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(54) WATERPUMP

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(57) **ABSTRACT**

An electrically driven waterpump includes a rotor having impellers for feeding fluid. The rotor is housed in a housing. The rotor includes: a working section located in the fluid and contacting the fluid in a main passage of the fluid stirred by the impellers; and a non-working section located in the fluid and apart from the main passage of the fluid. Water repellency is applied to at least either one of an outer surface of the non-working section or a plane of the housing confronting the outer surface of the non-working section with the fluid interposed, so that shear stress of the fluid is reduced, and pump efficiency is improved.

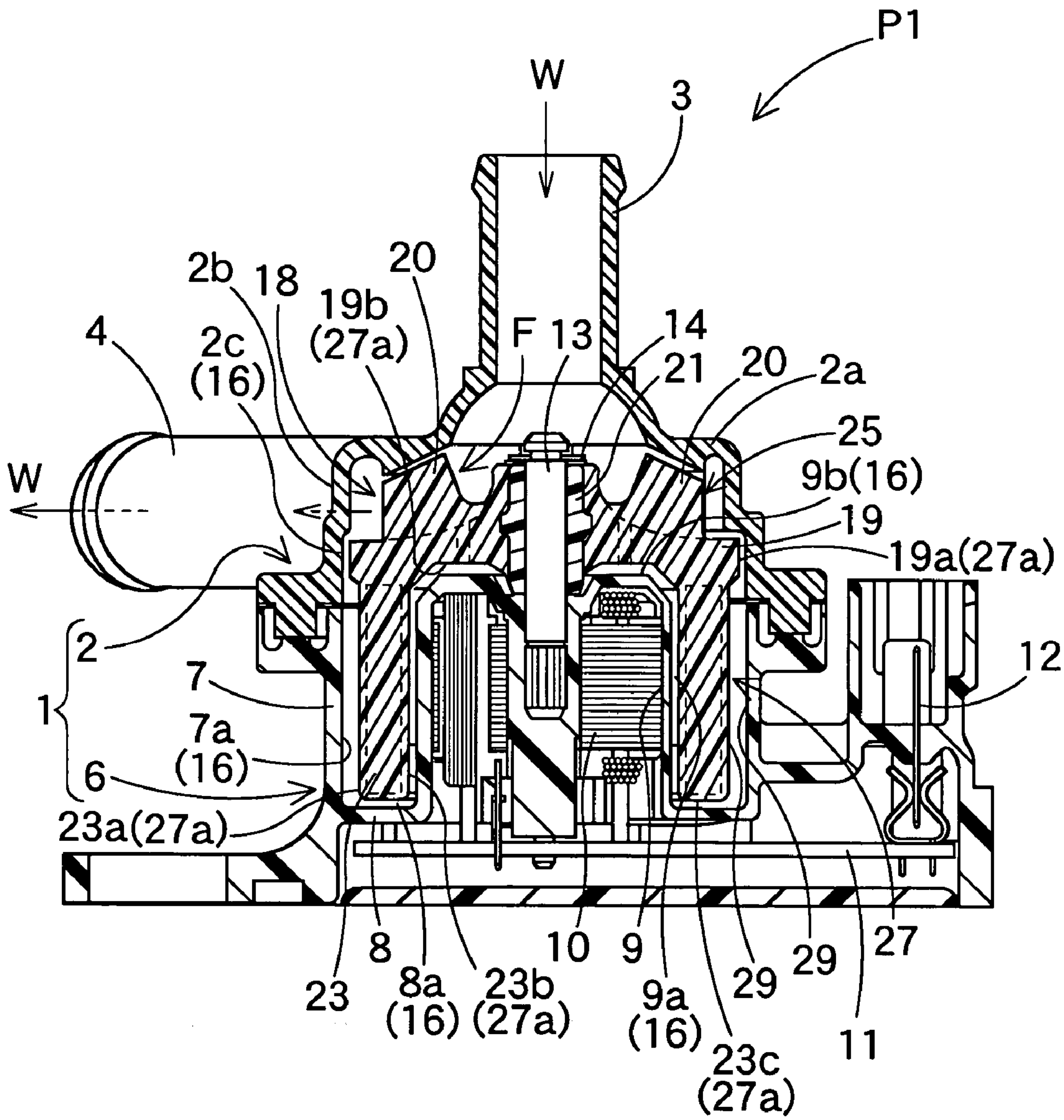


Fig.1

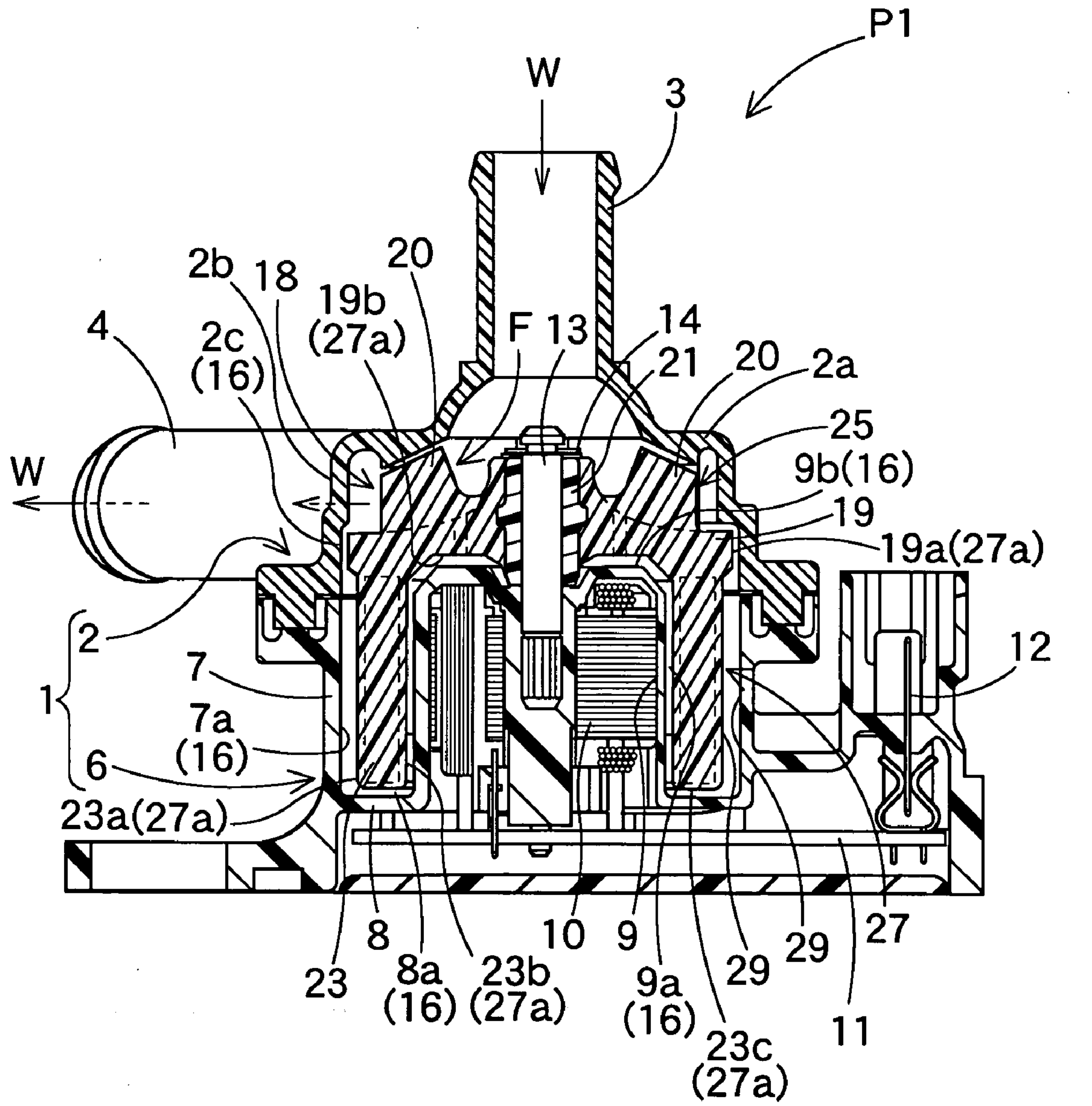

P1
W
3
20
2b
18
19b
(27a)
F
13
14
4
2c
(16)
21
20
2a
25
W
9b(16)
19
19a(27a)
2
12
1
7
7a
(16)
6
23a(27a)
23
8
8a
(16)
23b
(27a)
10
9
9a
(16)
29
29
23c
(27a)
27
11

Fig.2

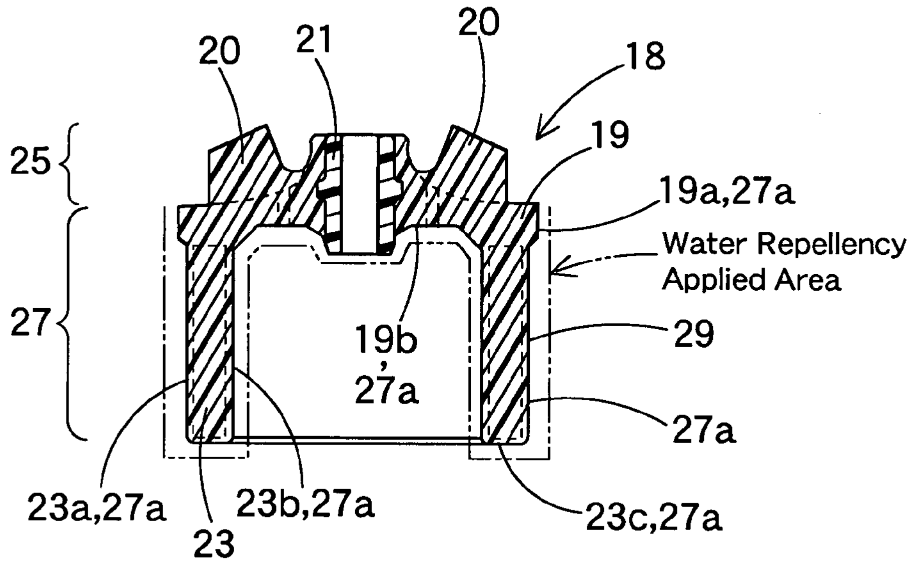
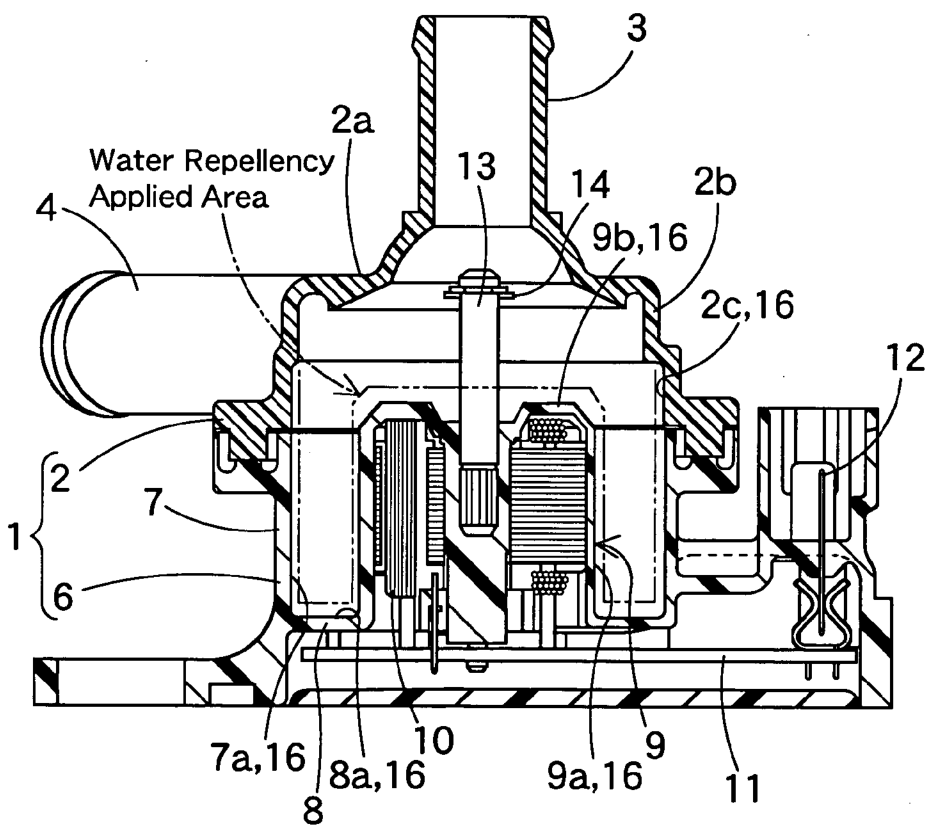

20
21
20
18
25
19
19a,27a
Water Repellency
Applied Area
27
19b
,
27a
29
27a
23a,27a
23
23b,27a
23c,27a

Fig.3


3
2a
13
14
2b
Water Repellency
Applied Area
4
9b,16
2c,16
12
2
7
1
6
7a,16
8
8a,16
10
9a,16
9
11

F i g. 4

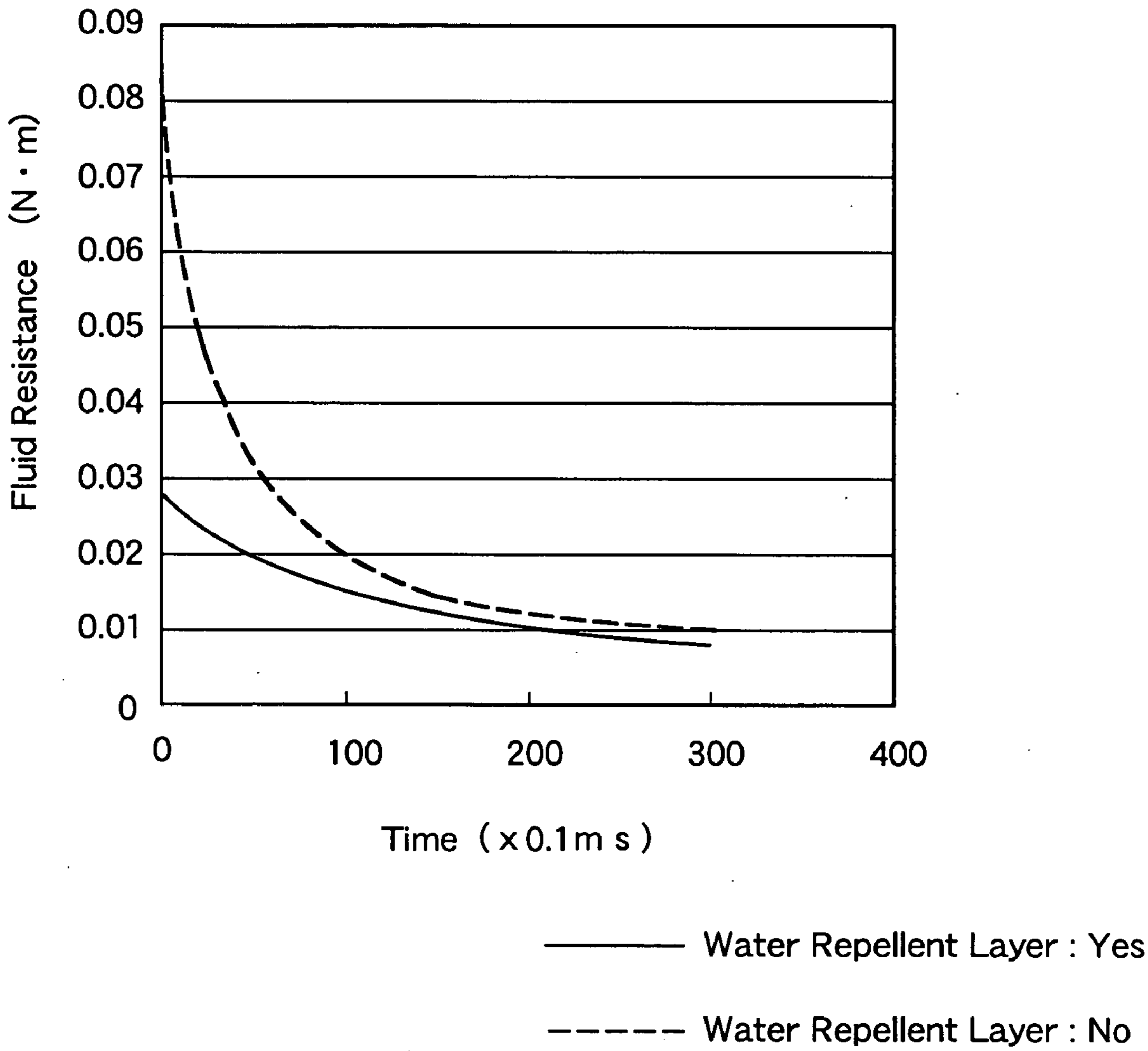

0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Fluid Resistance (N・m)
0
100
200
300
400
Time (x0.1m s)
Water Repellent Layer : Yes
Water Repellent Layer : No

Fig.5

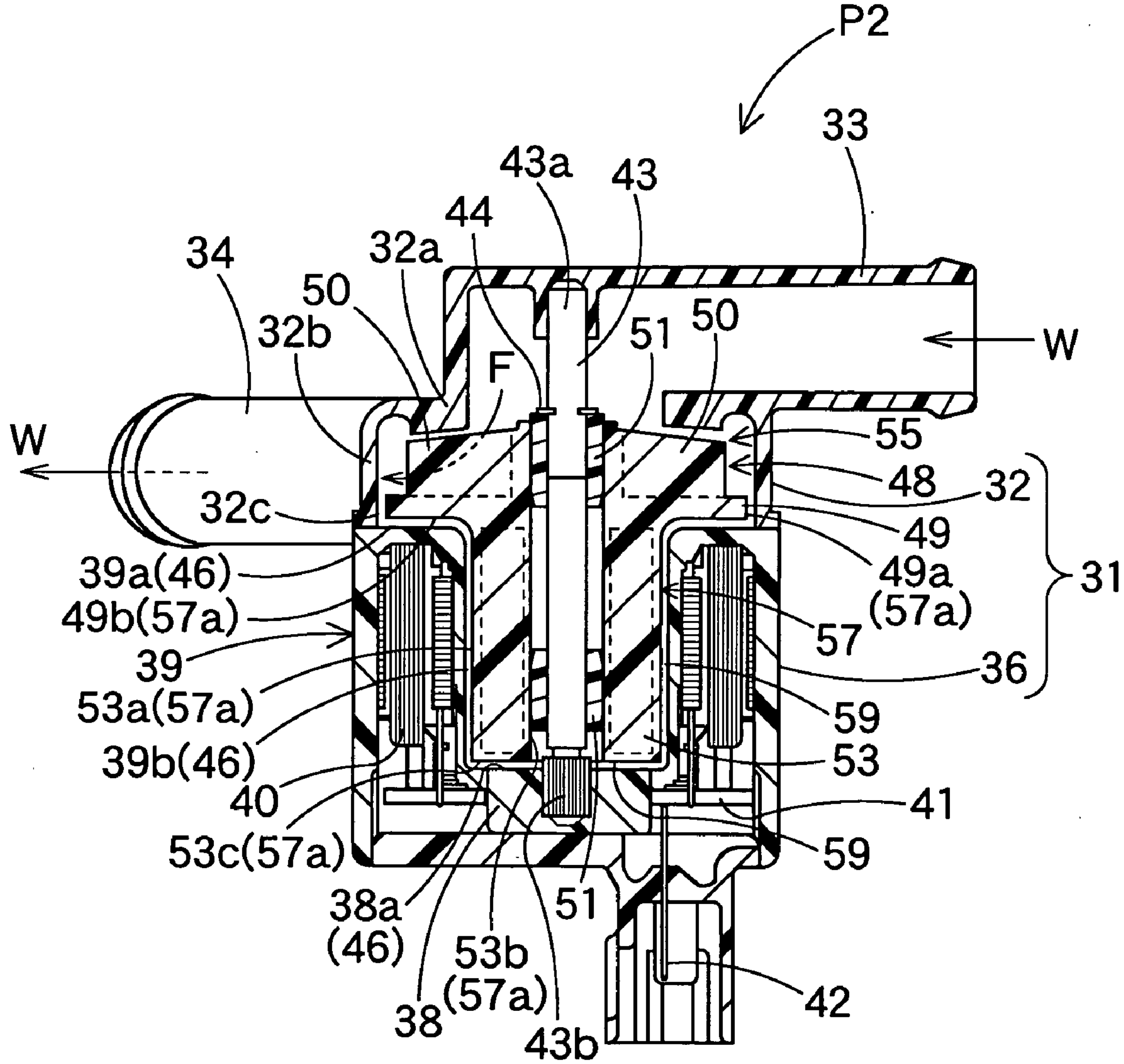

P2
33
43a
43
44
32a
34
50
32b
51
50
W
F
W
55
48
32
32c
49
39a(46)
49a
(57a)
31
49b(57a)
57
39
36
53a(57a)
59
39b(46)
53
40
41
53c(57a)
59
38a
(46)
51
53b
(57a)
42
38
43b

Fig.6

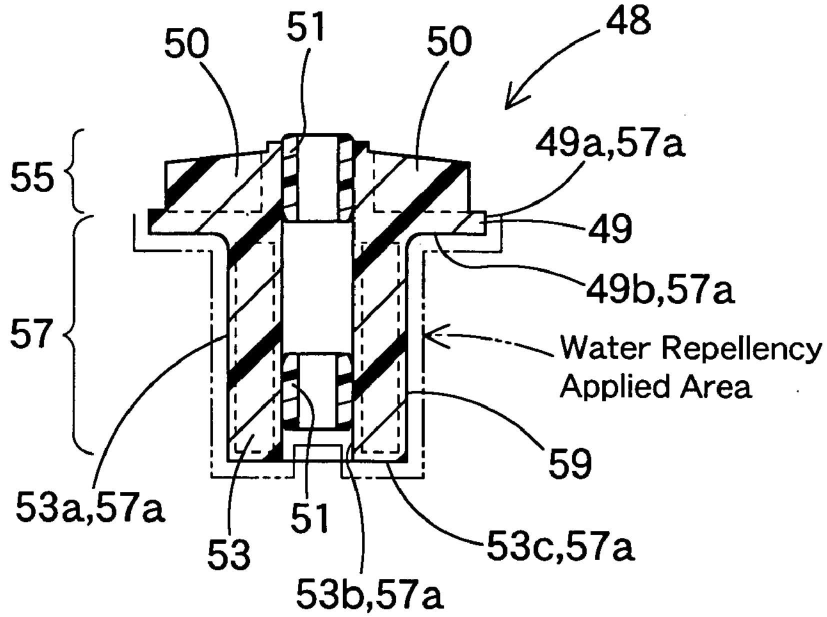
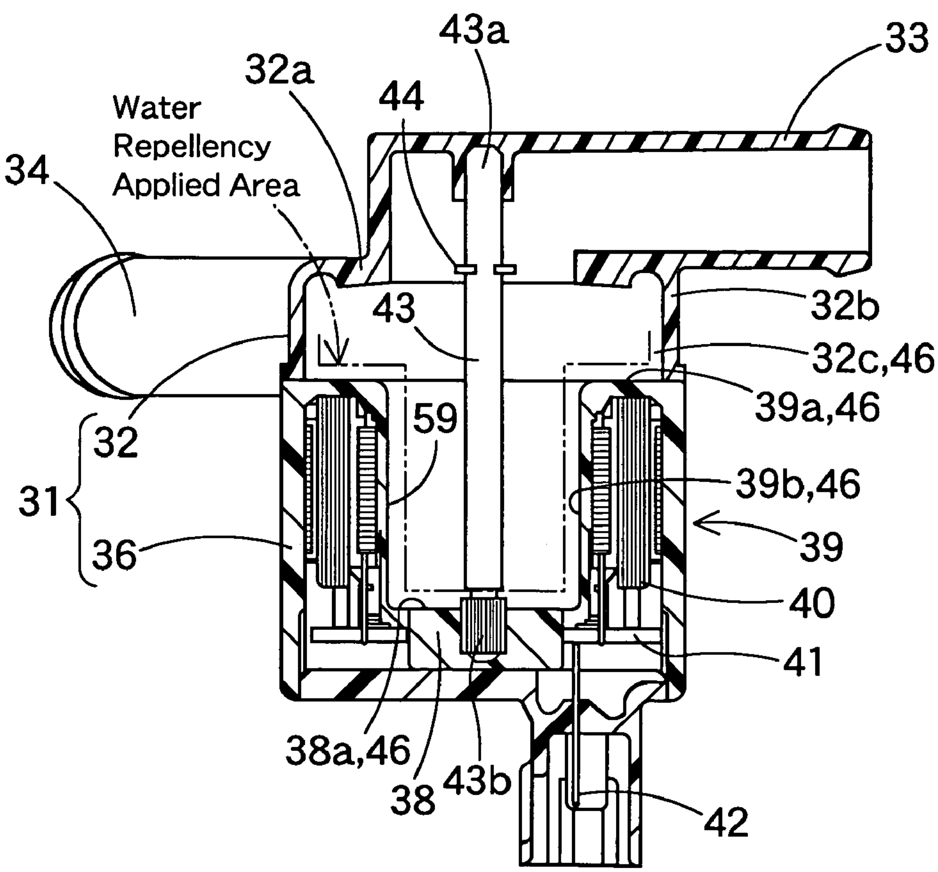

48
50
51
50
55
49a,57a
49
49b,57a
57
Water Repellency
Applied Area
59
53a,57a
51
53
53c,57a
53b,57a

Fig.7


43a
33
32a
44
Water
Repellency
Applied Area
34
43
32b
32c,46
39a,46
32
59
31
39b,46
39
36
40
41
38a,46
38
43b
42

WATERPUMP

[0001] The present application claims priority from Japanese Patent Application No. 2003-142386 of Hatano et al., filed on May 20, 2003, the entirety of which is hereby incorporated into the present application by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to an electric waterpump for pumping fluids such as engine coolant for vehicles.

[0004] 2. Description of the Related Art

[0005] In conventional electric waterpumps of this kind such as a magnetic coupling pump for engine coolant for vehicles, a rotor having impellers for feeding coolant is located in a housing, as disclosed in Japanese Laid Open Patent Application No. JP10-311290.

[0006] In this waterpump, a magnet section is located in a part of the rotor apart from impellers, while a stator is located around the rotor toward the housing to generate a rotating magnetic field for driving the magnet section when electrified.

[0007] The rotor is submerged in coolant, and is constituted by two parts: a working section which contacts with the coolant in a main passage of the coolant fed by impellers, and a non-working section which is an area apart from the main passage of the fluid and located in the coolant.

[0008] In conventional waterpumps, however, when in service, it is inevitable that shear stress of coolant occurs between an outer surface of the non-working section including the magnet section and a plane of the housing confronting the outer surface of the non-working section with coolant interposed. In other words, friction between the rotor and coolant is prone to restrain the quantity of coolant supplied and the pressure of the coolant in comparison with electricity supplied to the stator. Especially in rapid rotation area where the rotor rotates at over 3000 rpm, for example, increase of shear stress of the coolant becomes conspicuous, which lowers the pump efficiency compared with supplied electricity.

SUMMARY OF THE INVENTION

[0009] The present invention contemplates to solve the above mentioned problem, and therefore, has an object to provide a waterpump capable of reducing shear stress of fluid in the non-working section, and thus capable of improving pump efficiency.

[0010] The waterpump according to the present invention is driven electrically, and includes a rotor having impellers for feeding fluid. The rotor is housed in a housing. The rotor includes: a working section located in the fluid and contacting the fluid in a main passage of the fluid stirred by the impellers; and a non-working section located in the fluid and apart from the main passage of the fluid. Water repellency is applied to at least either one of an outer surface of the non-working section or a plane of the housing confronting the outer surface of the non-working section with the fluid interposed, so that shear stress of the fluid is reduced.

[0011] In the waterpump of the present invention, since at least either one of the outer surface of the non-working section or the plane of the housing confronting the outer surface has water repellency, fluid in the non-working section of the rotor in service reduces shear stress. Consequently, the rotor is able to rotate smoothly with less friction with the fluid.

[0012] Therefore, the waterpump of the present invention is able to improve pump efficiency by reducing shear stress of the fluid in the vicinity of the non-working section, and consequently consumes less electricity.

[0013] Water repellency in this invention refers to a property that enables reduction of shear stress of fluid in the surfaces of the non-working section and the housing in the vicinity of the non-working section. It is sufficient if the surfaces of the non-working section and the housing in the vicinity thereof are enabled to have an enlarged contact angle with fluid or reduced surface energy with fluid. Water repellency can be applied to the surfaces of the non-working section and the housing in the vicinity thereof, for example, by surface treatment such as coating the surf aces of the non-working section and the housing in the vicinity thereof with water repellant like fluorine plastic used for glass coating material by vapor deposition, welding, or dipping, or by plating for forming smooth surface, which is exemplified by electroless nickel plating. Alternatively, water repellency can be applied also by forming the non-working section and the housing from water repellent material such as fluorine plastic, or by mixing water repellent material into the material for forming the non-working section and the housing.

[0014] Waterpump is exemplified by a magnetic coupling pump including a stator in the housing, in which a rotor is provided in its non-working section with a magnet section, and is rotated by a rotating magnetic field generated by the stator. Moreover, this magnetic coupling pump is exemplified by an outer-rotor type magnetic coupling pump in which the stator is located near the rotation center of the rotor and the magnet section is located around the stator, or an inner-rotor type magnetic coupling pump in which a magnet section is located near the rotation center of the rotor and the stator is located around the magnet section.

[0015] Especially in the outer-rotor type pump, the magnet section to be the non-working section of the rotor has a greater radius than in an inner-rotor type pump, and thus the surface area of the non-working section is increased. Accordingly, with water repellency of the surfaces of the magnet section and the plane of the housing confronting the magnet section surface, a significant effect of improving pump efficiency is obtained in comparison with a case where no water repellency is applied.

BRIEF DESCRIPTION OF DRAWINGS

[0016] **FIG. 1** is a vertical section of a first embodiment of the waterpump according to the present invention;

[0017] **FIG. 2** is a vertical section of a rotor of the waterpump of **FIG. 1**;

[0018] **FIG. 3** is a vertical section of a housing of the waterpump of **FIG. 1**;

[0019] **FIG. 4** is a graph showing a result of CAE analysis of the first embodiment;

[0020] **FIG. 5** is a vertical section of a second embodiment of the waterpump according to the present invention;

[0021] **FIG. 6** is a vertical section of a rotor of the waterpump of **FIG. 5**; and

[0022] **FIG. 7** is a vertical section of a housing of the waterpump of **FIG. 5**.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0023] Preferred embodiments of the present invention are now described below with reference to the accompanying drawings. However, the invention is not limited to the embodiments disclosed herein. All modifications within the appended claims and equivalents relative thereto are intended to be encompassed in the scope of the claims.

[0024] FIGS. **1** to **3** illustrate a first embodiment P1 of the waterpump according to the present invention. The waterpump **P1** is a magnetic coupling pump for pumping engine coolant W for vehicles. The pump **P1** includes a housing **1** which is made from synthetic resin and has therein a rotor **18** with a plurality of impellers **20** for feeding the coolant W.

[0025] The housing **1** includes a pump chamber **2** in which the impellers **20** of the rotor **18** are located, and a motor chamber **6** located below the pump chamber **2**. The pump chamber **2** has a ceiling wall **2***a* and has a substantially cylindrical shape as a whole. An inlet pipe **3** for introducing the coolant W is projected upward from the ceiling wall **2***a*, and an outlet pipe **4** for exhausting the coolant W is projected outwardly from a circumferential wall **2***b*.

[0026] The motor chamber **6** includes a circumferential wall **7** having a substantially cylindrical shape, a bottom wall **8** extending from the lower inner part of the circumferential wall **7** and having an annular shape, and a stator section **9** protruding upward from the center of the bottom wall **8**. The stator section **9** includes therein a stator **10** for generating a rotating magnetic field when electrified. A member designated by a reference numeral **11** is a circuit board for rotating the rotor **18**, on which power transistors for driving the stator **10**, and a Hall element for detecting rotation angle of the stator **10**, and so on are located. A member designated by a reference numeral **12** is a terminal for supplying electricity to the circuit board **11**.

[0027] Fixed in the center of the stator section **9** is a shaft **13** for supporting the rotor **18** rotatably. An E-ring **14** is located proximate to top of the shaft **13** to prevent the rotor **18** from coming off from the shaft **13**. The E-ring **14** is required since the rotor **18** is prone to float up when rotating because of negative pressure in the inlet passage **3**. When the pump P1 is in service, the rotor **18** rotates at 3000 to 3800 rpm.

[0028] The rotor **18** includes a main body **19** which has a substantially disc shape and has impellers **20** projected upward, and a magnet section **23** which extends downward from the vicinity of the outer edge of the main body **19** to be located around the stator **10**, and has a substantially cylindrical shape. The magnet section **23** is driven and rotates by the rotating magnetic field generated by the stator **10**. The main body **19** is provided in its center with a bearing **21** which is made from resin or metal capable of reducing friction such that the rotor **18** rotates around the shaft **13** easily. In the foregoing embodiment, the magnet section **23** is made from a material made by mixing magnetic powder into synthetic resin such as polyamide that forms the rotor **18**.

[0029] The rotor **18** is submerged in the coolant W in the housing **1**, and can be split up into two parts: a working section **25** and a non-working section **27**. The working section **25** is a section that contacts with the coolant W in a main passage F of the coolant W fed by the impellers **20**. In the illustrated embodiment, the working section **25** refers to an area above the main body **19** having the impellers **20**.

[0030] The non-working section **27** is a section apart from the main passage F of the coolant W propelled by the impellers **20**. In the illustrated embodiment, the non-working section **27** includes an area below the main body **19** and the magnet section **23** located below the outlet pipe **4**. An outer surface **27***a* of the non-working section **27** is constituted by an outer circumference **19***a* of the main body **19**, a lower surface **19***b* of the main body **19**, an outer circumference **23***a* of the magnet section **23**, an inner circumference **23***b* of the magnet section **23** and a lower end face **23***c* of the magnet section **23**.

[0031] In the rotor **18** of the pump **P1**, the outer surface **27***a* of the non-working section **27** is provided with a water repellent layer **29** so as to reduce shear stress of the coolant W and improve water repellency.

[0032] The waterrepellent layer **29** is also formed on a confronting plane **16** of the housing **1** which confronts the outer surface **27***a* of the non-working section **27** with the coolant W interposed. The confronting plane **16** of the housing **1** is constituted by an inner circumference **2***c* of a lower part of a circumferential wall **2***b* of the pump chamber **2**, an inner circumference **7***a* of the circumferential wall **7**, a top surface **8***a* of the bottom wall **8**, an outer circumference **9***a* of the stator section **9** and a ceiling surface **9***b* of the stator section **9**.

[0033] The water repellent layer **29** in the first embodiment is formed by electroless nickel plating. Of course, however, the water repellent layer **29** may be formed by welding which is done, for example, by spraying and melt-and-resolidifying water repellant such as fluorine plastic, or by coating such as vapor deposition. Alternatively, it will also be appreciated to mix water repellent material such as fluorine plastic into the molding material of the rotor **18** and the housing **1**, and to form the rotor **18** and the housing **1** by that material such that the outer surface **27***a* and the confronting plane **16** have water repellency.

[0034] In the magnetic coupling pump P1, the outer surface **27***a* of the non-working section **27** and the plane **16** of the housing **1** confronting the outer surface **27***a* have the water repellent layer **29**. Accordingly, fluid W in the non-working section **27** of the rotating rotor **18** reduces shear stress, so that the rotor **18** is able to rotate smoothly with less friction with the coolant W as fluid.

[0035] Therefore, the magnetic coupling pump **P1** is able to improve pump efficiency by reducing shear stress of the coolant W in the vicinity of the non-working section **27**, and consequently consumes less electricity.

[0036] CAE analysis is conducted to verify the improvement of pump efficiency in the first embodiment. As shown in **FIG. 4**, fluid resistance is reduced at 20% in the first embodiment. The CAE analysis is conducted by simulating a condition that only the magnet section **23** is submerged in 100° C. coolant which includes 50 volume % LLC (Long Life Coolant) and that the magnet section rotates at 3000 rpm, and by calculating resistance values along the lapse of time.

[**0037**] In the first embodiment, the pump is exemplified by an outer-rotor type magnetic coupling pump P1 in which the stator **10** is located near the rotation center of the rotor **18** and the substantially cylindrical magnet section **23** is located around the stator **10**. However, it will also be appreciated to form a water repellent layer **59** similar to the water repellent layer **29** in an inner-rotor type magnetic coupling pump P2 shown in FIGS. **5** to **7**, which is a second embodiment of the present invention.

[**0038**] The pump P2 also includes a housing **31** which is made from synthetic resin and has therein a rotor **48** with a plurality of impellers **50** for propelling coolant W.

[**0039**] The housing **31** includes a pump chamber **32** in which the impellers **50** of the rotor **48** are located, and a motor chamber **36** located below the pump chamber **32**. The pump chamber **32** has a ceiling wall **32***a*, and has a substantially cylindrical shape as a whole. An inlet pipe **33** for introducing the coolant W is projected outwardly from the ceiling wall **32***a*, and an outlet pipe **34** for exhausting the coolant W is projected outwardly from a circumferential wall **32***b*. The top end **43***a* of a shaft **43** rotatably supporting the rotor **48** is fixed to a part of the inlet pipe **33**.

[**0040**] The motor chamber **36** includes a stator section **39** having a substantially cylindrical shape, and a disc-shaped bottom wall **38** extending from an inner lower part of the stator section **39**. The stator section **39** includes therein a stator **40** for generating a rotating magnetic field when electrified. Located below the stator **40** are a circuit board **41** for rotating the rotor **48**, on which power transistors for driving the stator **40** and a Hall element for detecting rotation angle of the stator **40** are located, and a terminal **42** for supplying electricity to the circuit board **41**. The lower end **43***b* of the shaft **43** rotatably supporting the rotor **48** is fixed to the bottom wall **38**, and an E-ring **44** is located proximate to the top end **43***a* of the shaft **43** for holding the rotor **48**.

[**0041**] The rotor **48** includes a main body **49** which has a substantially disc shape and has impellers **50** projected upward, and a magnet section **53** which extends downward from the vicinity of the center of the main body **49** to be located inward of the stator **40**, and has a substantially cylindrical shape. The magnet section **53** is driven and rotates by the rotating magnetic field generated by the stator **40**. Bearings **51** made from resin or metal capable of reducing friction are located in the center of the main body **49** and in a lower part of the magnet portion **53** for smooth rotation of the rotor **48** around the shaft **43**. The magnet section **53** is also made from a material made by mixing magnetic powder into synthetic resin material such as polyamide that forms the rotor **48**.

[**0042**] The rotor **48**, too, is submerged in the coolant W in the housing **31**, and can be split up into two parts: a working section **55** and a non-working section **57**. The working section **55** is a section that contacts with the coolant W in a main passage F of the coolant W fed by the impellers **50**. In the illustrated embodiment, the working section **55** refers to an area above the main body **49** having the impellers **50**.

[**0043**] The non-working section **57** is a section apart from the main passage F of the coolant W propelled by the impellers **50**. In the illustrated embodiment, the non-working section **57** includes an outer circumference of the main body **49** and the magnet section **53**. An outer surface **57***a* of the non-working section **57** is constituted by an outer circumference **49***a* of the main body **49**, a lower surface **49***b* of the main body **49**, an outer circumference **53***a* of the magnet section **53**, an inner circumference **53***b* of a lower part of magnet section **53** below the bearing **51** and a lower end face **53***c* of the magnet section **53**.

[**0044**] In the pump P2, too, the outer surface **57***a* of the non-working section **57** is provided with a water repellent layer **59** so as to reduce shear stress of the coolant W and improve water repellency. The water repellent layer **59** is also formed on a confronting plane **46** of the housing **31** which confronts the outer surface **57***a* of the non-working section **57** of the rotor **48** with the coolant W interposed. The confronting plane **46** of the housing **31** is constituted by an inner circumference **32***c* of a lower end part of a circumferential wall **32***b* of the pump chamber **32**, a top surface **39***a* of the stator section **39**, an inner circumference **39***b* of the stator section **39** and a top surface **38***a* of the bottom wall **38**.

[**0045**] In the pump P2, too, the outer surface **57***a* of the non-working section **57** and the plane **46** of the housing **31** confronting the outer surface **57***a* have the water repellent layer **59**. Accordingly, fluid W in the non-working section **57** of the rotating rotor **48** reduces shear stress, so that the rotor **48** is able to rotate smoothly with less friction with the fluid W. Consequently, pump efficiency is improved, and less electricity is consumed.

[**0046**] In the outer-rotor type pump **P1**, the magnet section **23** to be the non-working section **27** of the rotor **18** has a greater radius than in an inner-rotor type pump, and thus the surface area of the non-working section **27** is increased. Accordingly, with water repellency on the surface of the magnet section **23** and the plane **16** of the housing **1** confronting the magnet section surface, a significant effect of improving pump efficiency is obtained in comparison with a case where no water repellency is applied.

[**0047**] Preferred embodiments show the arrangement to apply water repellency both to the outer surface **27***a* or **57***a* of the non-working section **27** or **57** of the rotor **18** or **48**, and to the confronting plane **16** or **46** of the housing **1** or **31**. However, it will also be appreciated to apply water repellency to either one of the outer surface **27***a*, **57***a* or the confronting plane **16**, **46**.

[**0048**] Considering the rotating magnetic field for rotating the rotors **18** and **48**, clearance between the rotor **18** or **48** and the stator **10** or **40** is desirably narrow. However, more shear stress is prone to be generated as the clearance becomes narrower. In that case, it will be desirable to apply water repellency to either one of, or both of the confronting planes **23***b* and **9***a* in the pump **P1**, or to either one of, or both of the confronting planes **53***a* and **39***b* in the pump P2.

[**0049**] Although the preferred embodiments show the waterpumps P1 and P2 for supplying the engine coolant W to vehicles, the present invention is not intended to be limited thereby, but may be applied to waterpumps for supplying fluids such as purified water.

What is claimed is:

1. An electrically driven waterpump comprising a rotor having impellers for feeding fluid, the rotor being housed in a housing,

the rotor including: a working section located in the fluid and contacting the fluid in a main passage of the fluid stirred by the impellers; and a non-working section located in the fluid and apart from the main passage of the fluid, wherein

water repellency is applied to at least either one of an outer surface of the non-working section or a plane of the housing confronting the outer surface of the non-working section with the fluid interposed,

whereby shear stress of the fluid is reduced.

2. The waterpump according to claim 1, wherein:

the pump is a magnetic coupling pump including a stator in the housing; and

the rotor is provided in the non-working section thereof with a magnet section,

whereby the rotor is rotated by a rotating magnetic field generated by the stator.

3. The waterpump according to claim 2, wherein the pump is an outer-rotor type magnetic coupling pump in which the stator is located near the rotation center of the rotor and the magnet section is located around the stator.

4. The waterpump according to claim 2, wherein the pump is an inner-rotor type magnetic coupling pump in which the magnet section is located near the rotation center of the rotor and the stator is located around the magnet section.

* * * * *