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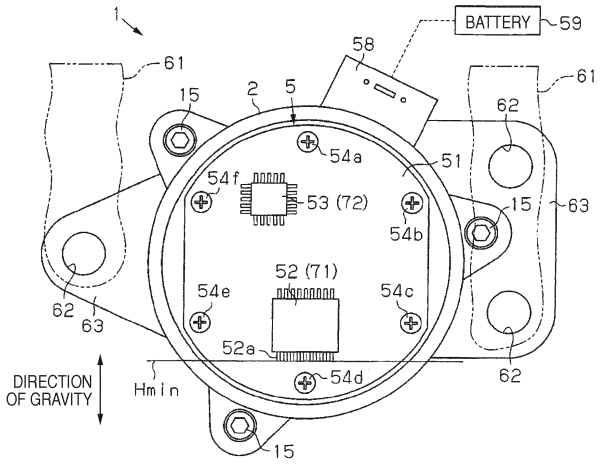
(54) ELECTRIC PUMP APPARATUS

(57) [Problem] An electrical pump apparatus is provided in which a situation where a failure detection circuit becomes inoperative before detection of a failure of an electric system can be avoided, and the certainty of failure detection can be enhanced.

[Means for Resolution] An attaching portion 63 which is to be attached to a vehicle body 61 is formed so that, in a state where an electrical pump apparatus 1 is attached to the vehicle body 61, a circuit board 51 of a control device 5 is perpendicular to the horizontal direction. A control IC chip 53 which constitutes a microcomputer 72 for detecting a failure of the electric system is placed on a circuit board 51 so as to be higher in the direction of gravity from a lowest water level Hmin at which flooding in a housing 2 causes the electric system to be short-circuited.

FIG. 2



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Description

Technical Field

[0001] The present invention relates to an electrical pump apparatus which is to be mounted on a vehicle.

Background Art

[0002] In a vehicle provided with a so-called idling stop function which, when the vehicle is temporarily stopped, automatically stops an engine, conventionally, an oil pressure supply to a transmission and the like is ensured even in the case of idling stop, by a use of an electrical pump apparatus. Such an electrical pump apparatus is mounted in a limited space of a vehicle. Therefore, an electrical pump apparatus is strongly requested to be miniaturized. Conventionally, therefore, an electrical pump apparatus has been proposed in which a pump that generates an oil pressure, a motor that drives the pump, and a control device that controls the operation of the motor are housed in a common housing to be integrated with one another, thereby causing the electrical pump apparatus to be miniaturized (for example, see Patent Document 1).

[0003] In the case where a vehicle runs along a water-covered road, for example, there is the possibility that an electrical pump apparatus may be submerged, and therefore rainwater and the like are prevented by a sealing member or the like from entering a housing. When such a sealing member deteriorates with age, for example, rainwater or the like may enter the housing. As a result, in an electrical pump apparatus in which a control device is integrally formed as described above, there arises the possibility that a failure may be caused by a short circuit which occurs in an electric system that electrically connects an electric power supply (battery) with a motor, or by deterioration of a portion (wiring or the like) of the electric system to which rainwater or the like adheres.

[0004] Assuming such a situation, usually, a control device is provided with a failure detection function. Specifically, a control device has a microcomputer for controlling the operation of a motor, and the microcomputer detects the values of the current and voltage supplied to the motor. When the detected current and voltage values become an impossible or discontinuous value, the microcomputer determines that a failure occurs, and informs the driver that an electrical pump apparatus breaks down.

Prior Art Reference

Patent Document

[0005] Patent Document 1: JP-A-2010-112330

Summary of the Invention

Problem that the Invention is to Solve

[0006] In a conventional electrical pump apparatus, in the case where flooding occurs in a housing, however, an IC chip (failure detection circuit) which constitutes a microcomputer having the failure detection function is covered with water before detection of a failure of an electric system, and therefore there is the possibility that the failure of the electric system may not be detected. In this point, there still remains a room for improvement.

[0007] The invention has been conducted in order to solve the problem. It is an object of the invention to provide an electrical pump apparatus in which a situation where a failure detection circuit becomes inoperative before detection of a failure of an electric system can be avoided, and the certainty of failure detection can be enhanced.

Means for Solving the Problem

[0008] In order to solve the problem, it is the gist of a first mode of the invention that, in an electrical pump apparatus comprising: a pump which is configured to generate an oil pressure; a motor which is configured to drive the pump; a control device which is configured to control an operation of the motor; and a housing which houses the pump, the motor, and the control device, and which has an attaching portion to be attached to a vehicle body, a failure detection circuit which is configured to detect a failure of an electric system that electrically connects the motor with an electric power supply is disposed on a circuit board of the control device, and the failure detection circuit is placed on the circuit board to be higher in a direction of gravity than a lowest water level at which flooding in the housing causes the electric system to break down.

[0009] In the case where flooding occurs in a housing, when a state where a failure detection circuit is submerged is produced, namely, it is estimated that detection of a failure of an electric system is certainly disabled. In this point, according to the configuration, the failure detection circuit is placed so as to be higher in the direction of gravity than the lowest water level at which a failure of the electric system occurs. In the case where flooding occurs in the housing, therefore, a part of the electric system is submerged and short-circuited to cause the electric system to break down, before the failure detection circuit is submerged and failure detection (operation) is surely disabled. According to the configuration, moreover, the failure detection circuit is placed in the higher side in the direction of gravity. Even in the case where a failure of the electric system does not occur, therefore, adhesion of rainwater or the like to the part of the electric system easily occurs in advance of adhesion to the failure detection circuit. Before the failure detection circuit becomes unable to detect a failure, consequently, the part

of the electric system deteriorates and breaks down. As a result, the failure detection circuit can detect more surely a failure of the electric system, and the certainty of failure detection in the system can be enhanced.

[0010] In the electrical pump apparatus, moreover, the attaching portion may be formed so that, in a state where the attaching portion is attached to the vehicle body, the circuit board is perpendicular to a horizontal direction. According to the configuration, the failure detection circuit is placed while being largely upward separated in the direction of gravity from the lowest water level at which a short circuit of the electric system occurs. Therefore, it is possible to surely prevent the failure detection circuit from being submerged before a short circuit occurs in the electric system.

[0011] In the electrical pump apparatus, moreover, the failure detection circuit may be placed to be higher than a range of 1/3 from a lower end of the circuit board in the direction of gravity. According to the configuration, it is possible to preferably prevent the failure detection circuit from being submerged before a failure of the electric system is detected.

[0012] Furthermore, the attaching portion may be formed so that, in a state where the attaching portion is attached to the vehicle body, the circuit board is in a horizontal direction. In this attachment mode, the failure detection circuit is mounted on an upper surface of the circuit board, whereby the circuit can be placed to be higher in the direction of gravity than the lowest water level.

[0013] Moreover, the electrical pump apparatus may further comprise: a current detecting means which is configured to detect a current supplied to the motor, and the failure detection circuit may detect the failure of the electric system based on the current detected by the current detecting unit. According to the configuration, a failure of the electric system can be easily detected by a simple configuration.

[0014] Moreover, the electrical pump apparatus may further comprise: a voltage detecting means which is configured to detect a voltage applied to the motor, and the failure detection circuit may detect the failure of the electric system based on the voltage detected by the voltage detecting unit. According to the configuration, a failure of the electric system can be easily detected by a simple configuration.

Effects of the Invention

[0015] According to the invention, it is possible to provide an electrical pump apparatus in which a situation where a failure detection circuit becomes inoperative before detection of a failure of an electric system can be avoided, and the certainty of failure detection can be enhanced.

Brief Description of the Drawings

[0016]

[Fig. 1] Fig. 1 is a sectional view diagrammatically showing the configuration of an electrical pump apparatus of Embodiment 1.

[Fig. 2] Fig. 2 is a rear view of the electrical pump apparatus of Embodiment 1 in a state where a cover is removed.

[Fig. 3] Fig. 3 is a block diagram showing the electrical configuration of the electrical pump apparatus of Embodiment 1.

[Fig. 4] Fig. 4 is a sectional view diagrammatically showing the configuration of an electrical pump apparatus of Embodiment 2.

Mode for Carrying Out the Invention

[0017] Hereinafter, Embodiments 1 and 2 in which the invention is embodied as an electrical pump apparatus that is to be mounted on a vehicle to supply an oil pressure to a transmission and the like will be described with reference to the drawings.

(Embodiment 1)

[0018] As shown in Fig. 1, an electrical pump apparatus 1 includes a housing 2 which is formed into an approximately cylindrical shape. In the housing 2, a pump 3 that generates an oil pressure, a motor 4 that drives the pump 3, and a control device 5 that controls the operation of the motor 4 are integrally housed. In the following description, a one axial end side (the left side in Fig. 1) of the housing 2 is referred to as the front side, and the other axial end side (the right side in Fig. 1) is referred to as the rear side.

[0019] The housing 2 includes: an approximately annular pump case 11; a pump plate 12 which is placed in front of the pump case 11; a cylindrical motor case 13 which is placed in rear of the pump case 11; and a cover 14 which closes a rear opening end of the motor case 13. The pump case 11 and the pump plate 12 are made of a metal material, and the motor case 13 and the cover 14 are made of a resin material. The pump case 11, the pump plate 12, and the motor case 13 are coupled to one another by bolts 15, and the cover 14 is fixed to the motor case 13 by means of welding (vibration welding or the like).

[0020] In the embodiment, a trochoid pump (internal gear pump) is employed as the pump 3. A brushless motor of the sensorless type in which a rotation sensor for detecting the rotation position of the rotor is not disposed is employed as the motor 4 which is the driving source for the pump 3, and rotated based on a three phase (U, V, W) driving electric power which is supplied from the control device 5.

[0021] In more detail, the pump 3 includes an outer

gear 21 in which a tooth portion is formed on the inner periphery, and an inner gear 22 in which a tooth portion is formed on the outer periphery. The outer gear 21 is rotatably housed in a housing hole 23 formed in the middle of the pump case 11, and the inner gear 22 is placed on the side of the inner periphery of the outer gear 21. A suction port 24 which is used for sucking hydraulic oil into a gap between the outer gear 21 and the inner gear 22, and a discharge port (not shown) which is used for discharging the hydraulic oil are formed in the pump plate 12 which closes the front end of the housing hole 23.

[0022] O-rings 16, 17 are interposed between the pump case 11 and the pump plate 12, and between the pump case 11 and the motor case 13, respectively. The cover 14 is welded to the motor case 13. Therefore, the portion other than a region through which the hydraulic oil in the housing 2 is introduced is liquid-tightly sealed, and rainwater or the like is prevented from entering the portion from the outside.

[0023] In the pump case 11, a cylindrical supporting portion 25 which is smaller in diameter than the motor case 13 that rearward projects is formed coaxially with the housing hole 23. In the supporting portion 25, an output shaft 26 of the motor 4 which functions as a driving shaft of the pump 3 is passed through in a state where the output shaft projects into the housing hole 23, and cantilever supported by a bearing device 27 which is disposed in a rear portion of the supporting portion 25. In the embodiment, the bearing device 27 is configured by two rolling bearings which are anteroposteriorly adjacent to each other. The inner gear 22 is integrally rotatably coupled to the front end of the output shaft 26. A sealing member 28 for preventing the hydraulic oil from leaking from the housing hole 23 toward the motor case 13 is disposed between a portion of the pump case 11 which is more forward than the supporting portion 25, and the output shaft 26.

[0024] The motor 4 includes a rotor 31 having the output shaft 26, and a stator 32 which is fixed to the inner periphery of the motor case 13. Specifically, the rotor 31 has a rotor core 34 which is fixed to the rear end of the output shaft 26, and magnets 35 which are fixed to the rotor core 34. The rotor core 34 is formed into a bottomed cylindrical shape which radially extends from the rear end of the output shaft 26, and which surrounds the supporting portion 25, and integrally rotatably coupled to the rear end of the output shaft 26. The magnets 35 are fixed to the outer peripheral surface of the rotor core 34 so as to be opposed to the stator 32.

[0025] By contrast, the stator 32 includes: a stator core 39 consisting of a cylinder portion 37 which is annularly formed, and teeth portions 38 which project radially inward from the cylinder portion 37; and three-phase motor coils 41 which are wound around the teeth portions 38 through an insulator 40, respectively. A pedestal portion 42 which extends from the rear end of the cylinder portion 37, and to which the control device 5 is fixed is formed in the insulator 40.

[0026] As shown in Figs. 1 and 2, a power IC chip 52 which constitutes a driving circuit 71 for supplying a driving electric power to the motor coils 41, and a control IC chip 53 which constitutes a microcomputer 72 for controlling the driving circuit 71 are mounted on a circuit board (printed circuit board) 51 of the control device 5. The control device 5 is fastened to the pedestal portion 42 of the insulator 40 by a plurality (in the embodiment, six) of screws 54a to 54f, so that the control device is fixed to the rear side of the motor 4.

[0027] As shown in Fig. 1, connection end portions 55 of the motor coils 41 of the respective phases are clampingly held between the circuit board 51 and the insulator 40, whereby the portions are electrically connected to the control device 5. In more detail, lands 57 made of a conductive material are disposed on the inner peripheral surfaces of through holes 56 which are placed in the vicinity of the power IC chip 52, and through which three screws 54c, 54d, 54e (in Fig. 1, only the screw 54d is shown) are passed, respectively. The connection end portions 55 of the motor coils 41 are clampingly held between the circuit board 51 and the insulator 40, and in contact with the lands 57, whereby the portions are electrically connected to the control device 5. As shown in Fig. 2, the control device 5 is connected to an on-vehicle power supply (battery) 59 through a connector portion 58 formed on the motor case 13.

[0028] The electrical pump apparatus 1 is attached to the vehicle body 61 so that the circuit board 51 is perpendicular to the horizontal direction. Specifically, as shown in Fig. 2, attaching portions 63 which project to the radially outer side of the pump case 11, and which have bolt holes 62 are formed in the pump plate 12. The attaching portions 63 are formed so that, when fastening bolts (not shown) are passed through the bolt holes 62, and the electrical pump apparatus 1 is attached to the vehicle body 61, the circuit board 51 is in a state where the board is perpendicular to the horizontal direction, i.e., parallel to the direction of gravity.

[0029] In the thus configured electrical pump apparatus 1, the three-phase driving electric power is supplied from the control device 5 to the motor 4, and the rotor 31 (output shaft 26) is rotated. Then, the inner gear 22 which is coupled to the output shaft 26 is rotated, whereby the pump 3 is driven and the oil pressure is supplied to the transmission and the like which are not shown.

[0030] Next, the electrical configuration of the electrical pump apparatus will be described.

As shown in Fig. 3, the control device 5 includes: the driving circuit 71 (power IC chip 52) which supplies the three-phase driving electric power to the motor coils 41u, 41v, 41w; and the microcomputer 72 (control IC chip 53) which outputs a motor control signal to the driving circuit 71 to drive the motor 4. The control device 5 supplies the three-phase driving electric power to the motor 4, by performing the 120-degree rectangular-wave conduction on the motor coils 41u, 41v, 41w of the respective phases.

[0031] In more detail, a well-known PWM inverter in

which, while using a pair of series connected switching elements as a basic unit (switching arm), three switching arms corresponding to the motor coils 41u, 41v, 41w of the respective phases are connected in parallel is used in the driving circuit 71. Namely, the motor control signal output from the microcomputer 72 defines the ON/OFF states (the duty ratios of the switching arms of the respective phases) of the switching elements of the respective phases constituting the driving circuit. The driving circuit 71 operates in response to the input of the motor control signal to supply the three-phase driving electric power to the motor.

[0032] Voltages sensors 73u, 73v, 73w functioning as a voltage detecting means which detects the terminal voltages Vu, Vv, Vw of the motor coils 41u, 41v, 41w are connected to the microcomputer 72. The microcomputer 72 estimates the rotation position (rotation angle) of the rotor 31 based on the induced voltages (counter electromotive forces) of the motor coils 41 which are detected by the voltages sensors 73u, 73v, 73w. Specifically, timings (zero cross points) when the induced voltages become a reference voltage are detected, thereby estimating the rotation position of the rotor 31. Then, the microcomputer 72 determines a conduction pattern which is a combination of switching elements that are to be set to the ON state in accordance with the estimated rotation position of the rotor 31, i.e., a combination of voltages that are to be applied to the motor coils 41u, 41v, 41w.

[0033] Furthermore, a current sensor 74 functioning as a current detecting means which detects an actual current value I that is flown to the motor 4, and a higher level ECU which controls the operation of the transmission are connected to the microcomputer 72. The microcomputer 72 performs a feedback control so that the actual current value I follows a current command value I* output from the higher level ECU, and determines the duty ratio corresponding to the deviation between current command value I* and the actual current value I. Then, the microcomputer 72 outputs the motor control signal indicating the conduction pattern and duty ratio which are determined as described above, to the driving circuit 71. As a result, the three-phase driving electric power is supplied from the driving circuit 71, and the motor 4 rotates.

(Failure detection)

[0034] Next, the failure detection in the electrical pump apparatus of the embodiment will be described.

The microcomputer 72 includes a failure detection function which detects a failure of an electric system that electrically connects the motor 4 with the electric power supply 59. Specifically, the microcomputer 72 is configured so that, when the actual current value I detected by the current sensor 74 becomes an impossible or discontinuous value, the microcomputer determines that a failure occurs in the electric system, and informs the driver that the electrical pump apparatus 1 breaks down. In the embodiment, namely, the microcomputer 72 (control IC chip 53) corresponds to a failure detection circuit. The electric system is configured by including the driving circuit 71, the connection end portions 55 of the motor coils 41, and wirings 75, 76 between the electric power supply 59 and the driving circuit 71, and between the driving circuit 71 and the connection end portions 55.

[0035] When, in a state where the O-rings 16, 17 deteriorate with age, the vehicle runs along a road which is covered by water due to heavy rain, for example, the electrical pump apparatus 1 is submerged, and rainwater or the like may enter the housing 2. At this time, when the control IC chip 53 having the failure detection function is covered with water, there arises the possibility that a failure of the electric system may not be detected. Particularly, it is estimated that, when the control IC chip 53 is in a submerged state, detection of a failure of the electric system is certainly impossible.

[0036] Considering this, as shown in Fig. 2, the control IC chip 53 is disposed at a position which is on the circuit board 51, and which is separated from the power IC chip 52, and placed so as to be higher (in the upper side in Fig. 2) in the direction of gravity than a lowest water level Hmin at which, in the state where the electrical pump apparatus 1 is attached to the vehicle body 61, a short circuit occurs in the electric system. In more detail, the control IC chip 53 is placed so as to be higher than a range of 1/3 from the lower end of the circuit board 51 in the direction of gravity, and higher in the direction of gravity than the screws 54c, 54d, 54e to which the connection end portions 55 of the motor coils 41 are connected, and the power IC chip 52. In the embodiment, the position where a plurality of terminals 52a downward extending in the direction of gravity from the power IC chip 52 are placed is at the lowest water level Hmin. According to the configuration, in the case where rainwater or the like enters the housing 2, the terminals of the power IC chip 52 are submerged in advance of the control IC chip 53 having the failure detection function as described above, and a short circuit occurs in the electric system.

[0037] As described above, the embodiment can attain the following functions and effects.

(1) The attaching portion 63 to be attached to the vehicle body 61 is formed so that, in the state where the electrical pump apparatus 1 is attached to the vehicle body 61, the circuit board 51 of the control device 5 is perpendicular to the horizontal direction. Then, the control IC chip 53 which constitutes the microcomputer 72 for detecting a failure of the electric system is placed on the circuit board 51 and so as to be higher in the direction of gravity than the lowest water level Hmin at which flooding in the housing 2 causes the electric system to be short-circuited.

[0038] According to the configuration, in the case where flooding occurs in the housing 2, a part of the electric system is submerged and short-circuited to cause the electric system to break down, before the control IC

chip 53 is submerged and failure detection (operation) is surely disabled. According to the configuration, moreover, the control IC chip 53 is placed in the higher side in the direction of gravity. Even in the case where the electric system is not short-circuited, therefore, adhesion of rainwater or the like to the part of the electric system easily occurs in advance of adhesion to the control IC chip 53. Before the control IC chip 53 becomes unable to detect a failure, consequently, the part of the electric system deteriorates and breaks down. As a result, the control IC chip 53 can detect more surely a failure of the electric system, and the certainty of failure detection in the system can be enhanced.

[0039] (2) Since the attaching portion 63 is formed so that, in a state where the attaching portion is attached to the vehicle body 61, the circuit board 51 is perpendicular to the horizontal direction, the control IC chip 53 can be placed while being largely upward separated in the direction of gravity from the lowest water level Hmin at which a short circuit of the electric system occurs. Therefore, it is possible to surely prevent the control IC chip 53 from being submerged before a short circuit occurs in the electric system.

[0040] (3) The control IC chip 53 (microcomputer 72) detects a failure of the electric system based on the actual current value I. Therefore, a failure of the electric system can be easily detected by a simple configuration.

[0041] (4) Since the control IC chip 53 is placed to be higher than the range of 1/3 from the lower end of the circuit board 51 in the direction of gravity, it is possible to preferably prevent the control IC chip 53 from being submerged before a failure of the electric system is detected.

[0042] The embodiment may be implemented in the following modes in which the embodiment is adequately changed.

- In the embodiment, the control IC chip 53 is placed so as to be higher than a range of 1/3 from the lower end of the circuit board 51 in the direction of gravity, and higher in the direction of gravity than the screws 54c, 54d, 54e to which the connection end portions 55 of the motor coils 41 are connected, and the power IC chip 52. However, the embodiment is not limited to this. The control IC chip 53 is requested to be placed so as to be higher in the direction of gravity than the lowest water level Hmin. For example, the control IC chip may be placed so as to be higher than a range of 1/3 from the lower end of the circuit board 51 in the direction of gravity. Alternatively, for example, the control IC chip 53 and the power IC chip 52 may be placed so as to be higher than a straight line connecting the screws 54c, 54e, and the power IC chip 52 may be placed so as to be higher than the control IC chip 53. In the alternative, the position of the straight line connecting the screws 54c, 54e is the lowest water level Hmin.

[0043] • In the embodiment, the microcomputer 72 detects a failure of the electric system based on the actual current value I. However, the embodiment is not limited to this. When the terminal voltages Vu, Vv, Vw detected by the voltages sensors 73u, 73v, 73w become an impossible or discontinuous value, the microcomputer may determine that a failure occurs in the electric system.

[0044] • In the embodiment, the attaching portion 63 is formed so that, in the state where the electrical pump apparatus 1 is attached to the vehicle body 61, the circuit board 51 is perpendicular to the horizontal direction. However, the embodiment is not limited to this. The attaching portion may be formed so that the circuit board 51 is oblique to the horizontal direction.

(Embodiment 2)

[0045] Fig. 4 shows an electrical pump apparatus of Embodiment 2. Embodiment 2 is configured similarly to Embodiment 1 except the manner of attachment of the control device 5, and therefore detailed description of the portions is omitted.

[0046] In Embodiment 2, the attaching portions are formed so that, in the state where the electrical pump apparatus 1 is attached to the vehicle body, the circuit board 51 is in the horizontal direction. The circuit board 51 is fixed to the motor case 13 and the pump case 11 through the screws 54. The control IC chip 53 is mounted on one surface of the circuit board 51, the power IC chip 52 is mounted on the other surface, and the control IC chip 53 is placed so as to be higher in the direction of gravity than the power IC chip 52. In the embodiment, the position where the plurality of terminals projecting from the power IC chip 52 is at the lowest water level Hmin. The cover 14 is fixed to the pedestal portion 42 of the motor case 13 by other bolts 60, and closes the control device 5 and the lower open and.

[0047] The functions and effects of Embodiment 2 are similar to those of Embodiment 1. According to the configuration, in the case where flooding occurs in the housing 2, namely, a part of the electric system is submerged and short-circuited to cause the electric system to break down, before the control IC chip 53 is submerged and failure detection (operation) is certainly disabled. According to the configuration, the control IC chip 53 is placed in the higher side in the direction of gravity. Even in the case where a short circuit of the electric system does not occur, therefore, adhesion of rainwater or the like to the part of the electric system easily occurs in advance of adhesion to the control IC chip 53. Before the control IC chip 53 becomes unable to detect a failure, consequently, the part of the electric system deteriorates and breaks down. As a result, the control IC chip 53 can detect more surely a failure of the electric system, and the certainty of failure detection in the system can be enhanced.

[0048] The application is based on Japanese Patent Application No. 2011-000123 filed January 4, 2011, and its disclosure is incorporated herein by reference.

Industrial Applicability

[0049] According to the invention, it is possible to provide an electrical pump apparatus in which a situation where a failure detection circuit becomes inoperative before detection of a failure of an electric system can be avoided, and the certainty of failure detection can be enhanced.

Description of Reference Numerals and Signs

[0050] 1 ... electrical pump apparatus, 2 ... housing, 3 ... pump, 4 ... motor, 5 ... control device, 11 ... pump case, 12 ... pump plate, 13 ... motor case, 14 ... cover, 21 ... outer gear, 22 ... inner gear, 26 ... output shaft, 31 ... rotor, 32 ... stator, 34 ... rotor core, 35 ... magnet, 39 ... stator core, 40 ... insulator, 41, 41u, 41v, 41w ... motor coil, 51 ... circuit board, 52 ... power IC chip, 53 ... control IC chip, 55 ... connection end portion, 59 ... on-vehicle power supply, 61 ... vehicle body, 63 ... attaching portion, 71 ... driving circuit, 72 ... microcomputer, 73u, 73v, 73w ... voltages sensor, 74 ... current sensor, 75, 76 ... wiring, Hmin ... lowest water level.

Claims

1. An electrical pump apparatus comprising: a pump which is configured to generate an oil pressure; a motor which is configured to drive the pump; a control device which is configured to control an operation of the motor; and a housing which houses the pump, the motor, and the control device, and which has an attaching portion to be attached to a vehicle body, **characterized in that**
a failure detection circuit which is configured to detect a failure of an electric system that electrically connects the motor with an electric power supply is disposed on a circuit board of the control device, and the failure detection circuit is placed on the circuit board to be higher in a direction of gravity than a lowest water level at which flooding in the housing causes the electric system to break down.

2. The electrical pump apparatus according to claim 1, **characterized in that** the attaching portion is formed so that, in a state where the attaching portion is attached to the vehicle body, the circuit board is perpendicular to a horizontal direction.

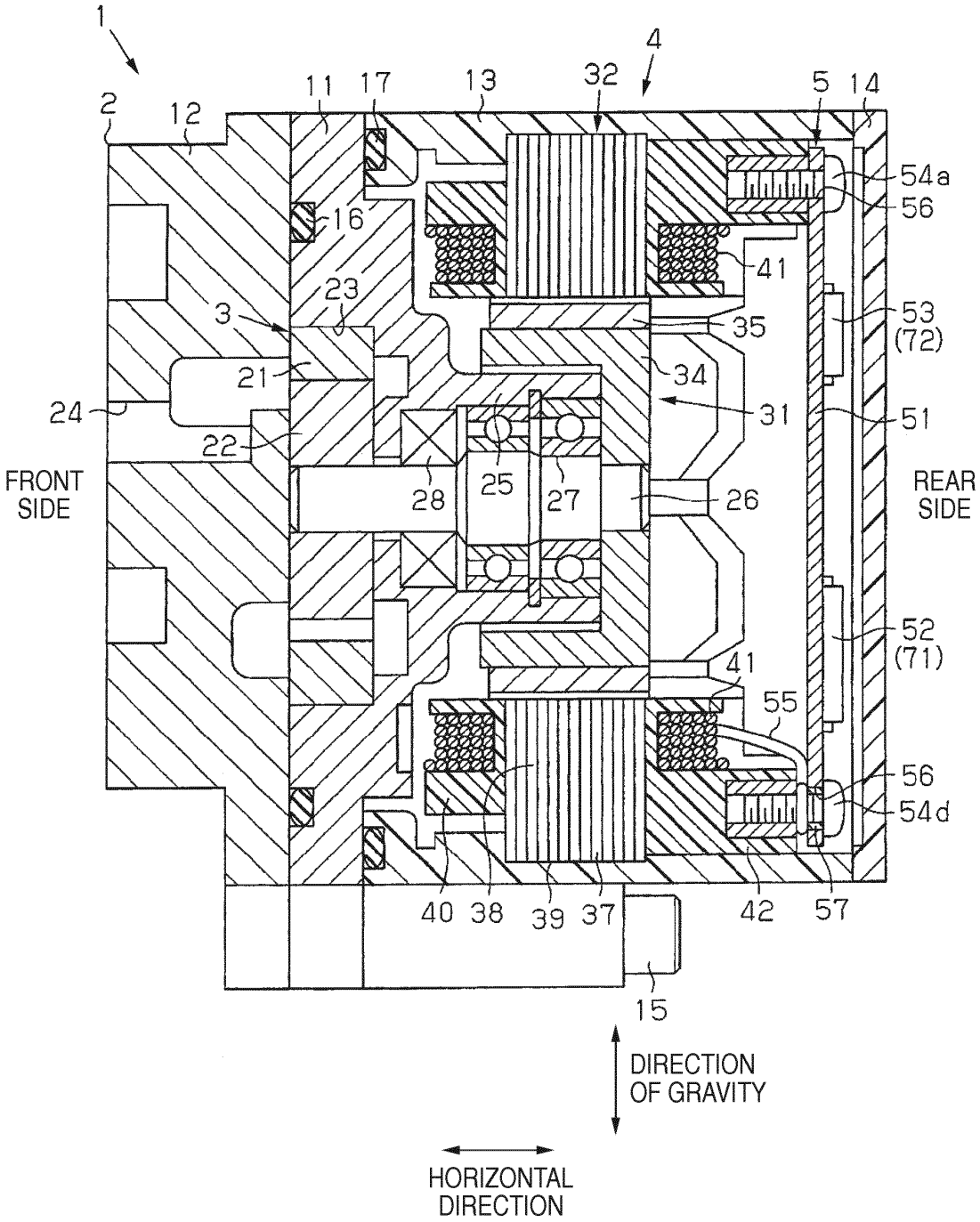
3. The electrical pump apparatus according to claim 1 or 2, **characterized in that** the failure detection circuit is placed to be higher than a range of 1/3 from a lower end of the circuit board in the direction of gravity.

4. The electrical pump apparatus according to claim 1, wherein the attaching portion is formed so that, in a state where the attaching portion is attached to the vehicle body, the circuit board is in a horizontal direction, and the failure detection circuit is mounted on an upper surface of the circuit board, whereby the failure detection circuit is placed so as to be higher in the direction of gravity than the lowest water level.

5. The electrical pump apparatus according to any one of claims 1 to 4, **characterized by** further comprising: a current detecting means which is configured to detect a current supplied to the motor, wherein the failure detection circuit detects the failure of the electric system based on the current detected by the current detecting means.

6. The electrical pump apparatus according to any one of claims 1 to 4, **characterized by** further comprising: a voltage detecting means which is configured to detect a voltage applied to the motor, wherein the failure detection circuit detects the failure of the electric system based on the voltage detected by the voltage detecting means.

FIG. 1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(71)
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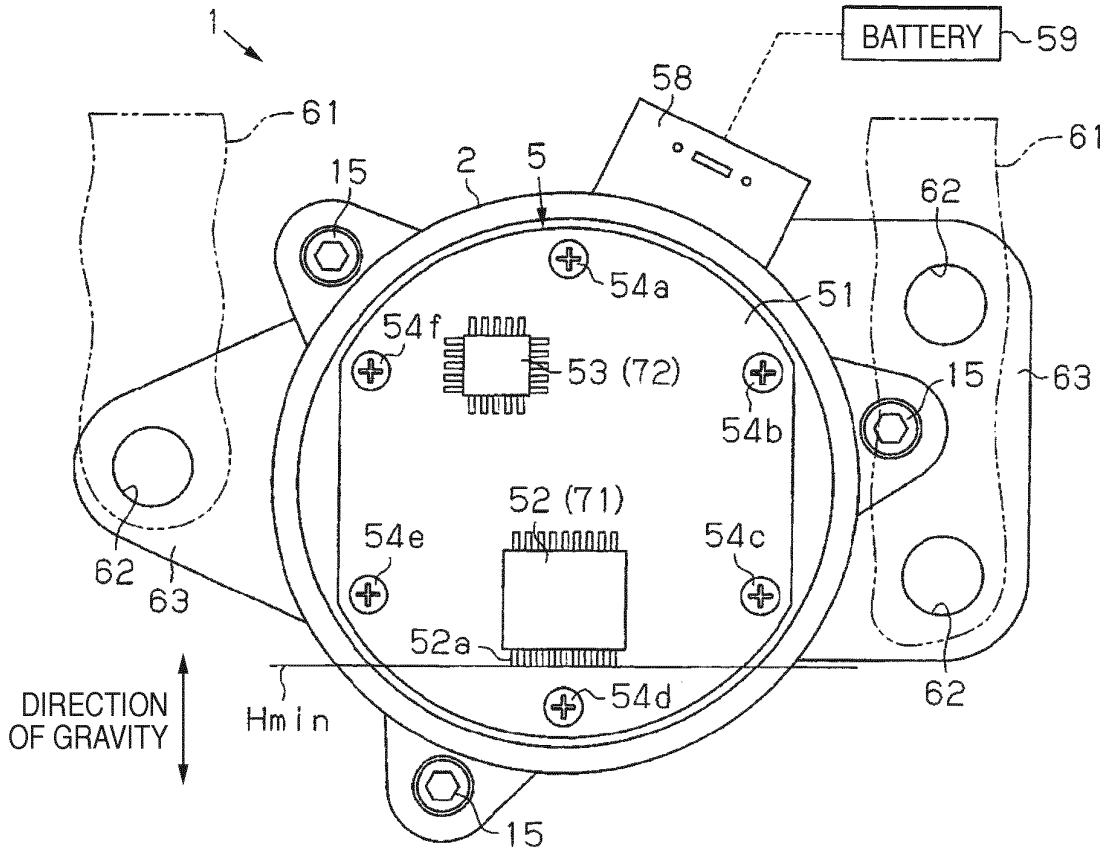
DIRECTION
OF GRAVITY
HORIZONTAL
DIRECTION

FIG. 2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15
63
54b
52 (71)
54e
54c
62
63
52a
54d
62
DIRECTION OF GRAVITY
Hmin
15

FIG. 3

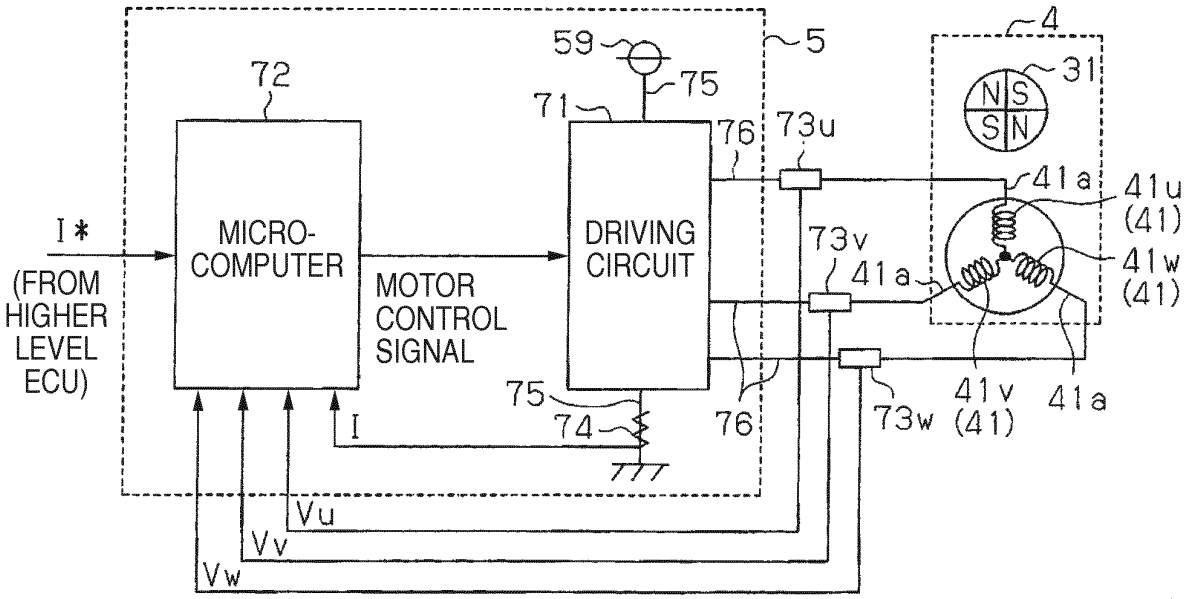
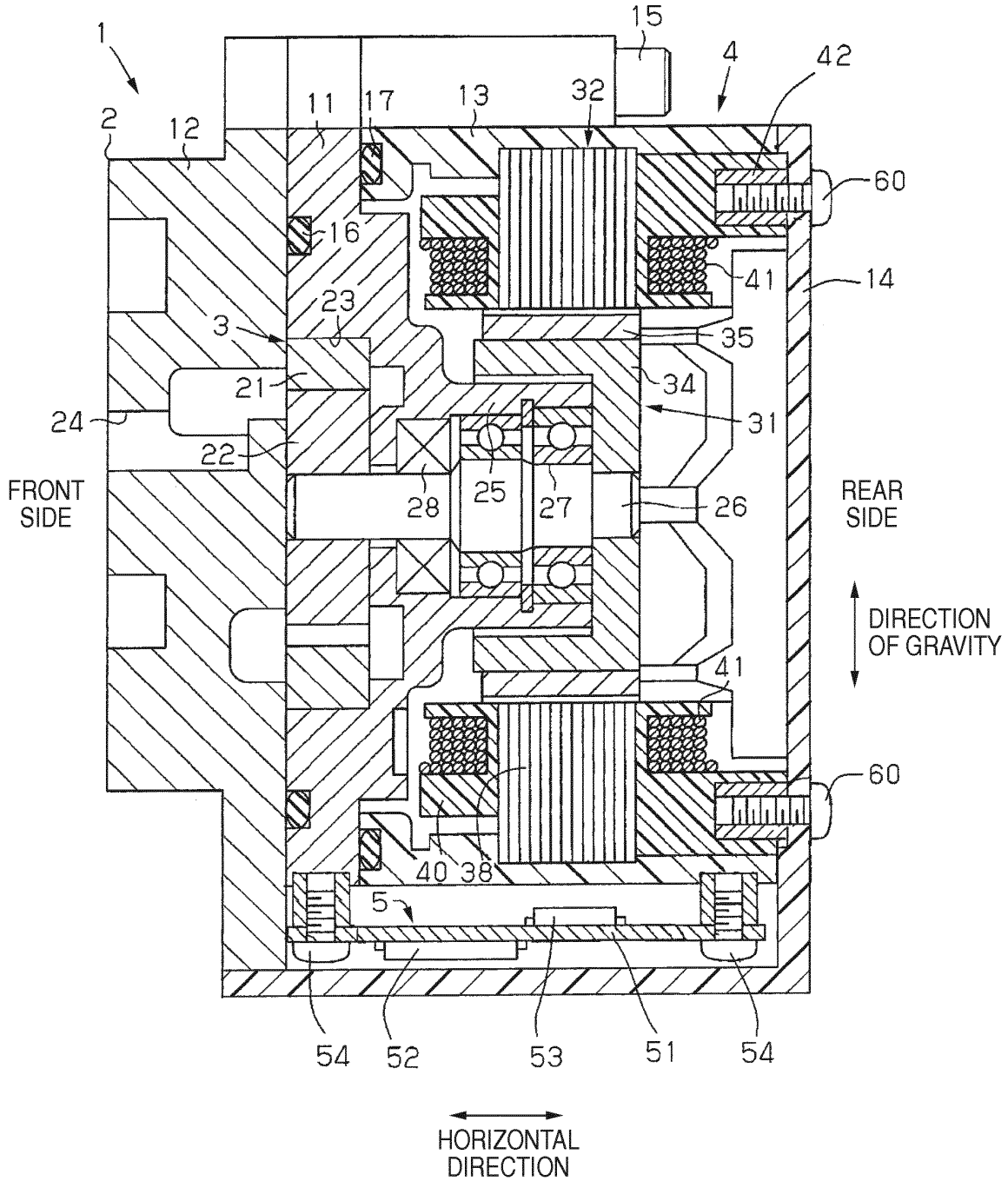

I*
(FROM HIGHER LEVEL ECU)
MICRO-COMPUTER
72
MOTOR CONTROL SIGNAL
DRIVING CIRCUIT
71
59
75
5
4
31
N
S
S
N
76
73u
73v
73w
41a
41u (41)
41w (41)
41v (41)
74
I
Vu
Vv
Vw

FIG. 4


1
2
12
11
17
13
32
15
4
42
60
16
41
14
23
3
35
21
34
24
31
22
FRONT SIDE
28
25
27
26
REAR SIDE
DIRECTION OF GRAVITY
41
60
40
38
5
54
52
53
51
54
HORIZONTAL DIRECTION

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/050035

A. CLASSIFICATION OF SUBJECT MATTER
F04B53/00(2006.01)i, *F04C14/28*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04B53/00, F04C14/28, H02H7/122, H02M7/48, H02P7/63

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2010-112330 A (JTEKT Corp.), 20 May 2010 (20.05.2010), paragraphs [0001], [0023] to [0024], [0030]; fig. 1 (Family: none)	1-2
A	JP 2005-312234 A (Nissan Motor Co., Ltd.), 04 November 2005 (04.11.2005), paragraphs [0012], [0014], [0019]; fig. 1 to 2 (Family: none)	1,5
A	JP 2010-25624 A (Denso Corp.), 04 February 2010 (04.02.2010), paragraphs [0019] to [0026]; fig. 1 (Family: none)	1,4

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search 30 March, 2012 (30.03.12)	Date of mailing of the international search report 10 April, 2012 (10.04.12)
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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2010112330 A **[0005]**
- JP 2011000123 A **[0048]**