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Fluid pressure shock absorber

Abstract

A fluid pressure shock absorber includes a damping valve that is capable of changing damping characteristic in response to a pilot pressure, and a pilot valve configured to supply the working fluid in the bottom-side chamber or the rod-side chamber to a pilot chamber of the damping valve as a pilot pressure. The pilot valve has a first pilot chamber configured such that the working fluid is guided from the bottom-side chamber, and a second pilot chamber configured such that the working fluid is guided from the rod-side chamber. When the fluid pressure shock absorber is not extended/contracted, the pilot valve supplies the pilot pressure to the pilot chamber of the damping valve, and when the fluid pressure shock absorber is extended/contracted, the pilot valve holds the pilot pressure in the pilot chamber of the damping valve supplied when the fluid pressure shock absorber is not extended/contracted.

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Background/Summary

TECHNICAL FIELD
(1) The present invention relates to a fluid pressure shock absorber.
BACKGROUND ART
(2) With the fluid pressure shock absorber described in JP2015-206374A, a piston rod has a rod portion that extends outside a cylinder and a piston that is connected to an end portion of the rod portion and slidably moves within the cylinder to divide an interior of the cylinder into a bottom-side chamber and a rod-side chamber. The rod portion has: a rod inner space that is formed in the rod portion and communicates with the bottom-side chamber of the cylinder; a first communicating passage that connects the rod inner space and the rod-side chamber of the cylinder; and an orifice plug that is provided in the first communicating passage and generates a damping force.
SUMMARY OF INVENTION
(3) With a vehicle having a large maximum load capacity, the overall weight of the vehicle varies greatly depending on whether the load weight is large or small. With the fluid pressure shock absorber as described in JP2015-206374A, in which the damping force is generated by the orifice plug, it is not possible to achieve an optimal damping characteristic in accordance with the size of the load weight.
(4) In order to achieve an optimal damping characteristic in accordance with the size of the load weight, it is conceivable to configure the fluid pressure shock absorber such that the damping characteristics can be changed by a solenoid valve. However, when the solenoid valve is to be mounted, wiring and switching control are required, and so, there is a problem in terms of cost.
(5) An object of the present invention is to achieve, at low cost, a configuration that is capable of changing damping characteristics in accordance with a load weight.
(6) According to one aspect of the present invention, a fluid pressure shock absorber mounted on a vehicle includes: a cylinder tube; a rod inserted into the cylinder tube so as to be movable back and

forth; a piston connected to the rod and dividing an interior of the cylinder tube into a bottom-side chamber and a rod-side chamber; a damping valve configured to impart resistance to a flow of working fluid between the bottom-side chamber and the rod-side chamber, the damping valve being capable of changing damping characteristic in response to a pilot pressure; and a pilot valve configured to supply the working fluid in the bottom-side chamber or the rod-side chamber to a pilot chamber of the damping valve as a pilot pressure, wherein the pilot valve has: a first pilot chamber configured such that the working fluid is guided from the bottom-side chamber; and a second pilot chamber provided so as to be opposed to the first pilot chamber, the second pilot chamber being configured such that the working fluid is guided from the rod-side chamber, when the fluid pressure shock absorber is not extended/contracted, the pilot valve supplies the pilot pressure to the pilot chamber of the damping valve, and when the fluid pressure shock absorber is extended/contracted, the pilot valve holds the pilot pressure in the pilot chamber of the damping valve supplied when the fluid pressure shock absorber is not extended/contracted.

Description

BRIEF DESCRIPTION OF DRAWINGS
(1) FIG. **1** is a fluid pressure circuit diagram of a fluid pressure shock absorber according to an embodiment of the present invention.
(2) FIG. **2** is a diagram for explaining the operation of the fluid pressure shock absorber in an empty state.
(3) FIG. **3** is a diagram for explaining the operation of the fluid pressure shock absorber in a loaded state.
(4) FIG. **4** is a fluid pressure circuit diagram of the fluid pressure shock absorber according to a modification of the embodiment of the present invention.
(5) FIG. **5** is a sectional view of the fluid pressure shock absorber according to the embodiment of the present invention.
(6) FIG. **6** is a fluid pressure circuit diagram of the fluid pressure shock absorber according to the modification of the embodiment of the present invention.
(7) FIG. **7** is a fluid pressure circuit diagram of the fluid pressure shock absorber according to the modification of the embodiment of the present invention.
DESCRIPTION OF EMBODIMENTS
(8) In the following, with reference to the drawings, a fluid pressure shock absorber according to an embodiment of the present invention will be described.
(9) In the following, a case in which the fluid pressure shock absorber is a hydraulic shock absorber **100**, which is to be mounted on a vehicle, will be described. The hydraulic shock absorber **100** is a device that suppresses vibration of a vehicle body by, for example, being interposed between the vehicle body and an axle shaft of the vehicle and by generating a damping force.
(10) As shown in FIG. **1**, the hydraulic shock absorber **100** includes a tubular cylinder tube **10**, a rod **12** that is inserted into the cylinder tube **10** so as to be movable back and forth and that extends outside the cylinder tube **10**, and a piston **14** that is connected to a tip end of the rod **12** and that is slidably moved along an inner circumferential surface of the cylinder tube **10**. The hydraulic shock absorber **100** is installed on the vehicle in an orientation at which the cylinder tube **10** is positioned at the upper side and the rod **12** is positioned at the lower side.
(11) An interior of the cylinder tube **10** is divided by the piston **14** into a bottom-side chamber **1** and a rod-side chamber **2**. The bottom-side chamber **1** and the rod-side chamber **2** are respectively filled with working oil serving as working fluid. In the bottom-side chamber **1**, pressurized gas G for exhibiting a spring effect by compensating for a volume change in the cylinder tube **10** due to inward and outward movement of the rod **12** relative to the cylinder tube **10** is sealed together with

the working oil. As described above, the hydraulic shock absorber **100** has a function of an air-suspension that is capable of supporting the vehicle body by the spring effect exerted by the gas G. In this case, even if a spring for supporting the vehicle body is not provided separately, it is possible to achieve generation of the damping force and support of the vehicle body by the hydraulic shock absorber **100**.

(12) Note that, the configuration is not limited to those described above, and the gas may not be sealed in the cylinder tube **10**. In addition, it may be possible to provide a free piston that is movably provided inside the bottom-side chamber **1** and that divides the bottom-side chamber **1** into a liquid chamber, into which the working oil is sealed, and a gas chamber, into which the gas G is sealed. In addition, an accumulator connected to the bottom-side chamber **1** may be provided outside the cylinder tube **10**, and the gas chamber may be provided in the accumulator.

(13) The bottom-side chamber **1** is connected to the rod-side chamber **2** through a flow path **3**. The hydraulic shock absorber **100** includes a damping valve **20** that is provided in the flow path **3** and that generates the damping force by imparting resistance to a flow of the working oil between the rod-side chamber **2** and the bottom-side chamber **1**.

(14) The flow path **3** is formed by being branched at an intermediate position, and has a first flow path **21** and a second flow path **22** that are parallel with each other. The damping valve **20** has a first damping valve **20**A that is provided in the first flow path **21** and that imparts resistance to the flow of the working oil, and a second damping valve **20**B that is provided in the second flow path **22** and that imparts resistance to the flow of the working oil. The first damping valve **20**A and the second damping valve **20**B are provided in parallel with each other.

(15) The first flow path **21** includes a check valve **23** that only allows the flow of the working oil from the bottom-side chamber **1** to the rod-side chamber **2**. Therefore, the first damping valve **20**A imparts the resistance only to the flow of the working oil directed from the bottom-side chamber **1** towards the rod-side chamber **2**. In this embodiment, the first damping valve **20**A is, for example, a fixed orifice.

(16) The second damping valve **20**B imparts the resistance to the flow of the working oil between the bottom-side chamber **1** and the rod-side chamber **2** in both directions. The position of the second damping valve **20**B is switched in response to a pilot pressure, and the resistances imparted to the flows of the working oil passing therethrough are different at respective positions. In other words, the damping characteristic of the second damping valve **20**B can be changed in response to the pilot pressure.

(17) In this embodiment, the second damping valve **20**B has two positions, i.e., a first restricting position **25**A, at which a predetermined resistance is imparted to the flow of the working oil passing therethrough, and a second restricting position **25**B, at which the resistance of a different magnitude is imparted compared to the resistance imparted at the first restricting position **25**A. In other words, the first restricting position **25**A and the second restricting position **25**B have different pressure loss characteristics for the flow of the working oil passing therethrough.

(18) The second damping valve **20**B has a valve body (not shown) that switches the position, a spring **26** serving as a biasing member that biases the valve body, and a pilot chamber **27** to which the pilot pressure is supplied. In the second damping valve **20**B, the valve body is biased by the spring **26** such that the second damping valve **20**B is positioned at the first restricting position **25**A. In the second damping valve **20**B, by the pilot pressure guided to the pilot chamber **27**, the valve body is moved against the biasing force exerted by the spring **26**, and thereby, the second damping valve **20**B is switched to the second restricting position **25**B.

(19) When the hydraulic shock absorber **100** is contracted, the pressure in the bottom-side chamber **1** is increased, and a part of the working oil in the bottom-side chamber **1** opens the check valve **23** and is guided to the rod-side chamber **2** by passing through the first damping valve **20**A, while the rest of the working oil is guided to the rod-side chamber **2** by passing through the second damping valve **20**B. As described above, when the hydraulic shock absorber **100** is contracted, the working

oil in the bottom-side chamber **1** is guided to the rod-side chamber **2** by passing through both of the first damping valve **20**A and the second damping valve **20**B. Therefore, when the hydraulic shock absorber **100** is contracted, the hydraulic shock absorber **100** generates the damping force corresponding to the overall flow path resistance exerted by the first damping valve **20**A and the second damping valve **20**B.

(20) When the hydraulic shock absorber **100** is extended, the pressure in the rod-side chamber **2** is increased, and the working oil in the rod-side chamber **2** is guided to the bottom-side chamber **1** by passing through the second damping valve **20**B. On the other hand, because the check valve **23** is closed by the increase in the pressure in the rod-side chamber **2**, the working oil in the rod-side chamber **2** is not guided to the bottom-side chamber **1** through the first damping valve **20**A. Thus, when the hydraulic shock absorber **100** is extended, the hydraulic shock absorber **100** generates the damping force corresponding to the flow path resistance exerted by the second damping valve **20**B. Therefore, when the hydraulic shock absorber **100** is contracted, because the flow of the working oil from the bottom-side chamber **1** to the rod-side chamber **2** through the first damping valve **20**A is allowed, the hydraulic shock absorber **100** generates a larger damping force during the extension than during the contraction correspondingly. As a result, in a case in which the vehicle drives over a bump on a road surface, the hydraulic shock absorber **100** is contracted in a relatively smoothly, and thereafter, the hydraulic shock absorber **100** generates the larger damping force during extension, thereby effectively damping the vibration exerted from the road surface to the vehicle body.

(21) Note that, the first flow path **21**, the first damping valve **20**A, and the check valve **23** are not essential configurations, and a configuration in which the damping force is generated only by the second damping valve **20**B may also be employed.

(22) The hydraulic shock absorber **100** includes a pilot valve **30** that supplies the working oil in the bottom-side chamber **1** to the pilot chamber **27** of the second damping valve **20**B as the pilot pressure. The pilot valve **30** is provided in a pilot passage **35**. The pilot passage **35** is provided by being branched from the flow path **3** and connects the bottom-side chamber **1** and the pilot chamber **27** of the second damping valve **20**B. The pilot passage **35** need only be configured to guide the working oil in the bottom-side chamber **1** to the pilot chamber **27** of the second damping valve **20**B as the pilot pressure, and may, for example, be directly connected to the bottom-side chamber **1**.

(23) Here, in a large-sized vehicle such as a damp truck, because the hydraulic shock absorber **100** to be mounted has a large size, the flow rate of the working oil passing through the damping valve **20** is large. In addition, in the vehicle such as the damp truck having a large maximum load capacity, because the overall weight of the vehicle is large, the pressure of the working oil in the hydraulic shock absorber **100** supporting the weight thereof is high. Furthermore, in the hydraulic shock absorber **100**, because the gas G is sealed in the cylinder tube **10** and the hydraulic shock absorber **100** also has the function of the air-suspension, the pressure of the working oil in the cylinder tube **10** becomes high. As described above, in a case in which the hydraulic shock absorber **100** is mounted on the large-sized vehicle, such as the damp truck, the working oil having a high pressure and a large flow rate flows through the damping valve **20**. In contrast, a pilot fluid supplied to the pilot chamber **27** of the second damping valve **20**B does not need to have the high pressure and the large flow rate, and so, the pilot passage **35** is formed to have a flow path diameter that is smaller than that of the flow path **3**.

(24) In this embodiment, the working oil in the bottom-side chamber **1** is used as the pilot pressure for switching the position of the second damping valve **20**B. Instead, the working oil in the rod-side chamber **2** may also be used as the pilot pressure for switching the position of the second damping valve **20**B. However, while the vehicle is travelling, when the wheel lands on a bottom of a depression in the road surface or when the wheel rides over the bump on the road surface, the hydraulic shock absorber **100** is contracted suddenly and temporarily, and thus, the pressure in the rod-side chamber **2** may become negative pressure. In contrast, the bottom-side chamber **1** supports

the weight of the vehicle body, and the pressurized gas G is sealed in the bottom-side chamber **1**, and thus, the pressure in the bottom-side chamber **1** does not become negative pressure during the operation of the hydraulic shock absorber **100**. Therefore, it is preferable to use the working oil in the bottom-side chamber **1** as the pilot pressure.
(25) The pilot valve **30** has three positions, i.e., a supply position **30**A, at which the pilot pressure is supplied, a first shut-off position **30**B, at which the supply of the pilot pressure is shut off, and a second shut-off position **30**C, at which the supply of the pilot pressure is shut off.
(26) The pilot valve **30** is a pilot-driven valve that can switch its position by the pilot pressure. The pilot valve **30** has: a spool valve (not shown) serving as the valve body that switches the position; a first pilot chamber **31** to which the working oil is guided from the bottom-side chamber **1** through a first pilot passage **36**; a second pilot chamber **32** that is provided so as to oppose to the first pilot chamber **31** with the valve body interposed therebetween and to which the working oil is guided from the rod-side chamber **2** through a second pilot passage **37**; a first spring **33** serving as a first biasing member that biases the valve body in the same direction as the pilot pressure in the first pilot chamber **31**; and a second spring **34** serving as a second biasing member that biases the valve body in the same direction as the pilot pressure in the second pilot chamber **32**.
(27) The pressure receiving area of the spool valve on which the pilot pressure in the first pilot chamber **31** acts and the pressure receiving area of the spool valve on which the pilot pressure in the second pilot chamber **32** acts are equivalent. In addition, the biasing force exerted by the first spring **33** and the biasing force exerted the second spring **34** are also equivalent. When the pilot pressure in the first pilot chamber **31** and the pilot pressure in the second pilot chamber **32** become equivalent, the pilot valve **30** is positioned at the supply position **30**A. In addition, when the pilot pressure in the first pilot chamber **31** becomes higher than the pilot pressure in the second pilot chamber **32**, and as the spool valve is moved against the biasing force exerted by the second spring **34**, the pilot valve **30** is switched to a first shut-off position **30**B. In addition, when the pilot pressure in the second pilot chamber **32** becomes higher than the pilot pressure in the first pilot chamber **31**, and as the spool valve is moved against the biasing force exerted by the first spring **33**, the pilot valve **30** is switched to a second shut-off position **30**C.
(28) In FIG. **1**, the first pilot passage **36** is provided by being branched from the pilot passage **35**. However, the first pilot passage **36** need only be configured to guide the working oil in the bottom-side chamber **1** to the first pilot chamber **31** of the pilot valve **30** as the pilot pressure, and may be provided by being branched from the flow path **3** or may be directly connected to the bottom-side chamber **1**, for example.
(29) In FIG. **1**, the second pilot passage **37** is provided by being branched from the flow path **3**. However, the second pilot passage **37** need only be configured to guide the working oil in the rod-side chamber **2** to the second pilot chamber **32** of the pilot valve **30** as the pilot pressure, and may, for example, be directly connected to the rod-side chamber **2**.
(30) Here, with the vehicle such as the damp truck having a large maximum load capacity, because the overall weight of the vehicle, including the load, varies significantly between an empty state with no load and a loaded state in which the load has a predetermined weight, the energy to be damped by the hydraulic shock absorber **100** also varies significantly. Thus, in this embodiment, the damping characteristic of the second damping valve **20**B is changed by the pilot valve **30** according to the load weight of the vehicle. Details will be described below.
(31) FIG. **2** is a diagram for explaining the operation of the hydraulic shock absorber **100** in the empty state, and FIG. **3** is a diagram for explaining the operation of the hydraulic shock absorber **100** in the loaded state. In FIGS. **2** and **3**, (a) each shows a situation when the hydraulic shock absorber **100** is not extended/contracted, (b) each shows a situation when the hydraulic shock absorber **100** is contracted, and (c) each shows a situation when the hydraulic shock absorber **100** is extended.
(32) The operation of the hydraulic shock absorber **100** in the empty state will be described first

with reference to FIG. **2**. In the empty state, because the overall weight of the vehicle is small, the internal pressure of the hydraulic shock absorber **100** is low. In addition, when the vehicle is in a stop state and the hydraulic shock absorber **100** is not extended/contracted, or even if the vehicle is travelling, when the travelling road surface is flat and the hydraulic shock absorber **100** is not extended/contracted, because there is no flow of the working oil between the bottom-side chamber **1** and the rod-side chamber **2**, the pressure in the bottom-side chamber **1** and the pressure in the rod-side chamber **2** become the same. As described above, when the vehicle is in the empty state and the hydraulic shock absorber **100** is not extended/contracted, the pressure in the bottom-side chamber **1** and the pressure in the rod-side chamber **2** become low at the same pressure. As described above, as shown in FIG. **2**(*a*), because the pilot pressure in the first pilot chamber **31** and the pilot pressure in the second pilot chamber **32** become the same, the pilot valve **30** is positioned at the supply position **30**A, and the working oil in the bottom-side chamber **1** is supplied to the pilot chamber **27** of the second damping valve **20**B as the pilot pressure. At this time, because the pressure of the working oil in the bottom-side chamber **1** is low, the second damping valve **20**B is positioned at the first restricting position **25**A by the biasing force exerted by the spring **26**. As described above, when the vehicle is in the empty state and the hydraulic shock absorber **100** is not extended/contracted, the low pilot pressure is supplied to the pilot chamber **27** of the second damping valve **20**B, and the second damping valve **20**B is positioned at the first restricting position **25**A. In other words, when the vehicle is in the empty state and the hydraulic shock absorber **100** is not extended/contracted, the biasing force exerted by the spring **26** is set such that the biasing force exerted by the spring **26** is greater than the load exerted by the pilot pressure of the pilot chamber **27**.

(33) As shown in FIG. **2**(*b*), when the hydraulic shock absorber **100** is contracted, because the pressure in the bottom-side chamber **1** becomes relatively high and the pressure in the rod-side chamber **2** becomes relatively low, the pilot pressure in the first pilot chamber **31** becomes higher than the pilot pressure in the second pilot chamber **32**, and the spool valve is moved against the biasing force exerted by the second spring **34**, and so, the pilot valve **30** is switched to the first shut-off position **30**B. As described above, the supply of the high pilot pressure from the bottom-side chamber **1** to the pilot chamber **27** of the second damping valve **20**B is shut off. At this time, because a downstream portion **35***a* of the pilot passage **35** on the downstream side of the pilot valve **30** between the pilot valve **30** and the pilot chamber **27** of the second damping valve **20**B is closed, the pilot chamber **27** is held at the low pilot pressure supplied when the hydraulic shock absorber **100** is not extended/contracted. As described above, the second damping valve **20**B is held at the first restricting position **25**A.

(34) As shown in FIG. **2**(*c*), when the hydraulic shock absorber **100** is extended, because the pressure in the bottom-side chamber **1** becomes relatively low, and the pressure in the rod-side chamber **2** becomes relatively high, the pilot pressure in the second pilot chamber **32** becomes higher than the pilot pressure in the first pilot chamber **31**, and the spool valve is moved against the biasing force exerted by the first spring **33**, and so, the pilot valve **30** is switched to the second shut-off position **30**C. As described above, the supply of the low pilot pressure from the bottom-side chamber **1** to the pilot chamber **27** of the second damping valve **20**B is shut off. At this time, because the downstream portion **35***a* of the pilot passage **35** on the downstream side of the pilot valve **30** is closed, the pilot chamber **27** is held at the low pilot pressure supplied when the hydraulic shock absorber **100** is not extended/contracted. As described above, the second damping valve **20**B is held at the first restricting position **25**A.

(35) Next, the operation of the hydraulic shock absorber **100** in the loaded state will be described with reference to FIG. **3**. In the loaded state, because the overall weight of the vehicle is larger, the internal pressure of the hydraulic shock absorber **100** is higher, and so, the pressure in the bottom-side chamber **1** and the pressure in the rod-side chamber **2** become medium pressure that is relatively high compared with those in the empty state. In addition, when the vehicle is in the stop

state and the hydraulic shock absorber **100** is not extended/contracted, or even if the vehicle is travelling, when the travelling road surface is flat and the hydraulic shock absorber **100** is not extended/contracted, because there is no flow of the working oil between the bottom-side chamber **1** and the rod-side chamber **2**, the pressure in the bottom-side chamber **1** and the pressure in the rod-side chamber **2** become the same. As described above, when the vehicle is in the loaded state and the hydraulic shock absorber **100** is not extended/contracted, the pressure in the bottom-side chamber **1** and the pressure in the rod-side chamber **2** become medium at the same pressure. As described above, as shown in FIG. **3**(*a*), because the pilot pressure in the first pilot chamber **31** and the pilot pressure in the second pilot chamber **32** become the same, the pilot valve **30** is positioned at the supply position **30**A, and the working oil in the bottom-side chamber **1** is supplied to the pilot chamber **27** of the second damping valve **20**B as the pilot pressure. At this time, because the working oil in the bottom-side chamber **1** is at medium pressure, the valve body is moved by the pilot pressure in the pilot chamber **27** against the biasing force exerted by the spring **26**, and so, the second damping valve **20**B is switched to the second restricting position **25**B. As described above, when the vehicle is in the loaded state and the hydraulic shock absorber **100** is not extended/contracted, the medium pilot pressure is supplied to the pilot chamber **27** of the second damping valve **20**B, and the second damping valve **20**B is positioned at the second restricting position **25**B. In other words, when the vehicle is in the loaded state and the hydraulic shock absorber **100** is not extended/contracted, the biasing force exerted by the spring **26** is set such that the load exerted by the pilot pressure of the pilot chamber **27** becomes greater than the biasing force exerted by the spring **26**. In other words, the timing at which the second damping valve **20**B is switched from the first restricting position **25**A to the second restricting position **25**B is determined by the biasing force exerted by the spring **26**. It is preferable that the switching timing of the second damping valve **20**B can be adjusted in accordance with the individual differences of the vehicle and the types of the load. In such a case, the switching timing of the second damping valve **20**B is adjusted by changing the initial load of the spring **26** by a nut, etc.

(36) As shown in FIG. **3**(*b*), when the hydraulic shock absorber **100** is contracted, because the pressure in the bottom-side chamber **1** becomes relatively high, and the pressure in the rod-side chamber **2** becomes relatively low, the pilot pressure in the first pilot chamber **31** becomes higher than the pilot pressure in the second pilot chamber **32**, and the spool valve is moved against the biasing force exerted by the second spring **34**, and so, the pilot valve **30** is switched to the first shut-off position **30**B. As described above, the supply of the high pilot pressure from the bottom-side chamber **1** to the pilot chamber **27** of the second damping valve **20**B is shut off. At this time, because the downstream portion **35***a* of the pilot passage **35** on the downstream side of the pilot valve **30** is closed, the pilot chamber **27** is held at the medium pilot pressure supplied when the hydraulic shock absorber **100** is not extended/contracted. As described above, the second damping valve **20**B is held at the second restricting position **25**B.

(37) As shown in FIG. **3**(*c*), when the hydraulic shock absorber **100** is extended, because the pressure in the bottom-side chamber **1** becomes relatively high and the pressure in the rod-side chamber **2** becomes relatively high, the pilot pressure in the second pilot chamber **32** becomes higher than the pilot pressure in the first pilot chamber **31**, and the spool valve is moved against the biasing force exerted by the first spring **33**, and so, the pilot valve **30** is switched to the second shut-off position **30**C. As described above, the supply of the low pilot pressure from the bottom-side chamber **1** to the pilot chamber **27** of the second damping valve **20**B is shut off. At this time, because the downstream portion **35***a* of the pilot passage **35** on the downstream side of the pilot valve **30** is closed, the pilot chamber **27** is held at the medium pilot pressure supplied when the hydraulic shock absorber **100** is not extended/contracted. As described above, the second damping valve **20**B is held at the second restricting position **25**B.

(38) The pilot pressure in the pilot chamber **27** of the second damping valve **20**B in the loaded state is the medium pressure. This medium pressure is lower than the pressure on the high pressure side

of the bottom-side chamber **1** and the rod-side chamber **2** and higher than the pressure on the low pressure side of the bottom-side chamber **1** and the rod-side chamber **2** during the extension and contraction operation of the hydraulic absorber **100** in the empty state and the loaded state.
(39) As described above, when the hydraulic shock absorber **100** is not extended/contracted, the pilot valve **30** supplies the working oil in the bottom-side chamber **1** to the pilot chamber **27** of the second damping valve **20**B as the pilot pressure, and when the hydraulic shock absorber **100** is extended/contracted, the pilot valve **30** holds the pilot pressure in the pilot chamber **27** supplied when the hydraulic shock absorber **100** is not extended/contracted. As described above, the pilot pressure in the pilot chamber **27** of the second damping valve **20**B becomes the pressure in the bottom-side chamber **1** when the hydraulic shock absorber **100** is not extended/contracted. In other words, the pilot pressure in the pilot chamber **27** of the second damping valve **20**B is determined according to the load weight of the vehicle. Specifically, when the load weight is less than a predetermined weight, the pilot pressure in the pilot chamber **27** of the second damping valve **20**B becomes low, and so, the second damping valve **20**B is positioned at the first restricting position **25**A, and when the load weight is equal to or greater than a predetermined weight, the pilot pressure in the pilot chamber **27** of the second damping valve **20**B becomes the medium pressure, and so, the second damping valve **20**B is positioned at the second restricting position **25**B. Therefore, the hydraulic shock absorber **100** can exhibit an optimal damping characteristic according to the load weight of the vehicle.
(40) During the extension/contraction of the hydraulic shock absorber **100**, the pressure level in the bottom-side chamber **1** and the rod-side chamber **2** of the hydraulic shock absorber **100** is switched every time expansion/contraction is performed, and thus, at the moment of the switching, the pressure in the bottom-side chamber **1** and the pressure in the rod-side chamber **2** become the same instantaneously. At this time, in order to prevent the pressure in the bottom-side chamber **1** from being guided to the pilot chamber **27** of the second damping valve **20**B through the pilot valve **30**, it is preferable to provide an orifice **38** serving as a restrictor in the pilot passage **35** as shown in FIG. **4**. By providing the orifice **38**, it becomes more difficult for the pressure in the bottom-side chamber **1** to be transmitted to the pilot chamber **27** of the second damping valve **20**B via the pilot valve **30** during the extension/contraction of the hydraulic shock absorber **100**, and so, it is possible to prevent the second damping valve **20**B from being unintentionally switched during the extension/contraction of the hydraulic shock absorber **100**. In FIG. **4**, the orifice **38** is provided on the upstream side of the pilot valve **30** in the pilot passage **35**. However, the orifice **38** may also be provided on the downstream side of the pilot valve **30** in the pilot passage **35**.
(41) Next, with reference to FIG. **5**, the structure of the hydraulic shock absorber **100**, and an example of mounting the damping valve **20** and the pilot valve **30** on the hydraulic shock absorber **100** will be described. FIG. **5** is a sectional view of the hydraulic shock absorber **100**.
(42) The cylinder tube **10** has a bottomed cylindrical shape, and a cylinder head **11**, through which the rod **12** is slidably inserted, is provided on its opening end. An attachment portion **10***a* for attaching the hydraulic shock absorber **100** to the vehicle is provided on a closing end of the cylinder tube **10** (the end portion on the opposite side from the cylinder head **11**).
(43) The rod **12** has a rod main body **51** that is connected to the piston **14** and that is slidably supported by the cylinder head **11** of the cylinder tube **10** and a head portion **52** that is exposed to the outside of the cylinder tube **10**.
(44) The rod main body **51** is formed with a rod inner space **40** that opens at an end surface on the piston **14** side. An end portion of the rod main body **51** is joined to the piston **14** by a bolt (not shown).
(45) The head portion **52** is formed to have a diameter larger than that of the rod main body **51**, and the head portion **52** is always exposed to the outside of the cylinder tube **10** regardless of the stroke position of the hydraulic shock absorber **100**. In other words, the head portion **52** is a portion of the rod **12** that does not slide with respect to the cylinder head **11**. The head portion **52** is, for example,

formed separately from the rod main body **51**, and is connected to the end portion of the rod main body **51** by welding, etc. The rod main body **51** and the head portion **52** may be formed integrally.
(46) The head portion **52** includes a stopper portion **52***a* that defines the stroke end when the hydraulic shock absorber **100** is contracted and an attachment portion **52***b* for attaching the hydraulic shock absorber **100** to the vehicle. The stopper portion **52***a* includes an annular cushion ring **53** that prevents collision between the cylinder head **11** and the rod **12** at the stroke end when the hydraulic shock absorber **100** is contracted.
(47) The rod inner space **40** includes a cylindrical pipe **43**. The one end of the pipe **43** is inserted into an insertion hole **52***c* formed in the head portion **52** and the other end thereof is inserted into an insertion hole **14***a* formed in the piston **14**. As described above, the pipe **43** is provided so as to be interposed between the head portion **52** and the piston **14**.
(48) By providing the pipe **43** in the rod inner space **40**, the rod inner space **40** is divided into a first space **41** that is a hollow portion in the pipe **43** and an annular second space **42** that is partitioned between an outer circumferential surface of the pipe **43** and an inner circumferential surface of the rod main body **51**. The first space **41** communicates with the bottom-side chamber **1** through a through hole **14***b* that is formed in the piston **14**. The second space **42** communicates with the rod-side chamber **2** through a plurality of through holes **51***a* that are formed in the rod main body **51** of the rod **12**. As described above, the rod inner space **40** has the first space **41** that communicates with the bottom-side chamber **1** and the second space **42** that communicates with the rod-side chamber **2**. The first space **41** and the second space **42** each forms a part of the flow path **3** that connects the bottom-side chamber **1** with the rod-side chamber **2**.
(49) The flow path **3**, the first damping valve **20**A, the second damping valve **20**B, and the pilot valve **30** are provided in the head portion **52** of the rod **12**. The pilot passage **35**, the first pilot passage **36**, and the second pilot passage **37** are also provided in the head portion **52**. The pilot pressure is guided to the pilot chamber **27** of the second damping valve **20**B from the bottom-side chamber **1** via the first space **41** and the pilot passage **35**. In addition, the pilot pressure is guided to the first pilot chamber **31** of the pilot valve **30** from the bottom-side chamber **1** via the first space **41** and the first pilot passage **36**. In addition, the pilot pressure is guided to the second pilot chamber **32** of the pilot valve **30** from the rod-side chamber **2** via the second space **42** and the second pilot passage **37**. As described above, in this configuration, each pilot pressure is guided through the rod inner space **40** and each of the pilot passages **35** to **37** provided in the head portion **52**, and the pilot pressure is guided out from the vertically lower side with respect to the gas G that is stored on the vertically upper side of the hydraulic shock absorber **100**. Therefore, because the gas G is prevented from being mixed with the pilot fluid, the operation of the second damping valve **20**B and the pilot valve **30** is stabilized. As described above, even if the gas chamber, into which the gas G is to be sealed, is not divided by the free piston, it is possible to prevent the gas G from being mixed into the pilot fluid by guiding out the pilot pressure from the vertically lower side with respect to the gas G.
(50) When the working oil in the rod-side chamber **2** is to be used as the pilot pressure for driving the second damping valve **20**B, the pilot pressure may be guided to the pilot chamber **27** of the second damping valve **20**B through the second space **42** and the pilot passages provided in the head portion **52**.
(51) According to the embodiment mentioned above, the advantages described below are afforded.
(52) In the hydraulic shock absorber **100**, the working oil in the bottom-side chamber **1** when the hydraulic shock absorber **100** is not extended/contracted is used as the pilot pressure to change the damping characteristic of the second damping valve **20**B, and so, the damping characteristic suitable for the load weight is achieved. In addition, the pilot valve **30** that supplies the pilot pressure to the second damping valve **20**B is operated by the working oil guided from the bottom-side chamber **1** and the working oil guided from the rod-side chamber **2**. As described above, because the second damping valve **20**B and the pilot valve **30** are the pilot-driven valves, electronic

devices such as solenoids, etc. are not required. Thus, it is possible to realize the configuration in which the damping characteristic can be changed in accordance with the load weight at low cost.
(53) In the following, modifications of the above-mentioned embodiment will be described. The modifications described below also fall within the scope of the present invention. It may also be possible to combine the following modifications with the configurations in the above-described embodiment, and it may also be possible to combine the following modifications with each other.
(54) (1) By referring to FIGS. **2** and **3**, a description has been given of the example in which the second damping valve **20**B is positioned at the first restricting position **25**A when the vehicle is in the empty state, and the second damping valve **20**B is positioned at the second restricting position **25**B when the vehicle is in the loaded state. However, the second damping valve **20**B may be positioned at the first restricting position **25**A when the load weight is less than a predetermined weight, and the second damping valve **20**B may be positioned at the second restricting position **25**B when the load weight is equal to or greater than a predetermined weight.
(55) (2) In a hydraulic shock absorber **101** shown in FIG. **6**, the damping characteristic can be changed in response to the pilot pressure also in the first damping valve **20**A. In other words, the first damping valve **20**A has the configuration that is the same as that of the second damping valve **20**B of the hydraulic shock absorber **100** according to the above-mentioned embodiment. The pilot pressure is supplied from the pilot valve **30** to both of the first damping valve **20**A and the second damping valve **20**B. In this modification, it is possible to realize an optimal damping characteristic according to the load weight of the vehicle.
(56) In the hydraulic shock absorber **101**, the check valve **23** provided in the first flow path **21** may be provided in the reverse direction. In other words, the first damping valve **20**A may be configured such that the resistance is imparted only to the flow of the working oil directed from the one of the bottom-side chamber **1** and the rod-side chamber **2** towards the other. Furthermore, the second flow path **22** in which the second damping valve **20**B is provided may be provided with a check valve that only allows the flow of the working oil from the rod-side chamber **2** to the bottom-side chamber **1**. In such a case, the second damping valve **20**B imparts the resistance only to the flow of the working oil directed from the rod-side chamber **2** towards the bottom-side chamber **1**.
(57) (3) In a hydraulic shock absorber **102** shown in FIG. **7**, in addition to the first restricting position **25**A and the second restricting position **25**B, the second damping valve **20**B has a third restricting position **25**C that imparts the resistance of a different magnitude compared to the resistance imparted by the first restricting position **25**A and the second restricting position **25**B. In this case, in the second damping valve **20**B, the damping characteristic is changed in three stages in response to the pilot pressure supplied to the pilot chamber **27** when the hydraulic shock absorber **100** is not extended/contracted. For example, the second damping valve **20**B may be set to the first restricting position **25**A, the second restricting position **25**B, and the third restricting position **25**C, respectively in the empty state, the loaded state in which the load weight is less than a predetermined weight, and the loaded state in which the load weight is equal to or greater than a predetermined weight. As described above, the second damping valve **20**B may be configured such that the damping characteristic can be changed in three or more stages or continuously in response to the pilot pressure supplied to the pilot chamber **27** when the hydraulic shock absorber **100** is not extended/contracted. Even in this modification, it is possible to realize an optimal damping characteristic according to the load weight of the vehicle.
(58) (4) In the above-mentioned embodiment, a description has been given of the configuration in which the hydraulic shock absorber **100** is mounted on the vehicle in the direction in which the cylinder tube **10** faces upward and the rod **12** faces downward. On the contrary, however, the hydraulic shock absorber **100** may be mounted on the vehicle in the direction in which the cylinder tube **10** faces downward and the rod **12** faces upward. In this case, in order to prevent upward movement of the gas G in the bottom-side chamber **1**, it is required to provide, in the bottom-side chamber **1**, a free piston that separates the liquid chamber in which the working oil is sealed and

the gas chamber in which the gas is sealed. Alternatively, an accumulator connected to the bottom-side chamber **1** may be provided outside the cylinder tube **10**, and a gas chamber may be provided in the accumulator.

(59) (5) In the above-mentioned embodiment, although the hydraulic shock absorber **100** is of a single-rod type in which the tip end of the rod **12** projects out to the outside of the cylinder tube **10**, the hydraulic shock absorber **100** may also be of a double rod type in which both ends of the rod **12** project out to the outside of the cylinder tube **10**.

(60) In the following, the configurations, operations, and effects of the respective embodiments of the present invention will be collectively described.

(61) The hydraulic shock absorber **100** (the fluid pressure shock absorber) mounted on the vehicle includes: the cylinder tube **10**; the rod **12** inserted into the cylinder tube **10** so as to be movable back and forth; the piston **14** connected to the rod **12** and dividing the interior of the cylinder tube **10** into the bottom-side chamber **1** and the rod-side chamber **2**; the damping valve **20** configured to impart the resistance to the flow of the working oil (the working fluid) between the bottom-side chamber **1** and the rod-side chamber **2**, the damping valve **20** being capable of changing the damping characteristic in response to the pilot pressure; and the pilot valve **30** configured to supply the working oil in the bottom-side chamber **1** or the rod-side chamber **2** to the pilot chamber **27** of the damping valve **20** as the pilot pressure, wherein the pilot valve **30** has: the first pilot chamber **31** to which the working oil is guided from the bottom-side chamber **1**; and the second pilot chamber **32** provided so as to be opposed to the first pilot chamber **31**, the second pilot chamber **32** being configured such that the working oil is guided from the rod-side chamber **2**, when the hydraulic shock absorber **100** is not extended/contracted, the pilot valve **30** supplies the pilot pressure to the pilot chamber **27** of the damping valve **20**, and when the hydraulic shock absorber **100** is extended/contracted, the pilot valve **30** holds the pilot pressure in the pilot chamber **27** of the damping valve **20** supplied when the hydraulic shock absorber **100** is not extended/contracted.

(62) In addition, the pilot valve **30** has: the supply position **30**A to which the pilot valve **30** is switched when the pressure in the first pilot chamber **31** and the pressure in the second pilot chamber **32** become the same when the hydraulic shock absorber **100** is not extended/contracted; the first shut-off position **30**B to which the pilot valve **30** is switched when the pressure in the first pilot chamber **31** becomes high and the pressure in the second pilot chamber **32** becomes low when the hydraulic shock absorber **100** is extended/contracted; and the second shut-off position **30**C to which the pilot valve **30** is switched when the pressure in the second pilot chamber **32** becomes high and the pressure in the first pilot chamber **31** becomes low when the hydraulic shock absorber **100** is extended/contracted.

(63) With these configurations, the working oil in the bottom-side chamber **1** or the rod-side chamber **2** when the hydraulic shock absorber **100** is not extended/contracted is used as the pilot pressure to change the damping characteristic of the damping valve **20**, and so, the damping characteristic suitable for the load weight is achieved. In addition, the pilot valve **30** that supplies the pilot pressure to the damping valve **20** is operated by the working oil guided from the bottom-side chamber **1** and the working oil guided from the rod-side chamber **2**. Thus, it is possible to realize the configuration in which the damping characteristic can be changed in accordance with the load weight at low cost.

(64) In addition, the hydraulic shock absorber **100** further includes: the pilot passage **35** provided with the pilot valve **30**, the pilot passage **35** connecting the bottom-side chamber **1** or the rod-side chamber **2** with the pilot chamber **27** of the damping valve **20**; and the orifice **38** (the restrictor) provided in the pilot passage **35**, the orifice **38** (the restrictor) being configured to impart the resistance to the flow of the pilot fluid.

(65) With this configuration, by providing the orifice **38**, it becomes more difficult for the pressure in the bottom-side chamber **1** or the rod-side chamber **2** to be transmitted to the pilot chamber **27** of the damping valve **20** through the pilot valve **30** during the extension/contraction of the hydraulic

shock absorber **100**, and so, it is possible to prevent the damping valve **20** from being unintentionally switched.
(66) In addition, the working oil in the bottom-side chamber **1** is used as the pilot pressure, and the pressurized gas G is sealed in the bottom-side chamber **1**.
(67) With this configuration, because the pressurized gas G is sealed in the bottom-side chamber **1**, and the pressure in the bottom-side chamber **1** does not become negative pressure during the operation of the hydraulic shock absorber **100**, it is possible to operate the damping valve **20** stably.
(68) In addition, the hydraulic shock absorber **100** has, as the damping valve **20**, the first damping valve **20**A and the second damping valve **20**B provided in parallel with each other, the first damping valve **20**A and the second damping valve **20**B being configured to impart the resistance to the flow of the working oil, and the first damping valve **20**A imparts the resistance only to the flow of the working oil directed from the one of the bottom-side chamber **1** and the rod-side chamber **2** towards the other of the bottom-side chamber **1** and the rod-side chamber **2**.
(69) In addition, the damping valve **20** is capable of changing the damping characteristic in three or more stages or continuously in response to the pilot pressure supplied to the pilot chamber **27** when the hydraulic shock absorber **102** is not extended/contracted.
(70) With these configurations, it is possible to realize an optimal damping characteristic according to the state of the vehicle.
(71) In addition, the rod **12** has: the rod main body **51** connected to the piston **14**, the rod main body **51** being slidably supported by the cylinder tube **10**; the head portion **52** exposed to the outside of the cylinder tube **10**; and the rod inner space **40** formed inside the rod main body **51**, the rod inner space **40** has: the first space **41** communicating with the bottom-side chamber **1**; and the second space **42** communicating with the rod-side chamber **2**, the damping valve **20** and the pilot valve **30** are provided in the head portion **52**, and the pilot pressure supplied to the pilot chamber **27** of the damping valve **20** is supplied through the first space **41** or the second space **42**.
(72) With this configuration, it is possible to prevent the gas from being mixed with the pilot fluid.
(73) Embodiments of this invention were described above, but the above embodiments are merely examples of applications of this invention, and the technical scope of this invention is not limited to the specific constitutions of the above embodiments.
(74) This application claims priority based on Japanese Patent Application No. 2022-35295 filed with the Japan Patent Office on Mar. 8, 2022, the entire contents of which are incorporated into this specification.

Claims

1. A fluid pressure shock absorber mounted on a vehicle, comprising: a cylinder tube; a rod inserted into the cylinder tube so as to be movable back and forth; a piston connected to the rod and dividing an interior of the cylinder tube into a bottom-side chamber and a rod-side chamber; a damping valve configured to impart resistance to a flow of working fluid between the bottom-side chamber and the rod-side chamber, the damping valve being capable of changing damping characteristic in response to a pilot pressure; and a pilot valve configured to supply the working fluid in the bottom-side chamber or the rod-side chamber to a pilot chamber of the damping valve as a pilot pressure, wherein the pilot valve has: a first pilot chamber configured such that the working fluid is guided from the bottom-side chamber; and a second pilot chamber provided so as to be opposed to the first pilot chamber, the second pilot chamber being configured such that the working fluid is guided from the rod-side chamber, when the fluid pressure shock absorber is not extended or contracted, the pilot valve supplies the pilot pressure to the pilot chamber of the damping valve, and when the fluid pressure shock absorber is extended or contracted, the pilot valve holds the pilot pressure in the pilot chamber of the damping valve supplied when the fluid pressure shock absorber is not extended or contracted.

2. The fluid pressure shock absorber according to claim 1, wherein the pilot valve has: a supply position to which the pilot valve is switched when pressure in the first pilot chamber and pressure in the second pilot chamber become same when the fluid pressure shock absorber is not extended or contracted; a first shut-off position to which the pilot valve is switched when the pressure in the first pilot chamber becomes high and the pressure in the second pilot chamber becomes low when the fluid pressure shock absorber is extended or contracted; and a second shut-off position to which the pilot valve is switched when the pressure in the second pilot chamber becomes high and the pressure in the first pilot chamber becomes low when the fluid pressure shock absorber is extended or contracted.

3. The fluid pressure shock absorber according to claim 1, further comprising: a pilot passage provided with the pilot valve, the pilot passage connecting the bottom-side chamber or the rod-side chamber with the pilot chamber of the damping valve; and a restrictor provided in the pilot passage, the restrictor being configured to impart resistance to a flow of a pilot fluid.

4. The fluid pressure shock absorber according to claim 1, wherein the working fluid in the bottom-side chamber is used as the pilot pressure, and a pressurized gas is sealed in the bottom-side chamber.

5. The fluid pressure shock absorber according to claim 1, wherein the damping valve comprises a first damping valve and a second damping valve provided in parallel with each other, the first damping valve and the second damping valve being configured to impart resistance to a flow of the working fluid, wherein the first damping valve imparts the resistance only to a flow of the working fluid directed from one of the bottom-side chamber and the rod-side chamber towards the other of the bottom-side chamber and the rod-side chamber.

6. The fluid pressure shock absorber according to claim 1, wherein the damping valve is configured to change damping characteristic in three or more stages or continuously in response to the pilot pressure supplied to the pilot chamber when the fluid pressure shock absorber is not extended or contracted.

7. The fluid pressure shock absorber according to claim 1, wherein the rod has: a rod main body connected to the piston, the rod main body being slidably supported by the cylinder tube; a head portion exposed to outside of the cylinder tube; and a rod inner space formed inside the rod main body, the rod inner space has a first space communicating with the bottom-side chamber and a second space communicating with the rod-side chamber, the damping valve and the pilot valve are provided in the head portion, and the pilot pressure supplied to the pilot chamber of the damping valve is supplied through the first space or the second space.