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Inventor(s)	Ikeda; Daisuke

Shock absorber and saddle-type vehicle

Abstract

A shock absorber includes a cylinder, a rod, a first damping force generating portion, and a second damping force generation portion. The second damping force generating portion includes a flow path which passes through the piston in the axial direction, a valve which opens and closes an opening portion at the second end portion side of the flow path, and an adjustment unit which adjusts a force required to open the valve from an outer side of the rod.

Inventors:	Ikeda; Daisuke (Hitachinaka, JP)
Applicant:	Hitachi Astemo, Ltd. (Hitachinaka, JP)
Family ID:	1000008750413
Assignee:	Hitachi Astemo, Ltd. (Hitachinaka, JP)
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Primary Examiner: Neacsu; Valentin

Assistant Examiner: Hymel; Abigail R

Attorney, Agent or Firm: Leason Ellis LLP

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION(S) (1) This application is a continuation of PCT application No. PCT/JP2019/029996, which was filed on Jul. 31, 2019, the content of which is

incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

(1) The present invention relates to a shock absorber and a saddle-type vehicle.

BACKGROUND OF THE INVENTION

(2) For example, a front fork disclosed in JP-A-2017-172739 includes an outer tube portion which is formed into a tubular shape and is positioned at a vehicle body side, and an inner tube portion which is formed into a tubular shape, is positioned at a wheel side, is connected to the outer tube portion, and moves relative to the outer tube portion in an axial direction of the outer tube portion. The front fork includes a cylindrical cylinder which is provided inside the outer tube portion and the inner tube portion and has a fragile portion at an outer circumference side in the axial direction, and a rod member which is positioned inside the outer tube portion and the inner tube portion and moves relative to the cylinder in the axial direction of the cylinder along with a movement of the outer tube portion and the inner tube portion. The front fork further includes a piston (first partition member) which is fixed to an end portion of the rod member, is provided in contact with the cylinder to be movable in the axial direction of the cylinder, partitions a space in the cylinder, and is provided with a damping mechanism which attenuates vibration generated due to a relative movement between the outer tube portion and the inner tube portion. The front fork further includes a piston (second partition member) which is disposed relative to the piston (first partition member) in the axial direction at a side where the cylinder is provided, partitions the space in the cylinder, and is provided with a damping mechanism, and a free piston (third partition member) which is disposed relative to the piston (second partition member) in the axial direction at a side where the cylinder is provided, partitions the space in the cylinder, and moves in the axial direction in the cylinder along with a movement of the rod member.

(3) A damper portion of the front fork (shock absorber) disclosed in JP-A-2017-172739 generates a damping force in a low speed range in which a piston moves at a low speed. The front fork disclosed in JP-A-2017-172739 has a function of adjusting the damping force generated by the damper portion. However, in the front fork disclosed in JP-A-2017-172739, an adjustment of a damping force in a medium speed range in which the piston moves at a medium speed faster than the low speed, or in a high speed range in which the piston moves at a high speed faster than the medium speed can be further improved.

(4) An object of the present invention is to provide a shock absorber and the like which can adjust a damping force over a large moving speed range of a piston.

SUMMARY OF THE INVENTION

(5) Hereinafter, the present disclosure will be described. In the following description, reference numerals in the accompanying drawings are added in parentheses to facilitate understanding of the present disclosure, but the present disclosure is not limited to the following embodiments.

(6) According to an aspect of the present invention, there is provided a shock absorber (1, 2, 3, 4, 5, 6). The shock absorber (1, 2, 3, 4, 5, 6) includes a cylinder (151) which has a first end portion in an axial direction thereof which is fixed to a vehicle body of a saddle-type vehicle, a rod (81) which holds a piston (83, 383) which slides in the cylinder at an end portion at a first end portion side of the rod (81), a second end portion of the rod being fixed to a front wheel side, the second end portion being at opposite side to the end portion at the first end portion side, a first damping force generating portion (190) which is fixed to the end portion at the first end portion side in the cylinder; and a second damping force generation portion (60, 260, 360, 460, 560, 660) which is disposed to be movable in the axial direction in the cylinder. The second damping force generating portion includes a flow path (83c, 383c) which passes through the piston in the axial direction, a valve (86, 286, 386, 486, 686) which opens and closes an opening portion at the second end portion side of the flow path, and an adjustment unit (90) which adjusts a force required to open the valve from an outer side of the rod.

- (7) Here, the adjustment unit (90) may include a first spring (91) which applies a force in a closing direction to the valve (86, 286, 386, 486, 686), a spring receiver (92) which supports an end portion at the second end portion side of the first spring, and an adjustment portion (96) which adjusts a position of the spring receiver.
- (8) The adjustment unit (90) may further include a first transmission member (95) which is disposed between an end portion at the first end portion side of the first spring (91) and the valve (86, 286, 386, 486) and transmits a force of the first spring to the valve.
- (9) The second damping force generating portion (460, 560, 660) may include a first support member (288, 488) which is disposed inside the first transmission member (95) and supports a surface at the second end portion side of the valve (86, 286, 486, 686), and a second spring (463) which is supported by the first support member at the first end portion side and applies a force in a closing direction to the valve.
- (10) The adjustment portion (96) may include a contact member (99) which is disposed inside the rod (81) and comes into contact with a second transmission member (97) which transmits a force to the spring receiver (92) by an end portion at the first end portion side, and an operation portion (185) which can change a position of the contact member by a rotation operation.
- (11) The flow path (83c, 383c) may include a first flow path (83c) and a second flow path (383c) which is provided outward of the first flow path in a radial direction of the piston (83, 383). The valve (86, 386, 686) may include a first valve (86, 686) which opens and closes an opening portion at the second end portion side of the first flow path, and a second valve (386) which opens and closes an opening portion at the second end portion side of the second flow path. The adjustment unit (90) may adjust a force required to open the second valve.
- (12) The adjustment unit (90) may further include the first transmission member (95) which is disposed between the second valve (386) and an end portion at the first end portion side of the first spring (91), and which transmits a force of the first spring (91) to the second valve, the first spring applying a force in a closing direction to the second valve (386).
- (13) The second damping force generating portion (660) may include the first support member (488) which is disposed inside the first transmission member (95) and supports a surface at the second end portion side of the first valve (686), and the second spring (463) which is supported by the first support member at the first end portion side and applies a force in a closing direction to the first valve.
- (14) The adjustment unit (90) may include the contact member (99) which is disposed inside the rod (81) and comes into contact with a second transmission member (97) which transmits a force to a spring receiver which supports an end portion at the second end portion side of the first spring (91), and the operation portion (185) which can change a position of the contact member by a rotation operation.
- (15) According to another aspect of the present disclosure, there is provided a saddle-type vehicle (10). The saddle-type vehicle (10) includes a vehicle body (104), a front wheel (105) disposed at a front side of the vehicle body in a traveling direction, a rear wheel (106) disposed at a rear side in the traveling direction, a first shock absorber (1, 2, 3, 4, 5, 6) disposed between the vehicle body and the front wheel, and a second shock absorber (8) disposed between the vehicle body and the rear wheel. At least the first shock absorber is any one of the shock absorber (1, 2, 3, 4, 5, 6) described above.

Advantageous Effects of Invention

- (16) According to the present invention, it is possible to provide a shock absorber or the like which can adjust a damping force over a large moving speed range of a piston.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

- (1) FIG. 1 is a diagram illustrating an example of a schematic configuration of a saddle-type vehicle **10**.
- (2) FIG. 2 is a cross-sectional view illustrating an example of a schematic configuration of a shock absorber **1** according to a first embodiment.
- (3) FIG. 3 is an enlarged view illustrating a portion III in FIG. 2.
- (4) FIG. 4 is an enlarged view illustrating a portion IV in FIG. 2.
- (5) FIG. 5 is an enlarged view illustrating a portion V in FIG. 2.
- (6) FIG. 6 is a perspective view illustrating an example of a first transmission member **95**.
- (7) FIG. 7 is a diagram illustrating a relationship between a speed V_p of a piston **83** and a damping force during a compression side stroke.
- (8) FIG. 8 is a cross-sectional view illustrating an example of a schematic configuration of a shock absorber **2** according to a second embodiment.
- (9) FIG. 9 is a cross-sectional view illustrating an example of a schematic configuration of a shock absorber **3** according to a third embodiment.
- (10) FIG. 10 is a cross-sectional view illustrating an example of a schematic configuration of a shock absorber **4** according to a fourth embodiment.
- (11) FIG. 11 is a cross-sectional view illustrating an example of a schematic configuration of a shock absorber **5** according to a fifth embodiment.
- (12) FIG. 12 is a cross-sectional view illustrating an example of a schematic configuration of a shock absorber **6** according to a sixth embodiment.

DETAILED DESCRIPTION OF THE INVENTION

(13) Hereinafter, embodiments will be described in detail with reference to the accompanying drawings. The present invention is not limited to the following embodiments.

First Embodiment

- (14) FIG. 1 is a diagram illustrating an example of a schematic configuration of a saddle-type vehicle **10**.
- (15) The saddle-type vehicle **10** includes a vehicle body **104**, a front wheel **105** disposed at a front side of the vehicle body **104** in a traveling direction, and a rear wheel **106** disposed at a rear side of the vehicle body **104** in the traveling direction. The vehicle body **104** includes a vehicle body frame **104a**, a handle **104b**, and a seat **104c** which form a framework of the saddle-type vehicle **10**.
- (16) The saddle-type vehicle **10** includes a first shock absorber **1** disposed between the vehicle body **104** and the front wheel **105**, and a second shock absorber **8** disposed between the vehicle body **104** and the rear wheel **106**. In the following description, the first shock absorber **1** may be simply referred to as a “shock absorber **1**”.
- (17) FIG. 2 is a cross-sectional view illustrating an example of a schematic configuration of the shock absorber **1** according to a first embodiment.
- (18) FIG. 3 is an enlarged view illustrating a portion III in FIG. 2.
- (19) FIG. 4 is an enlarged view illustrating a portion IV in FIG. 2.
- (20) FIG. 5 is an enlarged view illustrating a portion V in FIG. 2.
- (21) FIG. 6 is a perspective view illustrating an example of a first transmission member **95**.
- (22) The shock absorber **1** according to the first embodiment is an inverted front fork provided between a front wheel and a handle provided on a vehicle body of a saddle-type vehicle such as a motorcycle, and the shock absorber **1** is a device which buffers an impact or vibration input from a front wheel and transmits steering of the handle to the front wheel.
- (23) The shock absorber **1** includes an outer cylinder portion **20A** and an axle bracket portion **40A**. The outer cylinder portion **20A** and the axle bracket portion **40A** may be the same as the outer cylinder portion **20A** and the axle bracket portion **40A** disclosed in JP-A-2017-172739. The shock absorber **1** further includes a coil spring **30** which absorbs an impact input from the front wheel,

and a damper portion **100** corresponding to a damper portion provided in a first front fork disclosed in JP-A-2017-172739.

(24) Hereinafter, the damper portion **100** will be described in detail. In the following description, members and portions of the shock absorber **1** which have the same shape and function as the first front fork disclosed in JP-A-2017-172739 are denoted by the same reference numerals, and detailed description thereof will be omitted.

(25) (Outer Cylinder Portion **20A**)

(26) The outer cylinder portion **20A** includes an outer tube portion **110**, an inner tube portion **120**, and a fork bolt portion **130**.

(27) The outer tube portion **110** includes an outer tube **111**, a bush **112**, and a seal member **113**.

(28) The inner tube portion **120** includes an inner tube **121** and a bottom piece **122**.

(29) The outer tube **111** is positioned at a vehicle body side, and the inner tube **121** is positioned at a front wheel side. The outer tube **111** is disposed coaxially with the inner tube **121** and is disposed outside the inner tube **121** in a radial direction.

(30) In the following description, a center line direction of the outer tube **111** may be referred to as an “axial direction”. Relative to the axial direction, an upper side in FIG. **2** which is a first end portion side corresponding to an upper end may be referred to as one side, and a lower side in FIG. **2** which is a second end portion side corresponding to a lower end may be referred to as the other side. Further, an inner side in a radial direction from a center line of the outer tube **111** may be referred to as an “inner side” and an outer side in the radial direction from the center line of the outer tube **111** may be referred to as an “outer side”.

(31) The bottom piece **122** has a cylindrical first portion **122a** and a cylindrical second portion **122b** provided at the other side of the first portion **122a**. An outer diameter of the first portion **122a** is smaller than an inner diameter of the coil spring **30**. The first portion **122a** is disposed inside the coil spring **30** and guides the coil spring **30** to extend and contract. The second portion **122b** is interposed between a bracket **140** of the axle bracket portion **40A** and the inner tube **121** in the axial direction. The bracket **140** will be described later. An end portion at the one side of the second portion **122b** supports an end portion at the other side of the coil spring **30** via a washer.

(32) The fork bolt portion **130** includes a fork bolt **131** and a cylinder holding portion **132**. The fork bolt **131** closes an end portion side at the one side of the cylinder holding portion **132**. The cylinder holding portion **132** has a cylindrical shape and is inserted into an inner circumference of the outer tube **111**. The cylinder holding portion **132** is formed with a through hole **132K** which passes through the cylinder holding portion **132** in the radial direction.

(33) (Axle Bracket Portion **40A**)

(34) The axle bracket portion **40A** includes the bracket **140** which is provided with a tube holding portion **141**, an axle coupling portion **142**, and a rod holding portion **143**.

(35) The tube holding portion **141** is formed at the bracket **140** and is provided with a recessed portion **141a** in the axial direction. An end portion at the other side of the inner tube **121** is inserted into the recessed portion **141a**. The recessed portion **141a** is formed with a female screw which is tightened to a male screw formed at the end portion at the other side of the inner tube **121**.

(36) The axle coupling portion **142** is formed at the bracket **140** and is provided with an axle hole **142H** in a direction orthogonal to the axial direction. An axle of the front wheel is inserted into the axle hole **142H**. The axle coupling portion **142** holds the axle by tightening the axle of the front wheel inserted into the axle hole **142H** with a bolt.

(37) The rod holding portion **143** is provided with a holding nut **144** and a locking nut **145**. The holding nut **144** holds a rod member **81** to be described later in an axial through hole **143a** which is formed at the bracket **140** and allows an inner side of the recessed portion **141a** and an outer side of the rod holding portion **143** to communicate with each other.

(38) The holding nut **144** has a first portion **144a**, a second portion **144b**, and a third portion **144c** in this order from the one side to the other side. The first portion **144a**, the second portion **144b**,

and the third portion **144c** are three cylindrical portions having different inner diameters. An inner circumferential surface of the first portion **144a** is formed with a female screw which engages with a male screw formed at an end portion at the other side of the rod member **81**. The rod member **81** is tightened to the first portion **144a** and then is fixed to the holding nut **144** by the locking nut **145**. An inner diameter of the second portion **144b** is smaller than an inner diameter of the first portion **144a**, and an end surface at the one side of the second portion **144b** prevents the rod member **81** from moving to the other side. A first adjusting nut **181**, a second adjusting nut **186**, and the like which will be described later are accommodated in the third portion **144c**.

(39) The axle bracket portion **40A** includes a closing member **146** which closes an opening portion at the other side of the third portion **144c** of the holding nut **144**. The closing member **146** includes a cylindrical first portion **146a** and a disk-shaped second portion **146b** provided at the other side of the first portion **146a**. An end portion at the one side of the first portion **146a** is formed with a male screw which engages with a female screw formed at the bracket **140**. The first portion **146a** has a seal ring fitted into a groove recessed from an outer circumferential surface of the first portion **146a**, and the seal ring seals a gap between the first portion **146a** and an inner circumferential surface of the bracket **140**. The second portion **146b** is formed with a through hole **146c** through which a first adjuster **182** passes and an axial through hole **146d** through which a second adjuster **187** passes.

(40) (Damper Portion **100**)

(41) The damper portion **100** includes a cylinder **151**, a sub valve device **190** mounted to an end portion at the one side of the cylinder **151**, and a main valve device **60** disposed to be movable in the cylinder **151** in the axial direction.

(42) The cylinder **151** is a cylindrical member and is disposed inside the outer tube **111** and the inner tube **121**. The cylinder **151** is inserted into an inner circumference of the cylinder holding portion **132**, and the cylinder holding portion **132** holds the cylinder **151** by tightening the cylinder **151** with a female screw formed at the cylinder holding portion **132**.

(43) A gas chamber **T1** filled with air and an oil chamber **T2** filled with oil are provided between the outer tube **111** and the cylinder **151** and between the inner tube **121** and the cylinder **151**. The air in the gas chamber **T1** and the oil in the oil chamber **T2** comes into contact with each other via a free interface.

(44) The cylinder **151** is provided with a support member **151a** at an outer side, and the support member **151a** supports an end portion at the one side of the coil spring **30**.

(45) [Sub Valve Device **190**]

(46) The sub valve device **190** includes a rod member **191**, a sub bolt **195** mounted to an end portion at the other side of the rod member **191**, and a piston **192** mounted to an end portion at the other side of the sub bolt **195**. The sub valve device **190** includes a pressurizing spring **193**, a free piston **194**, and a nut **196**.

(47) The rod member **191** is a cylindrical member extending along the axial direction. An end portion at the one side of the rod member **191** is tightened to the fork bolt **131** in a state in which the end portion at the one side of the rod member **191** is inserted into an inner circumference of the fork bolt **131**.

(48) The sub bolt **195** has a first portion **195a**, a second portion **195b**, and a third portion **195c** in this order from the one side to the other side. The first portion **195a**, the second portion **195b**, and the third portion **195c** are three cylindrical portions having different inner diameters and outer diameters.

(49) An inner circumferential surface of the first portion **195a** is formed with a female screw which engages with a male screw formed at an end portion at the other side of the rod member **191**.

(50) An inner diameter of the second portion **195b** is smaller than an inner diameter of the first portion **195a**, and prevents the rod member **191** from moving to the other side. A plurality of through holes **195d** which pass through the second portion **195b** in the radial direction are formed

in the second portion **195b** in the circumferential direction.

(51) An inner diameter of the third portion **195c** is smaller than an inner diameter of the second portion **195b**. An end portion at the other side of the third portion **195c** is formed with a male screw which engages with a female screw formed at the nut **196**.

(52) The piston **192** is held at an end portion at the other side of the rod member **191**, and the piston **192** partitions an oil chamber **T4** and an oil chamber **T5**.

(53) The piston **192** is provided with a flow path **192PR** and a flow path **192NR** which allow the oil chamber **T4** and the oil chamber **T5** to communicate with each other. The piston **192** is provided with a valve **192PB** which opens and closes the flow path **192PR**, and a valve **192NB** which opens and closes the flow path **192NR**.

(54) The piston **192** is interposed between the second portion **195b** and the nut **196** by tightening the nut **196** to a male screw formed at an end portion at the other side of the sub bolt **195**. An internal flow path **195r** is formed inside the through holes **195d**, and oil flows in the internal flow path **195r** between the oil chamber **T4** and the oil chamber **T5** inside the second portion **195b** and the third portion **195c**.

(55) The pressurizing spring **193** is a coil spring which applies a spring force to the free piston **194** toward the piston **192**.

(56) The free piston **194** includes a bottom portion **194A**, a tubular portion **194B**, and an outer circumferential skirt portion **194C**. The free piston **194** slides on an inner diameter portion of the cylinder **151** in a liquid-tight manner. Accordingly, the free piston **194** partitions the oil chamber **T5** which communicates with the oil chamber **T4** at the piston **192** side and a gas chamber (volume compensation chamber) **T6** behind the free piston **194**.

(57) The sub valve device **190** includes an adjustment member **197** which adjusts a flow path area of the internal flow path **195r**, and an adjuster **198** which is operated to adjust a position of the adjustment member **197**.

(58) The adjustment member **197** includes a tip end portion **197a** which has a conical shape and is provided at an end portion at the other side of the adjustment member **197**, and a columnar portion **197b** which has a columnar shape and is provided at the one side relative to the tip end portion **197a**. The adjustment member **197** is disposed in a manner in which the columnar portion **197b** is disposed inside the hollow rod member **191**, and an end portion at the other side of the tip end portion **197a** is exposed from an end surface at the other side of the rod member **191**. The adjustment member **197** is provided with a seal ring that is fitted into a groove recessed from an outer circumferential surface of the columnar portion **197b**, and the seal ring seals a gap between the outer circumferential surface of the columnar portion **197b** and an inner circumferential surface of the rod member **191**. An end portion at the other side of the tip end portion **197a** is inserted into the second portion **195b**, and a gap between an outer circumferential surface of the tip end portion **197a** and an inner circumferential surface of the third portion **195c** serves as a throttle in the internal flow path **195r**.

(59) The adjuster **198** is inserted into the fork bolt **131**, and a male screw formed at an end portion at the other side of the adjuster **198** is tightened to a female screw formed at an end portion at the one side of the columnar portion **197b**. When the adjuster **198** is rotated from an outer side of the fork bolt **131**, the adjustment member **197** moves in the axial direction. For example, in a case where screws which engage the adjuster **198** with the adjustment member **197** are left-handed screws, when the adjuster **198** is rotated clockwise, the adjustment member **197** moves to the other side. Then, the tip end portion **197a** of the adjustment member **197** moves to the other side, a gap between an outer circumferential surface of the tip end portion **197a** and an inner circumferential surface of the third portion **195c** is narrowed, and the throttle in the internal flow path **195r** is increased. On the other hand, when the adjuster **198** is rotated counterclockwise, the adjustment member **197** moves to the one side. Then, the tip end portion **197a** moves to the one side, and the throttle in the internal flow path **195r** is reduced.

(60) [Main Valve Device **60**]

(61) The main valve device **60** includes a lower cylinder portion **170** and a rod portion **80**.

(62) The lower cylinder portion **170** is the same as the lower cylinder portion **170** disclosed in JP-A-2017-172739. As illustrated in FIG. **2**, the lower cylinder portion **170** includes a rod guide **171**, an oil lock collar **172**, a bush **173**, a rebound spring **174**, and a spring receiver **175**.

(63) The rod guide **171** is positioned at an end portion at the other side of the cylinder **151**, and is fixed to an end portion of the cylinder **151**. The rod guide **171** is provided in a manner in which the rod member **81** to be described later passes through a through hole **176**, and supports the rod member **81** so that the rod member **81** can slide in the axial direction.

(64) The rod guide **171** partitions the oil chamber T2 and the oil chamber T3.

(65) Hereinafter, the rod portion **80** will be described in detail.

(66) The rod portion **80** includes the rod member **81**, a main bolt **82** mounted to an end portion at the one side of the rod member **81**, a piston **83** mounted to an end portion at the one side of the main bolt **82**, and a nut **84** tightened to the main bolt **82**. The rod portion **80** further includes a valve **85** which generates a damping force at an extension side, a first valve **86** which generates a damping force at a compression side, a support member **87** which supports an end surface at the one side of the valve **85**, and a support member **88** which supports an end surface at the other side of the first valve **86**. The rod portion **80** further includes a first adjustment unit **70** which adjusts a flow path area of an internal flow path **82r** which will be described later and is formed in the main bolt **82**, and a second adjustment unit **90** which adjusts a force required to open the first valve **86**.

(67) The rod member **81** is a cylindrical member which is fixed to the axle bracket portion **40A** and extends along the axial direction. An end portion at the other side of the rod member **81** is formed with a male screw which engages with female screws formed at the holding nut **144** and the locking nut **145** of the axle bracket portion **40A**. Radial communication holes **81a** which allow an inner side and an outer side of the rod member **81** to communicate with each other are formed in the rod member **81** at every 180 degrees in the circumferential direction.

(68) The main bolt **82** is provided with a first portion **82a**, a second portion **82b**, a third portion **82c**, and a fourth portion **82d** in this order from the one side to the other side. The first portion **82a**, the second portion **82b**, the third portion **82c**, and the fourth portion **82d** are four cylindrical portions having different inner diameters and outer diameters.

(69) An end portion at the one side of the first portion **82a** is formed with a male screw which engages with a female screw formed at the nut **84**.

(70) An inner diameter of the second portion **82b** is the same as an inner diameter of the first portion **82a**, and an outer diameter of the second portion **82b** is larger than an outer diameter of the first portion **82a**.

(71) An inner diameter of the third portion **82c** is larger than an inner diameter of the second portion **82b** and is smaller than an outer diameter of the second portion **82b**. An outer diameter of the third portion **82c** is larger than an outer diameter of the second portion **82b**. A plurality of through holes **82e** which pass through the third portion **82c** in the radial direction are formed in the third portion **82c** in the circumferential direction.

(72) An inner diameter of the fourth portion **82d** is larger than an inner diameter of the third portion **82c** and is smaller than an outer diameter of the third portion **82c**. An outer diameter of the fourth portion **82d** is smaller than an outer diameter of the third portion **82c**. An inner circumferential surface of the fourth portion **82d** is formed with a male screw which engages with a female screw formed at an end portion at the one side of the rod member **81**.

(73) The main bolt **82** is mounted to the rod member **81** by being tightened to the end portion at the one side of the rod member **81** via a washer **82f**. The main bolt **82** is provided with the internal flow path **82r** which allows the oil chamber T3 and the oil chamber T4 to communicate with each other through an inner side of the first portion **82a**, an inner side of the second portion **82b**, and the through holes **82e** of the third portion **82c**.

(74) The piston **83** is formed with a central hole **83a** in a central portion of the piston **83**, and the first portion **82a** of the main bolt **82** passes through the central hole **83e**. The piston **83** is provided with a flow path **83b** at a position outside the central hole **83a**. The flow path **83b** is formed with a through hole which passes through the piston **83** in the axial direction and is formed, from an end portion at the other side of the through hole, with a through hole which passes through the piston **83** in the radial direction. The piston **83** is provided with a first flow path **83c** at a position outside the central hole **83a**. The first flow path **83c** is formed with a through hole which passes through the piston **83** in the axial direction and is formed, from an end portion at the one side of the through hole, with a through hole which passes through the piston **83** in the radial direction.

(75) The valve **85** is formed by stacking a plurality of disk valves, is disposed on an end surface at the one side of the piston **83**, and closes an opening portion at the one side of the flow path **83b**.

(76) The first valve **86** is formed by stacking a plurality of disk valves, is disposed on an end surface at the other side of the piston **83**, and closes an opening portion at the other side of the first flow path **83c**. An outer diameter of each disk valve is set as follows. That is, an outer diameter of a disk valve disposed closest to the one side is the largest, an outer diameter of a disk valve disposed in a central portion in a stacking direction is the smallest, and outer diameters are gradually reduced from the one side toward the central portion in the stacking direction. Outer diameters of the disk valves are gradually increased from the central portion in the stacking direction toward the other side.

(77) The support member **87** is an annular member in which a central hole **87a** is formed in a central portion of the support member **87**. A diameter of the central hole **87a** is larger than an outer diameter of the first portion **82a** of the main bolt **82**. The support member **87** is disposed to surround the main bolt **82** at the one side of the valve **85**.

(78) The support member **88** includes a central hole **88a** formed in a central portion of the support member **88**, a base portion **88b** having an annular shape, and a tubular portion **88c** having a cylindrical shape. A diameter of the central hole **88a** is larger than an outer diameter of the first portion **82a** of the main bolt **82** and is smaller than an outer diameter of the second portion **82b**. An outer diameter of the base portion **88b** is equal to or smaller than an outer diameter of an end surface at the other side of the first valve **86**. An outer diameter of the tubular portion **88c** is equal to or larger than an outer diameter of the second portion **82b** of the main bolt **82** and is smaller than the outer diameter of the base portion **88b**. The support member **88** is disposed to surround the circumference of the main bolt **82** at the other side of the first valve **86**.

(79) The support member **87**, the valve **85**, the piston **83**, the first valve **86**, and the support member **88** are interposed between the second portion **82b** of the main bolt **82** and the nut **84** in a state in which the support member **87**, the valve **85**, the piston **83**, the first valve **86**, and the support member **88** are in contact with members adjacent to one another.

(80) [First Adjustment Unit **70**]

(81) The first adjustment unit **70** includes an adjustment member **71** which adjusts a flow path area of the internal flow path **82r** of the main bolt **82**, a spring **72** which is a coil spring applying a force to the adjustment member **71** in a direction in which the adjustment member **71** moves to the other side, and an adjustment portion **73** which adjusts a position of the adjustment member **71**.

(82) The adjustment member **71** includes a tip end portion **71a** which has a conical shape and is provided at an end portion at the one side of the adjustment member **71**, and a columnar portion **71b** which has a columnar shape and is provided at the other side relative to the tip end portion **71a**. A protruding portion **71c** is provided at a central portion in the axial direction of the columnar portion **71b**, and the protruding portion **71c** protrudes from an outer circumferential surface of the columnar portion **71b** over the entire circumference and supports an end portion at the other side of the spring **72**. An end portion at the one side of the tip end portion **71a** of the adjustment member **71** is inserted into the second portion **82b** of the main bolt **82**. A gap between an outer circumferential surface of the tip end portion **71a** and an inner circumferential surface of the

second portion **82b** serves as a throttle in the internal flow path **82r**.

(83) The spring **72** is disposed inside the rod member **81** in the radial direction to surround the columnar portion **71b** of the adjustment member **71**, and is disposed between the protruding portion **71c** of the adjustment member **71** and the washer **82f** in the axial direction.

(84) The adjustment portion **73** includes an application member **74** which applies a force to the adjustment member **71** in a direction in which the adjustment member **71** moves to one side, and a first operation portion **180** which can change a position of the adjustment member **71** by a rotation operation.

(85) The application member **74** is a columnar member, and is provided with a protruding portion **74a** which protrudes from an outer circumferential surface of the application member **74** over the entire circumference. The application member **74** is provided with a seal ring **74b** fitted into a groove recessed from the outer circumferential surface of the protruding portion **74a**.

(86) [Second Adjustment Unit **90**]

(87) The second adjustment unit **90** includes a first spring **91** which is a coil spring applying a force in a closing direction to the first valve **86**, and a spring receiver **92** which supports an end portion at the other side of the first spring **91**. The second adjustment unit **90** includes a first transmission member **95** which supports one end portion at the one side of the first spring **91** and transmits a spring force of the first spring **91** to the first valve **86**, and a second adjustment portion **96** which adjusts a position of the spring receiver **92**.

(88) The spring receiver **92** is a member in which a central hole **92a** is formed in a central portion of the spring receiver **92**. A diameter of the central hole **92a** is larger than an outer diameter of the rod member **81**, and the spring receiver **92** is disposed to surround the rod member **81**.

(89) The spring receiver **92** includes a support portion **92b** which supports an end portion at the other side of the first spring **91**, a receiving portion **92c** which receives a force transmitted via a second transmission member **97** to be described later, and a connection portion **92d** which connects the support portion **92b** and the receiving portion **92c**.

(90) The support portion **92b** is an annular portion. A surface at the one side of the support portion **92b** is formed to such a shape in which an inner diameter of the surface is smaller than an inner diameter of the first spring **91** and an outer diameter of the surface is larger than an outer diameter of the first spring **91**. The surface at the one side of the support portion **92b** is in contact with the first spring **91**.

(91) The receiving portion **92c** is an annular portion provided inward of the support portion **92b** and provided at the one side.

(92) The connection portion **92d** is a cylindrical portion having an inner diameter and an outer diameter which gradually increase from the one side toward the other side. The connection portion **92d** prevents a radial movement of the first spring **91** disposed to surround the connection portion **92d**, and prevents a radial movement of the second transmission member **97** disposed inside the connection portion **92d**.

(93) The first transmission member **95** includes a cylindrical first portion **95a**, a cylindrical second portion **95b** which is provided on inward of the first portion **95a** and provided at the other side of the first portion **95a**, and a connection portion **95c** which connects the first portion **95a** and the second portion **95b**.

(94) An end portion at the one side of the first portion **95a** is in contact with an outermost diameter portion of the first valve **86**, and applies a spring force of the first spring **91** to the first valve **86**. A plurality of radial through holes are formed in the first portion **95a** in the circumferential direction. An inner diameter of the first portion **95a** is larger than an outer diameter of the base portion **88b** of the support member **88**, and the first portion **95a** is disposed to surround the support member **88**.

(95) An inner diameter of the second portion **95b** is equal to or larger than an outer diameter of the fourth portion **82d** of the main bolt **82**, and is smaller than an outer diameter of the third portion **82c**. An outer diameter of the second portion **95b** is smaller than an inner diameter of the first

spring **91**. In the axial direction, the second portion **95b** is disposed at the other side of the third portion **82c** of the main bolt **82**. In the radial direction, the second portion **95b** is disposed outward of the fourth portion **82d** of the main bolt **82** and inward of the first spring **91**.

(96) As illustrated in FIG. 6, a plurality of connection portions **95c** are provided in the circumferential direction. The connection portion **95c** has an orthogonal surface **95d** orthogonal to the axial direction. The orthogonal surface **95d** supports an end portion at the one side of the first spring **91**.

(97) The second adjustment portion **96** includes a second transmission member **97** which transmits a force to the spring receiver **92**, and a washer **98** which is disposed between the second transmission member **97** and the spring receiver **92**. The second adjustment portion **96** further includes a contact member **99** which comes into contact with the second transmission member **97**, and a second operation portion **185** which can change a position of the spring receiver **92** by a rotation operation.

(98) The second transmission member **97** is an annular member in which a central hole **97a** is formed in a central portion of the second transmission member **97**. An outer diameter of the second transmission member **97** is larger than an outer diameter of the application member **74**. The second transmission member **97** communicates with two communication holes **81a** of the rod member **81**.

(99) The washer **98** is an annular member in which a central hole **98a** is formed in a central portion of the washer **98**. A diameter of the central hole **98a** is larger than an outer diameter of the rod member **81**, and the washer **98** is disposed to surround the rod member **81**. The washer **98** is disposed inside the connection portion **92d**.

(100) The contact member **99** includes a first portion **99a**, a second portion **99b**, and a third portion **99c** in this order from the one side to the other side. The first portion **99a**, the second portion **99b**, and the third portion **99c** are three cylindrical portions having different inner diameters and outer diameters. The inner diameters of the first portion **99a**, the second portion **99b**, and the third portion **99c** are larger than an outer diameter of the application member **74**, and the contact member **99** is disposed inside the rod member **81** to surround the application member **74**.

(101) The inner diameter of the second portion **99b** is larger than an outer diameter of the protruding portion **74a** of the application member **74**, and the protruding portion **74a** is inserted into the second portion **99b**. The seal ring **74b** fitted into a groove recessed from the outer circumferential surface of the protruding portion **74a** seals the gap between the contact member **99** and the application member **74**.

(102) The inner diameter of the third portion **99c** is smaller than the outer diameter of the protruding portion **74a** of the application member **74**, and prevents the protruding portion **74a** from moving to the other side.

(103) [First Operation Portion **180** and Second Operation Portion **185**]

(104) The first operation portion **180** includes a first adjusting nut **181** which applies a force to the application member **74** in a direction of the one side, a first adjuster **182** which engages with a female screw formed at the first adjusting nut **181** and moves the first adjusting nut **181** in the axial direction, and a seal ring **183** which seals a gap between the first adjuster **182** and the closing member **146**.

(105) The second operation portion **185** includes a second adjusting nut **186** which applies a force to the contact member **99** in the direction of the one side, a second adjuster **187** which engages with a female screw formed at the second adjusting nut **186** and moves the second adjusting nut **186** in the axial direction, and a seal ring **188** which seals a gap between the second adjuster **187** and the closing member **146**.

(106) The first adjusting nut **181** is formed with a female screw which engages with a male screw of the first adjuster **182**, and a through hole through which the second adjuster **187** passes. Then, an end surface at the one side of the first adjusting nut **181** comes into contact with an end face at the other side of the application member **74**, and applies a force to the application member **74** in the

direction of the one side.

(107) The first adjuster **182** has a plurality of columnar portions which are arranged in the axial direction and have different outer diameters. More specifically, the first adjuster **182** includes a first portion **182a** provided at an end portion at the other side, and a second portion **182b** which is provided at the one side of the first portion **182a** and has an outer diameter larger than an outer diameter of the first portion **182a**. The first adjuster **182** includes a third portion **182c** provided at the one side of the second portion **182b** and having an outer diameter smaller than the outer diameter of the second portion **182b**, and a fourth portion **182d** provided at the one side of the third portion **182c** and having an outer diameter smaller than the outer diameter of the third portion **182c**.

(108) A seal ring **183** is fitted into a groove recessed from an outer circumferential surface of the first portion **182a**. An end surface at the other side of the first portion **182a** is formed with a recessed portion **182e** which is recessed from the end surface to the one side.

(109) An outer diameter of the second portion **182b** is larger than a hole diameter of a female screw formed at the first adjusting nut **181**.

(110) An outer circumferential surface of the third portion **182c** is formed with a male screw which engages with the female screw formed at the first adjusting nut **181**.

(111) The fourth portion **182d** passes through a through hole formed in the second adjusting nut **186**.

(112) The second adjusting nut **186** is formed with a female screw which engages with a male screw of the second adjuster **187** and a through hole through which the first adjuster **182** passes. An end surface at the one side of the second adjusting nut **186** comes into contact with an end face at the other side of the contact member **99**, and applies a force in the direction of the one side to the contact member **99**.

(113) The second adjuster **187** has a plurality of columnar portions which are arranged in the axial direction and have different outer diameters. More specifically, the second adjuster **187** includes a first portion **187a** provided at an end portion at the other side, and a second portion **187b** which is provided at the one side of the first portion **187a** and has an outer diameter larger than an outer diameter of the first portion **187a**. The second adjuster **187** includes a third portion **187c** provided at the one side of the second portion **187b** and having an outer diameter smaller than the outer diameter of the second portion **187b**, and a fourth portion **187d** provided at the one side of the third portion **187c** and having an outer diameter smaller than the outer diameter of the third portion **187c**.

(114) A seal ring **188** is fitted into a groove recessed from an outer circumferential surface of the first portion **187a**. An end surface at the other side of the first portion **187a** is formed with a recessed portion **187e** which is recessed from the end surface to the one side.

(115) An outer diameter of the second portion **187b** is larger than the hole diameter of the through hole formed in the first adjusting nut **181**.

(116) The third portion **187c** passes through a through hole formed in the first adjusting nut **181**.

(117) The fourth portion **187d** is formed with a male screw which engages with a female screw formed at the second adjusting nut **186**.

(118) [Function of First Adjustment Unit **70**]

(119) In the first adjustment unit **70**, the first adjuster **182** of the first operation portion **180** is rotated from an outer side of the bracket **140**. Then, the through hole of the first adjusting nut **181** and the third portion **187c** of the second adjuster **187** are fitted to each other, so that the first adjusting nut **181** which engages with the first adjuster **182** is prevented from rotating, and the first adjusting nut **181** moves in the axial direction. Accordingly, the application member **74** moves in the axial direction. For example, in a case where screws which engage the first adjuster **182** with the first adjusting nut **181** are left-handed screws, when the first adjuster **182** is rotated clockwise, the application member **74** moves to the one side. Then, the tip end portion **71a** of the adjustment

member **71** moves to the one side, and a gap between an outer circumferential surface of the tip end portion **71a** and an inner circumferential surface of the second portion **82b** of the main bolt **82** is narrowed. As a result, the throttle in the internal flow path **82r** is increased. On the other hand, when the first adjuster **182** is rotated counterclockwise, the application member **74** moves to the other side. Then, the tip end portion **71a** of the adjustment member **71** moves to the other side, and the throttle in the internal flow path **82r** is reduced.

(120) [Function of Second Adjustment Unit **90**]

(121) In the second adjustment unit **90**, the second adjuster **187** of the second operation portion **185** is rotated from an outer side of the bracket **140**. Then, the through hole of the second adjusting nut **186** and the fourth portion **182d** of the first adjuster **182** are fitted to each other, so that the second adjusting nut **186** which engages with the second adjuster **187** is prevented from rotating, and the second adjusting nut **186** moves in the axial direction. Accordingly, the contact member **99** moves in the axial direction. For example, in a case where screws which engage the second adjuster **187** with the second adjusting nut **186** are left-handed screws, when the second adjuster **187** is rotated clockwise, the contact member **99** moves to the one side. As the contact member **99** moves to the one side, the second transmission member **97** moves to the one side, and the spring receiver **92** moves to the one side. As a result, a length of the first spring **91** is shortened, and a preset load **F2** which is a preset load of the first spring **91** is increased. On the other hand, when the second adjuster **187** is rotated counterclockwise, the contact member **99** and the second transmission member **97** move to the other side, and the spring receiver **92** moves to the other side. As a result, the length of the first spring **91** is increased, and the preset load **F2** is reduced.

(122) In the damper portion **100** having the above-described configuration, even when a preset load **F2** has a minimum value, a pressure at which the first valve **86** is opened is set to be higher than a pressure at which the valve **192PB** is opened. For example, when the preset load **F2** has the minimum value, the valve **192PB** opens the flow path **192PR** when a pressure **Ps** of the oil chamber **T4** is equal to or higher than a first pressure **P1** determined according to bending rigidity of the valve **192PB**. The first valve **86** opens the first flow path **83c** when the pressure **Ps** is equal to or higher than a second pressure **P2** (>the first pressure **P1**) determined according to the preset load **F2**.

(123) [Function of Shock Absorber **1**]

(124) <Extension Side Stroke>

(125) In an extension side stroke in which the piston **83** moves to a front wheel side in the cylinder **151** due to an upward and downward movement of the front wheel, the outer tube **111** and the inner tube **121** move in a direction in which the outer tube **111** and the inner tube **121** are relatively separated from each other in the axial direction. At this time, the piston **83** and the lower cylinder portion **170** move in a direction in which the piston **83** and the lower cylinder portion **170** relatively come close to each other in the axial direction. The piston **83** and the piston **192** move in a direction in which the piston **83** and the piston **192** are relatively separated from each other in the axial direction.

(126) As the piston **83** and the lower cylinder portion **170** come close to each other, a volume of the oil chamber **T3** is reduced. On the other hand, as the piston **83** and the piston **192** are separated from each other, a volume of the oil chamber **T4** is increased. As a result, the oil in the oil chamber **T3** passes through the flow path **83b**, opens the valve **85**, and moves to the oil chamber **T4**. When the oil push-opens the valve **85** and passes through the valve **85**, a damping force is generated.

(127) At this time, the rod member **81** is retracted from the oil chamber **T3**. Therefore, the oil at an amount corresponding to a volume of the rod member **81** retracted from the oil chamber **T3** moves from the oil chamber **T5** to the oil chamber **T4**. In this case, the oil in the oil chamber **T5** opens the valve **192NB**, passes through the flow path **192NR**, and moves to the oil chamber **T4**. When the oil push-opens the valve **192NB** and passes through the valve **192NB**, a damping force is generated.

(128) When the oil moves to the oil chamber **T4**, the free piston **194** moves to the other side in the

axial direction. As a result, a volume of the gas chamber T6 is increased. The gas at an amount corresponding to the increased volume of the gas chamber T6 passes through the through hole 132K and moves from the gas chamber T1 to the gas chamber T6.

(129) (Compression Side Stroke)

(130) In a compression side stroke in which the piston 83 moves to a vehicle body side in the cylinder 151, the outer tube 111 and the inner tube 121 move in a direction in which the outer tube 111 and the inner tube 121 relatively come close to each other in the axial direction. At this time, the piston 83 and the lower cylinder portion 170 move in a direction in which the piston 83 and the lower cylinder portion 170 are relatively separated from each other in the axial direction. The piston 83 and the piston 192 move in a direction in which the piston 83 and the piston 192 relatively come close to each other in the axial direction.

(131) As the piston 83 and the lower cylinder portion 170 are separated from each other, the volume of the oil chamber T3 is increased. On the other hand, as the piston 83 and the piston 192 come close to each other, the volume of the oil chamber T4 is reduced. Accordingly, the oil in the oil chamber T4 passes through the internal flow path 82r of the main bolt 82 and moves to the oil chamber T3. When the oil passes through a gap between an outer circumferential surface of the tip end portion 71a of the adjustment member 71 and an inner circumferential surface of the second portion 82b and the gap serves as a throttle of the internal flow path 82r, a damping force is generated. The damping force generated at this time can be adjusted by operating the first adjuster 182.

(132) At this time, the rod member 81 enters the oil chamber T3. Therefore, the oil at an amount corresponding to the volume of the rod member 81 entering the oil chamber T3 moves from the oil chamber T4 to the oil chamber T5. In this case, the oil in the oil chamber T4 passes through the internal flow path 195r of the sub bolt 195 and moves to the oil chamber T5. When the oil passes through a gap between an outer circumferential surface of the tip end portion 197a of the adjustment member 197 and an inner circumferential surface of the third portion 195c and the gap serves as a throttle of the internal flow path 195r, a damping force is generated. The damping force generated at this time can be adjusted by operating the adjuster 198.

(133) When the oil moves to the oil chamber T5, the free piston 194 moves to the one side in the axial direction. As a result, a volume of the gas chamber T6 is reduced. The gas at an amount corresponding to the reduced volume of the gas chamber T6 passes through the through hole 132K and moves from the gas chamber T6 to the gas chamber T1.

(134) When the pressure Ps in the oil chamber T4 is equal to or higher than the first pressure P1, the oil in the oil chamber T4 opens the valve 192PB and moves to the oil chamber T5 through the flow path 192PR. When the oil push-opens the valve 192PB and passes through the valve 192PB, a damping force is generated.

(135) When the pressure Ps in the oil chamber T4 is equal to or higher than the second pressure P2, the oil in the oil chamber T4 opens the first valve 86 and moves to the oil chamber T3 through the first flow path 83c. When the oil push-opens the first valve 86 and passes through the first valve 86, a damping force is generated.

(136) FIG. 7 is a diagram illustrating a relationship between a speed Vp of the piston 83 and a damping force during a compression side stroke. In FIG. 7, a damping force D of the shock absorber 1 according to the first embodiment is indicated by a solid line. A damping force D1 of a configuration (hereinafter, may be referred to as a “first comparative configuration”) in which the first valve 86 is not opened as compared with the shock absorber 1 is indicated by a dashed line. A damping force D2 of a configuration (hereinafter, may be referred to as a “second comparative configuration”) in which the valve 192PB and the first valve 86 are not opened as compared with the shock absorber 1 is indicated by a two-dot chain line.

(137) In the second comparative configuration, a damping force corresponding to the speed Vp is generated at throttles of the internal flow path 82r and the internal flow path 195r. Therefore, the

damping force **D2** is increased as the speed V_p increases in the second comparative configuration. (138) In the shock absorber **1** and the first comparative configuration, since the valve **192PB** is opened, the damping force **D** and the damping force **D1** are smaller than the damping force **D2** at a speed equal to or higher than the speed V_p at which the pressure P_s is equal to a pressure at which the valve **192PB** is opened.

(139) In the shock absorber **1**, since the first valve **86** is opened, the damping force **D** is smaller than the damping force **D1** and the damping force **D2** at a speed equal to or higher than the speed V_p at which the pressure P_s is equal to a pressure at which the first valve **86** is opened.

(140) Therefore, according to the shock absorber **1**, ride comfort in a high speed range in which the speed V_p is high and the first valve **86** is opened can be improved compared with the ride comfort in the first comparative configuration and the second comparative configuration. According to the shock absorber **1**, ride comfort in the medium speed range in which the speed V_p is high, the first valve **86** is not opened, and the valve **192PB** is opened can be improved compared with the ride comfort in the second comparative configuration.

(141) Since the shock absorber **1** includes the second adjustment unit **90**, the damping force **D** in the high speed range can be adjusted.

(142) For example, in the second comparative configuration, when the ride comfort in the low speed range and the medium speed range is good but the ride comfort in the high speed range is poor, a size of the throttle of the internal flow path **82r** or the internal flow path **195r** needs to be changed. In this manner, when the size of the throttle of the internal flow path **82r** or the internal flow path **195r** is changed, damping characteristics in the low speed range and the medium speed range as well as in the high speed range are changed.

(143) In the first comparative configuration, when the ride comfort in the low speed range and the medium speed range is good but the ride comfort in the high speed range is poor, a size of the throttle of the internal flow path **82r** or the internal flow path **195r** or specifications of the valve **192PB** needs to be changed. In this manner, when the size of the throttle of the internal flow path **82r** or the internal flow path **195r** or the specifications of the valve **192PB** is changed, damping characteristics in the low speed range and the medium speed range as well as in the high speed range are changed.

(144) On the other hand, since the shock absorber **1** includes the main valve device **60**, the damping force **D** in the high speed range can be adjusted independently of an adjustment of the damping force in the low speed range generated corresponding to the throttle of the internal flow path **82r** or the internal flow path **195r** and an adjustment of the damping force in the medium speed range generated corresponding to the specifications of the valve **192PB**. Therefore, according to the shock absorber **1**, the damping force can be adjusted over a larger moving speed range of the piston than the first comparative configuration and the second comparative configuration.

Second Embodiment

(145) FIG. **8** is a cross-sectional view illustrating an example of a schematic configuration of a shock absorber **2** according to a second embodiment.

(146) The shock absorber **2** according to the second embodiment is different from the shock absorber **1** according to the first embodiment in a main valve device **260** corresponding to the main valve device **60**.

(147) Hereinafter, differences of the main valve device **260** from the main valve device **60** will be described. Components having the same functions in the main valve device **260** and the main valve device **60** are denoted by the same reference numerals, and detailed description thereof will be omitted.

(148) The main valve device **260** is different from the main valve device **60** in which the main valve device **260** includes a first support member **288** corresponding to the support member **88** of the main valve device **60**, and one end portion at the one side of the first transmission member **95** of the second adjustment unit **90** comes into contact with the first support member **288** and

transmits a spring force of the first spring **91** to the first support member **288**. The main valve device **260** is different from the main valve device **60** in which the main valve device **260** includes a first valve **286** corresponding to the first valve **86** of the main valve device **60** and a cylindrical collar **289** which is interposed between the piston **83** and the second portion **82b** of the main bolt **82** inside the first support member **288**. The first valve **286** has an inner diameter larger than that of the first valve **86**, so that the collar **289** can be disposed inside the first valve **286**.

(149) The first support member **288** is provided with a central hole **288a** formed in a central portion, a base portion **288b** having an annular shape, and a tubular portion **288c** having a cylindrical shape. A diameter of the central hole **288a** is larger than an outer diameter of the collar **289** and is smaller than an outer diameter of the second portion **82b** of the main bolt **82**. An outer diameter of the base portion **288b** is larger than an outer diameter of the first portion **95a** of the first transmission member **95**, and an end portion at the one side of the first transmission member **95** comes into contact with an end surface at the other side of the base portion **288b**. An outer diameter of the tubular portion **288c** is equal to or larger than the outer diameter of the second portion **82b** of the main bolt **82**, and is smaller than an inner diameter of the first transmission member **95**. A size of the first support member **288** in the axial direction is smaller than A size of the collar **289**.

(150) In the main valve device **260** having the above-described configuration, the first valve **286** and the first support member **288** slide relative to the collar **289** in accordance with the pressure P_s in the oil chamber **T4**. More specifically, when the pressure P_s is equal to or higher than a third pressure P_3 determined according to bending rigidity of the first valve **286**, among a plurality of disk valves of the first valve **286**, a disk valve disposed at the one side of a central portion in the axial direction of the first valve **286** is opened. Further, when the pressure P_s is equal to or higher than a fourth pressure P_4 (>the third pressure P_3) determined according to the preset load **F2**, the first valve **286** and the first support member **288** move to the other side against the spring force of the first spring **91**.

(151) Therefore, according to the shock absorber **2**, the third pressure P_3 at which the first valve **286** starts to be opened can be changed by changing specifications of the plurality of disk valves constituting the first valve **286**. Therefore, according to the shock absorber **2**, a damping force can be adjusted over a larger moving speed range of the piston than the first comparative configuration and the second comparative configuration.

Third Embodiment

(152) FIG. **9** is a cross-sectional view illustrating an example of a schematic configuration of a shock absorber **3** according to a third embodiment.

(153) The shock absorber **3** according to the third embodiment is different from the shock absorber **1** according to the first embodiment in a main valve device **360** corresponding to the main valve device **60**.

(154) Hereinafter, differences of the main valve device **360** from the main valve device **60** will be described. Components having the same functions in the main valve device **360** and the main valve device **60** are denoted by the same reference numerals, and detailed description thereof will be omitted.

(155) The main valve device **360** is different from the main valve device **60** in a piston **383** corresponding to the piston **83** of the main valve device **60**. In addition to the first flow path **83c**, the piston **383** includes a second flow path **383c** which passes through the piston **383** in the axial direction of the piston **383** at a position different from the first flow path **83c**. The second flow path **383c** is formed outward of the first flow path **83c**. The piston **383** has an outer wall **383e** outward of the second flow path **383c** and at an end portion at the other side of the piston **383**. The outer wall **383e** protrudes to the other side. The outer wall **383e** is formed with a through hole **383f** which passes through the outer wall **383e** in the radial direction.

(156) Further, the main valve device **360** is different from the main valve device **60** in which the main valve device **360** includes a second valve **386** which opens and closes the second flow path

383c. The second valve **386** is, for example, a single disk valve. An inner diameter of the second valve **386** is larger than an outer diameter of the first valve **86**, and the second valve **386** is disposed to surround the first valve **86**. The second valve **386** is prevented from moving in the radial direction by the outer wall **383e** of the piston **383**.

(157) In the main valve device **360**, an end portion at the one side of the first transmission member **95** of the second adjustment unit **90** comes into contact with the second valve **386**, and transmits the spring force of the first spring **91** to the second valve **386**.

(158) In the main valve device **360** having the above-described configuration, the first valve **86** and the second valve **386** are opened in accordance with the pressure P_s in the oil chamber **T4**. More specifically, when the pressure P_s is equal to or higher than a fifth pressure P_5 determined according to bending rigidity of the first valve **86**, among the plurality of disk valves of the first valve **86**, a disk valve disposed at the one side of a central portion in the axial direction of the first valve **286** is opened. Further, when the pressure P_s is equal to or higher than a sixth pressure P_6 (>the fifth pressure P_5) determined according to the preset load F_2 , the second valve **386** is opened against the spring force of the first spring **91**. When the oil push-opens the second valve **386** and passes through the second valve **386**, a damping force is generated. The sixth pressure P_6 at which the second valve **386** starts to be opened can be changed by changing the preset load F_2 of the first spring **91**, and the damping force can be adjusted.

(159) Therefore, according to the shock absorber **3**, the fifth pressure P_5 at which the first valve **86** starts to be opened can be changed by changing specifications of the plurality of disk valves constituting the first valve **86**. In addition, according to the shock absorber **3**, the sixth pressure P_6 at which the second valve **386** starts to be opened can be changed by changing the preset load F_2 . Therefore, according to the shock absorber **3**, a damping force can be adjusted over a larger moving speed range of the piston than the first comparative configuration and the second comparative configuration.

Fourth Embodiment

(160) FIG. **10** is a cross-sectional view illustrating an example of a schematic configuration of a shock absorber **4** according to a fourth embodiment.

(161) The shock absorber **4** according to the fourth embodiment is different from the shock absorber **1** according to the first embodiment in a main valve device **460** corresponding to the main valve device **60**.

(162) Hereinafter, differences of the main valve device **460** from the main valve device **60** will be described. Components having the same functions in the main valve device **460** and the main valve device **60** are denoted by the same reference numerals, and detailed description thereof will be omitted.

(163) The main valve device **460** includes a first valve **486** and a first support member **488** respectively corresponding to the first valve **86** and the support member **88** of the main valve device **60**. The main valve device **460** includes a second spring **463** which is a coil spring applying a force to the first support member **488** in a direction in which the first valve **486** is closed, and a guide **464** which is disposed inside the second spring **463** and prevents the second spring **463** from moving in the radial direction. The main valve device **460** includes a cylindrical collar **489** interposed between the piston **83** and the guide **464** inside the first valve **486** and the first support member **488**. That is, the support member **87**, the valve **85**, the piston **83**, the collar **489**, and the guide **464** are interposed between the second portion **82b** of the main bolt **82** and the nut **84** in a state in which the support member **87**, the valve **85**, the piston **83**, the collar **489**, and the guide **464** are in contact with members adjacent to one another. The first valve **486** has an inner diameter larger than that of the first valve **86**, so that the collar **489** can be disposed inside the first valve **486**.

(164) The first support member **488** is provided with a central hole **488a** formed in a central portion, a base portion **488b** having an annular shape, and a tubular portion **488c** having a

cylindrical shape. A diameter of the central hole **488a** is larger than an outer diameter of the collar **489**, and an outer diameter of the base portion **488b** is smaller than an inner diameter of the first portion **95a** of the first transmission member **95**. An outer diameter of the tubular portion **488c** is smaller than an inner diameter of the second spring **463**, and a length in the axial direction of the first support member **488** is smaller than a length in the axial direction of the collar **489**.

(165) An end portion at the one side of the second spring **463** is supported by the base portion **488b** of the first support member **488** via a washer, and an end portion at the other side of the second spring **463** is supported by the third portion **82c** of the main bolt **82**.

(166) The guide **464** is provided with a cylindrical first portion **464a** and a second portion **464b** provided at the other side of the first portion **464a**. An inner diameter of the first portion **464a** is larger than an outer diameter of the first portion **82a** of the main bolt **82** and is smaller than an outer diameter of the collar **489**. An inner diameter of the second portion **464b** is larger than an outer diameter of the second portion **82b** of the main bolt **82** and is smaller than an inner diameter of the second spring **463**. The guide **464** is disposed to surround the main bolt **82**, and guides the second spring **463** to expand and contract.

(167) In the main valve device **460** having the above-described configuration, in accordance with the pressure P_s in the oil chamber **T4**, the first valve **486** is opened and the first valve **486** and the first support member **488** slide relative to the collar **489**. More specifically, when the pressure P_s is equal to or higher than a seventh pressure P_7 determined according to the preset load F_2 of the first spring **91** and bending rigidity of the first valve **486**, among a plurality of disk valves of the first valve **486**, a disk valve disposed at the one side of a central portion in the axial direction of the first valve **286** is opened against a spring force of the first spring **91**. Further, when the pressure P_s is equal to or higher than an eighth pressure P_8 (>the seventh pressure P_7) determined according to a preset load F_3 which is a preset load of the second spring **463**, the first valve **486** and the first support member **488** move to the other side against a spring force of the second spring **463**.

(168) Therefore, according to the shock absorber **4**, the seventh pressure P_7 at which the first valve **486** starts to be opened can be changed by changing specifications of the plurality of disk valves constituting the first valve **486** or the preset load F_2 . According to the shock absorber **4**, the eighth pressure P_8 at which the first valve **486** and the first support member **488** start to move to the other side can be changed by changing the specifications (the preset load F_3) of the second spring **463**. Therefore, according to the shock absorber **4**, a damping force can be adjusted over a larger moving speed range of the piston than the first comparative configuration and the second comparative configuration.

Fifth Embodiment

(169) FIG. **11** is a cross-sectional view illustrating an example of a schematic configuration of a shock absorber **5** according to a fifth embodiment.

(170) The shock absorber **5** according to the fifth embodiment is different from the shock absorber **2** according to the second embodiment in a main valve device **560** corresponding to the main valve device **260**.

(171) Hereinafter, differences of the main valve device **560** from the main valve device **260** will be described. Components having the same functions in the main valve device **560** and the main valve device **260** are denoted by the same reference numerals, and detailed description thereof will be omitted.

(172) The main valve device **560** has a configuration in which the second spring **463**, the guide **464**, and the collar **489** provided in the main valve device **460** according to the fourth embodiment are applied to the configuration of the main valve device **260**. The support member **87**, the valve **85**, the piston **83**, the collar **489**, and the guide **464** are interposed between the second portion **82b** of the main bolt **82** and the nut **84** in a state in which the support member **87**, the valve **85**, the piston **83**, the collar **489**, and the guide **464** are in contact with members adjacent to one another.

(173) In the main valve device **560** having the above-described configuration, in accordance with

the pressure P_s in the oil chamber T4, the first valve **286** is opened and the first valve **286** and the first support member **288** slide relative to the collar **489**. More specifically, when the pressure P_s is equal to or higher than a ninth pressure P_9 determined according to rigidity of the first valve **286**, among a plurality of disk valves of the first valve **286**, a disk valve disposed at the one side of a central portion in the axial direction of the first valve **286** is opened. Further, when the pressure P_s is equal to or higher than a tenth pressure P_{10} (>the ninth pressure P_9) determined according to the preset load F2 of the first spring **91** and the preset load F3 of the second spring **463**, the first valve **286** and the first support member **288** move to the other side against spring forces of the first spring **91** and the second spring **463**.

(174) Therefore, according to the shock absorber **5**, the ninth pressure P_9 at which the first valve **286** starts to be opened can be changed by changing bending rigidity of the plurality of disk valves constituting the first valve **286**. Further, according to the shock absorber **5**, the tenth pressure P_{10} at which the first valve **286** and the first support member **288** start to move to the other side can be changed by changing the specifications (the preset load F3) of the second spring **463** and the preset load F2. Therefore, according to the shock absorber **5**, a damping force can be adjusted over a larger moving speed range of the piston than the first comparative configuration and the second comparative configuration.

Sixth Embodiment

(175) FIG. **12** is a cross-sectional view illustrating an example of a schematic configuration of a shock absorber **6** according to a sixth embodiment.

(176) The shock absorber **6** according to the sixth embodiment is different from the shock absorber **3** according to the third embodiment in a main valve device **660** corresponding to the main valve device **360**.

(177) Hereinafter, differences of the main valve device **660** from the main valve device **360** will be described. Components having the same functions in the main valve device **660** and the main valve device **360** are denoted by the same reference numerals, and detailed description thereof will be omitted.

(178) The main valve device **660** has a configuration in which the second spring **463**, the guide **464**, the first support member **488**, and the collar **489** provided in the main valve device **460** according to the fourth embodiment are applied to the configuration of the main valve device **360**. The first valve **686** corresponding to the first valve **86** of the main valve device **360** has an inner diameter larger than that of the first valve **86**, so that the collar **489** can be disposed inside the first valve **686**. The support member **87**, the valve **85**, the piston **383**, the collar **489**, and the guide **464** are interposed between the second portion **82b** of the main bolt **82** and the nut **84** in a state in which the support member **87**, the valve **85**, the piston **83**, the collar **489**, and the guide **464** are in contact with members adjacent to one another.

(179) In the main valve device **660** having the above-described configuration, in accordance with the pressure P_s in the oil chamber T4, the first valve **686** and the second valve **386** are opened and the first valve **686** and the first support member **488** slide relative to the collar **489**. More specifically, when the pressure P_s is equal to or higher than an eleventh pressure P_{11} determined according to rigidity of the first valve **686**, among a plurality of disk valves of the first valve **686**, a disk valve disposed at the one side of a central portion in the axial direction of the first valve **686** is opened. Further, when the pressure P_s is equal to or higher than a twelfth pressure P_{12} (>the eleventh pressure P_{11}) determined according to the preset load F3 of the second spring **463**, the first valve **686** and the first support member **488** move to the other side against a spring force of the second spring **463**. Further, when the pressure P_s is equal to or higher than a thirteenth pressure P_{13} (>the twelfth pressure P_{12}) determined according to the preset load F2 of the first spring **91**, the second valve **386** moves to the other side against a spring force of the first spring **91**.

(180) Therefore, according to the shock absorber **6**, the eleventh pressure P_{11} at which the first valve **686** starts to be opened can be changed by changing specifications of the plurality of disk

valves constituting the first valve **686**. According to the shock absorber **6**, the twelfth pressure **P12** at which the first valve **686** and the first support member **488** start to move to the other side can be changed by changing the specifications (the preset load **F3**) of the second spring **463**. Further, the thirteenth pressure **P13** at which the second valve **386** starts to move to the other side can be changed by changing the preset load **F2**. Therefore, according to the shock absorber **6**, a damping force can be adjusted over a larger moving speed range of the piston than the first comparative configuration and the second comparative configuration. Specifications of the first spring **91** and the second spring **463** may be set such that the pressure **Ps** at which the second valve **386** starts to move to the other side against the spring force of the first spring **91** is smaller than the pressure **Ps** at which the first valve **686** and the first support member **488** start to move to the other side against the spring force of the second spring **463**.

(181) Although the spring force of the first spring **91** is applied to the first valve **86**, the first valve **486**, the first valve **686**, or the second valve **386** via the first transmission member **95** In the first, third, fourth, and sixth embodiments described above, the present invention is not particularly limited thereto. The spring force of the first spring **91** may be applied to the first valve **86**, the first valve **486**, the first valve **686**, or the second valve **386** by bringing an end portion at the one side of the first spring **91** into contact with the first valve **86**, the first valve **486**, the first valve **686**, or the second valve **386**. Although the spring force of the first spring **91** is applied to the first support member **288** via the first transmission member **95** in the second and fifth embodiments described above, the present invention is not particularly limited thereto. The spring force of the first spring **91** may be applied to the first support member **288** by bringing an end portion at the one side of the first spring **91** into contact with the first support member **288**.

Claims

1. A shock absorber comprising: a cylinder which has a first end in an axial direction thereof, said first end being fixed to a vehicle body of a vehicle with a saddle; a rod which holds a piston at a first end of the rod, said piston configured to slide in the cylinder, and has a second end being at an opposite side to the first end of the rod; a rod holding member that is fixed to the second end of the rod; a first damping force generating portion which is fixed to the first end of the cylinder; and a second damping force generation portion which is disposed to be movable in the axial direction in the cylinder, wherein the second damping force generating portion includes: a first flow path which passes through the piston in the axial direction; a second flow path which passes through the piston in the axial direction and is provided outward of the first flow path in a radial direction of the piston; a first valve which opens and closes an opening portion of the first flow path; a second valve which opens and closes an opening portion of the second flow path; and an adjustment unit which adjusts a force required to open the second valve from an outer side of the rod.
2. The shock absorber according to claim 1, wherein the adjustment unit includes: a first spring which applies a force in a closing direction to the second valve; a spring receiver which supports a second end of the first spring; and an adjustment portion which adjusts a position of the spring receiver.
3. The shock absorber according to claim 2, wherein the adjustment unit further includes a first transmission member which is disposed between a first end of the first spring and the second valve, and which transmits the force of the first spring to the second valve, the first spring applying the force in the closing direction to the second valve.
4. A vehicle with a saddle comprising: a vehicle body; a front wheel disposed at a front side of the vehicle body in a traveling direction; a rear wheel disposed at a rear side of the vehicle body in the traveling direction; a first shock absorber disposed between the vehicle body and the front wheel; and a second shock absorber disposed between the vehicle body and the rear wheel, wherein at least the first shock absorber is the shock absorber according to claim 3.

5. A vehicle with a saddle comprising: a vehicle body; a front wheel disposed at a front side of the vehicle body in a traveling direction; a rear wheel disposed at a rear side of the vehicle body in the traveling direction; a first shock absorber disposed between the vehicle body and the front wheel; and a second shock absorber disposed between the vehicle body and the rear wheel, wherein at least the first shock absorber is the shock absorber according to claim 2.
6. The shock absorber according to claim 1, wherein the adjustment unit further includes a first transmission member which is disposed between a first end of a first spring and the second valve, and which transmits a force of the first spring to the second valve, the first spring applying the force in a closing direction to the second valve.
7. The shock absorber according to claim 6, wherein the second damping force generating portion includes: a first support member which is disposed inside the first transmission member and supports a surface of the first valve; and a second spring which is supported by the first support member and applies a force in a closing direction to the first valve.
8. The shock absorber according to claim 7, wherein the adjustment unit includes: a contact member which is disposed inside the rod and comes into contact with a second transmission member which transmits a force to the spring receiver which supports a second end of the first spring; and an operation portion configured to change a position of the contact member by a rotation operation.
9. A vehicle with a saddle comprising: a vehicle body; a front wheel disposed at a front side of the vehicle body in a traveling direction; a rear wheel disposed at a rear side of the vehicle body in the traveling direction; a first shock absorber disposed between the vehicle body and the front wheel; and a second shock absorber disposed between the vehicle body and the rear wheel, wherein at least the first shock absorber is the shock absorber according to claim 8.
10. A vehicle with a saddle comprising: a vehicle body; a front wheel disposed at a front side of the vehicle body in a traveling direction; a rear wheel disposed at a rear side of the vehicle body in the traveling direction; a first shock absorber disposed between the vehicle body and the front wheel; and a second shock absorber disposed between the vehicle body and the rear wheel, wherein at least the first shock absorber is the shock absorber according to claim 7.
11. The shock absorber according to claim 6, wherein the adjustment unit includes: a contact member which is disposed inside the rod and comes into contact with a second transmission member which transmits a force to the spring receiver which supports a second end of the first spring; and an operation portion configured to change a position of the contact member by a rotation operation.
12. A vehicle with a saddle comprising: a vehicle body; a front wheel disposed at a front side of the vehicle body in a traveling direction; a rear wheel disposed at a rear side of the vehicle body in the traveling direction; a first shock absorber disposed between the vehicle body and the front wheel; and a second shock absorber disposed between the vehicle body and the rear wheel, wherein at least the first shock absorber is the shock absorber according to claim 11.
13. A vehicle with a saddle comprising: a vehicle body; a front wheel disposed at a front side of the vehicle body in a traveling direction; a rear wheel disposed at a rear side of the vehicle body in the traveling direction; a first shock absorber disposed between the vehicle body and the front wheel; and a second shock absorber disposed between the vehicle body and the rear wheel, wherein at least the first shock absorber is the shock absorber according to claim 6.
14. A vehicle with a saddle comprising: a vehicle body; a front wheel disposed at a front side of the vehicle body in a traveling direction; a rear wheel disposed at a rear side of the vehicle body in the traveling direction; a first shock absorber disposed between the vehicle body and the front wheel; and a second shock absorber disposed between the vehicle body and the rear wheel, wherein at least the first shock absorber is the shock absorber according to claim 1.
15. A shock absorber comprising: a cylinder which has a first end in an axial direction thereof, said first end being fixed to a vehicle body of a vehicle with a saddle; a rod which holds a piston at a

first end of the rod, said piston configured to slide in the cylinder, and has a second end being at an opposite side to the first end of the rod; a rod holding member that is fixed to the second end of the rod; a first damping force generating portion which is fixed to the first end of the cylinder; and a second damping force generation portion which is disposed to be movable in the axial direction in the cylinder, wherein the second damping force generating portion includes: a flow path which passes through the piston in the axial direction; a valve which opens and closes an opening portion of the flow path; and an adjustment unit which adjusts a force required to open the valve from an outer side of the rod, wherein the adjustment unit includes: a first spring which applies a force in a closing direction to the valve; a spring receiver which supports a second end of the first spring; and an adjustment portion which adjusts a position of the spring receiver, wherein the adjustment unit further includes a first transmission member which abuts the valve at a first end thereof, is disposed between a first end of the first spring and the valve and transmits the force applied by the first spring to the valve, and wherein the second damping force generating portion includes: a first support member which is disposed inside the first transmission member and supports a surface of a second end of the valve; and a second spring whose first end is supported by the first support member, said second spring applying a force in the closing direction to the valve.

16. The shock absorber according to claim 15, wherein the adjustment portion includes: a contact member which is disposed inside the rod and comes into contact with a second transmission member which transmits a force to the spring receiver by a first end of the second transmission member; and an operation portion which can change a position of the contact member by a rotation operation.

17. A vehicle with a saddle comprising: a vehicle body; a front wheel disposed at a front side of the vehicle body in a traveling direction; a rear wheel disposed at a rear side of the vehicle body in the traveling direction; a first shock absorber disposed between the vehicle body and the front wheel; and a second shock absorber disposed between the vehicle body and the rear wheel, wherein at least the first shock absorber is the shock absorber according to claim 16.

18. A vehicle with a saddle comprising: a vehicle body; a front wheel disposed at a front side of the vehicle body in a traveling direction; a rear wheel disposed at a rear side of the vehicle body in the traveling direction; a first shock absorber disposed between the vehicle body and the front wheel; and a second shock absorber disposed between the vehicle body and the rear wheel, wherein at least the first shock absorber is the shock absorber according to claim 15.
