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Inventor(s)	Oota; Yusuke et al.

Unit

Abstract

Provided is a unit including: a housing configured to accommodate a differential gear mechanism, in which the housing has a flow path through which a coolant flows, the flow path has a portion that overlaps the differential gear mechanism when viewed in a radial direction, and the flow path has a portion that is positioned above a horizontal plane passing through an axis of an output shaft of the differential gear mechanism and orthogonal to a gravity direction.

Inventors:	Oota; Yusuke (Ebina, JP), Yokoyama; Kazuhiko (Fuji, JP)
Applicant:	JATCO Ltd (Fuji, JP)
Family ID:	1000008763739
Assignee:	JATCO LTD (Fuji, JP)
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Primary Examiner: Diaz; Thomas C

Attorney, Agent or Firm: Foley & Lardner LLP

Background/Summary

TECHNICAL FIELD

(1) The present invention relates to a unit.

BACKGROUND ART

(2) Patent Document 1 discloses a unit including a motor and a power transmission mechanism.

PRIOR ART DOCUMENT

Patent Document

(3) Patent Document 1: JP 2008-185078 A

SUMMARY OF INVENTION

(4) The unit includes a housing which accommodates the motor and the power transmission. The

temperature of the housing rises as the components constituting the motor and the power transmission rotate and generate heat. Provided is a flow path through which a coolant being cooling water or the like flows. The temperature rise of the housing is reduced by heat exchange with the coolant.

(5) It is required to improve the heat exchange efficiency between the housing and the coolant.

(6) A unit according to an aspect of the present invention is a unit including: a housing configured to accommodate a differential gear mechanism, in which the housing has a flow path through which a coolant flows, the flow path has a portion that overlaps the differential gear mechanism when viewed in a radial direction, and the flow path has a portion that is positioned above a horizontal plane passing through an axis of an output shaft of the differential gear mechanism and orthogonal to a gravity direction.

(7) According to an aspect of the present invention, the heat exchange efficiency between the housing and the coolant can be improved.

Description

BRIEF DESCRIPTION OF DRAWINGS

(1) FIG. 1 is a skeleton diagram illustrating a unit mounted on a vehicle.

(2) FIG. 2 is an external view of the unit.

(3) FIG. 3 is a schematic cross-sectional view of the unit.

(4) FIG. 4 is an enlarged view around a planetary reduction gear.

(5) FIG. 5 is a top view of a motor case with a second case member removed.

(6) FIG. 6 is a diagram illustrating a flow of cooling water in the unit.

(7) FIG. 7 is a diagram illustrating oil scraping up by a differential case.

(8) FIG. 8 is a diagram of a gear case when viewed from a rotation axis direction.

(9) FIG. 9 is a cross-sectional view of a cooling chamber taken along line A-A in FIG. 8.

(10) FIG. 10 is a diagram illustrating a cooling path in the cooling chamber.

(11) FIG. 11 is a schematic cross-sectional view taken along line A-A in FIG. 10.

DESCRIPTION OF EMBODIMENTS

(12) First, definitions of terms in the present specification will be described.

(13) A “unit” is also referred to as a “motor unit”, a “power transmission device”, or the like. The motor unit is a unit that includes at least a motor. The power transmission device is a device that includes at least a power transmission mechanism, and is, for example, a gear mechanism and/or a differential gear mechanism. A unit that is a device including a motor and a power transmission mechanism belongs to the concept of both the motor unit and the power transmission device.

(14) A “housing” accommodates a motor, a gear, and an inverter. The housing includes one or more cases.

(15) “3-in-1” means a form in which a part of a motor case accommodating a motor and a part of an inverter case accommodating an inverter are integrally formed. For example, when a cover and a case constitute one case, in “3-in-1”, the case accommodating a motor and the case accommodating an inverter are integrally formed.

(16) A “motor” is a rotating electrical machine that has a motor function and/or a generator function.

(17) When referring to a second element (component, portion, or the like) connected to a first element (component, portion, or the like), the second element (component, portion, or the like) connected downstream of the first element (component, portion, or the like), and the second element (component, portion, or the like) connected upstream of the first element (component, portion, or the like), it means that the first element and the second element are connected such that power can be transmitted. A power input side is upstream, and a power output side is downstream.

The first element and the second element may be connected to each other via another element (clutch, other gear mechanism, or the like).

(18) The description “overlap when viewed in a predetermined direction” means that a plurality of elements are disposed in a predetermined direction, and has the same meaning as the description “overlap in a predetermined direction”. The “predetermined direction” is, for example, an axial direction, a radial direction, a gravity direction, or a vehicle traveling direction (vehicle forward direction, vehicle backward direction).

(19) When the drawing shows that a plurality of elements (components, portions, or the like) are disposed in a predetermined direction, in the description of the specification, it may be considered that there is a sentence explaining that the plurality of elements overlap when viewed in the predetermined direction.

(20) The descriptions “do not overlap when viewed in a predetermined direction” and “are offset when viewed in a predetermined direction” mean that a plurality of elements are not disposed in a predetermined direction, and have the same meaning as the descriptions “do not overlap in a predetermined direction” and “are offset in a predetermined direction”. The “predetermined direction” is, for example, an axial direction, a radial direction, a gravity direction, or a vehicle traveling direction (vehicle forward direction, vehicle backward direction).

(21) When the drawing shows that a plurality of elements (components, portions, or the like) are not disposed in a predetermined direction, in the description of the specification, it may be considered that there is a sentence explaining that the plurality of elements do not overlap when viewed in the predetermined direction.

(22) The description “a first element (component, portion, or the like) is positioned between a second element (component, portion, or the like) and a third element (component, portion, or the like) when viewed in a predetermined direction” means that when viewed from the predetermined direction, it can be observed that the first element is between the second element and the third element. The “predetermined direction” is an axial direction, a radial direction, a gravity direction, a vehicle traveling direction (vehicle forward direction, vehicle backward direction), or the like.

(23) For example, when the second element, the first element, and the third element are disposed in this order along the axial direction, it can be said that the first element is positioned between the second element and the third element when viewed in the radial direction. When the drawing shows that the first element is positioned between the second element and the third element when viewed in a predetermined direction, in the description of the specification, it may be considered that there is a sentence explaining that the first element is between the second element and the third element when viewed in the predetermined direction.

(24) In a case where two elements (components, portions, or the like) overlap when viewed in the axial direction, the two elements are coaxial.

(25) The “axial direction” means an axial direction of a rotation axis of a component that constitutes a unit. The “radial direction” means a direction orthogonal to the rotation axis of the component that constitutes a unit. Examples of components include a motor, a gear mechanism, and a differential gear mechanism.

(26) When a rotating element (for example, sun gear, carrier, or ring gear) of a planetary gear mechanism is “fixed” to another element, the rotating element may be directly fixed or may be fixed via another member.

(27) A “downstream side in a rotation direction” means a downstream side in a rotation direction when a vehicle moves forward or in a rotation direction when the vehicle moves backward. It is preferable to regard it as the downstream side in the rotation direction when the vehicle moves forward, which occurs frequently. A downstream side in a rotation direction of the planetary gear mechanism means a downstream side in a revolution direction of a pinion gear.

(28) A “catch tank” is an element (component, portion, or the like) that has a function of a tank (container) into which oil is introduced. The supply of oil from the outside of the tank to the tank is

expressed as “catch”. The catch tank is provided, for example, using at least a part of the housing, or is provided separately from the housing. The integrated formation of the catch tank and the housing contributes to a reduction in the number of components.

(29) A “coolant” is a refrigerant and is a type of heat exchange medium. For example, the “coolant” is a liquid (cooling water or the like) or a gas (air or the like). The coolant is a concept that includes oil, but when both oil and coolant are described in the present specification, it means that the coolant is made of a material different from that of the oil.

(30) A “heat exchange unit” is an element (component, portion, or the like) that exchanges heat between two different heat exchange media. Combinations of the two heat exchange media are, for example, oil and cooling water, cooling water and air, or air and oil. The heat exchange unit includes, for example, a heat exchanger (oil cooler), a flow path through which a coolant flows, and a heat pipe. In the present invention, it is preferable to use, for example, a flow path, through which the coolant flows, formed in the housing as the heat exchange unit. This can contribute to a reduction in dimension of the unit.

(31) The “flow path, through which the coolant flows, formed in the housing” is a portion integrally formed with the housing. For example, heat is exchanged between the coolant and the oil and/or air in the housing via a wall portion of the housing.

(32) A “vehicle room” means a room in a vehicle into which occupants enter.

(33) Hereinafter, an embodiment of the present invention will be described.

(34) FIG. 1 is a skeleton diagram illustrating a unit mounted on a vehicle.

(35) FIG. 2 is an external view of the unit.

(36) FIG. 3 is a schematic cross-sectional view of the unit. FIG. 3 shows a state in which an inverter case is removed.

(37) FIG. 4 is an enlarged view around a planetary reduction gear.

(38) FIG. 5 is a top view of a motor case with a second case member removed.

(39) FIG. 6 is a diagram showing a circulation system of cooling water in the unit.

(40) FIG. 7 is a diagram illustrating a catch tank of a gear case.

(41) As shown in FIG. 1, a unit 1 is a 3-in-1 unit, and includes a motor 2, a power transmission mechanism 3 that transmits the power output from the motor 2 to drive wheels K and K of a vehicle, and an inverter 7 (see FIG. 2) that is a power conversion device of the motor 2.

(42) In the embodiment, as shown in FIG. 1, the unit 1 includes, as the power transmission mechanism 3, a planetary reduction gear 4 (reduction gear mechanism, planetary gear mechanism), a differential mechanism 5 (differential gear mechanism), and drive shafts DA and DB as output shafts.

(43) In the unit 1, the planetary reduction gear 4, the differential mechanism 5, and the drive shafts DA and DB are provided along a transmission path of output rotation about a rotation axis X of the motor 2. Axes of the drive shafts DA and DB are coaxial with the rotation axis X of the motor 2, and the differential mechanism 5 is coaxial with the motor 2.

(44) In the unit 1, the output rotation of the motor 2 is decelerated by the planetary reduction gear 4 and input to the differential mechanism 5, and then transmitted to the left and right drive wheels K and K of the vehicle on which the unit 1 is mounted via the drive shafts DA and DB.

(45) Here, the planetary reduction gear 4 is connected downstream of the motor 2. The differential mechanism 5 is connected downstream of the motor 2 via the planetary reduction gear 4. The drive shafts DA and DB are connected downstream of the differential mechanism 5.

(46) As shown in FIG. 2, the unit 1 includes, as a 3-in-1 type housing, a housing HS that accommodates the motor 2, the power transmission mechanism 3 and the inverter 7. The housing HS includes one or more cases. The housing HS includes, for example, a motor case 10 that accommodates the motor 2, a gear case 14 that accommodates the power transmission mechanism 3, and an inverter case 17 that accommodates the inverter 7. The gear case 14 is joined to one end of the motor case 10 in a rotation axis X direction. The inverter case 17 is joined above the motor

case **10** in a gravity direction when the unit **1** is mounted on the vehicle.

(47) The inverter **7** is an electronic component including a smoothing capacitor, a power semiconductor element, a driver board, and the like. The inverter **7** is electrically connected to the motor **2** inside the motor case **10** by wiring (not shown).

(48) In the inverter case **17**, a cooling path CP2 through which cooling water CL (see FIG. **6**) for cooling the inverter **7** flows is formed.

(49) The motor **2** has a portion that overlaps the differential mechanism **5** (differential gear mechanism) when viewed in an axial direction (see FIG. **3**). Here, “when viewed in an axial direction” means when viewed from the rotation axis X direction. “When viewed in a radial direction” means when viewed from the radial direction of the rotation axis X direction.

(50) When viewed in the axial direction, the motor **2** has a portion that overlaps the planetary reduction gear **4** (reduction gear mechanism).

(51) When viewed in the axial direction, the planetary reduction gear **4** (reduction gear mechanism) has a portion that overlaps the differential mechanism **5** (differential gear mechanism).

(52) When viewed in the axial direction, the planetary reduction gear **4** (reduction gear mechanism) has a portion that overlaps the motor **2**.

(53) When viewed in the axial direction, the differential mechanism **5** (differential gear mechanism) has a portion that overlaps the planetary reduction gear **4** (reduction gear mechanism).

(54) When viewed in the axial direction, the differential mechanism **5** (differential gear mechanism) has a portion that overlaps the motor **2**.

(55) When viewed in the axial direction, the motor **2** has a portion that overlaps the differential mechanism **5** (differential gear mechanism).

(56) As shown in FIG. **3**, the motor case **10** includes a first case member **11**, a second case member **12** fitted onto the first case member **11**, and a cover member **13** joined to one end of the first case member **11**. The first case member **11** includes a cylindrical support wall portion **111** and a flange-shaped joint portion **112** provided at one end **111a** of the support wall portion **111**.

(57) The support wall portion **111** is provided in a direction along the rotation axis X of the motor **2**. The motor **2** is accommodated inside the support wall portion **111**.

(58) The second case member **12** includes a cylindrical peripheral wall portion **121**, a flange-shaped joint portion **122** provided at one end **121a** of the peripheral wall portion **121**, and a flange-shaped joint portion **123** provided at the other end **121b** of the peripheral wall portion **121**.

(59) The peripheral wall portion **121** of the second case member **12** is formed with an inner diameter that allows the peripheral wall portion **121** to be fitted onto the support wall portion **111** of the first case member **11**.

(60) The first case member **11** and the second case member **12** are assembled by fitting the peripheral wall portion **121** of the second case member **12** onto the support wall portion **111** of the first case member **11**.

(61) The joint portion **122** at the one end **121a** of the peripheral wall portion **121** comes into contact with the joint portion **112** of the first case member **11** from the rotation axis X direction. The joint portions **122** and **112** are connected with bolts (not shown).

(62) As shown in FIG. **5**, a protrusion **111b** is provided on an outer periphery of the support wall portion **111** of the first case member **11**. The protrusion **111b** is a wall surrounding the rotation axis X at intervals. The protrusion **111b** of the support wall portion **111** is provided in a spiral shape with a phase shifted from one end toward the other end in the rotation axis X direction. The protrusion **111b** surrounds the outer periphery of the support wall portion **111** over the entire circumference of the support wall portion **111**.

(63) As shown in FIG. **3**, the peripheral wall portion **121** of the second case member **12** is fitted onto the support wall portion **111** of the first case member **11**. In this state, since an inner periphery of the peripheral wall portion **121** comes into contact with an outer periphery of the spiral protrusion **111b** of the support wall portion **111**, a space is formed between the peripheral wall

portion **121** and the support wall portion **111**. The space surrounds the rotation axis X with gaps therebetween and is continuously formed in a spiral shape in the rotation axis X direction. The spiral space forms a cooling path CP1 through which the cooling water CL (see FIG. 6), which is a coolant, flows. In FIG. 6, the spiral cooling path CP1 is simplified and shown as a straight line.

(64) In the outer periphery of the support wall portion **111** of the first case member **11**, ring grooves **111c** and **111c** are formed on both sides of the region where the protrusion **111b** is provided. Seal rings **113** and **113** are fitted and attached to the ring grooves **111c** and **111c**.

(65) The seal rings **113** are pressed against the inner periphery of the peripheral wall portion **121** fitted onto the support wall portion **111** to seal gaps between the outer periphery of the support wall portion **111** and the inner periphery of the peripheral wall portion **121**.

(66) A wall portion **120** (cover) extending radially inward is provided at the other end **121b** of the second case member **12**. The wall portion **120** is provided in a direction orthogonal to the rotation axis X. An opening **120a** through which the drive shaft DA is inserted is provided in a region of the wall portion **120** intersecting the rotation axis X.

(67) A tubular motor support portion **125** that surrounds the opening **120a** and extends toward the motor **2** is provided on a surface of the wall portion **120** closer to the motor **2** (right side in the drawing).

(68) The motor support portion **125** is inserted inside a coil end **253b**, which will be described later. The motor support portion **125** faces an end portion **21b** of a rotor core **21** with a gap therebetween in the rotation axis X direction. A bearing B1 is supported on an inner periphery of the motor support portion **125**. An outer periphery of a motor shaft **20** is supported by the motor support portion **125** via a bearing B1.

(69) A tubular wall portion **126** extending toward the differential mechanism **5** is provided on a surface of the wall portion **120** closer to the differential mechanism **5** (left side in the drawing). The tubular wall portion **126** has a cylindrical shape surrounding the opening **120a**, and an inner periphery of the tubular wall portion **126** supports a bearing B2. The bearing B2 supports a tubular wall portion **61** of a differential case **50**, which will be described later.

(70) The cover member **13** includes a wall portion **130** orthogonal to the rotation axis X and a joint portion **132**.

(71) When viewed from the first case member **11**, the cover member **13** is positioned on an opposite side (right side in the drawing) to the differential mechanism **5**. The joint portion **132** of the cover member **13** is joined to the joint portion **112** of the first case member **11** from the rotation axis X direction. The cover member **13** and the first case member **11** are connected to each other with bolts (not shown). In this state, in the first case member **11**, an opening of the support wall portion **111** closer to the joint portion **112** (right side in the drawing) is closed by the cover member **13**.

(72) In the cover member **13**, an insertion hole **130a** for the drive shaft DA is provided in a central portion of the wall portion **130**.

(73) A lip seal RS is provided on an inner periphery of the insertion hole **130a**. The lip seal RS brings a lip portion (not shown) into elastic contact with an outer periphery of the drive shaft DA. A gap between the inner periphery of the insertion hole **130a** and the outer periphery of the drive shaft DA is sealed by the lip seal RS.

(74) A peripheral wall portion **131** surrounding the insertion hole **130a** is provided on a surface of the wall portion **130** closer to the first case member **11** (left side in the drawing). The drive shaft DA is supported on an inner periphery of the peripheral wall portion **131** via a bearing B4.

(75) A motor support portion **135** and a connection wall **136** are provided on an inner diameter side of the joint portion **132**. The motor support portion **135** is provided closer to the motor **2** (left side in the drawing) when viewed from the peripheral wall portion **131**. The motor support portion **135** has a tubular shape surrounding the rotation axis X with a gap therebetween.

(76) The cylindrical connection wall **136** is connected to an outer periphery of the motor support

portion **135**. The connection wall **136** is formed with a larger outer diameter than the peripheral wall portion **131** in the wall portion **130** (right side in the drawing). The connection wall **136** is provided along the rotation axis X and extends away from the motor **2**. The connection wall **136** connects the motor support portion **135** and the joint portion **132**.

(77) One end **20a** of the motor shaft **20** penetrates the inside of the motor support portion **135** from the motor **2** side to the peripheral wall portion **131** side.

(78) A bearing **B1** is supported on an inner periphery of the motor support portion **135**. The outer periphery of the motor shaft **20** is supported by the motor support portion **135** via the bearing **B1**.

(79) A lip seal **RS** is provided at a position adjacent to the bearing **B1**.

(80) Oil holes **136a** and **136b** are opened in an inner periphery of the connection wall **136**. Oil **OL** flows from the oil hole **136a** into a space (internal space **Sc**) surrounded by the connection wall **136**. The oil **OL** flowing into the internal space **Sc** is discharged from the oil hole **136b**. The lip seal **RS** is provided to prevent the oil **OL** in the connection wall **136** from flowing into the motor **2**.

(81) The gear case **14** includes a peripheral wall portion **141** and a flange-shaped joint portion **142** provided at an end portion of the peripheral wall portion **141** closer to the motor case **10**. A support portion **145** for a bearing **B2**, which will be described later, is provided at an end portion of the peripheral wall portion **141** on a side (left side in the drawing) opposite to the joint portion **142**. The peripheral wall portion **141** includes a tubular wall portion **141a** connected to the joint portion **142**, an inclined portion **141c** (wall portion) connected to the support portion **145**, and a connection wall portion **141b** connecting the tubular wall portion **141a** and the inclined portion **141c**. The tubular wall portion **141a** and the connection wall portion **141b** are gradually reduced in diameter from the joint portion **142** and connected to the inclined portion **141c**. The inclined portion **141c** is inclined radially inward from the connection wall portion **141b** toward the support portion **145**. The planetary reduction gear **4** and the differential mechanism **5** as the power transmission mechanism **3** are accommodated inside the peripheral wall portion **141**.

(82) The gear case **14** is positioned closer to the differential mechanism **5** (left side in the drawing) when viewed from the motor case **10**. The joint portion **142** of the gear case **14** is joined to the joint portion **123** of the second case member **12** of the motor case **10** from the rotation axis X direction. The gear case **14** and the second case member **12** are connected to each other with bolts (not shown).

(83) A space formed inside the joined motor case **10** and gear case **14** is divided into two spaces by the wall portion **120** (cover) of the second case member **12**. A side of the wall portion **120** in the motor case **10** is a motor chamber **Sa** that accommodates the motor **2**, and a side of the wall portion **120** in the gear case **14** is a gear chamber **Sb** that accommodates the planetary reduction gear **4** and the differential mechanism **5**. The wall portion **120** as a cover is sandwiched between the motor **2** and the differential mechanism **5** inside the housing **HS**.

(84) The cover may have a portion accommodated in the housing **HS**, or the entire cover may be accommodated in the housing **HS** like the wall portion **120**. The cover may be, for example, separate from the second case member **12**. In this case, the cover may be sandwiched and fixed between the motor case **10** and the gear case **14**. A part of the cover may be exposed outside of the housing **HS**.

(85) The motor **2** includes the cylindrical motor shaft **20**, the cylindrical rotor core **21** fitted onto the motor shaft **20**, and a stator core **25** surrounding an outer periphery of the rotor core **21** with a gap therebetween.

(86) In the motor shaft **20**, the bearings **B1** and **B1** are fitted and fixed to both sides of the rotor core **21**.

(87) The bearing **B1** positioned on the one end **20a** (right side in the drawing) of the motor shaft **20** when viewed from the rotor core **21** is supported on the inner periphery of the motor support portion **135** of the cover member **13**. The bearing **B1** positioned on the other end **20b** (left side in the drawing) is supported on the inner periphery of the cylindrical motor support portion **125** of the

second case member **12**.

(88) The motor support portion **135** is disposed facing one end portion **21a** of the rotor core **21** with a gap therebetween in the rotation axis X direction on an inner diameter side of a coil end **253a**, which will be described later, and the motor support portion **125** is disposed facing the other end portion **21b** of the rotor core **21** with a gap therebetween in the rotation axis X direction on an inner diameter side of a coil end **253b**, which will be described later.

(89) The rotor core **21** is formed by laminating a plurality of silicon steel plates. Each of the silicon steel plates is fitted onto the motor shaft **20** in a state in which relative rotation with respect to the motor shaft **20** is restricted.

(90) When viewed from the rotation axis X direction of the motor shaft **20**, the silicon steel plate has a ring shape. On an outer peripheral side of the silicon steel plate, N-pole and S-pole magnets (not shown) are alternately provided in a circumferential direction around the rotation axis X.

(91) The stator core **25** surrounding the outer periphery of the rotor core **21** is formed by laminating a plurality of electromagnetic steel plates. The stator core **25** is fixed to the inner periphery of the cylindrical support wall portion **111** of the first case member **11**.

(92) Each of the electromagnetic steel plates includes a ring-shaped yoke portion **251** fixed to the inner periphery of the support wall portion **111**, and a teeth portion **252** protruding from an inner periphery of the yoke portion **251** toward the rotor core **21**.

(93) In the present embodiment, the stator core **25** in which a winding **253** is wound around the plurality of teeth portions **252** in a distributed manner is adopted. The stator core **25** is longer than the rotor core **21** in the rotation axis X direction by lengths of the coil ends **253a** and **253b** protruding in the rotation axis X direction.

(94) A stator core in which windings are concentratedly wound around each of the plurality of teeth portions **252** protruding toward the rotor core **21** may be adopted.

(95) The opening **120a** is provided in the wall portion **120** (motor support portion **125**) of the second case member **12**. The other end **20b** of the motor shaft **20** penetrates through the opening **120a** to the differential mechanism **5** (left side in the drawing) and is positioned in the gear case **14**.

(96) The other end **20b** of the motor shaft **20** faces a side gear **54A**, which will be described later, inside the gear case **14** with a gap therebetween in the rotation axis X direction.

(97) A lip seal RS is inserted between the motor shaft **20** and the opening **120a** of the wall portion **120**.

(98) The oil OL for lubricating the planetary reduction gear **4** and the differential mechanism **5** are sealed on an inner diameter side of the gear case **14**.

(99) The lip seal RS is provided to prevent the oil OL in the gear case **14** from flowing into the motor case **10**.

(100) As shown in FIG. **4**, a sun gear **41** of the planetary reduction gear **4** is spline-fitted in a region of the motor shaft **20** positioned in the gear case **14**.

(101) A teeth portion **41a** is formed on an outer periphery of the sun gear **41**, and a large-diameter gear portion **431** of a stepped pinion gear **43** meshes with the teeth portion **41a**.

(102) The stepped pinion gear **43** includes the large-diameter gear portion **431** (large pinion) that meshes with the sun gear **41** and a small-diameter gear portion **432** (small pinion) that has a smaller diameter than the large-diameter gear portion **431**.

(103) The large-diameter gear portion **431** and the small-diameter gear portion **432** are integrated gear components disposed side by side in a direction of an axis X1 parallel to the rotation axis X.

(104) An outer periphery of the small-diameter gear portion **432** meshes with an inner periphery of a ring gear **42**. The ring gear **42** has a ring shape surrounding the rotation axis X with a gap therebetween. On an outer periphery of the ring gear **42**, engagement teeth are provided, and the engagement teeth are spline-fitted to a teeth portion **146a** provided on an inner periphery of the connection wall portion **141b**. The ring gear **42** is restricted from rotating about the rotation axis X.

(105) A pinion shaft **44** penetrates inner diameter sides of the large-diameter gear portion **431** and

the small-diameter gear portion **432**. The stepped pinion gear **43** is rotatably supported on an outer periphery of the pinion shaft **44** via needle bearings NB, NB.

(106) As shown in FIG. 3, the differential mechanism **5** includes the differential case **50** as an input element, the drive shafts DA and DB (output shafts) as output elements, and a differential gear set as a differential element. Although detailed description is omitted, the differential case **50** may be configured by two case members assembled in a rotation axis direction.

(107) The differential case **50** also functions as a carrier that supports the stepped pinion gear **43** of the planetary reduction gear **4**. The stepped pinion gear **43** is rotatably supported by the differential case **50** via the pinion shaft **44**. As shown in FIG. 7, three stepped pinion gears **43** are disposed at intervals in the circumferential direction around the rotation axis X.

(108) As shown in FIG. 3, in the differential case **50**, as the differential gear set, a pinion mate gear **52**, which is a bevel gear type differential gear, and side gears **54A** and **54B** are provided. The pinion mate gear **52** is supported by a pinion mate shaft **51**.

(109) The pinion mate shaft **51** includes a central member **510** disposed on the rotation axis X and shaft members **511** connected to an outer diameter side of the central member **510**. Although not shown, the plurality of shaft members **511** are provided at equal intervals in the circumferential direction around the rotation axis X. The shaft members **511** are inserted through a support hole **69** extending in a radial direction of the differential case **50** and supported.

(110) The pinion mate gear **52** is fitted onto the shaft members **511** and is rotatably supported.

(111) In the differential case **50**, the side gear **54A** is positioned on one side of the central member **510** in the rotation axis X direction, and the side gear **54B** is positioned on the other side of the central member **510**. The side gears **54A** and **54B** are rotatably supported by the differential case **50**.

(112) The side gear **54A** meshes with the pinion mate gear **52** from one side in the rotation axis X direction. The side gear **54B** meshes with the pinion mate gear **52** from the other side in the rotation axis X direction.

(113) An opening **60** and a tubular wall portion **61** surrounding the opening **60** and extending toward the motor case **10** are provided in a central portion of one end (right side in the drawing) of the differential case **50**. An outer periphery of the tubular wall portion **61** is supported by the wall portion **120** of the second case member **12** via the bearing B2.

(114) The drive shaft DA inserted through the opening **60** is inserted into the differential case **50** from the rotation axis X direction. The drive shaft DA penetrates the insertion hole **130a** of the wall portion **130** of the cover member **13**, and is provided across inner diameter sides of the motor shaft **20** of the motor **2** and the sun gear **41** of the planetary reduction gear **4** in the rotation axis X direction.

(115) As shown in FIG. 3, a through hole **65** and a tubular wall portion **66** surrounding the through hole **65** are formed in a central portion on the other end side (left side in the drawing) of the differential case **50**. The bearing B2 is fitted onto the tubular wall portion **66**. The bearing B2 fitted onto the tubular wall portion **66** is held by the support portion **145** of the gear case **14**. The tubular wall portion **66** of the differential case **50** is rotatably supported by the gear case **14** via the bearing B2.

(116) The drive shaft DB penetrating an opening **145a** of the gear case **14** is inserted into the support portion **145** from the rotation axis X direction. The drive shaft DB is rotatably supported by the support portion **145**. The tubular wall portion **66** functions as a shaft support portion that supports the outer periphery of the drive shaft DB.

(117) A lip seal RS is fixed to an inner periphery of the opening **145a**. A lip portion (not shown) of the lip seal RS is in elastic contact with an outer periphery of the tubular wall portion **540** of the side gear **54B** that is fitted onto the drive shaft DB.

(118) Thus, a gap between the outer periphery of the tubular wall portion **540** of the side gear **54B** and the inner periphery of the opening **145a** is sealed.

(119) Inside the differential case **50**, distal end portions of the drive shafts DA and DB face each other with a gap therebetween in the rotation axis X direction.

(120) The side gears **54A** and **54B** supported by the differential case **50** are spline-fitted to outer peripheries of the distal end portions of the drive shafts DA and DB. The side gears **54A** and **54B** and the drive shafts DA and DB are coupled to each other so as to be integrally rotatable about the rotation axis X.

(121) In this state, the side gears **54A** and **54B** are disposed facing each other with a gap therebetween in the rotation axis X direction. The central member **510** of the pinion mate shaft **51** is positioned between the side gears **54A** and **54B**.

(122) The pinion mate gear **52** is assembled to the side gear **54A** positioned on one side in the rotation axis X direction and the side gear **54B** positioned on the other side in a state in which teeth portions thereof are meshed with each other.

(123) As shown in FIG. **4**, a support hole **62** at one end **44a** of the pinion shaft **44** is formed an outer diameter side of the opening **60** at the one end (right side in the drawing) of the differential case **50**. A support hole **68** at the other end **44b** of the pinion shaft **44** is formed at the other end (left side in the drawing) of the differential case **50**.

(124) The support holes **62** and **68** are formed at overlapping positions in the rotation axis X direction. The support holes **62** and **68** are formed at intervals in the circumferential direction around the rotation axis X in accordance with the position where the stepped pinion gear **43** is disposed. The one end **44a** of the pinion shaft **44** is inserted into the support hole **62**, and the other end **44b** is inserted into the support hole **68**. The other end **44b** of the pinion shaft **44** is press-fitted into the support hole **68**, so that the pinion shaft **44** is fixed to the differential case **50** so as not to be rotatable relative to the differential case **50**. The stepped pinion gear **43** fitted onto the pinion shaft **44** is rotatably supported about the axis X1 parallel to the rotation axis X.

(125) Although not shown, the oil OL for lubrication is stored inside the gear case **14**. When the differential case **50** rotates about the rotation axis X, the oil OL is scraped up by the differential case **50**.

(126) Although detailed description is omitted, an oil passage, an oil hole, and the like for introducing the oil OL scraped up by the differential case **50** are provided in the differential case **50**, the pinion shaft **44**, and the like. As a result, the oil OL is easily introduced into rotating members such as the bearing B2 and the needle bearing NB.

(127) As shown in FIG. **7**, a catch tank **15** is provided above the differential case **50** inside the gear case **14**. The catch tank **15** is positioned on one side (left side in the drawing) of a vertical line VL orthogonal to the rotation axis X. The catch tank **15** and an accommodation portion **140** of the differential case **50** communicate with each other via a communication port **147**. Part of the oil OL scraped up by the differential case **50** and scattered flows into the catch tank **15** from the communication port **147** and is collected.

(128) When the vehicle equipped with the unit **1** travels forward, the differential case **50** rotates in a counterclockwise direction CCW about the rotation axis X when viewed from the motor case **10**. As shown in FIG. **4**, the small-diameter gear portion **432** of the stepped pinion gear **43** meshes with the ring gear **42** fixed to an inner periphery of the gear case **14**. Therefore, as shown in FIG. **7**, the large-diameter gear portion **431** of the stepped pinion gear **43** revolves about the rotation axis X in the counterclockwise direction CCW while rotating clockwise about the axis X1.

(129) The catch tank **15** is positioned on the left side of the vertical line VL, that is, on a downstream side in a rotation direction of the differential case **50**. As a result, most of the oil OL scraped up by the differential case **50** rotating about the rotation axis X can flow into the catch tank **15**.

(130) As shown in FIG. **3**, the catch tank **15** is connected to a space Rx between the lip seal RS and the bearing B2 via an oil passage **151a**. The catch tank **15** is connected to an oil cooler **83** (see FIG. **6**) via an oil passage, a pipe, or the like (not shown). The oil cooler **83** is connected to the oil hole

136a (see FIG. 3) formed in the connection wall **136** via a pipe, an oil passage, or the like (not shown). In FIG. 3, the catch tank **15** is indicated by an imaginary line for description, and the actual position of the catch tank **15** is not reflected.

(131) An oil hole **Ha** is formed in the peripheral wall portion **141** of the gear case **14**. The oil hole **Ha** is connected to the oil hole **136b** formed in the internal space **Sc** via a pipe (not shown). The oil **OL** discharged from the internal space **Sc** through the oil hole **136b** is supplied again into the gear chamber **Sb** through the oil hole **Ha**.

(132) As shown in FIG. 2, a cooling chamber **9** is provided in the inclined portion **141c** (wall portion) of the gear case **14**. As shown in FIG. 6, a cooling path **CP3** through which the cooling water **CL** flows is provided inside the cooling chamber **9**. The cooling water **CL** after flowing through the cooling path **CP1** of the motor case **10** is introduced into the cooling path **CP3**.

(133) As shown in FIG. 6, the unit **1** is provided with a circulation system **80** for the cooling water **CL**. The circulation system **80** circulates the cooling water **CL** between the cooling path **CP1** of the motor case **10**, the cooling path **CP2** of the inverter case **17**, and the cooling path **CP3** of the cooling chamber **9**. The circulation system **80** further includes the oil cooler **83**, a water pump **WP**, and a radiator **82** between the cooling path **CP3** and the cooling path **CP2**, which are connected by pipes or the like through which the cooling water **CL** flows.

(134) The water pump **WP** feeds the cooling water **CL** through the circulation system **80**.

(135) The radiator **82** is a device that dissipates the heat of the cooling water **CL** to cool the cooling water **CL**.

(136) The oil cooler **83** is a heat exchanger that exchanges heat between the cooling water **CL** and the oil **OL**. The oil **OL** collected by the catch tank **15** provided in the gear chamber **Sb** of the gear case **14** is introduced into the oil cooler **83**. The oil **OL** is cooled by heat exchange with the cooling water **CL**. The cooled oil **OL** is supplied from the oil hole **136a** of the motor case **10** to the internal space **Sc**. The oil **OL** supplied to the oil cooler **83** is not limited to the oil **OL** collected by the catch tank **15**, and may be supplied from another oil passage appropriately provided in the housing **HS**. The oil **OL** discharged from the oil cooler **83** may be supplied to a location other than the internal space **Sc**.

(137) The cooling water **CL** is supplied to the oil cooler **83** after flowing through the cooling path **CP3** of the cooling chamber **9**. After the heat exchange with the oil **OL** in the oil cooler **83**, the cooling water **CL** is cooled by the radiator **82** and supplied to the cooling path **CP2** of the inverter case **17** again.

(138) As shown in FIG. 2, the cooling chamber **9** is provided in the inclined portion **141c** (wall portion) of the gear case **14**.

(139) The inclined portion **141c** has a truncated cone shape that decreases in diameter in a direction away from the motor case **10**. A space around the inclined portion **141c** is larger than a space around the motor case **10** and the like of the unit **1** by the reduced diameter of the gear case **14**. In the embodiment, the cooling chamber **9** is disposed in the space around the inclined portion **141c**. Hereinafter, a configuration of the cooling chamber **9** will be described.

(140) FIG. 8 is a diagram of the gear case **14** when viewed from the rotation axis **X** direction.

(141) FIG. 9 is a cross-sectional view of a main body portion **90** of the cooling chamber **9** taken along line A-A in FIG. 8. In FIG. 9, the gear case **14** and the drive shaft **DB** are indicated by imaginary lines for convenience of description.

(142) FIG. 10 is a diagram illustrating the cooling path **CP3** inside the cooling chamber **9**. In FIG. 10, the inside of the cooling chamber **9** is indicated by a broken line.

(143) FIG. 11 is a schematic cross-sectional view taken along line A-A in FIG. 10. In FIG. 11, the inside of the gear case **14** is simplified.

(144) As shown in FIG. 8, the cooling chamber **9** is disposed adjacent to the catch tank **15** provided in an upper portion of the gear case **14**. The cooling chamber **9** includes the main body portion **90** (arc-shaped portion) that is an arc-shaped member when viewed from the rotation axis **X** direction.

The main body portion **90** is disposed in the circumferential direction around the rotation axis X so as to surround the drive shaft DB, and is joined to the inclined portion **141c**. As shown in FIG. 9, the main body portion **90** is joined to an end portion **141d** closer to the motor case **10** (right side in the drawing) of the inclined portion **141c** and an end portion **141e** on the opposite side (left side in the drawing).

(145) As shown in FIG. 9, the main body portion **90** includes a first wall portion **91** and a second wall portion **92**.

(146) In the first wall portion **91**, one end portion **91a** is joined to the one end portion **141d** of the inclined portion **141c**. The first wall portion **91** extends along the rotation axis X direction. The other end portion **91b** of the first wall portion **91** is spaced apart from the inclined portion **141c**.

(147) In the second wall portion **92**, one end portion **92a** is joined to the end portion **141e**. The second wall portion **92** extends radially outward of the rotation axis X. The second wall portion **92** is provided in a direction substantially orthogonal to the rotation axis X when the main body portion **90** is attached to the gear case **14**. The other end portion **92b** of the second wall portion **92** is connected to the end portion **91b** of the first wall portion **91**.

(148) As shown in FIG. 9, in the cooling chamber 9, a triangular space surrounded by the first wall portion **91** and the second wall portion **92** of the main body portion **90** and the inclined portion **141c** is formed in a cross-sectional view. This space constitutes the cooling path CP3 through which the cooling water CL, which is a coolant, flows. That is, the cooling path CP3, which is a flow path through which a coolant flows, is a portion integrally formed with the housing HS.

(149) As shown in FIG. 11, the inclined portion **141c** constitutes part of a wall surface of the catch tank **15** formed inside the gear case **14**. That is, the cooling path CP3 and the catch tank **15** are adjacent to each other with the inclined portion **141c** interposed therebetween.

(150) As shown in FIG. 10, when viewed from the rotation axis X direction, the cooling path CP3 has an arc shape extending from one side of the vertical line VL orthogonal to the rotation axis X to the other side of the vertical line VL via a lower side of the rotation axis X. One end and the other end in a longitudinal direction of the cooling path CP3 are closed by third wall portions **93** of the main body portion **90**.

(151) The third wall portions **93** and **93** extend and are connected to the first wall portion **91**, the second wall portion **92**, and a wall surface of the inclined portion **141c**.

(152) As shown in FIG. 10, the cooling path CP3 has an arc shape surrounding the rotation axis X when viewed from the rotation axis X direction. With respect to a horizontal plane S passing through the rotation axis X and orthogonal to the vertical line VL, the cooling path CP3 has a portion positioned above the horizontal plane S and a portion positioned below the horizontal plane S.

(153) An introduction portion **95** and a discharge portion **96** for the cooling water CL are provided above the main body portion **90** in the vertical line VL direction.

(154) The introduction portion **95** has an opening **95a** provided through the first wall portion **91** of the main body portion **90**, and a peripheral wall portion **95b** surrounding the opening **95a** and extending upward in the vertical line VL direction. The introduction portion **95** communicates with one end side (right side in the drawing) of the cooling path CP3 in the circumferential direction around the rotation axis X through the opening **95a**.

(155) The discharge portion **96** has an opening **96a** provided through the first wall portion **91** of the main body portion **90**, and a peripheral wall portion **96b** surrounding the opening **96a** and extending upward in the vertical line VL direction. The discharge portion **96** communicates with the other end side (left side in the drawing) of the cooling path CP3 in the circumferential direction around the rotation axis X through the opening **96a**.

(156) The introduction portion **95** and the discharge portion **96** are positioned above the horizontal plane S. The cooling path CP3 has a portion positioned above the horizontal plane S and connected to the introduction portion **95** and the discharge portion **96**, and a portion positioned below the

horizontal plane S. In other words, the introduction portion **95** is connected to the discharge portion **96** via the portion of the cooling path CP3 positioned below the horizontal plane S.

(157) The peripheral wall portion **95b** of the introduction portion **95** is connected to the cooling path CP1 (see FIG. 6) of the motor case **10** via a pipe or the like (not shown). The peripheral wall portion **96b** of the discharge portion **96** is connected to the radiator **82** (see FIG. 6) via a pipe or the like (not shown). As shown in FIG. 8, the catch tank **15** is positioned on one side of the vertical line VL on which the introduction portion **95** is disposed when viewed from the rotation axis X direction.

(158) As shown in FIG. 11, an inner surface of the inclined portion **141c** comes into contact with the oil OL stored in the catch tank **15** above the rotation axis X. As shown in FIG. 9, the inner surface of the inclined portion **141c** comes into contact with the oil OL stored in the gear chamber Sb below the rotation axis X.

(159) On the other hand, an outer surface of the inclined portion **141c** comes into contact with the cooling water CL introduced into the cooling path CP3. That is, the oil OL inside the gear case **14** and the cooling water CL in the cooling path CP3 can exchange heat via the inclined portion **141c** which is a wall portion.

(160) The operation of the unit **1** having such a configuration will be described.

(161) As shown in FIG. 1, in the unit **1**, the planetary reduction gear **4**, the differential mechanism **5**, and the drive shafts DA and DB are provided along a transmission path of output rotation of the motor **2**.

(162) As shown in FIG. 3, when the motor **2** is driven and the rotor core **21** rotates about the rotation axis X, the rotation is input to the sun gear **41** of the planetary reduction gear **4** via the motor shaft **20** that rotates integrally with the rotor core **21**.

(163) In the planetary reduction gear **4**, the sun gear **41** serves as an input portion for the output rotation of the motor **2**, and the differential case **50** supporting the stepped pinion gear **43** serves as an output portion for the input rotation.

(164) As shown in FIG. 4, when the sun gear **41** rotates about the rotation axis X by the input rotation, the stepped pinion gear **43** (large-diameter gear portion **431** and small-diameter gear portion **432**) rotates about the axis X1 by the rotation input from the sun gear **41**.

(165) Here, the small-diameter gear portion **432** of the stepped pinion gear **43** meshes with the ring gear **42** fixed to the inner periphery of the gear case **14**. Therefore, the stepped pinion gear **43** revolves around the rotation axis X while rotating about the axis X1.

(166) Here, in the stepped pinion gear **43**, an outer diameter of the small-diameter gear portion **432** is smaller than an outer diameter of the large-diameter gear portion **431**.

(167) As a result, the differential case **50** supporting the stepped pinion gear **43** rotates about the rotation axis X at a rotation speed lower than that of the rotation input from the motor **2**.

(168) Therefore, the rotation input to the sun gear **41** of the planetary reduction gear **4** is greatly decelerated by the stepped pinion gear **43** and then output to the differential case **50** (differential mechanism **5**).

(169) As shown in FIG. 3, when the differential case **50** rotates about the rotation axis X by the input rotation, the drive shafts DA and DB meshing with the pinion mate gear **52** rotate about the rotation axis X in the differential case **50**. As a result, the left and right drive wheels K and K (see FIG. 1) of the vehicle equipped with the unit **1** are rotated by the transmitted rotational driving force.

(170) As shown in FIG. 3, the oil OL for lubrication is stored in the gear chamber Sb. In the gear chamber Sb, when the output rotation of the motor **2** is transmitted, the stored oil OL is scraped up by the differential case **50** rotating about the rotation axis X.

(171) As shown in FIGS. 3 and 4, the scraped-up oil OL lubricates a meshing portion between the sun gear **41** and the large-diameter gear portion **431**, a meshing portion between the small-diameter gear portion **432** and the ring gear **42**, and meshing portions between the pinion mate gear **52** and

the side gears **54A** and **54B**.

(172) As shown in FIG. 7, the differential case **50** rotates in the counterclockwise direction CCW about the rotation axis X.

(173) The catch tank **15** is provided on an upper portion of the gear case **14**. The catch tank **15** is positioned on the downstream side in the rotation direction of the differential case **50**, and part of the oil OL scraped up by the differential case **50** flows into the catch tank **15**.

(174) As shown in FIG. 3, part of the oil OL flowing into the catch tank **15** is supplied to the space Rx between the lip seal RS and the bearing B2 via the oil passage **151a** to lubricate the bearing B2. Part of the oil OL flowing into the catch tank **15** is introduced into the oil cooler **83** via an oil passage, pipe, or the like (not shown), and is cooled by heat exchange with the cooling water CL.

(175) The cooled oil OL is discharged from the oil cooler **83** and supplied to the internal space Sc (see FIG. 3) formed in the connection wall **136** via an oil passage, a pipe, or the like (not shown). The oil OL supplied to the internal space Sc lubricates the bearings B1 and B4 and is discharged from the oil hole **136b**. The oil OL discharged from the oil hole **136b** is supplied into the gear chamber Sb from the oil hole Ha via a pipe or the like (not shown).

(176) As shown in FIG. 3, the gear case **14** of the housing HS includes the inclined portion **141c** as a wall portion surrounding the differential mechanism 5 in the radial direction of the rotation axis X. As shown in FIG. 2, the cooling chamber 9 is disposed in the inclined portion **141c**. The cooling path CP3 is provided inside the cooling chamber 9.

(177) As shown in FIG. 10, the cooling water CL after flowing through the cooling path CP2 (see FIG. 6) is introduced into the cooling path CP3 through the peripheral wall portion **95b** and the opening **95a** of the introduction portion 95. The cooling water CL introduced to the one end in the longitudinal direction of the cooling path CP3 flows toward the discharge portion **96** on the other end of the cooling path CP3.

(178) As shown in FIGS. 9 and 11, the inclined portion **141c** constitutes a part of the cooling path CP3. That is, the outer surface of the inclined portion **141c** comes into contact with the cooling water CL flowing through the cooling path CP3. The heat exchange between the inclined portion **141c** and the cooling path CP3 reduces the temperature rise of the gear case **14** of the housing HS.

(179) Further, the inner surface of the inclined portion **141c** comes into contact with the oil OL in the gear chamber Sb. Specifically, the inner surface of the inclined portion **141c** comes into contact with the oil OL stored in the catch tank **15** above the rotation axis X (above horizontal plane S in FIG. 8) (see FIG. 11). The inner surface of the inclined portion **141c** comes into contact with the oil OL stored in a lower portion of the gear chamber Sb below the rotation axis X (below horizontal plane S in FIG. 8).

(180) As described above, since the inclined portion **141c** comes into contact with the oil OL, the heat of the oil OL is transmitted to the inclined portion **141c**. That is, the heat is exchanged between the oil OL in the gear chamber Sb and the cooling water CL flowing through the cooling path CP3 via the inclined portion **141c**. The oil OL whose temperature rises by the heat exchange with the components inside the gear chamber Sb is cooled by the heat exchange with the cooling water CL whose temperature is lower than that of the oil OL.

(181) As described above, since the inclined portion **141c** of the gear case **14** constitutes a part of the cooling path CP3, the cooling water CL directly comes into contact with the inclined portion **141c**, so that the efficiency of the heat exchange with the oil OL can be improved.

(182) The cooling water CL that exchanges heat with the oil OL is discharged from the cooling path CP3 via the opening **96a** and the peripheral wall portion **96b** of the discharge portion 96. The cooling water CL discharged from the cooling path CP3 is cooled by the radiator **82** (see FIG. 6) and then supplied to the cooling path CP2.

(183) As shown in FIG. 2, the cooling chamber 9 forming the cooling path CP3 is disposed at a position overlapping the inclined portion **141c** of the housing HS in the rotation axis X direction. Disposing the cooling chamber 9 utilizing the space around the inclined portion **141c** contributes to

a reduction in dimension of the unit **1** in the radial direction of the rotation axis X.

(184) As shown in FIG. **8**, the cooling chamber **9** disposed to surround the inclined portion **141c** overlaps the inclined portion **141c** in the radial direction of the rotation axis X. This also contributes to a reduction in dimension of the unit **1** in the rotation axis X direction.

(185) As shown in FIG. **8**, the main body portion **90** of the cooling chamber **9** has the portion positioned above the horizontal plane S passing through the rotation axis X and orthogonal to the vertical line VL direction. As shown in FIG. **2**, the main body portion **90** has a portion positioned above the differential mechanism **5** in the vertical line VL direction. Further, the main body portion **90** has a portion overlapping the stepped pinion gear **43** in the rotation axis X direction. As described above, the main body portion **90** of the cooling chamber **9** has a portion positioned on an upper side in the vertical line VL direction in the unit **1**.

(186) As shown in FIG. **3**, in the unit **1**, the motor **2** and the differential mechanism **5** are coaxial, and the differential mechanism **5** has a portion overlapping the motor **2** when viewed in the rotation axis X direction. As described above, in the unit **1** in which the motor **2** and the differential mechanism **5** are coaxial, the layout on the upper side in the vertical line VL direction (vehicle height direction) is less constrained than on a lower side in the vertical line VL direction (vehicle height direction). Since the main body portion **90** of the cooling chamber **9** has the portion positioned on the upper side in the vertical line VL direction in which the layout is less constrained in the unit **1**, a flow path area of the cooling water CL in the cooling path CP**3** can be increased. As a result, an area where the cooling water CL comes into contact with the outer surface of the inclined portion **141c** is increased, and a heat exchange rate with the oil OL can be improved.

(187) The introduction portion **95** of the cooling water CL positioned above the horizontal plane S is connected to the discharge portion **96** via the cooling path CP**3** having the portion positioned below the horizontal plane S. As a result, the cooling water CL introduced into the cooling path CP**3** from the introduction portion **95** can flow to the discharge portion **96** using gravity. As described above, the circulation system **80** (see FIG. **6**) is provided with the water pump WP that feeds the cooling water CL, and the cooling water CL can flow more smoothly using gravity.

(188) As shown in FIG. **8**, the cooling chamber **9** is disposed adjacent to the catch tank **15**, and the catch tank **15** is positioned on the introduction portion **95** of the cooling water CL side. The temperature of the cooling water CL rises as the cooling water CL flows through the cooling path CP**3** and exchanges heat with the oil OL. The temperature of the cooling water CL in the introduction portion **95** before heat exchange is lower than that of the cooling water CL in the discharge portion **96**. By positioning the catch tank **15** closer to the introduction portion **95**, heat can be exchanged between the oil OL stored in the catch tank **15** and the low-temperature cooling water CL on the introduction portion **95** side, and the heat exchange efficiency can be improved.

(189) The unit **1** may be disposed on a rear side of the vehicle which is less likely to be affected by the traveling wind of the vehicle. As shown in FIG. **8**, when the unit **1** is mounted on the vehicle, a vehicle room VR is disposed above a space SP in which the unit **1** is disposed. The vehicle is provided with a ventilation port VP that communicates the space SP in which the unit **1** is disposed with the vehicle room VR.

(190) By driving an air conditioner in the vehicle room VR or opening windows of the vehicle room VR, the air Air in the vehicle room VR is discharged from the ventilation port VP and flows into the space SP. The temperature of the air Air in the vehicle room VR is adjusted in accordance with the outside air temperature. For example, when the outside air temperature is high, cooling is used in the vehicle or the windows are opened. For example, when the outside air temperature is low, heating is used.

(191) When the air Air whose temperature is adjusted according to the outside air temperature flows into the space SP, the air exchanges heat with the housing HS disposed in the space SP. As a result, on the rear side of the vehicle which is less likely to be affected by the traveling wind, the heat can be exchanged in a direction in which the temperature of the housing HS approaches the

proper temperature. Further, the cooling chamber **9** attached to the housing **HS** can also exchange heat with the air **Air**. Thereby, the temperature rise in the cooling chamber **9** can be reduced, and as a result, the heat exchange efficiency between the cooling water **CL** flowing through the cooling chamber **9** and the oil **OL** inside the housing **HS** is improved. By improving the heat exchange efficiency, the size of the cooling chamber **9** can be reduced, which contributes to a reduction in dimensions of the entire housing **HS**.

(192) A fan or the like may be provided so that the air **Air** in the vehicle room **VR** easily flows into the space **SP**.

(193) As described above, the unit **1** according to the embodiment has the following configuration.

(194) (1) The unit **1** includes the housing **HS** configured to accommodate the differential mechanism **5** (differential gear mechanism).

(195) The housing **HS** includes the cooling path **CP3** as a flow path through which the cooling water **CL** (coolant) flows.

(196) When viewed in the radial direction of the rotation axis **X** (when viewed in radial direction), the cooling path **CP3** has a portion overlapping the differential mechanism **5**.

(197) The cooling path **CP3** has a portion that is positioned above the horizontal plane **S** passing through the rotation axis **X** coaxial with the axis of the drive shaft **DB**, which is the output shaft of the differential mechanism **5**, and orthogonal to the vertical line **VL** direction (gravity direction).

(198) With such a configuration, it is possible to improve the heat exchange efficiency between the housing **HS** and the cooling water **CL**, which is a coolant.

(199) On the upper side of the horizontal plane **S** in the vicinity of the differential mechanism **5** in the unit **1**, the layout is less constrained and there is a margin in space. Using this space, the cooling chamber **9** having the cooling path **CP3** is disposed. As a result, a contact area between the housing **HS** and the cooling water **CL** flowing through the cooling path **CP3** is increased, and the heat exchange efficiency between the cooling water **CL** and the housing **HS** is improved.

(200) (2) The cooling path **CP3** has a portion positioned below the horizontal plane **S**.

(201) The cooling chamber **9** provided with the cooling path **CP3** has a portion positioned below the horizontal plane **S** in addition to a portion positioned above the horizontal plane **S**. As a result, the contact area between the housing **HS** and the cooling water **CL** flowing through the cooling path **CP3** is increased, and the heat exchange efficiency between the cooling water **CL** and the housing **HS** is improved.

(202) (3, 4) When viewed in the rotation axis **X** direction (when viewed in axial direction), the cooling path **CP3** has a portion overlapping the housing **HS**.

(203) With such a configuration, the cooling path **CP3** is less likely to protrude from the housing **HS** in the radial direction of the rotation axis **X**, which contributes to a reduction in dimension of the unit **1**.

(204) (5) When viewed in the rotation axis **X** direction (when viewed in axial direction), the cooling chamber **9** has a shape including an arc-shaped portion (main body portion **90**) disposed to surround the rotation axis **X** which is an axis of the drive shaft **DB** which is an output shaft of the differential mechanism **5**.

(205) By forming the main body portion **90** of the cooling chamber **9** as an arc-shaped portion and joining the main body portion **90** to the inclined portion **141c** so as to surround the rotation axis **X**, the cooling chamber **9** is prevented from greatly protruding from the unit **1** while maintaining a flow path area of the cooling path **CP3**, which contributes to a reduction in dimension of the unit **1**.

(206) (6) The housing **HS** includes, above the horizontal plane **S**, the inclined portion **141c** (wall portion) having an outer surface in contact with the cooling water **CL** and an inner surface in contact with the oil **OL**.

(207) The inclined portion **141c** constitutes a part of the cooling path **CP3** and is in contact with the cooling water **CL** on the outer surface thereof. The inner surface of the inclined portion **141c** constitutes a wall surface of the catch tank **15** above the horizontal plane **S** and is in contact with

the oil OL. Since heat is exchanged between the cooling water CL and the oil OL via the wall surface of the inclined portion **141c**, the heat exchange efficiency is improved.

(208) In the embodiment, although an example has been described in which the inclined portion **141c** (wall portion) is configured as a part of the catch tank **15** to which the oil OL is supplied, the present invention is not limited thereto. In addition to the catch tank **15**, a part of an oil passage through which the oil OL flows in the housing HS, a wall portion of the housing HS to which the oil OL guided by an oil guide is supplied, and the like can be used as the wall portion.

(209) In an aspect of the present invention, the power transmission mechanism **3** includes, for example, a gear mechanism and an annular mechanism.

(210) The gear mechanism includes, for example, a reduction gear mechanism, an acceleration gear mechanism, and a differential gear mechanism (differential mechanism).

(211) The reduction gear mechanism and the acceleration gear mechanism include, for example, a planetary gear mechanism and a parallel gear mechanism.

(212) The annular mechanism includes, for example, an endless annular component.

(213) The endless annular component includes, for example, a chain sprocket, a belt, and a pulley.

(214) The differential mechanism **5** is, for example, a bevel gear type differential gear, a planetary gear type differential gear.

(215) The differential mechanism **5** includes a differential case as an input element, two output shafts as output elements, and a differential gear set as a differential element.

(216) In the bevel gear type differential gear, the differential gear set includes bevel gears.

(217) In the planetary gear type differential gear, the differential gear set includes planetary gears.

(218) The unit **1** includes a gear that rotates integrally with the differential case.

(219) For example, a final gear (differential ring gear) of the parallel gear mechanism rotates integrally with the differential case. For example, when a carrier of the planetary gear mechanism is connected to the differential case, a pinion gear rotates (revolves) integrally with the differential case.

(220) For example, a reduction gear mechanism is connected downstream of the motor **2**. A differential gear mechanism is connected downstream of the reduction gear mechanism. That is, a differential gear mechanism is connected downstream of the motor **2** via a reduction gear mechanism. An acceleration gear mechanism may be used instead of the reduction gear mechanism.

(221) A single-pinion type planetary gear mechanism can use, for example, a sun gear as an input element, a ring gear as a fixed element, and a carrier as an output element.

(222) A double-pinion type planetary gear mechanism can include, for example, a sun gear as an input element, a ring gear as an output element, and a carrier as a fixed element.

(223) As a pinion gear of the single-pinion type planetary gear mechanism or the double-pinion type planetary gear mechanism, for example, a stepped pinion gear or a non-stepped pinion gear can be used.

(224) The stepped pinion gear includes a large pinion and a small pinion. For example, it is preferable to mesh the large pinion with the sun gear. For example, it is preferable to fit the small pinion into the ring gear.

(225) The non-stepped pinion gear is a type that is not a stepped pinion gear.

(226) In the present embodiment, although an example in which the unit **1** according to an aspect of the present invention is mounted on a vehicle has been described, the present invention is not limited to this aspect. The present invention can be applied to other than vehicles. When a plurality of examples and modifications are described in the present embodiment, these examples and modifications may be freely combined.

(227) Although the embodiment of the present invention has been described above, the above embodiment is merely an application example of the present invention and is not intended to limit the technical scope of the present invention to the specific configuration of the above embodiment.

The embodiment can be changed as appropriate within the scope of the technical idea of the invention.

(228) The present application claims a priority based on Japanese Patent Application No. 2021-105241 filed with the Japan Patent Office on Jun. 24, 2021, all the contents of which are hereby incorporated by reference.

DESCRIPTION OF REFERENCE SIGNS

(229) **1** unit **2** motor **5** differential mechanism (differential gear mechanism) **14** gear case **141c** inclined portion (wall portion) **9** cooling chamber **90** main body portion (arc-shaped portion) **HS** housing **DA, DB** drive shaft (output shaft) **X** rotation axis (axis) **CL** cooling water (coolant) **CP3** cooling path (flow path) **VL** vertical line direction (gravity direction) **S** horizontal plane

Claims

1. A unit comprising: a housing configured to accommodate a differential gear mechanism, wherein the housing has a flow path through which a coolant flows, the flow path has a portion that overlaps the differential gear mechanism when viewed in a radial direction, and the flow path has a portion that is positioned above a horizontal plane passing through an axis of an output shaft of the differential gear mechanism and orthogonal to a gravity direction, and the coolant is configured to flow above a wall portion which is positioned above the differential gear mechanism, wherein the housing includes, above the horizontal plane, the wall portion having an outer surface in contact with the coolant and an inner surface in contact with oil.
 2. The unit according to claim 1, wherein the flow path has a portion that is positioned below the horizontal plane passing through the axis of the output shaft of the differential gear mechanism and orthogonal to the gravity direction.
 3. The unit according to claim 1, wherein the flow path has a portion that overlaps the housing when viewed in an axial direction.
 4. The unit according to claim 2, wherein the flow path has a portion that overlaps the housing when viewed in an axial direction.
 5. The unit according to claim 1, wherein when viewed in the axial direction, the flow path has a shape including an arc-shaped portion disposed so as to surround the axis of the output shaft of the differential gear mechanism.
 6. The unit according to claim 1, wherein the flow path is disposed adjacent to a catch tank which is positioned in the housing and provided on an upper portion of the housing.
 7. The unit according to claim 1, wherein in the flow path, an introduction portion and a discharge portion of the coolant are provided above the horizontal plane.
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