That is, in the travel device disclosed in Patent Document 1, the vehicle body is inclined in a forward and rearward direction during acceleration and deceleration, and the ride quality is not good.

[0010]

Here, an object of the present invention is to provide a vehicle capable of suppressing inclination of a vehicle body during acceleration and deceleration and improving a ride quality during acceleration and deceleration, and a travel device for the same.

[Means for Solving the Problems]

[0011]

According to a travel device of a vehicle according to a first aspect of the present invention, the travel device of the vehicle disposed at a front side and a rear side of a lower portion of a vehicle body includes:

an axle support configured to support an axle to which wheels are attached; a support section disposed close to a center of the vehicle body with reference to the axle support and extending downward from the vehicle body; and a link configured to connect the support section and the axle support and in which the axle support is movable with respect to the support section in a vertical direction.

The link has a lower link configured to be connected to the support section and the axle support by pin coupling, and an upper link disposed over the lower link and configured to be connected to the support section and the axle support by pin coupling. In addition, in the lower link, a pin coupling position between the lower link and the axle support is disposed lower than a pin coupling position between the lower link and the support section of the suspension frame in the vertical direction. Further, when a

section 16 of the suspension frame 15 are connected by pin coupling, being inclined and parallel to each other in the forward and rearward direction.

[0026]

In the embodiment, the support section 16 of the suspension frame 15, the bogie frame main body 12 and the axle bearing 13, and the two links 14a and 14b constitute a four-link parallel mechanism. For this reason, the bogie frame main body 12 and the axle bearing 13 can move the vertical direction without varying a direction with respect to the support section 16 of the suspension frame 15. In addition, the two links 14a and 14b function as a traction rod configured to transmit a driving force or a decelerating force of the running tire 3 to the vehicle body 1.

[0027]

The air suspension 19 is installed between the bogie frame main body 12 and the vehicle body 1. As the air suspension 19 is installed, relative upward/downward vibrations of the running tire 3 and the axle 5 with respect to the vehicle body 1 are decreased.

[0028]

The steering guide device 20 includes a king pin (not shown) constituting a steering shaft of the running tire 3, a steering arm 28 configured to integrally swing with the running tire 3 with reference to the king pin, a guide transverse beam 21 extending in a width direction of the vehicle body 1 and disposed at a rear side of the suspension system 10, the guide wheels 22 installed at both ends of the guide transverse beam 21, a forward/rearward movement switching unit 23 and a turning arm 24 configured to connect the guide transverse beam 21 to the main body 12 of the bogie frame 11 to be capable of displacing in the width direction of the vehicle body 1, a connecting rod 25 configured to connect one end of the steering arm 28 of one of the pair of left and right running tires 3 to

the forward/rearward movement switching unit 23, and a tie rod 26 configured to connect the other end of the steering arm 28 of the one running tire 3 to an end of the steering arm 28 of the other running tire 3.

[0029]

One end of the connecting rod 25 is connected to the forward/rearward movement switching unit 23 by pin coupling, and the other end of the connecting rod 25 is connected to one end of the steering arm 28 of one of the pair of left and right running tires 3 by pin coupling. In addition, both ends of the tie rod 26 are connected to ends of the steering arms 28 of the pair of running tires 3 by pin coupling.

[0030]

When the guide wheel 22 of the steering guide device 20 comes in contact with the side guide tracks G to receive a load in a transverse direction from the side guide tracks G, the guide rod 22 is displaced in a vehicle width direction of the vehicle body 1. The displacement in the vehicle width direction of the guide transverse beam 21 is transmitted to the steering arm 28 of the one running tire 3 via the forward/rearward movement switching unit 23 and the connecting rod 25. Then, the one running tire 3 and the steering arm 28 swing with reference to the king pin. In addition, swing of the steering arm 28 of the one running tire 3 is transmitted to the steering arm 28 of the other running tire 3 via the tie rod 26. Then, the other running tire 3 and the steering arm 28 also swing with reference to the king pin, same as the one running tire 3.

[0031]

In addition, both of FIG. 1 and FIG. 2 show the travel device of the front side of the vehicle, and as shown in FIG. 3A and FIG. 3B, the travel device of the rear side of the vehicle is reversed with respect to the travel device of the front side in the forward and rearward direction.

For this reason, in the travel device of the front side of the vehicle, for example, while the support section 16 of the suspension frame is disposed at the rear side of the axle bearing 13 of the bogie frame 11, in the travel device of the rear side, the support section 16 of the suspension frame 15 is disposed at the front side of the axle bearing 13 of the bogie frame 11. In addition, in the travel device of the front side, both of the upper link 14a and the lower link 14b have the pin coupling positions 11a and 11b of the front side disposed lower than the pin coupling positions 15a and 15b of the rear side, and in the travel device of the rear side, the upper link and the lower link have the pin coupling positions 11a and 11b of the rear side disposed lower than the pin coupling positions 15a and 15b of the front side.

[0032]

Accordingly, in the embodiment, in both the travel device of the front side and the travel device of the rear side, the upper link 14a is inclined at an inclination angle θ such that the position 11a at which the upper link 14a and the bogie frame main body 12 are connected by pin coupling is lower than the position 15a at which the upper link 14a and the suspension frame 15 are connected by pin coupling. In addition, the lower link 14b is also inclined at the inclination angle θ such that the position 11b at which the lower link 14b and the axle bearing 13 are connected by pin coupling is lower than the position 15b at which the lower link 14b and the suspension frame 15 are connected by pin coupling. Further, both of the inclination angles θ of the upper link 14a and the lower link 14b are values when the vehicle is in a stop state with no passenger.

[0033]

Next, an inertial moment applied to the vehicle body during acceleration and deceleration will be described.

[0034]

Both of the components of forces F1t and F2t in the vertical direction applied to the links 14a and 14b are applied to the vehicle body 1 as a moment. The moment, i.e., a tire reactive force moment Mt, is represented bythe following equation.

$$Mt = (F1t+F2t)\cdot B$$

$$= [(P\cdot a/b)\cdot\tan\theta + (-P\cdot c/b)\cdot\tan\theta]\cdot B$$

$$= [(a-c)/b]\cdot P\cdot B\cdot\tan\theta$$

$$= P\cdot B\cdot\tan\theta \ (\because\ b=a-c)$$

B: distance between support section of suspension frame of front side travel device and support section of suspension frame of rear side travel device

[0051]

Accordingly, in the embodiment, when the vehicle accelerates, since the tire reactive force moment Mt (= P•B•tanθ) acts in the counterclockwise direction and negates the inertial moment Ma (=−α•h•Ws) in the clockwise direction, in which the vehicle body 1 is inclined in the forward and rearward direction, inclination of the vehicle body 1 upon acceleration can be suppressed. Accordingly, in the embodiment, the ride quality upon acceleration can be improved.

[0052]

In addition, when the vehicle decelerates forward at the acceleration α, since the component of force in the horizontal direction of the force applied to the upper link 14a inclined with respect to the horizontal direction at the inclination angle θ is the same as the force F2 applied to the upper link 14a of the travel device of the related art, the component of force F2t in the vertical direction of the force applied to the upper link 14a is represented by the following equation (3).

$$F2t = F2\cdot\tan\theta = (P\cdot c/b)\cdot\tan\theta$$

[0053]

negating the inertial moment Ma are applied to the vehicle body 1, inclination of the vehicle body 1 upon acceleration and deceleration of the vehicle can be suppressed.

[0057]

Specifically, upon acceleration at the acceleration α, in the travel device in which the inclination angle θ of the link is 0°, i.e., in the travel device of the related art, a raising amount of the front portion of the vehicle body 1 is 10 mm, in the travel device of the embodiment in which the inclination angle θ of the link is set to 10°, even in the one-axis drive, the raising amount of the front portion of the vehicle body 1 is reduced by half to 5 mm or less, and in the case of two-axis drive, the raising amount of the front portion of the vehicle body 1 is further reduced, largely suppressing inclination of the vehicle body 1.

[0058]

In addition, the inclination angles θ of the upper link 14a and the lower link 14b with respect to the horizontal direction may be basically, as will be described below, 5° or more and 15° or less.

$$5° \leq \theta \leq 15°$$

[0059]

When the inclination angle θ is less than 5°, the tire reactive force moment Mt is small, and an effect of negating the inertial moment Ma cannot be expected. For this reason, the inclination angle θ may be 5° or more. In addition, when the inclination angle θ exceeds 15°, a movement amount in the forward and rearward direction and relative movement in the vertical direction of the running tire 3, the axle and the bogie frame with respect to the suspension frame 15 are increased, and thus an unnecessary load applied to the position at which the links 14a and 14b are connected by pin coupling is increased. For this reason, the inclination angle θ may be 15° or less.

[0060]

CLAIMS

1. A travel device of a vehicle disposed at a front side and a rear side of a lower portion of a vehicle body, the travel device comprising:

an axle support configured to support an axle to which wheels are attached;

a support section disposed close to a center of the vehicle body with reference to the axle support and extending downward from the vehicle body; and

a link configured to connect the support section and the axle support and in which the axle support is movable with respect to the support section in a vertical direction, wherein

the link has a lower link configured to be connected to the support section and the axle support by pin coupling, and an upper link disposed over the lower link and configured to be connected to the support section and the axle support by pin coupling,

in the lower link, a pin coupling position between the lower link and the axle support is disposed lower than a pin coupling position between the lower link and the support section of the suspension frame in the vertical direction, and

when a distance in the vertical direction from the pin coupling position between the lower link and the support section to the pin coupling position between the lower link and the axle support is a vertical reference distance, in the upper link, a pin coupling position between the upper link and the axle support is disposed lower than a pin coupling position between the upper link and the support section in the vertical direction within a range of the vertical reference distance.

2. The travel device of a vehicle according to claim 1, wherein, in the upper link, the pin coupling position between the upper link and the axle support is disposed lower than

the pin coupling position between the upper link and the support section of the suspension frame in the vertical direction at the vertical reference distance.

3. The travel device of a vehicle according to claim 1, wherein, in the upper link, the pin coupling position between the upper link and the axle support are connected by pin coupling is disposed at the same level of the pin coupling position between the upper link and the support section of the suspension frame in the vertical direction.

4. A vehicle comprising:

the vehicle body; and

the travel device according to any one of claims 1 to 3.

That is, in the travel device disclosed in Patent Document 1, the vehicle body is inclined in a forward and rearward direction during acceleration and deceleration, and the ride quality is not good.

[0010]

Here, an object of the present invention is to provide a vehicle capable of suppressing inclination of a vehicle body during acceleration and deceleration and improving a ride quality during acceleration and deceleration, and a travel device for the same.

[Means for Solving the Problems]

[0011]

According to a travel device of a vehicle according to a first aspect of the present invention, the travel device of the vehicle disposed at a front side and a rear side of a lower portion of a vehicle body includes:

an axle support configured to support an axle to which wheels are attached; a suspension frame having a support section disposed close to a center of the vehicle body with reference to the axle support and extending downward from the vehicle body; and a link configured to connect the support section and the axle support and in which the axle support is movable with respect to the support section in a vertical direction.

The link has a lower link configured to be connected to the support section and the axle support by pin coupling, and an upper link disposed over the lower link and configured to be connected to the support section and the axle support by pin coupling. In addition, in the lower link, a pin coupling position between the lower link and the axle support is disposed lower than a pin coupling position between the lower link and the support section of the suspension frame in the vertical direction. Further, when a

section 16 of the suspension frame 15 are connected by pin coupling, being inclined and parallel to each other in the forward and rearward direction.

[0026]

In the embodiment, the support section 16 of the suspension frame 15, the bogie frame main body 12 and the axle bearing 13, and the two links 14a and 14b constitute a four-link parallel mechanism. For this reason, the bogie frame main body 12 and the axle bearing 13 can move the vertical direction without varying a direction with respect to the support section 16 of the suspension frame 15. In addition, the two links 14a and 14b function as a traction rod configured to transmit a driving force or a decelerating force of the running tire 3 to the vehicle body 1.

[0027]

The air suspension 19 is installed between the bogie frame main body 12 and the vehicle body 1. As the air suspension 19 is installed, relative upward/downward vibrations of the running tire 3 and the axle 5 with respect to the vehicle body 1 are decreased.

[0028]

The steering guide device 20 includes a king pin (not shown) constituting a steering shaft of the running tire 3, a steering arm 28 configured to integrally swing with the running tire 3 with reference to the king pin, a guide transverse beam 21 extending in a width direction of the vehicle body 1 and disposed at a front side of the suspension system 10, the guide wheels 22 installed at both ends of the guide transverse beam 21, a forward/rearward movement switching unit 23 and a turning arm 24 configured to connect the guide transverse beam 21 to the main body 12 of the bogie frame 11 to be capable of displacing in the width direction of the vehicle body 1, a connecting rod 25 configured to connect one end of the steering arm 28 of one of the pair of left and right running tires 3 to

the forward/rearward movement switching unit 23, and a tie rod 26 configured to connect the other end of the steering arm 28 of the one running tire 3 to an end of the steering arm 28 of the other running tire 3.

[0029]

One end of the connecting rod 25 is connected to the forward/rearward movement switching unit 23 by pin coupling, and the other end of the connecting rod 25 is connected to one end of the steering arm 28 of one of the pair of left and right running tires 3 by pin coupling. In addition, both ends of the tie rod 26 are connected to ends of the steering arms 28 of the pair of running tires 3 by pin coupling.

[0030]

When the guide wheel 22 of the steering guide device 20 comes in contact with the side guide tracks G to receive a load in a transverse direction from the side guide tracks G, the guide transverse beam 21 is displaced in a vehicle width direction of the vehicle body 1. The displacement in the vehicle width direction of the guide transverse beam 21 is transmitted to the steering arm 28 of the one running tire 3 via the forward/rearward movement switching unit 23 and the connecting rod 25. Then, the one running tire 3 and the steering arm 28 swing with reference to the king pin. In addition, swing of the steering arm 28 of the one running tire 3 is transmitted to the steering arm 28 of the other running tire 3 via the tie rod 26. Then, the other running tire 3 and the steering arm 28 also swing with reference to the king pin, same as the one running tire 3.

[0031]

In addition, both of FIG. 1 and FIG. 2 show the travel device of the front side of the vehicle, and as shown in FIG. 3A and FIG. 3B, the travel device of the rear side of the vehicle is reversed with respect to the travel device of the front side in the forward and rearward direction.

For this reason, in the travel device of the front side of the vehicle, for example, while the support section 16 of the suspension frame 15 is disposed at the rear side of the axle bearing 13 of the bogie frame 11, in the travel device of the rear side, the support section 16 of the suspension frame 15 is disposed at the front side of the axle bearing 13 of the bogie frame 11. In addition, in the travel device of the front side, both of the upper link 14a and the lower link 14b have the pin coupling positions 11a and 11b of the front side disposed lower than the pin coupling positions 15a and 15b of the rear side, and in the travel device of the rear side, the upper link and the lower link have the pin coupling positions 11a and 11b of the rear side disposed lower than the pin coupling positions 15a and 15b of the front side.

[0032]

Accordingly, in the embodiment, in both the travel device of the front side and the travel device of the rear side, the upper link 14a is inclined at an inclination angle θ such that the position 11a at which the upper link 14a and the bogie frame main body 12 are connected by pin coupling is lower than the position 15a at which the upper link 14a and the suspension frame 15 are connected by pin coupling. In addition, the lower link 14b is also inclined at the inclination angle θ such that the position 11b at which the lower link 14b and the axle bearing 13 are connected by pin coupling is lower than the position 15b at which the lower link 14b and the suspension frame 15 are connected by pin coupling. Further, both of the inclination angles θ of the upper link 14a and the lower link 14b are values when the vehicle is in a stop state with no passenger.

[0033]

Next, an inertial moment applied to the vehicle body during acceleration and deceleration will be described.

[0034]

Both of the components of forces F1t and F2t in the vertical direction applied to the links 14a and 14b are applied to the vehicle body 1 as a moment. The moment, i.e., a tire reactive force moment Mt, is represented bythe following equation.

$$Mt = (F1t+F2t)\cdot B$$

$$= [(P\cdot a/b)\cdot\tan\theta + (-P\cdot c/b)\cdot\tan\theta]\cdot B$$

$$= [(a-c)/b]\cdot P\cdot B\cdot\tan\theta$$

$$= P\cdot B\cdot\tan\theta \ (\because \ b=a-c)$$

B: distance between support section of suspension frame of front side travel device and support section of suspension frame of rear side travel device

[0051]

Accordingly, in the embodiment, when the vehicle accelerates, since the tire reactive force moment Mt (= $P\cdot B\cdot\tan\theta$) acts in the counterclockwise direction and negates the inertial moment Ma (=$-\alpha\cdot h\cdot Ws$) in the clockwise direction, in which the vehicle body 1 is inclined in the forward and rearward direction, inclination of the vehicle body 1 upon acceleration can be suppressed. Accordingly, in the embodiment, the ride quality upon acceleration can be improved.

[0052]

In addition, when the vehicle decelerates forward at the acceleration α, since the component of force in the horizontal direction of the force applied to the upper link 14a inclined with respect to the horizontal direction at the inclination angle θ is the same as the force F2 applied to the upper link 14a of the travel device of the related art, the component of force F2t in the vertical direction of the force applied to the upper link 14a is represented by the following equation.

$$F2t = F2\cdot\tan\theta = (P\cdot c/b)\cdot\tan\theta$$

[0053]

negating the inertial moment Ma are applied to the vehicle body 1, inclination of the vehicle body 1 upon acceleration and deceleration of the vehicle can be suppressed.

[0057]

Specifically, upon acceleration at the acceleration α, in the travel device in which the inclination angle θ of the link is 0°, i.e., in the travel device of the related art, a raising amount of the front portion of the vehicle body 1 is 10 mm, in the travel device of the embodiment in which the inclination angle θ of the link is set to 10°, even in the one-axis drive, the raising amount of the front portion of the vehicle body 1 is reduced by half to 5 mm or less, and in the case of two-axis drive, the raising amount of the front portion of the vehicle body 1 is further reduced, largely suppressing inclination of the vehicle body 1.

[0058]

In addition, the inclination angles θ of the upper link 14a and the lower link 14b with respect to the horizontal direction may be basically, as will be described below, 5° or more and 15° or less.

$$5° \leq \theta \leq 15°$$

[0059]

When the inclination angle θ is less than 5°, the tire reactive force moment Mt is small, and an effect of negating the inertial moment Ma cannot be expected. For this reason, the inclination angle θ may be 5° or more. In addition, when the inclination angle θ exceeds 15°, a movement amount in the forward and rearward direction and relative movement in the vertical direction of the running tire 3, the axle 5 and the bogie frame 11 with respect to the suspension frame 15 are increased, and thus an unnecessary load applied to the position at which the links 14a and 14b are connected by pin coupling is increased. For this reason, the inclination angle θ may be 15° or less.

[0060]

CLAIMS

1. A travel device of a vehicle disposed at a front side and a rear side of a lower portion of a vehicle body, the travel device comprising:

an axle support configured to support an axle to which wheels are attached;

a suspension frame including a hanging section disposed close to a center of the vehicle body with reference to the axle support and extending downward from the vehicle body; and

a link configured to connect the hanging section and the axle support and in which the axle support is movable with respect to the hanging section in a vertical direction, wherein

the link has a lower link configured to be connected to the hanging section and the axle support by pin coupling, and an upper link disposed over the lower link and configured to be connected to the hanging section and the axle support by pin coupling,

in the lower link, a pin coupling position between the lower link and the axle support is disposed lower than a pin coupling position between the lower link and the hanging section of the suspension frame in the vertical direction;

when a distance in the vertical direction from the pin coupling position between the lower link and the hanging section to the pin coupling position between the lower link and the axle support is a vertical reference distance, in the upper link, a pin coupling position between the upper link and the axle support is disposed lower than a pin coupling position between the upper link and the hanging section of the suspension frame in the vertical direction at the vertical reference distance, and

inclination angles of the upper link and the lower link with respect to a horizontal direction are 5° or more and 15° or less.

2. A vehicle comprising:

a vehicle body; and

the travel device according to claim 1.