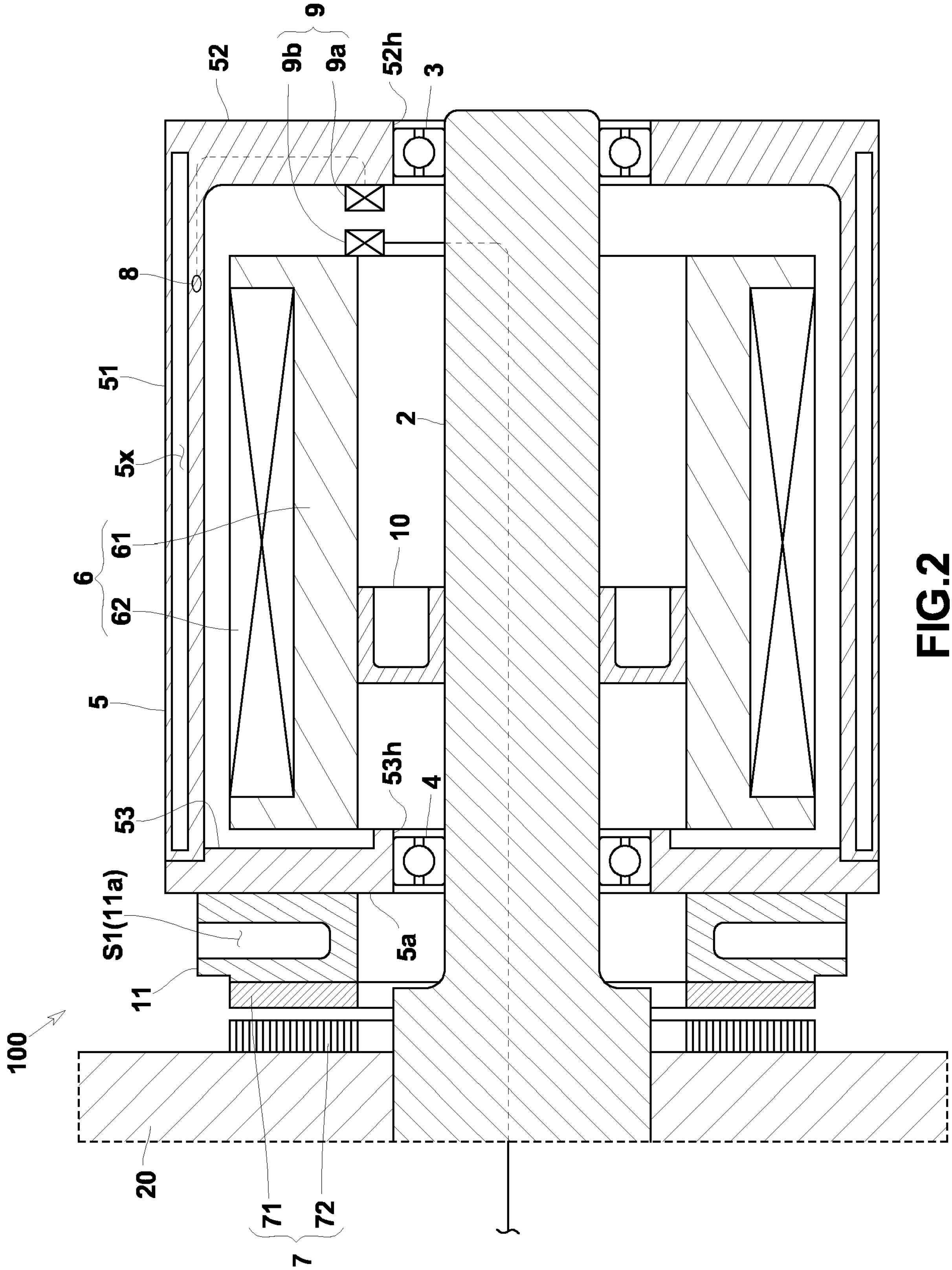
12. The single-sided support induction heated roll apparatus (100) according to claim 9 or 10, **characterized in that**

a cooling medium flow path (121) through which a cooling medium flows is formed inside the stationary shaft (2),
the cooling medium flow path (121) is open on an outer peripheral surface of the stationary shaft (2) and supplies the cooling medium to the axial gap motor (7), and
a flow path (71R) is formed between the plurality of permanent magnets (71m) adjacent to each other in the rotor (71), and the cooling medium flows through the flow path (71R) from an inner side toward an outer side in a radial direction.



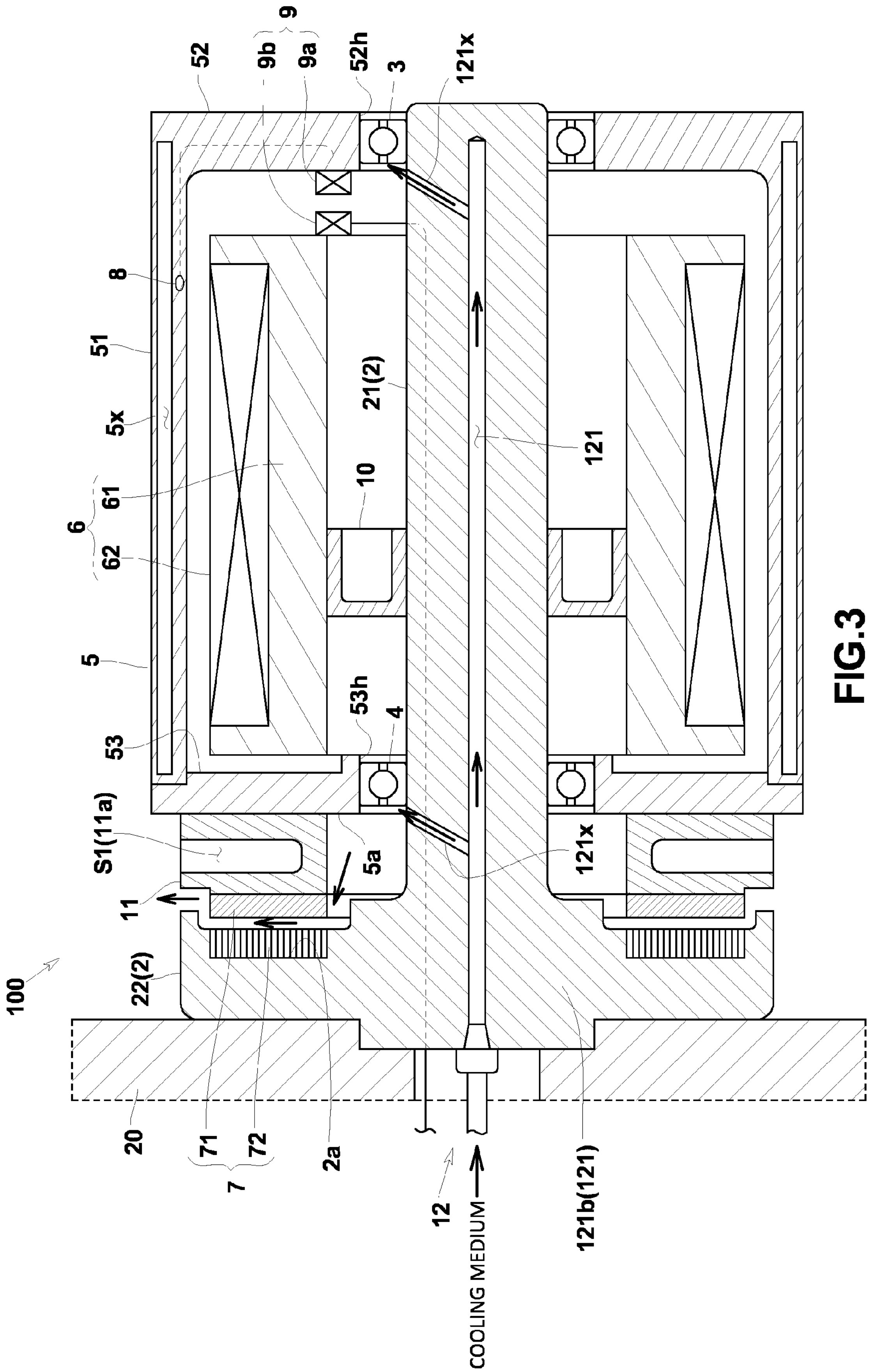
100
20
22(2)
11
S1(11a)
53
5
62
6
61
5x
51
8
52
9b
9
9a
52h
3
71
72
7
2a
121b(121)
12
COOLING MEDIUM
P1
P2
121b(121)
5a
4
53h
10
21(2)
121a(121)

FIG.1



9
52
9b
9a
52h
3
8
51
2
5x
10
6
61
62
5
53h
4
53
S1(11a)
5a
11
100
20
71
72
7

FIG.2



9
9b
9a
52
52h
3
121x
8
51
5x
61
6
62
5
53
53h
4
10
21(2)
121
S1(11a)
11
5a
121x
100
22(2)
20
71
72
7
2a
12
COOLING MEDIUM
121b(121)

FIG.3

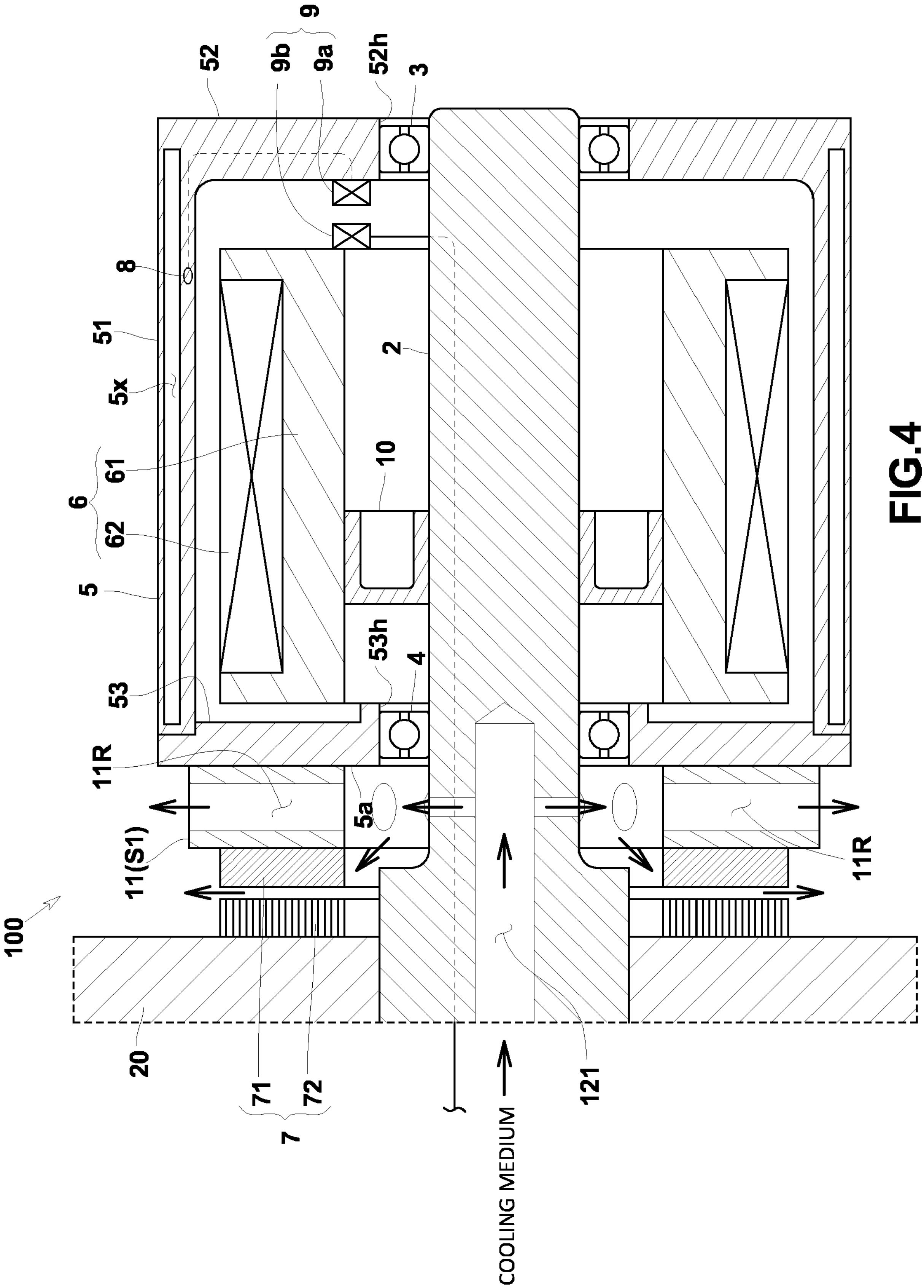

9
9b
9a
52
52h
3
8
51
2
5x
10
6
61
62
5
53h
4
53
11R
5a
11(S1)
11R
100
20
71
72
7
COOLING MEDIUM
121

FIG.4

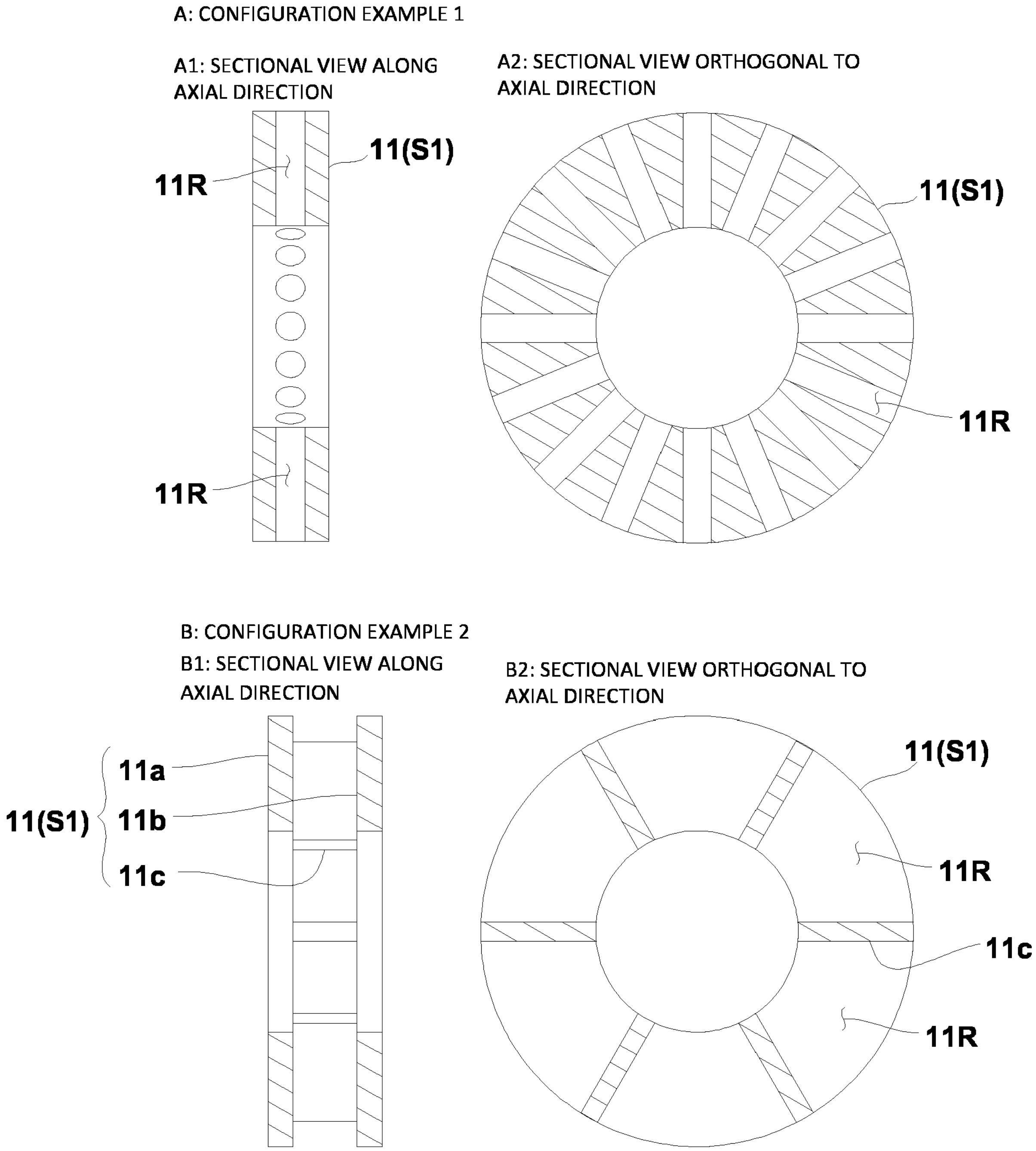

A: CONFIGURATION EXAMPLE 1
A1: SECTIONAL VIEW ALONG AXIAL DIRECTION
A2: SECTIONAL VIEW ORTHOGONAL TO AXIAL DIRECTION
11(S1)
11R
11R
11(S1)
11R
B: CONFIGURATION EXAMPLE 2
B1: SECTIONAL VIEW ALONG AXIAL DIRECTION
B2: SECTIONAL VIEW ORTHOGONAL TO AXIAL DIRECTION
11a
11(S1)
11b
11c
11(S1)
11R
11c
11R

FIG.5

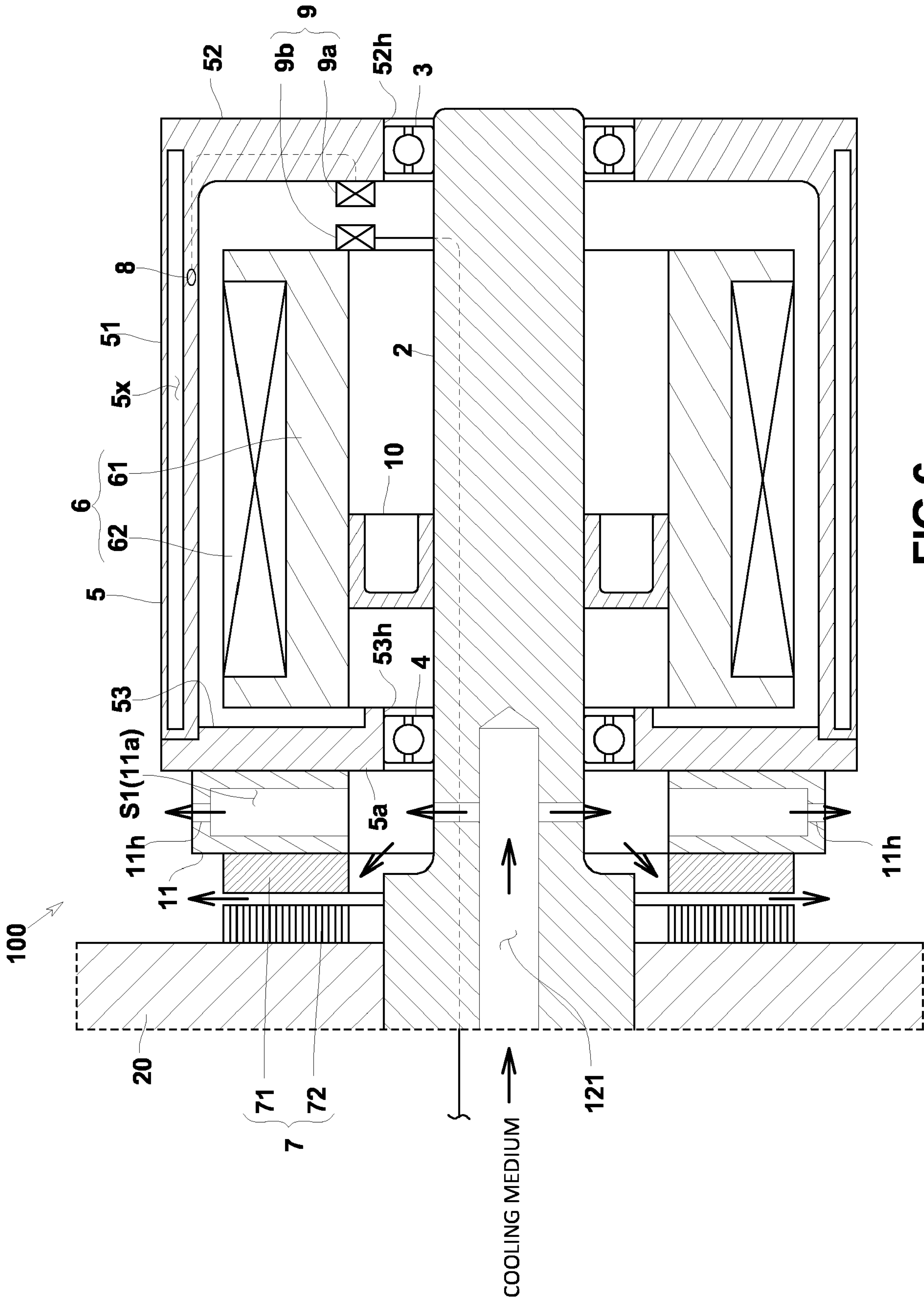

9
9b
9a
52
52h
3
8
51
5x
2
6
61
62
10
5
53h
4
53
S1(11a)
5a
11h
11
11h
100
20
71
72
7
121
COOLING MEDIUM

FIG.6

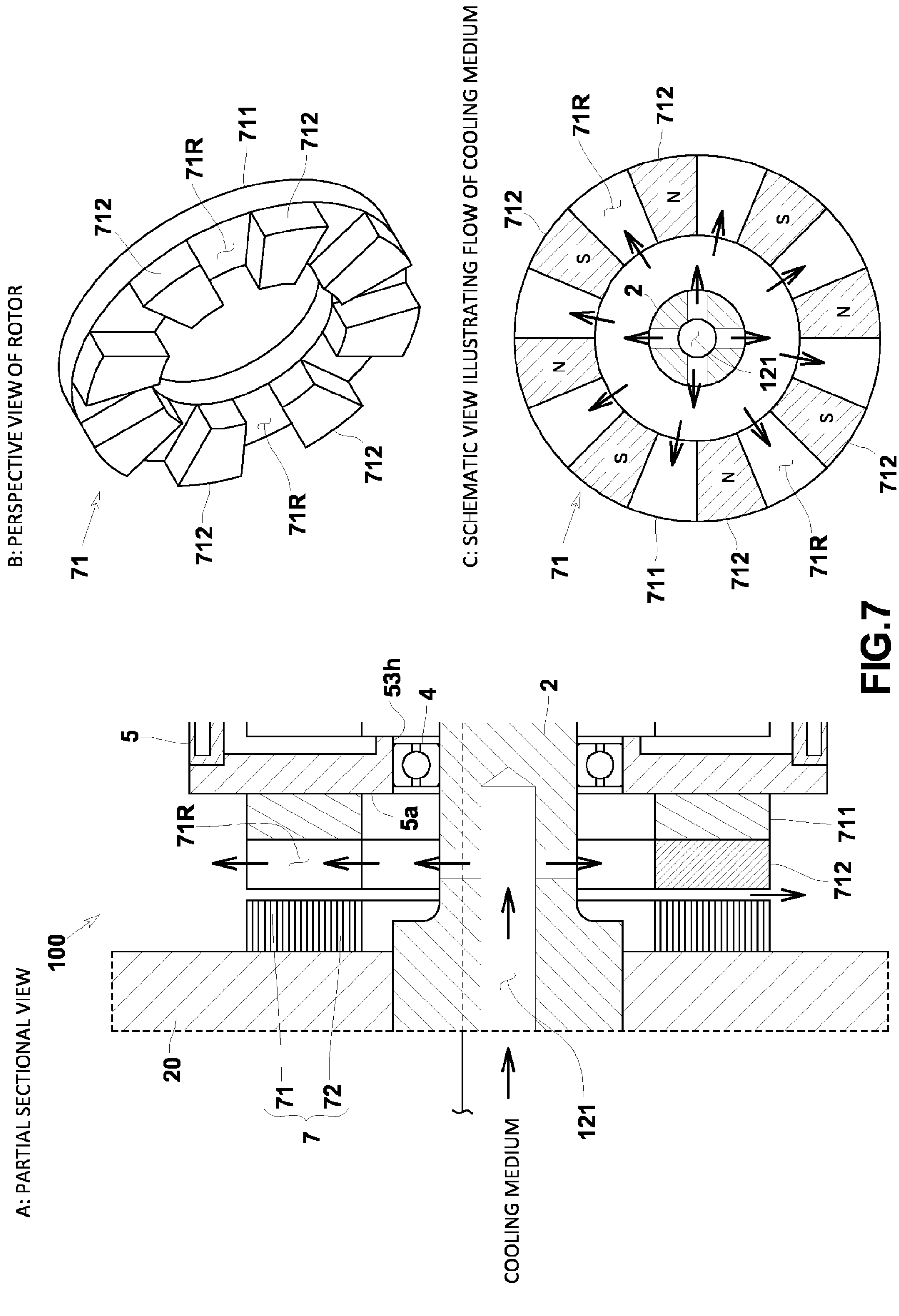

A: PARTIAL SECTIONAL VIEW
100
20
71
72
7
COOLING MEDIUM
121
71R
5a
5
53h
4
2
711
712
B: PERSPECTIVE VIEW OF ROTOR
71
712
71R
711
C: SCHEMATIC VIEW ILLUSTRATING FLOW OF COOLING MEDIUM
N
S

FIG.7

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EUROPEAN SEARCH REPORT

Application Number
EP 22 19 9620

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2018/235036 A1 (KITANO TAKATSUGU [JP] ET AL) 16 August 2018 (2018-08-16) * paragraph [0054] - paragraph [0072]; claims 1-19; figures 1-5 * -----	1-12	INV. H05B6/14 B65H51/04 D02J13/00 B21B27/08 B21B27/10
A	JP 2015 180147 A (MAZDA MOTOR) 8 October 2015 (2015-10-08) * abstract; claims 1-12; figures 1, 7,11, 15 * -----	1-12	
			TECHNICAL FIELDS SEARCHED (IPC)
			H05B B65H D02J B21B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	2 March 2023	Durucan, Emrullah

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02-03-2023

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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- JP H06111920 A **[0008] [0010]**