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(54) **VEHICLE BRAKING DEVICE**

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(57) **ABSTRACT**

A vehicle braking device includes: a first hydraulic pressure generation unit that is connected to a first wheel cylinder via a first fluid passage, and generates a hydraulic pressure in the first wheel cylinder; a second hydraulic pressure generation unit that is connected to a second wheel cylinder via a second fluid passage, and generates a hydraulic pressure in the second wheel cylinder; a first power supply unit that supplies electric power to the first hydraulic pressure generation unit; a second power supply unit that supplies electric power to the second hydraulic pressure generation unit; and a normally open communication passage opening and closing unit that is provided in a communication passage connecting the first fluid passage and the second fluid passage, and opens and closes the communication passage.

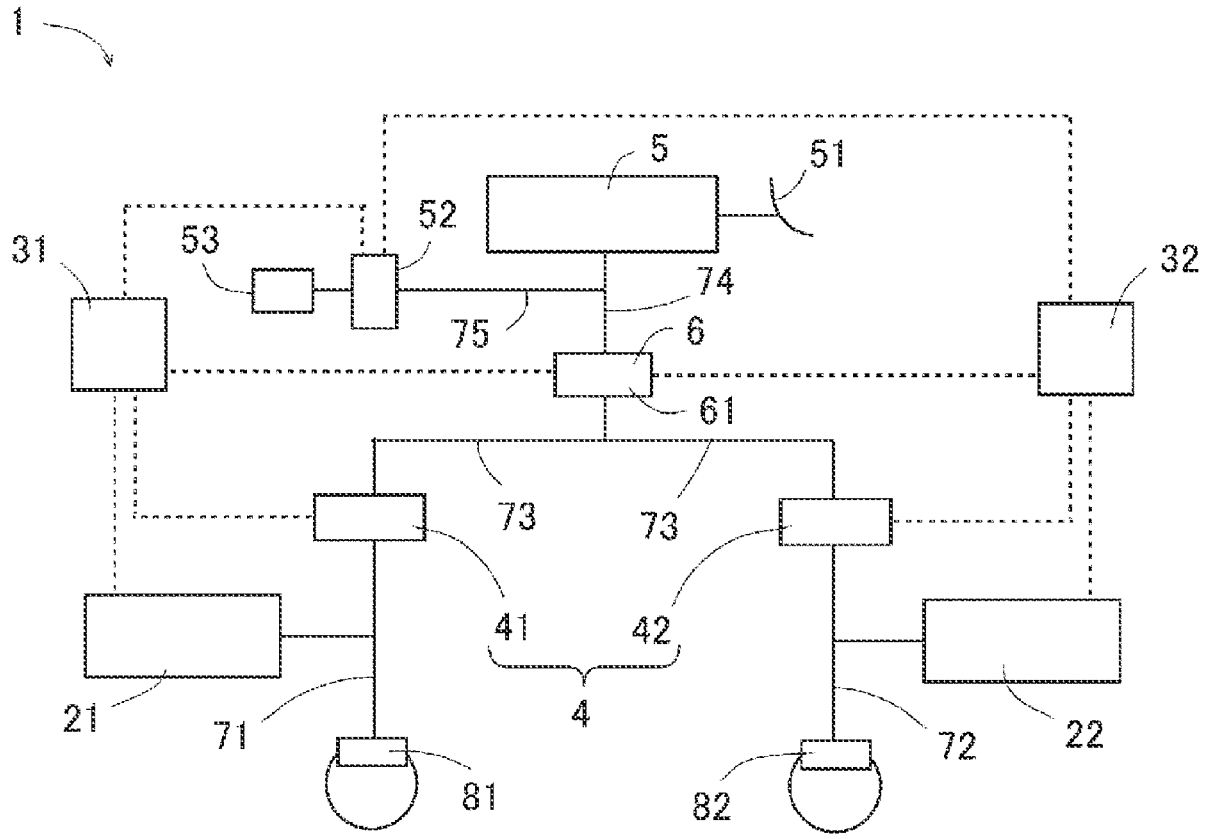
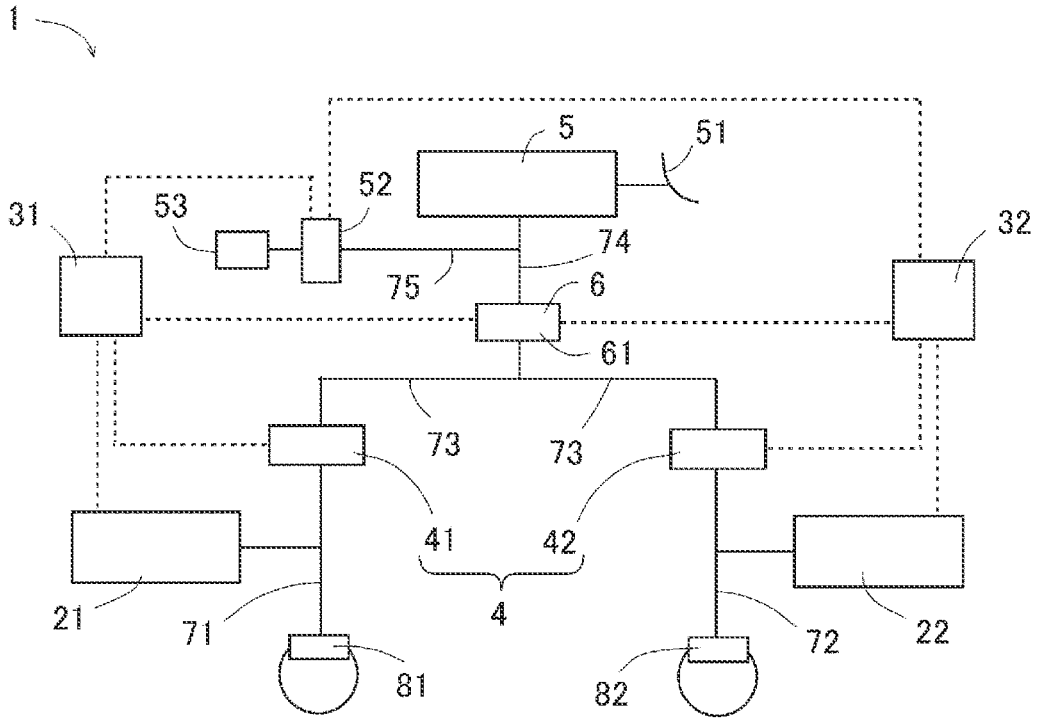


FIG. 1


1
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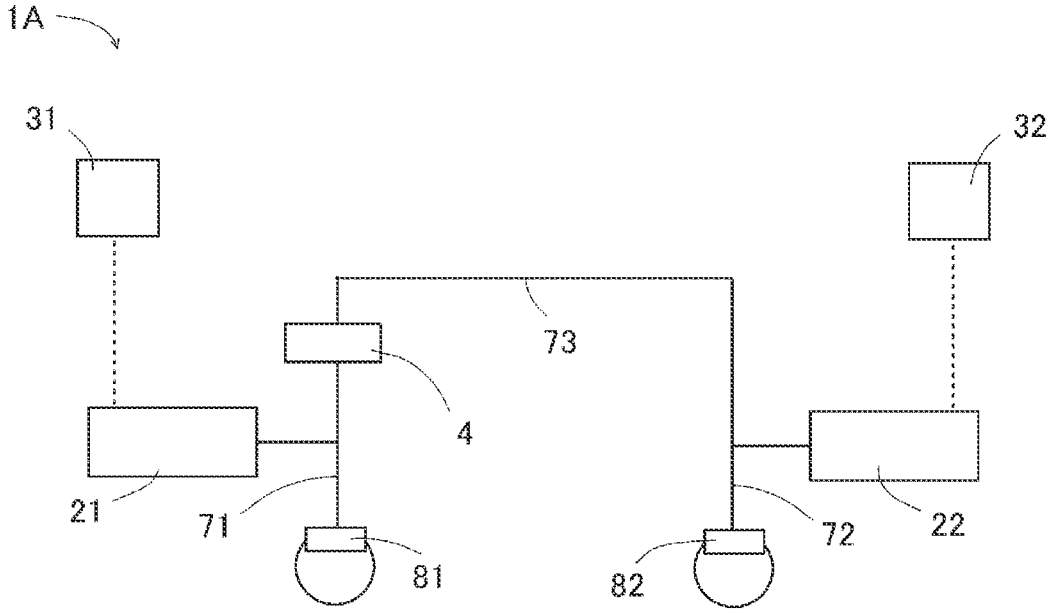
81
82

FIG. 2


1A
31
32
73
4
21
71
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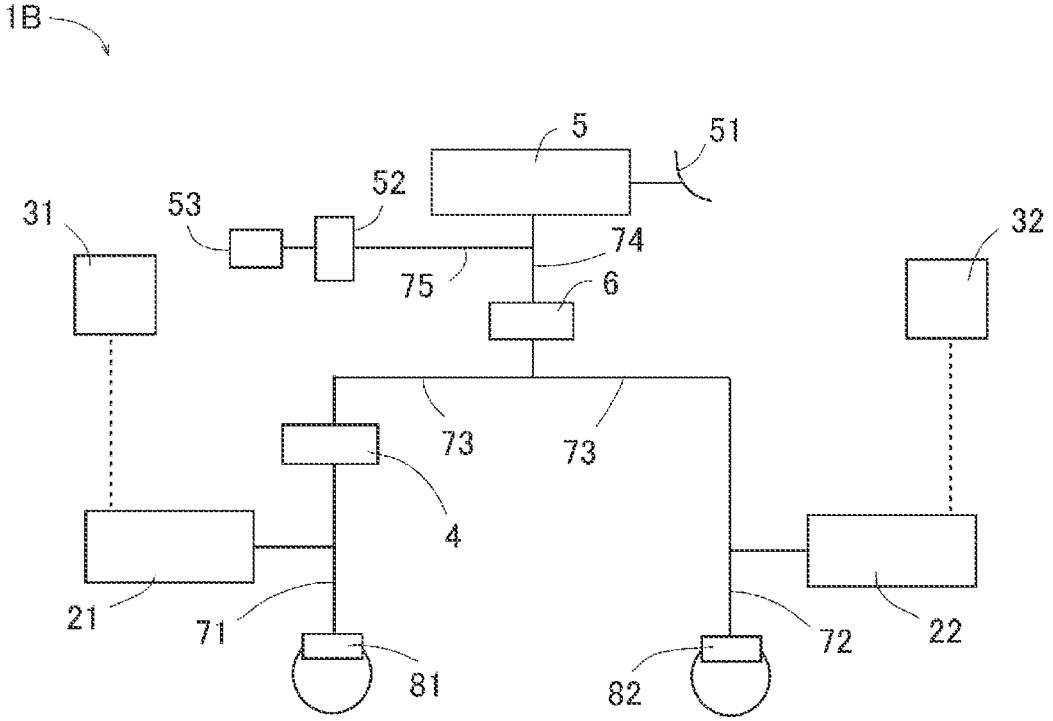
22
81
82

FIG. 3


1B
5
51
52
53
31
32
74
75
6
73
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4
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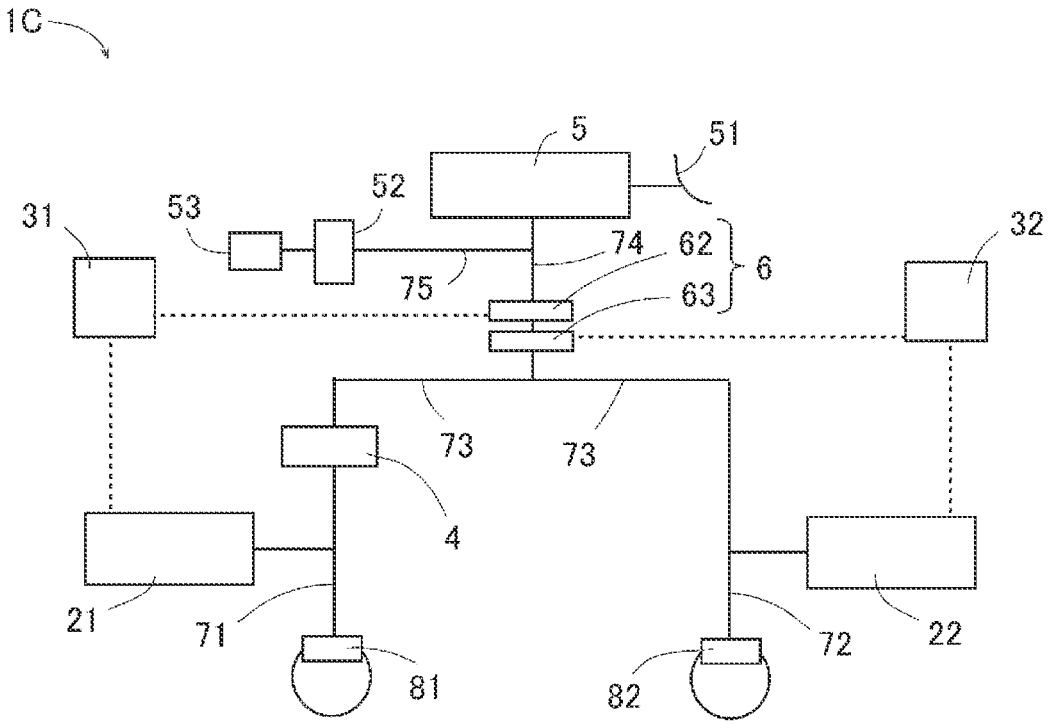
71
72
22
81
82

FIG. 4


1C
5
51
52
53
31
32
74
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6
75
63
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73
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21
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81
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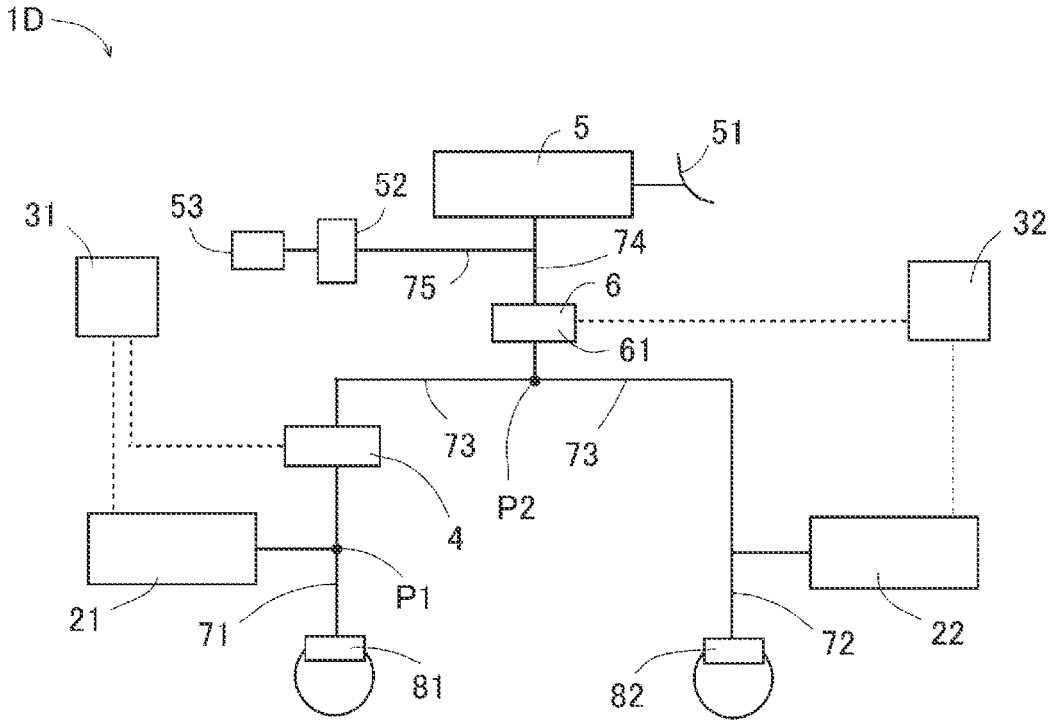
FIG. 5


1D
5
51
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53
31
32
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75
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61
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73
P2
4
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21
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72
22
81
82

FIG. 6

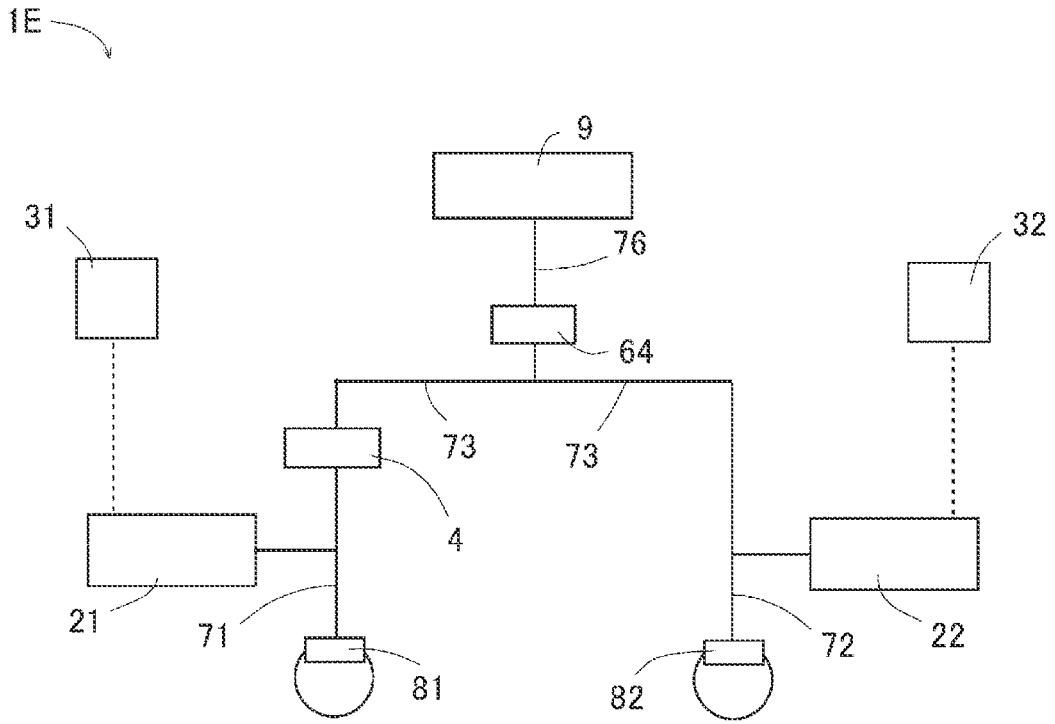

1E
9
31
32
76
64
73
73
4
21
71
72
22
81
82

FIG. 7

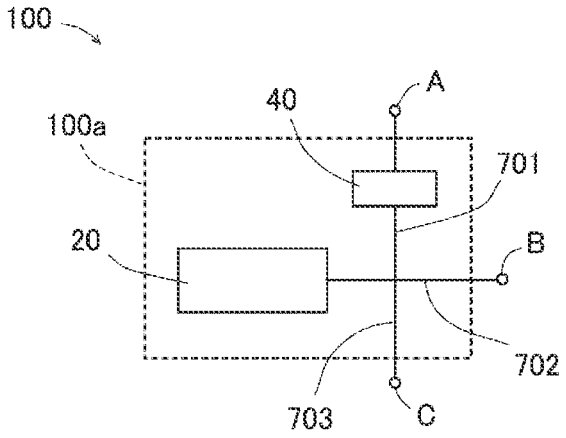


FIG. 8

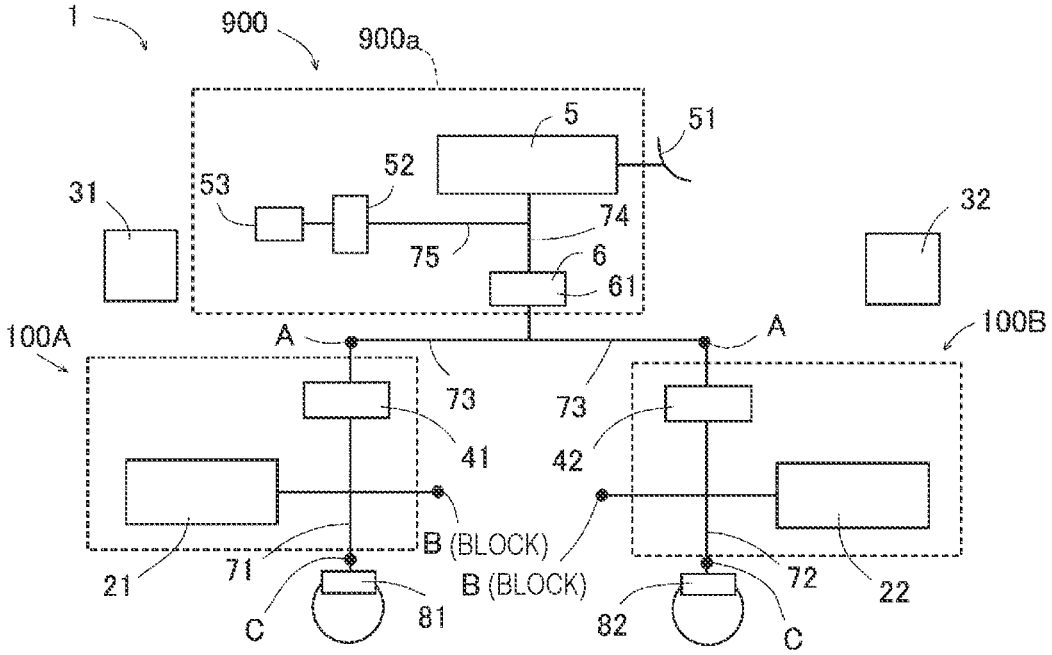


FIG. 9

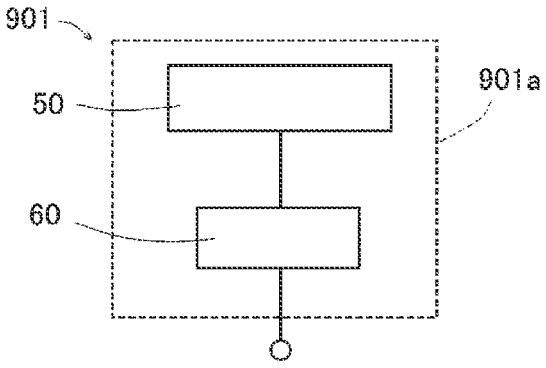


FIG. 10

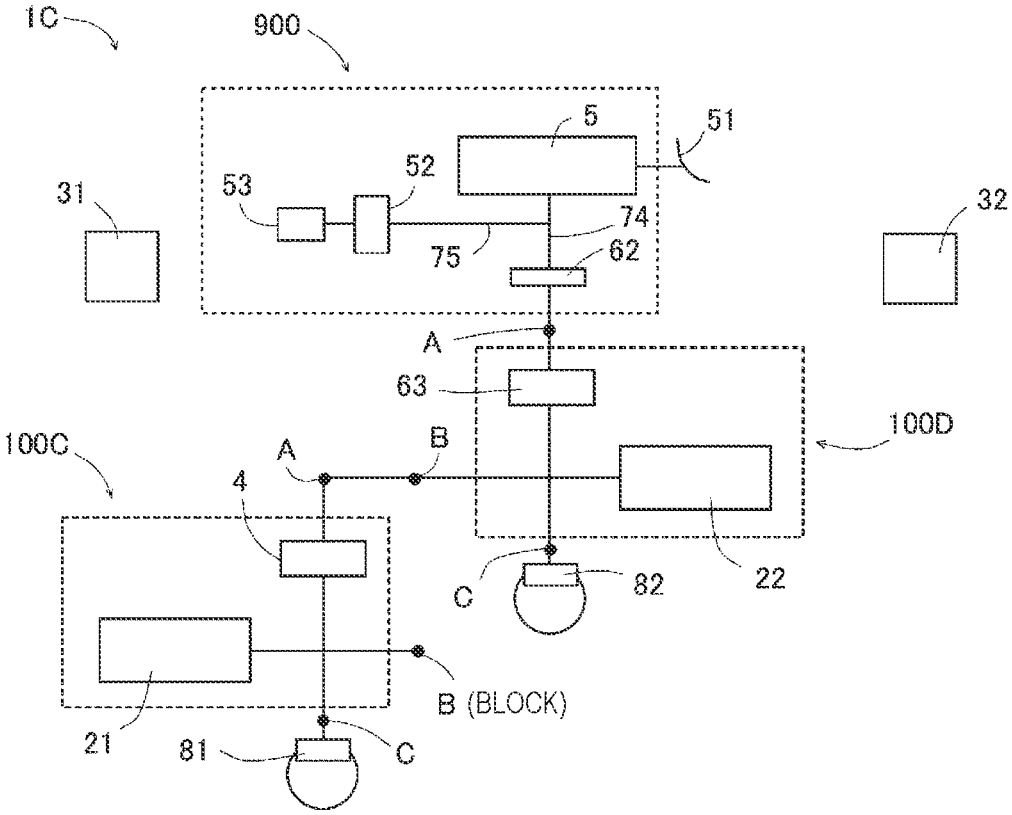
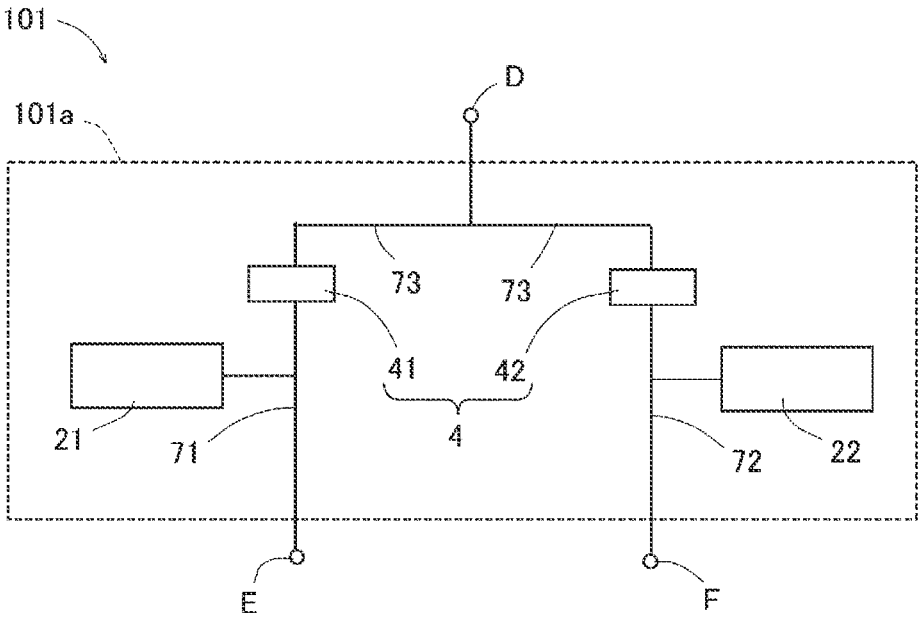

1C
900
5
51
52
53
31
32
74
75
62
A
63
100D
100C
A
B
4
C
82
22
B (BLOCK)
21
81
C

FIG. 11


101
D
101a
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73
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VEHICLE BRAKING DEVICE

TECHNICAL FIELD

[0001] The present disclosure relates to a vehicle braking device.

BACKGROUND ART

[0002] A vehicle braking device is configured to supply a hydraulic pressure to a plurality of wheel cylinders. For example, a braking device described in JP6394562B includes a wheel cylinder in a first system, which is connected to a first hydraulic unit, a wheel cylinder in a second system, which is connected to a second hydraulic unit, a normally closed electromagnetic valve provided in a communication passage connecting the first hydraulic unit and the second hydraulic unit, and an ECU that executes various controls.

CITATION LIST

Patent Literature

[0003] PTL 1: JP6394562B

SUMMARY

Technical Problem

[0004] With the development in autonomous vehicles, the importance of a system having redundancy in braking force is further increasing. Therefore, the present inventors have developed a new system that can independently control hydraulic pressures in a plurality of wheel cylinders in a normal state and can generate the hydraulic pressures in the plurality of wheel cylinders even in a case where one power supply unit fails.

[0005] An object of the present disclosure is to provide a new vehicle braking device that can independently control hydraulic pressures in a plurality of wheel cylinders and generate hydraulic pressures in the plurality of wheel cylinders even in a case where one power supply unit fails.

Solution to Problem

[0006] A vehicle braking device according to the present disclosure includes: a first hydraulic pressure generation unit that is connected to a first wheel cylinder via a first fluid passage and generates a hydraulic pressure in the first wheel cylinder; a second hydraulic pressure generation unit that is connected to a second wheel cylinder via a second fluid passage and generates a hydraulic pressure in the second wheel cylinder; a first power supply unit that supplies electric power to the first hydraulic pressure generation unit; a second power supply unit that supplies electric power to the second hydraulic pressure generation unit; and a normally open communication passage opening and closing unit that is provided in a communication passage connecting the first fluid passage and the second fluid passage, opens and closes the communication passage, and is opened in a state where electric power is not supplied.

Advantageous Effects

[0007] According to the present disclosure, the first fluid passage and the second fluid passage are separated from each other in terms of hydraulic pressure by closing the communication passage opening and closing unit, and fluid pressures in the wheel cylinders can be independently controlled. In addition, since the communication passage opening and closing unit is normally open, the communication passage opening and closing unit can be brought into an open state regardless of the presence or absence of a failure in the power supply unit even in a case where one of the first power supply unit and the second power supply unit fails. In a state where the first fluid passage and the second fluid passage communicate with each other through the communication passage, a normal power supply unit (the other of the first power supply unit and the second power supply unit) drives the corresponding hydraulic pressure generation unit. Accordingly, the hydraulic pressure can be generated in both the first wheel cylinder and the second wheel cylinder by one of the hydraulic pressure generation units. According to the present disclosure, the hydraulic pressures in the plurality of wheel cylinders can be independently controlled, and even in a case where one power supply unit fails, the hydraulic pressures can be generated in the plurality of wheel cylinders.

BRIEF DESCRIPTION OF DRAWINGS

[0008] FIG. **1** is a configuration diagram of a vehicle braking device according to the present embodiment.

[0009] FIG. **2** is a configuration diagram of a vehicle braking device according to a first modification.

[0010] FIG. **3** is a configuration diagram of a vehicle braking device according to a second modification.

[0011] FIG. **4** is a configuration diagram of a vehicle braking device according to a third modification.

[0012] FIG. **5** is a configuration diagram of a vehicle braking device according to a fourth modification.

[0013] FIG. **6** is a configuration diagram of a vehicle braking device according to a fifth modification.

[0014] FIG. **7** is a configuration diagram of a common unit.

[0015] FIG. **8** is a configuration diagram of an example of a vehicle braking device using the common unit.

[0016] FIG. **9** is a configuration diagram of another example of the common unit.

[0017] FIG. **10** is a configuration diagram of another example of the vehicle braking device using the common unit.

[0018] FIG. **11** is a configuration diagram of still another example of the common unit.

DESCRIPTION OF EMBODIMENTS

[0019] Hereinafter, an embodiment of the vehicle brake device will be described with reference to the drawings. In the following embodiment and modifications, the same or equivalent parts are denoted by the same reference numerals in the drawings. Further, each drawing used in the description is a conceptual diagram.

[0020] In the example of the present embodiment, a vehicle braking device **1** applies a braking force to two front wheels, and another braking device, for example, an electronic mechanical brake (EMB) or another vehicle braking device **1** that is independent of the front wheels, applies a braking force to two rear wheels. In the vehicle braking device **1** according to the present embodiment, for example,

a first wheel cylinder **81** corresponds to a right front wheel, and a second wheel cylinder **82** corresponds to a left front wheel.

[0021] As shown in FIG. **1**, the vehicle braking device **1** according to the present embodiment includes a first hydraulic pressure generation unit **21**, a second hydraulic pressure generation unit **22**, a first power supply unit **31**, a second power supply unit **32**, a communication passage opening and closing unit **4**, a master cylinder **5**, and a master fluid passage opening and closing unit **6**.

[0022] The first hydraulic pressure generation unit **21** is a device that is connected to the first wheel cylinder **81** via a first fluid passage **71** and generates a hydraulic pressure in the first wheel cylinder **81**. The first hydraulic pressure generation unit **21** according to the present embodiment is an electric cylinder, and includes a motor, a linear motion conversion member, a cylinder, and a piston, which are not shown. A brake fluid in the cylinder flows out to the first fluid passage **71** by a movement of the piston in one direction, and the brake fluid flows into the cylinder from the first fluid passage **71** by a movement of the piston in the other direction. The first hydraulic pressure generation unit **21** may also be called a pressure regulating device that regulates the hydraulic pressure in the first wheel cylinder **81** by the movement of the piston.

[0023] The second hydraulic pressure generation unit **22** is a device that is connected to the second wheel cylinder **82** via a second fluid passage **72** and generates a hydraulic pressure in the second wheel cylinder **82**. The second hydraulic pressure generation unit **22** is a separate device independent of the first hydraulic pressure generation unit **21**. Similar to the first hydraulic pressure generation unit **21**, the second hydraulic pressure generation unit **22** according to the present embodiment is an electric cylinder, and includes a motor, a linear motion conversion member, a cylinder, and a piston, which are not shown. The second hydraulic pressure generation unit **22** may also be called a pressure regulating device that regulates the hydraulic pressure in the second wheel cylinder **82** by the movement of the piston.

[0024] The first power supply unit **31** is a device that supplies electric power to the first hydraulic pressure generation unit **21**. The first power supply unit **31** according to the present embodiment includes a first power supply (for example, a first battery) and a first electronic control unit (ECU), which are not shown. The first power supply unit **31** controls the first hydraulic pressure generation unit **21**.

[0025] The second power supply unit **32** is a device that supplies electric power to the second hydraulic pressure generation unit **22**. The second power supply unit **32** according to the present embodiment is a device separate from the first power supply unit **31**, and includes a second power supply (for example, a second battery) and a second ECU, which are not shown. The second power supply unit **32** is configured to supply power to a power supply target independently of the first power supply unit **31**. The second power supply unit **32** controls the second hydraulic pressure generation unit **22**.

[0026] The communication passage opening and closing unit **4** is a normally open valve device that is provided in a communication passage **73** connecting the first fluid passage **71** and the second fluid passage **72**, and opens and closes the communication passage **73**. In the present disclosure, the term "normally open" means a configuration that opens (communicates) in a state where electric power is not supplied. The communication passage opening and closing unit **4** includes a first communication electromagnetic valve **41** that is a normally open electromagnetic valve, and a second communication electromagnetic valve **42** that is a normally open electromagnetic valve disposed in series with the first communication electromagnetic valve **41**.

[0027] The master cylinder **5** is a member that is connected to the communication passage **73** via a master fluid passage **74** and generates a hydraulic pressure corresponding to an operation amount of a brake pedal **51**. The master cylinder **5** according to the present embodiment is a single type master cylinder including a cylinder, a piston, a reservoir, and the like, which are not shown. The master cylinder **5** is configured such that the piston causes a brake fluid in the cylinder to flow out to the master fluid passage **74** in accordance with the operation amount of the brake pedal **51**. The operation amount of the brake pedal **51** is detected by, for example, a stroke sensor or a pressure sensor, which is not shown.

[0028] The master fluid passage **74** connects the master cylinder **5** and a part of the communication passage **73** between the first communication electromagnetic valve **41** and the second communication electromagnetic valve **42**. Therefore, the master cylinder **5** and the first wheel cylinder **81** are connected to each other via the master fluid passage opening and closing unit **6** and the first communication electromagnetic valve **41**. The master cylinder **5** and the second wheel cylinder **82** are connected to each other via the master fluid passage opening and closing unit **6** and the second communication electromagnetic valve **42**.

[0029] In the present embodiment, the first communication electromagnetic valve **41** is an electromagnetic valve that includes a valve body disposed on a first wheel cylinder **81** side, and a valve seat disposed on a master cylinder **5** side. That is, in a valve closed state, the valve body of the first communication electromagnetic valve **41** receives a force in a closing direction by self-sealing in a case where a hydraulic pressure in the first wheel cylinder **81** is higher than a hydraulic pressure on the master cylinder **5** side. With the same arrangement, in the valve closed state, a valve body of the second communication electromagnetic valve **42** also receives a force in a closing direction by self-sealing in a case where a hydraulic pressure in the second wheel cylinder **82** is higher than a hydraulic pressure on the master cylinder **5** side. A flow passage cross-sectional area (a size of the valve body) of each of the first communication electromagnetic valve **41** and the second communication electromagnetic valve **42** is larger than a flow passage cross-sectional area of a master electromagnetic valve **61** to be described later.

[0030] The master fluid passage opening and closing unit **6** is a normally open valve device that is provided in the master fluid passage **74** and opens and closes the master fluid passage **74**. The master fluid passage opening and closing unit **6** according to the present embodiment is implemented by the master electromagnetic valve **61** that is a normally open electromagnetic valve. The master electromagnetic valve **61** is driven by the first power supply unit **31** and the second power supply unit **32**. That is, the master electromagnetic valve **61** is configured to be supplied with power from both the first power supply unit **31** and the second power supply unit **32**. For example, a double winding coil is employed as a coil in the master electromagnetic valve **61**.

[0031] The master electromagnetic valve **61** is closed by being supplied with power from at least one of the first power supply unit **31** and the second power supply unit **32**. For example, when the master electromagnetic valve **61** is to be closed, in a case where both the power supply units **31** and **32** are normal, power is supplied from both the power supply units **31** and **32** so that the master electromagnetic valve **61** can be closed, and in a case where one of the power supply units fails, power is supplied from the other of the power supply units so that the master electromagnetic valve **61** can be closed.

[0032] In the present embodiment, the master electromagnetic valve **61** is an electromagnetic valve including a valve body disposed on a communication passage **73** side and a valve seat disposed on the master cylinder **5** side. Therefore, in the valve closed state, the valve body of the master electromagnetic valve **61** receives a force in a closing direction by self-sealing in a case where a hydraulic pressure on the communication passage **73** side is higher than a hydraulic pressure on the master cylinder **5** side.

[0033] The master electromagnetic valve **61**, the first communication electromagnetic valve **41**, and the second communication electromagnetic valve **42** are designed such that, in the valve closed state, shut-off between the master cylinder **5** and the wheel cylinders **81** and **82** is maintained even in a case where the hydraulic pressure in the master cylinder **5** is higher than the hydraulic pressure in each of the wheel cylinders **81** and **82** by a specified value by the brake operation.

[0034] A stroke simulator **53** is connected to a part of the master fluid passage **74** between the master cylinder **5** and the master electromagnetic valve **61** via a fluid passage **75** and a simulator cut valve **52**. The simulator cut valve **52** is a normally closed electromagnetic valve that is closed in a state where electric power is not supplied. In the present disclosure, the term "normally closed" means a configuration that is closed (shut off) in a state where electric power is not supplied. The stroke simulator **53** is a device that applies a force by a hydraulic pressure generated by the operation of the brake pedal **51**. Similar to the master electromagnetic valve **61**, the simulator cut valve **52** is configured to be supplied with power from both the first power supply unit **31** and the second power supply unit **32**.

(Normal State)

[0035] An example of an operation of the vehicle braking device **1** in a normal state will be described. When a power supply of the vehicle is turned on (when the ignition is turned on), the simulator cut valve **52** is opened by the first power supply unit **31** and the second power supply unit **32**, and the master cylinder **5** and the stroke simulator **53** communicate with each other. The master electromagnetic valve **61** is closed by the first power supply unit **31** and the second power supply unit **32**, the first communication electromagnetic valve **41** is closed by the first power supply unit **31**, and the second communication electromagnetic valve **42** is closed by the second power supply unit **32**.

[0036] In a case where the brake pedal **51** is operated or in a case where there is a separate braking request, the first power supply unit **31** drives the first hydraulic pressure generation unit **21** and the second power supply unit **32** drives the second hydraulic pressure generation unit **22** in accordance with a target braking force (target wheel pressure). The brake fluid is supplied to the first wheel cylinder **81** via the first fluid passage **71** by the drive of the first hydraulic pressure generation unit **21**, and the brake fluid is supplied to the second wheel cylinder **82** via the second fluid passage **72** by the drive of the second hydraulic pressure generation unit **22**. In this way, the hydraulic pressures in the wheel cylinders **81** and **82** are controlled.

(A Case where One of Power Supply Units Fails)

[0037] Next, a control example in a case where one (the first power supply unit **31** in this example) of the first power supply unit **31** and the second power supply unit **32** fails will be described. In a case where the first power supply unit **31** fails, power cannot be supplied from the first power supply unit **31**. Therefore, the first communication electromagnetic valve **41** is brought into a non-energized state and is opened. In addition, the first hydraulic pressure generation unit **21** cannot be driven. The master electromagnetic valve **61** and the simulator cut valve **52** are driven by being supplied with power only by the second power supply unit **32**.

[0038] For example, in a case where a failure in the first power supply unit **31** is detected, the second power supply unit **32** increases a current supplied from the second power supply unit **32** to the master electromagnetic valve **61** and maintains the master electromagnetic valve **61** in a closed state. Similarly, the second power supply unit **32** increases a current supplied from the second power supply unit **32** to the simulator cut valve **52** and maintains the simulator cut valve **52** in an open state. In addition, the second power supply unit **32** stops power supply to the second communication electromagnetic valve **42** to open the second communication electromagnetic valve **42**.

[0039] In this state, in a case where the brake pedal **51** is operated or in a case where there is a separate braking request, the normal second power supply unit **32** drives the second hydraulic pressure generation unit **22**, in accordance with the target braking force, to supply a brake fluid to the second fluid passage **72**. The brake fluid supplied to the second fluid passage **72** is supplied to the second wheel cylinder **82** and is also supplied to the first wheel cylinder **81** via the communication passage **73**.

[0040] At this time, since the master electromagnetic valve **61** is closed, the brake fluid is not supplied to the master cylinder **5**. In this way, the hydraulic pressures in both the first wheel cylinder **81** and the second wheel cylinder **82** can be increased by driving the second hydraulic pressure generation unit **22**. The failure in the first power supply unit **31** can be detected by, for example, detecting an output voltage or an output current of the first power supply unit **31**. In addition, even if the failure occurs in the second power supply unit **32**, the same operation is performed only by switching the first power supply unit **31** and the second power supply unit.

Operation and Effect of the Present Embodiment

[0041] According to the present embodiment, the first fluid passage **71** and the second fluid passage **72** are separated from each other in terms of hydraulic pressure by closing the communication passage opening and closing unit **4**, and the hydraulic pressures in the wheel cylinders **81** and **82** can be independently controlled. In addition, since the communication passage opening and closing unit **4** is normally open, the communication passage opening and closing unit **4** can be brought into the open state regardless of the presence or absence of the failure in the power supply unit even in a case where one of the first power supply unit **31**

and the second power supply unit **32** fails. In a state where the first fluid passage **71** and the second fluid passage **72** communicate with each other through the communication passage **73**, a normal power supply unit (the other of the first power supply unit **31** and the second power supply unit **32**) drives the corresponding hydraulic pressure generation unit. Accordingly, hydraulic pressures can be generated in both the first wheel cylinder **81** and the second wheel cylinder **82** by one of the hydraulic pressure generation units.

(Common Effect)

[0042] According to the present embodiment, the hydraulic pressures in the plurality of wheel cylinders **81** and **82** can be independently controlled, and even when one power supply unit fails, the hydraulic pressures can be generated in the plurality of wheel cylinders **81** and **82**.

(Effects Generated by Series Arrangement of Master Fluid Passage Opening and Closing Unit and Communication Passage Opening and Closing Unit)

[0043] As described above, as the control example in the normal state, the first power supply unit **31** and the second power supply unit **32** drive the first hydraulic pressure generation unit **21** and the second hydraulic pressure generation unit **22** in a state where the master electromagnetic valve **61**, the first communication electromagnetic valve **41**, and the second communication electromagnetic valve **42** are closed. Accordingly, at least two electromagnetic valves are normally interposed between the master cylinder **5** and each of the wheel cylinders **81** and **82** in a closed state. Therefore, as a configuration for maintaining the shut-off between the master cylinder **5** and the wheel cylinders **81** and **82**, it is sufficient to perform the hydraulic shut-off by the two electromagnetic valves. In other words, when the brake pedal **51** is operated and the hydraulic pressure in the master cylinder **5** is higher than the hydraulic pressure in each of the wheel cylinders **81** and **82**, the maximum withstanding pressure design of the electromagnetic valve required to maintain the valve closing can be distributed with the two electromagnetic valves.

[0044] When a differential pressure between two ports (inlet and outlet ports) of the electromagnetic valve is referred to as an inter-port differential pressure, a maximum inter-port differential pressure (hereinafter, referred to as a maximum withstanding pressure), by which a closed state can be maintained when the pressure on the valve seat side is relatively high, is set for the electromagnetic valve. The two electromagnetic valves are disposed in series, so that the maximum withstanding pressure of each electromagnetic valve can be set to be smaller than that in the case where one electromagnetic valve is disposed. Accordingly, the size of the electromagnetic valve can be reduced.

[0045] Further, according to the present configuration, the flow passages in the first communication electromagnetic valve **41** and the second communication electromagnetic valve **42** can be enlarged. In general, when the flow passage cross-sectional area of the electromagnetic valve is increased, the valve body is increased in size, and a larger size and electric power are required to set the same maximum withstanding pressure. However, in the present configuration, the maximum withstanding pressure required for shutting off the fluid passage may be implemented by the two electromagnetic valves. Therefore, the maximum withstanding pressure of each electromagnetic valve can be reduced, or a difference can be provided in the maximum withstanding pressure between both the electromagnetic valves. Since the maximum withstanding pressure can be reduced, the flow passage in the electromagnetic valve can be enlarged.

[0046] In the present configuration, the flow passage cross-sectional area of each of the first communication electromagnetic valve **41** and the second communication electromagnetic valve **42** is larger than the flow passage cross-sectional area of the master electromagnetic valve **61**. Accordingly, even when only one of the hydraulic pressure generation units is driven, a large flow passage can be ensured in the communication passage **73**, so that both of the wheel cylinders **81** and **82** can be pressurized with good responsiveness.

(Effects Generated by Power Supply Configuration to Master Fluid Passage Opening and Closing Unit)

[0047] The master electromagnetic valve **61** constituting the master fluid passage opening and closing unit **6** is driven by the first power supply unit **31** and the second power supply unit **32**. According to the present configuration, even if one of the power supply units fails, the master electromagnetic valve **61** can be closed by the other of the power supply units. Therefore, even in a case where one of the power supply units fails, the master cylinder **5** and the communication passage **73** can be separated from each other in terms of hydraulic pressure.

(Effects Generated by Master Cylinder)

[0048] The master cylinder **5** is connected to the communication passage **73**, so that when both the first power supply unit **31** and the second power supply unit **32** fail, the brake fluid can be supplied from the master cylinder **5** to the wheel cylinders **81** and **82** based on the operation of the brake pedal **51**. In this case, the master electromagnetic valve **61** is opened, the simulator cut valve **52** is closed, and the first communication electromagnetic valve **41** and the second communication electromagnetic valve **42** are opened.

<Modification 1>

[0049] As shown in FIG. **2**, a vehicle braking device **1**A according to Modification 1 includes the first hydraulic pressure generation unit **21**, the second hydraulic pressure generation unit **22**, the first power supply unit **31**, the second power supply unit **32**, and the normally open communication passage opening and closing unit **4**. The communication passage opening and closing unit **4** includes, for example, one or a plurality of normally open electromagnetic valves that can communicate with the communication passage **73** when not energized. According to this configuration, even if one of the power supply units fails, the communication passage opening and closing unit **4** is opened, and the hydraulic pressure generation unit is driven by the other of the power supply units. That is, in the configuration of Modification 1, the same effect as the "common effect" in the present embodiment is also exhibited.

<Modification 2>

[0050] As shown in FIG. **3**, a vehicle braking device **1**B according to Modification 2 includes the master cylinder **5** and the normally open master fluid passage opening and

closing unit **6** in addition to the configuration in FIG. **2**. According to this configuration, the same effects as the "common effect" and the "effects generated by the master cylinder" in the present embodiment are exhibited. The master fluid passage opening and closing unit **6** and the communication passage opening and closing unit **4** may be driven by the first power supply unit **31**, the second power supply unit **32**, or another power supply unit.

[0051] In addition, in the configuration in FIG. **3**, the master fluid passage opening and closing unit **6** may be configured to be supplied with power from both the first power supply unit **31** and the second power supply unit **32**. In this case, for example, as in the master fluid passage opening and closing unit **6** (master electromagnetic valve **61**) in FIG. **1**, the master fluid passage opening and closing unit **6** in FIG. **3** is driven by the first power supply unit **31** and the second power supply unit **32**. According to this configuration, the same effects as the "effects generated by the power supply configuration to the master fluid passage opening and closing unit" in the present embodiment described above are further exhibited.

<Modification 3>

[0052] As shown in FIG. **4**, in a vehicle braking device **1**C according to Modification 3, the master fluid passage opening and closing unit **6** in the configuration in FIG. **3** includes two electromagnetic valves connected in series. The master fluid passage opening and closing unit **6** includes a normally open first master electromagnetic valve **62** driven by the first power supply unit **31**, and a normally open second master electromagnetic valve **63** connected in series with the first master electromagnetic valve **62** and driven by the second power supply unit **32**.

[0053] According to this configuration, even in a case where one of the power supply units fails, the other of the power supply units can close the corresponding master electromagnetic valve. That is, even in a case where one of the power supply units fails, the master fluid passage **74** can be shut off, and the master cylinder **5** and the wheel cylinders **81** and **82** can be separated from each other in terms of hydraulic pressure.

[0054] As the first master electromagnetic valve **62** and the second master electromagnetic valve **63**, electromagnetic valves (for example, existing products) used in a current vehicle can be used, and the versatility of the system is increased. In addition, two independent electromagnetic valves are used, so that design and an arrangement change in the circuit are easy.

<Modification 4>

[0055] As shown in FIG. **5**, in a vehicle braking device **1**D according to Modification 4, the first power supply unit **31** drives the communication passage opening and closing unit **4**, and the second power supply unit **32** drives the master fluid passage opening and closing unit **6**, based on the configuration in FIG. **3**.

[0056] The communication passage opening and closing unit **4** is provided between a connection point P**1** of the communication passage **73** and the first fluid passage **71** and a connection point P**2** of the communication passage **73** and the master fluid passage **74** in the communication passage **73**. That is, the communication passage opening and closing unit **4** is disposed on the first wheel cylinder **81** side relative to the connection point P**2** in the communication passage **73**. The communication passage opening and closing unit **4** is, for example, one or a plurality of normally open electromagnetic valves that can communicate with the communication passage **73** when not energized.

[0057] According to this configuration, in a case where the first power supply unit **31** fails, the communication passage opening and closing unit **4** is opened, and the second hydraulic pressure generation unit **22** and the master fluid passage opening and closing unit **6** are driven by the second power supply unit **32**. Accordingly, in a state where the master fluid passage **74** is closed, both the wheel cylinders **81** and **82** are pressurized by the second hydraulic pressure generation unit **22**.

[0058] In a case where the second power supply unit **32** fails, the master fluid passage opening and closing unit **6** is opened, and the first hydraulic pressure generation unit **21** and the communication passage opening and closing unit **4** are driven by the first power supply unit **31**. Accordingly, the first hydraulic pressure generation unit **21** pressurizes the first wheel cylinder **81** in a state where the communication passage opening and closing unit **4** is closed, and the brake fluid is supplied from the master cylinder **5** to the second wheel cylinder **82** by the brake operation of a driver. That is, even in a case where the second power supply unit **32** fails, both the wheel cylinders **81** and **82** are pressurized.

[0059] In addition, even in a case where both of the power supply units **31** and **32** fail, the master cylinder **5** can supply the brake fluid to both of the wheel cylinders **81** and **82**. In this way, according to Modification 4, the same effects as the "common effect" and the "effects generated by the master cylinder" in the present embodiment are also exhibited.

<Modification 5>

[0060] As shown in FIG. **6**, in a vehicle braking device **1**E according to Modification 5, a reservoir **9** is disposed instead of the master cylinder **5**, and a normally closed reservoir fluid passage opening and closing unit **64** is disposed instead of the normally open master fluid passage opening and closing unit **6**, based on the configuration in FIG. **3**. That is, the vehicle braking device **1**E includes the first hydraulic pressure generation unit **21**, the second hydraulic pressure generation unit **22**, the first power supply unit **31**, the second power supply unit **32**, the communication passage opening and closing unit **4**, the reservoir **9**, and the reservoir fluid passage opening and closing unit **64**.

[0061] The reservoir **9** is a reservoir tank for storing a brake fluid, and is connected to the communication passage **73** via a reservoir fluid passage **76**. The reservoir fluid passage opening and closing unit **64** is a normally closed valve device that is provided in the reservoir fluid passage **76** and opens and closes the reservoir fluid passage **76**. The reservoir fluid passage opening and closing unit **64** includes, for example, one or a plurality of normally closed electromagnetic valves that can shut off the reservoir fluid passage **76** when not energized. Power is supplied from the first power supply unit **31**, the second power supply unit **32**, or another power supply unit to the reservoir fluid passage opening and closing unit **64**. The reservoir **9** can replenish the communication passage **73** with the brake fluid.

[0062] According to this configuration, even in a case where one of the power supply units fails, the other of the power supply units can drive the corresponding hydraulic pressure generation unit in a state where the reservoir fluid

passage opening and closing unit **64** is closed and the communication passage opening and closing unit **4** is opened. Accordingly, according to the configuration of Modification 5, the same effect as the "common effect" in the present embodiment is also exhibited.

<Others>

[0063] The present disclosure is not limited to the above-described embodiment and modifications. For example, the hydraulic pressure generation units **21** and **22** are not limited to an electric cylinder, and may be implemented by, for example, a pump, an electromagnetic valve, or the like. For example, in the configuration in FIG. **1**, the communication passage opening and closing unit **4** and the master fluid passage opening and closing unit **6** may be driven by a power supply unit other than the first power supply unit **31** and the second power supply unit **32**. In the present embodiment and the modifications described above, power from another power supply may be supplied to the simulator cut valve **52**. However, as in the configuration in FIG. **1**, it is preferable that the power from both the power supply units **31** and **32** is also supplied to the simulator cut valve **52**. In addition, Modifications 2 and 5 that do not include the master cylinder **5** are provided, for example, for a wheel cylinder in a rear wheel or for a wheel of a fully autonomous vehicle.

(Common Unit)

[0064] In addition, as shown in FIG. **7**, the configurations in FIGS. **1** to **6** may be implemented by combining a plurality of common units **100** each formed in one housing **100***a* (as one housing). The common unit **100** includes a hydraulic pressure generation unit **20** that generates a hydraulic pressure at a connection destination, fluid passages **701**, **702**, and **703** which are formed by branching in three directions corresponding to connection portions A, B, and C which are output destinations of the hydraulic pressure generation unit **20**, and an electromagnetic valve **40** that opens and closes the fluid passage **701** of the fluid passages **701** to **703** obtained by branching. The fluid passages **701** to **703** obtained by branching in three directions may be connected to fluid passages of other units, or may also be blocked without being connected to other fluid passages.

[0065] A case where FIG. **1** is configured using the common unit **100** will be described with reference to FIG. **8**. In order to implement the configuration in FIG. **1**, two common units **100** are used, and thus, the two common units **100** are defined as a common unit **100**A and a common unit **100**B below. In addition, a part that cannot be implemented by the common units **100**A and **100**B is implemented by an optional unit **900**. The optional unit **900** is unitized by a housing **900***a* different from the common units **100**A and **100**B, and the configuration thereof can be changed according to necessary functions. In this example, the optional unit **900** is used, for which the configuration above the master electromagnetic valve **61** in FIG. **1** (for example, the part excluding the brake pedal **51**) is used as one housing.

[0066] The connection portion A of the common unit **100**A is connected to the connection portion A of the common unit **100**B and the master electromagnetic valve **61** of the optional unit **900**. The connection portion C of the common unit **100**A is connected to the first wheel cylinder **81**, and the connection portion B of the common unit **100**A is blocked. The connection portion C of the common unit **100**B is connected to the second wheel cylinder **82**, and the connection portion B of the common unit **100**B is blocked. Accordingly, the configuration in FIG. **1** can be implemented using the common units **100**.

[0067] An advantage of using the common unit **100** is that various system configurations can be flexibly coped with by increasing or decreasing the number of common units **100** or changing the configuration of the optional unit **900** in accordance with necessary performance. For example, in a case where the master cylinder **5** does not need to generate the braking force when a part of the power supply unit fails, the optional unit **900** in FIG. **8** may also be changed to an optional unit **901** shown in FIG. **9**, which is implemented by a housing **901***a* including a reservoir **50** and an electromagnetic valve **60**. In addition, cost reduction can also be achieved by producing a large number of housings having the same shape.

[0068] As an example different from FIG. **8**, a case where FIG. **4** is configured using the common units **100** will be described with reference to FIG. **10**. The two common units **100** used in FIG. **10** are referred to as a common unit **100**C and a common unit **100**D, respectively. In addition, a part that cannot be implemented by the common units **100**C and **100**D is implemented by the optional unit **900**. The optional unit **900** used in FIG. **10** is the same as the optional unit **900** used in FIG. **8**. The connection portion A of the common unit **100**C is connected to the connection portion B of the common unit **100**D. The connection portion C of the common unit **100**C is connected to the first wheel cylinder **81**, and the connection portion B of the common unit **100**C is blocked. The connection portion A of the common unit **100**D is connected to the first master electromagnetic valve **62** of the optional unit **900**. The connection portion C of the common unit **100**D is connected to the second wheel cylinder **82**. Accordingly, the configuration in FIG. **4** can be implemented by using the common units **100**. In the example of FIG. **8**, the electromagnetic valves in the common units **100**A and **100**B are caused to function as communication electromagnetic valves, and in the example of FIG. **10**, the electromagnetic valve in the common unit **100**D is caused to function as the second master electromagnetic valve **63**.

[0069] The configuration of the common unit **100** is not limited to that shown in FIG. **7**. As shown in FIG. **11**, the configuration of a common unit **101** may be employed. The common unit **101** is a unit in which a part below the master electromagnetic valve **61** excluding the first wheel cylinder **81** and the second wheel cylinder **82** in FIG. **1** is formed in one housing **101***a* (as one housing). The common unit **101** includes the first hydraulic pressure generation unit **21**, the first communication electromagnetic valve **41**, the second hydraulic pressure generation unit **22**, and the second communication electromagnetic valve **42**. An output of the first hydraulic pressure generation unit **21** branches in two directions, one of which is connected to a connection portion E, and the other of which is connected to a connection portion D and the second communication electromagnetic valve **42** via the first communication electromagnetic valve **41**. An output of the second hydraulic pressure generation unit **22** branches in two directions, one of which is connected to a connection portion F, and the other of which is connected to

the connection portion D and the first communication electromagnetic valve **41** via the second communication electromagnetic valve **42**.

[0070] The connection portion D of the common unit **101** is connected to the master electromagnetic valve **61** of the optional unit **900** common to FIG. **8**, the connection portion E is connected to the first wheel cylinder **81**, and the connection portion F is connected to the second wheel cylinder **82**, so that the configuration in FIG. **1** using the common unit **101** can be implemented. In the case of using the common unit **101**, various system configurations can be flexibly coped with by increasing or decreasing the number of common units or changing the configuration of the optional unit according to the necessary performance, as in the case of using the common unit **100**.

[0071] The configuration using the above-described common unit **100** can be described as follows. That is, the vehicle braking device includes: a first housing that is a single housing including a hydraulic pressure generation unit connected to a wheel cylinder via a first hydraulic passage and generating a hydraulic pressure in the wheel cylinder, and a fluid passage opening and closing unit that is provided in a branched fluid passage, which is a fluid passage branched from the first fluid passage, and opens and closes the branched fluid passage; and a second housing that is a housing having the same configuration as the first housing. The vehicle braking device is implemented by combining the first housing and the second housing.

1. A vehicle braking device, comprising:
- a first hydraulic pressure generation unit that is connected to a first wheel cylinder via a first fluid passage and configured to generate a hydraulic pressure in the first wheel cylinder;
- a second hydraulic pressure generation unit that is connected to a second wheel cylinder via a second fluid passage and configured to generate a hydraulic pressure in the second wheel cylinder;
- a first power supply unit that is configured to supply electric power to the first hydraulic pressure generation unit;
- a second power supply unit that is configured to supply electric power to the second hydraulic pressure generation unit; and
- a normally open communication passage opening and closing unit that is provided in a communication passage connecting the first fluid passage and the second fluid passage, and configured to open and close the communication passage.

2. The vehicle braking device according to claim **1**, further comprising:
- a master cylinder that is connected to the communication passage via a master fluid passage and configured to generate a hydraulic pressure corresponding to an operation amount of a brake pedal; and
- a normally open master fluid passage opening and closing unit that is provided in the master fluid passage and configured to open and close the master fluid passage.

3. The vehicle braking device according to claim **2**, wherein
- the master fluid passage opening and closing unit is driven by the first power supply unit and the second power supply unit.

4. The vehicle braking device according to claim **2**, wherein
- the master fluid passage opening and closing unit includes
  - a normally open first master electromagnetic valve that is configured to be driven by the first power supply unit, and
  - a normally open second master electromagnetic valve that is connected in series with the first master electromagnetic valve and configured to be driven by the second power supply unit.

5. The vehicle braking device according to claim **2**, wherein
- the communication passage opening and closing unit is provided between a connection point of the communication passage and the first fluid passage and a connection point of the communication passage and the master fluid passage in the communication passage,
- the first power supply unit drives the communication passage opening and closing unit, and
- the second power supply unit drives the master fluid passage opening and closing unit.

6. The vehicle braking device according to claim **4**, wherein
- the communication passage opening and closing unit includes a normally open first communication electromagnetic valve and a normally open second communication electromagnetic valve disposed in series with the first communication electromagnetic valve,
- the master fluid passage opening and closing unit includes at least one normally open master electromagnetic valve, and
- the master fluid passage connects the master cylinder and a part of the communication passage between the first communication electromagnetic valve and the second communication electromagnetic valve.

7. The vehicle braking device according to claim **6**, wherein
- the first communication electromagnetic valve is driven by the first power supply unit, and
- the second communication electromagnetic valve is driven by the second power supply unit.

8. The vehicle braking device according to claim **1**, further comprising:
- a reservoir that is connected to the communication passage via a reservoir fluid passage and configured to store a brake fluid; and
- a normally closed reservoir fluid passage opening and closing unit that is provided in the reservoir fluid passage and configured to open and close the reservoir fluid passage.

9. The vehicle braking device according to claim **3**, wherein
- the communication passage opening and closing unit includes a normally open first communication electromagnetic valve and a normally open second communication electromagnetic valve disposed in series with the first communication electromagnetic valve,
- the master fluid passage opening and closing unit includes at least one normally open master electromagnetic valve, and
- the master fluid passage connects the master cylinder and a part of the communication passage between the first communication electromagnetic valve and the second communication electromagnetic valve.

10. The vehicle braking device according to claim **2**, wherein

the communication passage opening and closing unit includes a normally open first communication electromagnetic valve and a normally open second communication electromagnetic valve disposed in series with the first communication electromagnetic valve,

the master fluid passage opening and closing unit includes at least one normally open master electromagnetic valve, and

the master fluid passage connects the master cylinder and a part of the communication passage between the first communication electromagnetic valve and the second communication electromagnetic valve.

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