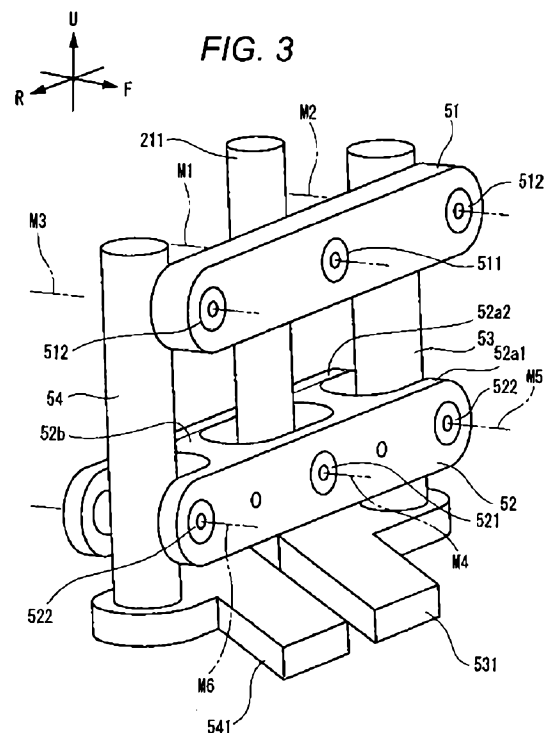


FASCICULE DE BREVET D'INVENTION

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54 Titre : Vehicle.	

57 Abrégé :

An object of the invention is to provide a vehicle including a vehicle body frame that can lean and two front wheels that can enhance the degree of freedom in designing a link mechanism while maintaining the function of the link mechanism. There is provided a vehicle 1 that includes a vehicle body frame that can lean and a right front wheel and a left front wheel and in which an upper cross portion and a lower cross portion of a link mechanism 5 each include a piece of part that is supported on side portions at a right end portion and a left end portion thereof and that is supported on a vehicle body frame at a middle portion thereof. In the vehicle 1, an upper right displacement X1 and an upper left displacement X2 that result when a rearward test force is exerted individually on a lower right supporting portion and a lower left supporting portion that support the lower cross portion 52 with the lower cross portion 52 removed are larger than a lower right displacement X3 and a lower left displacement X4 that result when a force that is the same in magnitude and direction as the forces exerted on the lower right and left supporting portions is exerted individually on an upper right supporting portion and an upper left supporting portion that support the upper cross member 51 with the upper cross portion 51 removed.



ORIGINAL**DEMANDE DE BREVET D'INVENTION
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1766/15

DESCRIPTION

VEHICLE

Technical Field

[0001]

5 The present invention relates to a vehicle that includes a vehicle body frame that can lean and two front wheels.

Background Art

[0002]

 A vehicle is known which includes a vehicle body frame that leans to
10 the left or right when the vehicle is cornering and two front wheels that are provided so as to be aligned in a left-and-right direction of the vehicle body frame (for example, refer to Patent Documents 1, 2 and Non-patent Document 1).

[0003]

15 The vehicle including the vehicle body frame that can lean and the two front wheels includes a link mechanism. The link mechanism includes an upper cross portion and a lower cross portion. In addition, the link mechanism also includes a right side portion which supports right end portions of the upper cross portion and the lower cross and a left side portion which supports left
20 end portions of the upper cross portion and the lower cross portion. Middle portions of the upper cross portion and the lower cross portion are supported on the vehicle body frame at directly ahead of a steering shaft. The upper cross portion and the lower cross portion are supported on the vehicle body frame so as to turn about axes that extend substantially in a front-and-rear

direction of the vehicle body frame. The upper cross portion and the lower cross portion turn relative to the vehicle body frame as the vehicle body frame leans, whereby a relative position of the two front wheels in an up-and-down direction of the vehicle body frame changes. The upper cross portion and the lower cross portion are provided above the two front wheels in the up-and-down direction of the vehicle body frame in such a state that the vehicle body frame rests in an upright state.

[0004]

The vehicle including the vehicle body frame that can lean and the two front wheels includes a right shock absorbing device which supports the right front wheel so as to move in the up-and-down direction of the vehicle body frame and a left shock absorbing device which supports the left front wheel so as to move in the up-and-down direction of the vehicle body frame. The right shock absorbing device is supported on the right side portion so as to turn about an axis of the right side portion. The left shock absorbing device is supported on the left side portion so as to turn about an axis of the left side portion. Vehicles described in Patent Documents 1 and 2 include further a handlebar, a steering shaft and a turning transmission mechanism. The handlebar is fixed to the steering shaft. The steering shaft is supported on the vehicle body frame so as to turn relative thereto. When the handlebar is turned, the steering shaft also turns. The turning transmission mechanism transfers the turn of the steering shaft to the right shock absorbing device and the left shock absorbing device.

[0005]

The vehicle including the vehicle body frame that can lean and the two front wheels includes many on-board components which are provided on the periphery of the steering shaft. The on-board components include lamps such as a headlamp, a radiator, a reservoir tank, electric components such as a horn, and a main switch of the vehicle, a stowage box, a stowage pocket and the like.

Related Art Document

Patent Document

[0006]

10 [Patent Document 1] Japanese Patent Unexamined publication JP-A-2005-313876

[Patent Document 2] U.S. Design Patent D547, 242S

[Non-Patent Document 1] Catalogo partidi ricambio, MP3 300 LT Mod. ZAPM64102, Piaggio

15 Summary of the Invention

Problem that the Invention is to solve

[0007]

In the vehicles that are described in Patent Documents 1 and 2, loads that are borne by the right front wheel and the left front wheel are transferred to the link mechanism by way of the right shock absorbing device or the left shock absorbing device. The loads are transferred to the right side portion or the left side portion from the right shock absorbing device or the left shock absorbing device. The loads are transferred to the upper cross portion and the lower cross portion from the right side portion or the left side portion. The loads

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are transferred further to the vehicle body frame that is positioned on the periphery of the steering shaft from the upper cross portion and the lower cross portion. The link mechanism includes bearings that are provided between the right side portion or the left side portion and the upper cross portion and the lower cross portion and bearings that are provided between the upper cross portion and the lower cross portion and the vehicle body frame. These bearings function to enable the right side portion or the left side portion to turn smoothly relative to the upper cross portion and the lower cross portion and the upper cross portion and the lower cross portion to turn smoothly relative to the vehicle body frame. The bearings also function to transfer the loads borne by the link mechanism to the vehicle body frame. Additionally, the right side portion, the left side portion, the upper cross portion and the lower cross portion are each formed highly rigid in order to enhance the function to turn smoothly and the function to transfer the loads. This enlarges the right side portion, the left side portion, the upper cross portion and the lower cross portion in external size. This results in enlargement of the link mechanism that is made up of those portions. Further, the enlargement of the link mechanism results in a further expansion of the movable range of the link mechanism.

[0008]

20 The vehicles that are described in Patent Documents 1 and 2 include the link mechanism that is provided on the periphery of the steering shaft so as to move as the vehicle body frame leans. Because of this, in the vehicle including the vehicle body frame that can lean and the two front wheels, it is required that the interference of the movable range of the link mechanism with

the on-board components should be avoided. This requires the enhancement of degree of freedom in designing the link mechanism in the vehicle that includes the vehicle body frame that can lean and the two front wheels.

[0009]

- 5 An object of the invention is to provide a vehicle including a vehicle body frame that can lean and two front wheels that can enhance the degree of freedom in designing a link mechanism while maintaining the function of the link mechanism.

Means for Solving the Problem

10 [0010]

 A vehicle that is driven by power from a power source including:
 a left front wheel and a right front wheel that are disposed side by side in a left-and-right direction as seen from a front of the vehicle and that are steerable;

- 15 a right shock absorbing device that supports the right front wheel at a lower portion thereof and that absorbs an upward displacement of the right front wheel in an up-and-down direction of the vehicle body frame;

 a left shock absorbing device that supports the left front wheel at a lower portion thereof and that absorbs an upward displacement of the left front

- 20 wheel in the up-and-down direction of a vehicle body frame;

 a link mechanism including:

 a right side portion that supports an upper portion of the right shock absorbing device so as to turn about a right steering axis that extends in the up-and-down direction of the vehicle body frame;

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a left side portion that supports an upper portion of the left shock absorbing device so as to turn about a left steering axis that is parallel to the right steering axis;

an upper cross portion that includes a piece of part that supports an upper portion of the right side portion at a right end portion thereof so as to turn about an upper right axis that extends in a front-and-rear direction of the vehicle body frame via an upper right bearing, that supports an upper portion of the left side portion at a left end portion thereof so as to turn about an upper left axis that is parallel to the upper right axis via an upper left bearing and that is supported on the vehicle body frame at a middle portion thereof so as to turn about an upper middle axis that is parallel to the upper right axis and the upper left axis via an upper middle bearing; and

a lower cross portion that includes a piece of part that supports a lower portion of the right side portion at a right end portion thereof so as to turn about a lower right axis that is parallel to the upper right axis via a lower right bearing, that supports a lower end portion of the left side portion at a left end portion thereof so as to turn about a lower left axis that is parallel to the upper left axis via a lower left bearing and that is supported on the vehicle body frame at a middle portion thereof so as to turn about a lower middle axis that is parallel to the upper middle axis via a lower middle bearing;

a steering shaft that is supported on the vehicle body frame between the right side portion and the left side portion in a left-and-right direction of the vehicle body frame, of which an upper end portion is provided above the lower middle axis in the up-and-down direction of the vehicle body frame and that is

turnable about a middle steering axis that extends in the up-and-down direction of the vehicle body frame;

a handlebar that is provided at the upper portion of the steering shaft;

and

- 5 a turning transmission mechanism that transfers a turn of the steering shaft according to an operation of the handlebar to the right shock absorbing device and the left shock absorbing device, wherein

with the lower cross portion removed that includes the piece of part that is supported at the right end portion and the left end portion thereof and
10 that is supported at the middle portion thereof and the upper cross portion mounted that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof, an upper right displacement of the upper cross portion that results when a forward or rearward test force in relation to the direction of the
15 lower right axis is exerted on a lower right supporting portion of the right side portion where the lower cross member is supported and an upper left displacement of the upper cross portion that results when a force that is the same in magnitude and direction as the test force is exerted on a lower left supporting portion of the left side portion are equal to each other,

- 20 with the upper cross portion removed that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof and the lower cross portion mounted that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle

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portion thereof, a lower right displacement of the lower cross portion that results when a force that is the same in magnitude and direction as the test force is exerted on an upper right supporting portion of the right side portion where the upper cross member is supported and a lower left displacement of
5 the lower cross portion that results when a force that is the same as in magnitude and direction as the test force is exerted on an upper left supporting portion of the left side portion where the upper cross member is supported are equal to each other,

the upper right displacement of the upper cross portion is larger than
10 the lower right displacement of the lower cross portion, and

the upper left displacement of the upper cross portion is larger than the lower left displacement of the lower cross portion.

[0011]

The right side portion, the left side portion, the upper cross portion and
15 the lower cross portion that make up the link mechanism are each formed highly rigid to enhance the function to turn smoothly and the function to transfer loads. This enlarges the right side portion, the left side portion, the upper cross portion and the lower cross portion in external size. This results in enlargement of the link mechanism that is made up of those portions. Further,
20 the enlargement of the link mechanism results in a further expansion of the movable range of the link mechanism. The vehicle that includes the vehicle body frame that can lean and the two front wheels has the large link mechanism that moves as the vehicle body frame leans on the periphery of the steering shaft. Because of this, in the vehicle including the vehicle body frame

that can lean and the two front wheels, the on-board components need to be provided so that the on-board components do not interfere with the movable range of the link mechanism. This requires the enhancement of degree of freedom in designing the link mechanism in the vehicle that includes the
5 vehicle body frame that can lean and the two front wheels.

Then, a detailed analysis has been carried out on the function of the link mechanism. The link mechanism has the function to enable the right side portion or the left side portion to turn smoothly relative to the upper cross portion and the lower cross portion and the function to enable the upper cross
10 portion and the lower cross portion to turn smoothly relative to the vehicle body frame. Additionally, the link mechanism has the function to transfer loads borne by the right side portion or the left side portion to the vehicle body frame.

This analysis has found out that the upper cross portion and the lower cross portion are twisted by the loads borne by the link mechanism. The
15 analysis has found out that the twisting of the upper cross portion occurs along an upper center axis that passes through a center of the upper right bearing of the upper cross member in the direction of the upper right axis and a center of the upper left bearing of the upper cross member in the direction of the upper left axis. The analysis has found out that the twisting of the lower cross portion
20 occurs along a lower center axis that passes through a center of the lower right bearing of the lower cross member in the direction of the lower right axis and a center of the lower left bearing of the lower cross member in the direction of the lower left axis.

q

Then, various cross portions that are different in torsional rigidity about the upper center axis and in torsional rigidity about the lower center axis have been studied. The results of the study have found out that even though the torsional rigidity of the upper cross portion that includes the piece of part that is supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof is made to differ from the torsional rigidity of the lower cross portion that includes the piece of part that is supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof, in the event that the torsional rigidity of the lower cross portion that includes the piece of part that is supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof is made higher than the torsional rigidity of the upper cross portion that includes the piece of part that is supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof, the smooth operation of the link mechanism is easy to be maintained. It is considered that this is attributed to the fact that a difference between a distance between an axle of the right front wheel and the upper right bearing that lies between the upper cross portion and the right side portion and a distance between the axle of the right front wheel and the lower right bearing that lies between the lower cross portion and the right side portion differs from a difference between a distance between an axle of the left front wheel and the upper left bearing that lies between the upper cross portion and

the left side portion and a distance between the axle of the left front wheel and the lower left bearing that lies between the lower cross portion and the left side portion. The distance between the axle of the right front wheel and the lower right bearing that lies between the lower cross portion and the right side portion is shorter than the distance between the axle of the right front wheel and the upper right bearing that lies between the upper cross portion and the right side portion. The distance between the axle of the left front wheel and the lower left bearing that lies between the lower cross portion and the left side portion is shorter than the distance between the axle of the left front wheel and the upper left bearing that lies between the upper cross portion and the left side portion. It is considered that these facts affect the smooth operation of the link mechanism.

According to the vehicle of this invention, the torsional rigidity of the lower cross portion that includes the piece of part that is supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof is made higher than the torsional rigidity of the upper cross portion that includes the piece of part that is supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof. Therefore, the smooth operation of the link mechanism is easy to be maintained. Moreover, the upper cross portion and the lower cross portion are each made to include the piece of part that is supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion

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thereof, and the torsional rigidity of the upper cross portion is made to differ from the torsional rigidity of the lower cross portion. Therefore, it is possible to enhance the degree of freedom in designing the link mechanism.

Consequently, it is possible to enhance the degree of freedom in
5 designing the link mechanism while maintaining the function of the link mechanism in the vehicle that includes the vehicle body frame that can lean and the two front wheels.

[0012]

In the vehicle according to the invention, a shape of the upper cross
10 portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof may be different from a shape of the lower cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof.

15 [0013]

According to the vehicle of the invention, the movable range of the link mechanism can be changed from a simple shape like a rectangular parallelepiped to an arbitrary shape by making the shape of the upper cross portion that includes the piece of part that is supported on the side portions at
20 the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof differ from the shape of the lower cross portion that includes the piece of part that is supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof. This makes

it easy to avoid the interference of the movable range of the link mechanism with the on-board components. Consequently, it is possible to enhance the degree of freedom in designing the link mechanism while maintaining the function of the link mechanism in the vehicle that includes the vehicle body frame that can lean and the two front wheels.

[0014]

In the vehicle according to the invention, a shape of the upper cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof may be smaller than a shape of the lower cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof.

[0015]

According to the vehicle of the invention, the movable range of the link mechanism can be changed from the simple shape like a rectangular parallelepiped to a shape in which an upper portion is small by making the shape of the upper cross portion that includes the piece of part that is supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof smaller than the shape of the lower cross portion that includes the piece of part that is supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof. This makes it easy to avoid the interference of the movable range of the link mechanism with the on-board components.

Consequently, it is possible to enhance the degree of freedom in designing the link mechanism while maintaining the function of the link mechanism in the vehicle that includes the vehicle body frame that can lean and the two front wheels.

5 [0016]

In the vehicle according to the invention, a volume of the upper cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof may be different from a volume of the lower cross portion that includes
10 the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof.

[0017]

According to the vehicle of the invention, the movable range of the link mechanism can be changed from the simple shape like a rectangular
15 parallelepiped to an arbitrary shape by making the volume of the upper cross portion that includes the piece of part that is supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof differ from the volume of the lower cross portion that includes the piece of part that is supported on the
20 side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof. This makes it easy to avoid the interference of the movable range of the link mechanism with the on-board components. Consequently, it is possible to enhance the degree of freedom in designing the link mechanism while maintaining the

function of the link mechanism in the vehicle that includes the vehicle body frame that can lean and the two front wheels.

[0018]

In the vehicle according to the invention, a volume of the upper cross
5 portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof may be smaller than a volume of the lower cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof.

10 [0019]

According to the vehicle of the invention, the movable range of the link mechanism can be changed from the simple shape like a rectangular parallelepiped to a shape in which an upper portion is small by making the volume of the upper cross portion that includes the piece of part that is
15 supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof smaller than the volume of the lower cross portion that includes the piece of part that is supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at
20 the middle portion thereof. This makes it easy to avoid the interference of the movable range of the link mechanism with the on-board components. Consequently, it is possible to enhance the degree of freedom in designing the link mechanism while maintaining the function of the link mechanism in the

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vehicle that includes the vehicle body frame that can lean and the two front wheels.

[0020]

In the vehicle according to the invention, a material of the upper cross
5 portion that includes the piece of part that is supported at the right end portion
and the left end portion and that is supported at the middle portion may be
identical to a material of the lower cross portion that includes the piece of part
that is supported at the right end portion and the left end portion and that is
supported at the middle portion.

10 [0021]

According to the vehicle of the invention, the balance between rigidity
and shape is easy to be controlled by making the volume of the upper cross
portion that includes the piece of part that is supported on the side portions at
the right end portion and the left end portion thereof and that is supported on
15 the vehicle body frame at the middle portion thereof differ from the volume of
the lower cross portion that includes the piece of part that is supported on the
side portions at the right end portion and the left end portion thereof and that is
supported on the vehicle body frame at the middle portion thereof. This makes
it easy to avoid the interference of the movable range of the link mechanism
20 with the on-board components. Consequently, it is possible to enhance the
degree of freedom in designing the link mechanism while maintaining the
function of the link mechanism in the vehicle that includes the vehicle body
frame that can lean and the two front wheels.

[0022]

In the vehicle according to the invention, a material of the upper cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof may be different from a material of the lower cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof.

[0023]

According to the vehicle of the invention, the material of the upper cross portion or the lower cross portion is made different from that of the other, and therefore, a controlling range of the balance between rigidity and shape can be expanded. For example, in the event that the upper cross portion whose rigidity is smaller than that of the lower cross portion is formed from a material having high rigidity, the shape of the upper cross portion can be made small. This makes it easy to avoid the interference of the movable range of the link mechanism with the on-board components. Consequently, it is possible to enhance the degree of freedom in designing the link mechanism while maintaining the function of the link mechanism in the vehicle that includes the vehicle body frame that can lean and the two front wheels.

[0024]

In the vehicle according to the invention, the vehicle body frame may include a link supporting portion that turnably supports the upper cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof and the lower cross portion that includes the piece of part that is supported at the

right end portion and the left end portion thereof and that is supported at the middle portion thereof, and a shape of a front portion of the upper cross portion that lies ahead of the link supporting portion in the direction of the upper right axis may differ from a shape of a rear portion of the upper cross portion that
5 lies behind the link supporting portion.

[0025]

According to the vehicle of the invention that includes the vehicle body frame that can lean and the two front wheels, the shape of the front portion of the upper cross portion that lies ahead of the link supporting portion is made to
10 differ from the shape of the rear portion of the upper cross portion that lies behind the link supporting portion, and therefore, the movable range of the link mechanism can be changed from the simple shape like a rectangular parallelepiped to an arbitrary shape. This makes it easy to avoid the interference of the movable range of the link mechanism with the on-board
15 components. Consequently, it is possible to enhance the degree of freedom in designing the link mechanism while maintaining the function of the link mechanism in the vehicle that includes the vehicle body frame that can lean and the two front wheels.

[0026]

20 In the vehicle according to the invention, the vehicle body frame may include a link supporting portion that turnably supports the upper cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof and the lower cross portion that includes the piece of part that is supported at the

right end portion and the left end portion thereof and that is supported at the middle portion thereof, and a shape of a front portion of the lower cross portion that lies ahead of the link supporting portion in the direction of the lower right axis may differ from a shape of a rear portion of the lower cross portion that
5 lies behind the link supporting portion.

[0027]

According to the vehicle of the invention that includes the vehicle body frame that can lean and the two front wheels, the shape of the front portion of the lower cross portion that lies ahead of the link supporting portion is made to
10 differ from the shape of the rear portion of the lower cross portion that lies behind the link supporting portion, and therefore, the movable range of the link mechanism can be changed from the simple shape like a rectangular parallelepiped to an arbitrary shape. This makes it easy to avoid the interference of the movable range of the link mechanism with the on-board
15 components. Consequently, it is possible to enhance the degree of freedom in designing the link mechanism while maintaining the function of the link mechanism in the vehicle that includes the vehicle body frame that can lean and the two front wheels.

[0028]

20 In the vehicle according to the invention, the vehicle body frame may include a link supporting portion that supports the upper cross portion that includes the piece of part that is turnably supported at the right end portion and the left end portion and that is supported at the middle portion and the lower cross portion that includes the piece of part that is supported at the right end

portion and the left end portion and that is supported at the middle portion, and the upper cross portion may include a piece of upper front part that lies ahead of the link supporting portion in the direction of the upper right axis, that is supported at the right end portion and the left end portion and that is supported at the middle portion and a piece of upper rear part that lies behind the link supporting portion in the direction of the upper right axis, that is supported at the right end portion and the left end portion and that is supported at the middle portion.

[0029]

10 According to the vehicle of the invention that includes the vehicle body frame that can lean and the two front wheels, the upper cross portion includes the piece of upper front part that lies ahead of the link supporting portion and the piece of upper rear part that lies behind the link supporting portion, and therefore, the balance between rigidity and shape of the upper cross portion is
15 easy to be controlled. This can enhance the degree of freedom in designing a peripheral lower portion of the steering shaft. This makes it easy to avoid the interference of the movable range of the link mechanism with the on-board components. Consequently, it is possible to enhance the degree of freedom in designing the link mechanism while maintaining the function of the link
20 mechanism in the vehicle that includes the vehicle body frame that can lean and the two front wheels.

[0030]

 In the vehicle according to the invention, the vehicle body frame may include a link supporting portion that turnably supports the upper cross portion

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that includes the piece of part that is supported at the right end portion and the left end portion and that is supported at the middle portion and the lower cross portion that includes the piece of part that is supported at the right end portion and the left end portion and that is supported at the middle portion, and the
5 lower cross portion may include a piece of lower front part that lies ahead of the link supporting portion in the direction of the lower right axis, that is supported at the right end portion and the left end portion and that is supported at the middle portion and a piece of lower rear part that lies behind the link supporting portion in the direction of the lower right axis, that is supported at
10 the right end portion and the left end portion and that is supported at the middle portion.

[0031]

According to the vehicle of the invention that includes the vehicle body frame that can lean and the two front wheels, the lower cross portion includes
15 the piece of lower front part that lies ahead of the link supporting portion and the piece of lower rear part that lies behind the link supporting portion, and therefore, the balance between rigidity and shape of the lower cross portion is easy to be controlled. This can enhance the degree of freedom in designing a peripheral lower portion of the steering shaft. This makes it easy to avoid the
20 interference of the movable range of the link mechanism with the on-board components. Consequently, it is possible to enhance the degree of freedom in designing the link mechanism while maintaining the function of the link mechanism in the vehicle that includes the vehicle body frame that can lean and the two front wheels.

[0032]

In the vehicle according to the invention, the vehicle body frame may include a link supporting portion that turnably supports the upper cross portion that includes the piece of part that is supported at the right end portion and the
5 left end portion thereof and that is supported at the middle portion thereof and the lower cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof, and the upper cross portion or the lower cross portion may be provided only either ahead of or behind the link supporting portion and
10 may not be provided both ahead of and behind the link supporting portion.

[0033]

According to the vehicle of the invention that includes the vehicle body frame that can lean and the two front wheels, the upper cross portion or the lower cross portion is provided only either ahead of or behind the link
15 supporting portion, and therefore, the movable range of the link mechanism can be changed from the simple shape like a rectangular parallelepiped to an irregular shape in which an upper portion is smaller than a lower portion. This makes it easy to avoid the interference of the movable range of the link mechanism with the on-board components. Consequently, it is possible to
20 enhance the degree of freedom in designing the link mechanism while maintaining the function of the link mechanism in the vehicle that includes the vehicle body frame that can lean and the two front wheels.

[0034]

In the vehicle according to the invention, a front end of the upper cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof and a front end of the lower cross portion that includes the piece of part
5 that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof may be provided in different positions in relation to the direction of the upper right axis.

[0035]

According to the vehicle that includes the vehicle body frame that can
10 lean and the two front wheels, the front end of the upper cross portion and the front end of the lower cross portion are provided in the different positions in relation to the direction of the upper right axis, and therefore, the movable range of the link mechanism can be changed from the simple shape like a rectangular parallelepiped to a shape that is irregular in relation to a front-and-
15 rear direction of the vehicle body frame. This makes it easy to avoid the interference of the movable range of the link mechanism with the on-board components. Consequently, it is possible to enhance the degree of freedom in designing the link mechanism while maintaining the function of the link mechanism in the vehicle that includes the vehicle body frame that can lean
20 and the two front wheels.

[0036]

In the vehicle according to the invention, a rear end of the upper cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion

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thereof and a rear end of the lower cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof may be provided in different positions in relation to the direction of the upper right axis.

5 [0037]

According to the vehicle of the invention, the rear end of the upper cross portion and the rear end of the lower cross portion are provided in the different positions in relation to the direction of the upper right axis, and therefore, the movable range of the link mechanism can be changed from the
10 simple shape like a rectangular parallelepiped to the shape that is irregular in relation to the front-and-rear direction of the vehicle body frame. This makes it easy to avoid the interference of the movable range of the link mechanism with the on-board components. Consequently, it is possible to enhance the degree of freedom in designing the link mechanism while maintaining the function of
15 the link mechanism in the vehicle that includes the vehicle body frame that can lean and the two front wheels.

[0038]

In the vehicle according to the invention, the vehicle body frame may include a link supporting portion that turnably supports the upper cross portion
20 that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof and the lower cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the

middle portion thereof, and the link supporting portion may turnably support the steering shaft.

[0039]

According to the vehicle of the invention that includes the vehicle body
5 frame that can lean and the two front wheels, the link supporting portion supports the link mechanism that supports the right front wheel, the left front wheel, the right shock absorbing device and the left shock absorbing device and is highly rigid. This makes it easy to avoid the interference of the movable range of the link mechanism with the on-board components. Consequently, it is
10 possible to enhance the degree of freedom in designing the link mechanism while maintaining the function of the link mechanism in the vehicle that includes the vehicle body frame that can lean and the two front wheels.

[0040]

According to the vehicle of the invention that includes the vehicle body
15 frame that can lean and the two front wheels, it is possible to enhance the degree of freedom in designing the link mechanism while maintaining the function of the link mechanism.

Brief Description of Drawings

[0041]

20 [Fig. 1] Fig. 1 is a left side view of a vehicle according to an embodiment of the invention.

[Fig. 2] FIG. 2 is an overall front view of the vehicle with a body cover removed.

[Fig. 3] Fig. 3 is a perspective view of a link mechanism.

[Fig. 4] Fig. 4 is a side sectional view of the link mechanism.

[Fig. 5] FIG. 5 is an overall front view showing a state in which the vehicle is caused to lean.

[Fig. 6] Fig. 6 shows schematic drawings showing how to measure
5 rigidity with a lower cross portion removed.

[Fig. 7] Fig. 7 shows schematic drawings showing how to measure rigidity with an upper cross portion removed.

[Fig. 8] Fig. 8 is a view similar to Fig. 4 and shows a vehicle according to a modified example of the invention.

10 [Fig. 9] Fig. 9 is a front view of a vehicle according to a different modified example of the invention.

[Fig. 10] Fig. 10 is a plan view of the vehicle according to the different modified example of the invention.

Mode for Carrying out the Invention

15 [0042]

Hereinafter, a vehicle 1 that is one type of a vehicle according to an embodiment of the invention will be described by reference to the drawings. In the drawings, like reference numerals are given to like or corresponding portions and the description thereof will not be made repeatedly.

20 [0043]

In the following description, an arrow F in the drawings denotes a forward direction of the vehicle 1. An arrow R in the drawings denotes a rightward direction of a vehicle body frame of the vehicle 1. An arrow L in the drawings denotes a leftward direction of the vehicle body frame of the vehicle 1.

An arrow U denotes a perpendicularly upward direction. A transversely middle position means a central position in the direction of a width of the vehicle as seen from the front. A transversely lateral direction of the vehicle means a leftward or rightward direction from the transversely middle position.

5 [0044]

<Overall Configuration>

Fig. 1 is a schematic overall side view of the vehicle 1. In the following description, when front, rear, left and right are referred to in indicating directions, they denote front, rear, left and right as seen from a rider who rides
10 on the vehicle 1.

[0045]

The vehicle 1 includes a vehicle main body 2, front wheels 3 and a rear wheel 4. The vehicle main body 2 includes a vehicle body frame 21, a body cover 22, a handlebar 23, a seat 24 and a power unit 25.

15 [0046]

The vehicle body frame 21 supports the power unit 25, the seat 24 and the like. The power unit 25 includes a power source such as an engine or an electric motor, a transmission and the like. In Fig. 1, the vehicle body frame 21 is shown by broken lines.

20 [0047]

The vehicle body frame 21 includes a headstock 211, a front frame 212, and a rear frame 213. The headstock 211 is disposed at a front portion of the vehicle. A link mechanism 5 is disposed on the periphery of the headstock 211.

[0048]

A steering shaft 60 is inserted into the headstock 211 so as to turn therein. The steering shaft 60 extends in an up-and-down direction. The handlebar 23 is mounted on an upper end of the steering shaft 60. The front
5 frame 212 is inclined obliquely downward from a front end thereof to the rear. The front frame 212 is connected to the headstock 211 in a position that lies behind an upper cross portion 51, which will be described later. The rear frame 213 supports the seat 24 and a tail lamp.

[0049]

10 The vehicle body frame 21 is covered by the body cover 22. The body cover 22 includes a front cover 221, front mudguards 223 and a rear mudguard 224.

[0050]

The front cover 221 is positioned ahead of the seat 24. The front cover
15 221 covers the headstock 211 and the link mechanism 5.

[0051]

The front mudguards 223 are provided individually directly above a pair of left and right front wheels 3. The front mudguards 223 are disposed directly below the front cover 221. The rear mudguard 224 is disposed directly above
20 the rear wheel 4.

[0052]

The front wheels 3 are disposed below the headstock 211 and the link mechanism 5. The front wheels 3 are disposed directly below the front cover 221.

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[0053]

<Configuration of Front Portion of Vehicle>

Fig. 2 is an overall front view of the vehicle 1 with the body cover 22 removed. In Fig. 2, the front frame 212 and the like are omitted from the illustration.

[0054]

The vehicle 1 includes the handlebar 23, the steering shaft 60, the headstock 211, the pair of left and front wheels 3, and the link mechanism 5. The link mechanism 5 is disposed on the periphery of the headstock 211. The link mechanism 5 is connected to the pair of left and right front wheels 3, that is, a left front wheel 31 and a right front wheel 32. Additionally, the link mechanism 5 is turnably mounted on the headstock 211. The link mechanism 5 has the upper cross portion 51, a lower cross portion 52, a left side portion 53, a right side portion 54, a first bracket 335, a second bracket 336, a left shock absorber 33, a right shock absorber 34, and a tie-rod 6.

[0055]

The front wheels 3 are disposed so as to be aligned side by side in a left-and-right direction of the vehicle body frame 21 and include the left front wheel 31 and the right front wheel 32 that can be steered. A left front mudguard 223a is disposed directly above the left front wheel 31. A right front mudguard 223b is disposed directly above the right front wheel 32. The right front wheel 32 is disposed symmetrically with the left front wheel 31 with respect to the headstock 211 in relation to the left-and-right direction of the vehicle body frame 21.

[0056]

When referred to in this description, a "rightward direction RF of the vehicle body frame21" denotes a rightward direction of directions that intersect an axial direction of the headstock 211 perpendicularly when the vehicle 1 is seen from the front. Additionally, an upward direction UF of the vehicle body frame21 denotes an upward direction of the vehicle body frame21 when the vehicle 1 rests upright. For example, the upward direction of the vehicle body frame21 coincides with an axial direction of the headstock 211 when the vehicle 1 is seen from the front. In such a state that the vehicle 1 rests in an upright state as shown in Fig. 2, the rightward direction RF of the vehicle body frame21 coincides with a rightward direction R in the horizontal direction. Because of this, only the rightward direction R in the horizontal direction is shown in Fig. 2. In such a state that the vehicle 1 leans relative to a road surface G as shown in Fig. 5, the rightward direction RF of the vehicle body frame 21 does not coincide with the rightward direction R in the horizontal direction, and the upward direction UF of the vehicle body frame 21 does not coincide with an upward direction U in a perpendicular direction.

[0057]

The left front wheel 31 is connected to the left shock absorber 33. The left front wheel 31 is connected to a lower portion of the left shock absorber 33. The left front wheel 31 can rotate about a rotational axis 311. The rotational axis 311 extends in the left-and-right direction of the vehicle body frame 21. The left front wheel 31 can turn about a turning axis 312. The vehicle 1

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changes its traveling direction as a result of the left front wheel 31 turning about the turning axis 312.

[0058]

The right front wheel 32 is connected to the right shock absorber 34.

- 5 The right front wheel 32 is connected to a lower portion of the right shock absorber 34. The right front wheel 32 can rotate about a rotational axis 321. The rotational axis 321 extends in the left-and-right direction of the vehicle body frame 21. The right front wheel 32 can turn about a turning axis 322. The vehicle 1 changes its traveling direction as a result of the right front wheel 32
- 10 turning about the turning axis 322.

[0059]

- The left shock absorber 33 absorbs impact exerted on the left front wheel 31. The left shock absorber 33 is disposed below the link mechanism 5 in relation to the up-and-down direction of the vehicle body frame 21. The left
- 15 shock absorber 33 is provided between the left side portion 53 (refer to Fig. 3), which will be described later, and the left front wheel 31. The left shock absorber 33 extends along a left steering axis N1 that extends in a direction in which the steering shaft 60 and the headstock 211 extend. The left shock absorber 33 is disposed on the left of the headstock 211 in relation to the left-
- 20 and-right direction of the vehicle body frame 21. The left shock absorber 33 is disposed to the right of the left front wheel 31 in relation to the left-and-right direction of the vehicle body frame 21.

[0060]

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The right shock absorber 34 absorbs impact exerted on the right front wheel 32. The right shock absorber 34 is disposed below the link mechanism 5 in relation to the up-and-down direction of the vehicle body frame 21. The right shock absorber 34 is provided between the right side portion 54 (refer to Fig. 5 3), which will be described later, and the right front wheel 32. The right shock absorber 34 extends along a right steering axis N2 in which the steering shaft 60 and the headstock 211 extend. The right shock absorber 34 is disposed on the right of the headstock 211 in relation to the left-and-right direction of the vehicle body frame 21. The right shock absorber 34 is disposed on the left of 10 the right front wheel 32 in relation to the left-and-right direction of the vehicle body frame 21.

[0061]

The tie-rod 6 transfers a turn of the handlebar 23 to the left front wheel 31 and the right front wheel 32. By doing so, the left front wheel 31 and the 15 right front wheel 32 can be steered by the handlebar 23. The tie-rod 6 is provided ahead of the headstock 211. The tie-rod 6 extends in the left-and-right direction of the vehicle body frame 21. The tie-rod 6 is disposed directly below the lower cross portion 52, which will be described later, and directly above the left front wheel 31 and the right front wheel 32 in relation to the up- 20 and-down direction of the vehicle body frame 21. The tie-rod 6 is connected to a lower end portion of the steering shaft 60. When the steering shaft 60 is turned, the tie-rod 6 moves laterally to the left or right.

[0062]

(Side Portions)

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Fig. 3 is a perspective view of the link mechanism 5 with the left shock absorber 33 and the right shock absorber 34 omitted from the illustration.

[0063]

The left side portion 53 is disposed on the left of the headstock 211 in relation to the left-and-right direction of the vehicle body frame 21. The right side portion 54 is disposed on the right of the headstock 211 in relation to the left-and-right direction of the vehicle body frame 21. The left side portion 53 and the right side portion 54 are a circular cylindrical member.

[0064]

The left side portion 53 and the right side portion 54 extend in the up-and-down direction with the vehicle resting in the upright state. A mounting piece 531 where the left shock absorber 33 is mounted is provided at a lower end of the left side portion 53. A lower portion of the left side portion 53 supports the left shock absorber 33 so as to turn about the left steering axis N1. A mounting piece 541 where the right shock absorber 34 is mounted is provided at a lower end of the right side portion 54. A lower portion of the right side portion 54 supports the right shock absorber 34 so as to turn about the right steering axis N2.

[0065]

(Upper Cross Portion)

In this embodiment, the upper cross portion 51 is made up of a single plate-shaped part that extends in the left-and-right direction when seen from the front of the vehicle. The upper cross portion 51 is provided ahead of the vehicle of the headstock 211 to the front of the vehicle. The upper cross

portion 51 includes an upper middle bearing 511 that is provided at a middle portion of the upper cross portion 51 in relation to the left-and-right direction of the vehicle body frame 21 and an upper left bearing 512 and an upper right bearing 512 that are provided at or near leftmost and rightmost portions of the upper cross portion 51 in relation to the left-and-right direction of the vehicle body frame 21. An upper middle axis M1 that is a turning center of the upper middle bearing 511, an upper left axis M2 that is a turning center of the upper left bearing 512, and an upper right axis M3 that is a turning center of the upper right axis 512 are provided parallel to one another.

10 [0066]

The upper cross portion 51 is mounted on the headstock 211 via the upper middle bearing 511. This allows the upper cross portion 51 to be supported on the headstock 211 so as to turn about the upper middle axis M1 relative to the headstock 211.

15 [0067]

The upper cross portion 51 is connected to an upper portion of the left side portion 53 and an upper portion of the right side portion 54 via the upper left bearing 512 and the upper right bearing 512, respectively. This allows the upper cross portion 51 to turn about the upper left axis M2 and the upper right axis M3 relative to the left side portion 53 and the right side portion 54, respectively.

20 [0068]

In this embodiment, the upper cross portion 51 is made up of a single part that supports the upper portion of the right side portion 54 at a right end

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portion thereof so as to turn about the upper right axis M3 that extends in a front-and-rear direction of the vehicle body frame 21 via the upper right bearing 512 and supports the upper portion of the left side portion 53 at a left end portion thereof so as to turn about the upper left axis M2 that is parallel to the upper right axis M3 via the upper left bearing 512 and that is supported on the vehicle body frame 21 at the middle portion thereof so as to turn about the upper middle axis M1 that is parallel to the upper right axis M3 and the upper left axis M2 via the upper middle bearing 511.

[0069]

10 (Lower Cross Portion)

The lower cross portion 52 extends in the left-and-right direction of the vehicle body frame 21 when seen from the front of the vehicle. A length in the left-and-right direction of the lower cross portion 52 is substantially equal to a length in the left-and-right direction of the upper cross portion 51. The lower cross portion 52 is provided below the upper cross portion 51. The lower cross portion 52 has rigidity that is set to be larger than that of the upper cross portion 51. The rigidity of these cross portions will be described in detail later.

[0070]

The lower cross portion 52 includes a pair of front lower cross part 52a1 and rear lower cross part 52a2 that hold the headstock 211 therebetween in the front-and-rear direction of the vehicle body frame 21 and a connecting portion 52b where the front lower cross part 52a1 and the rear lower cross part 52a2 are connected together with bolts. The connecting portion 52b is a part that is formed integrally with the front lower cross part 52a1. The connecting

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portion 52b is provided in a position where the connecting portion 52b does not interfere with the headstock 211, the left side portion 53 and the right side portion 54 even though the link mechanism 5 is actuated to operate as will be described later. In this embodiment, the front lower cross part 52a1 and the rear lower cross part 52a2 are set so that a thickness in the front-and-rear direction of the vehicle body frame 21 is equal to a thickness in the front-and-rear direction of the vehicle body frame 21 of the upper cross portion 51. Additionally, the upper cross portion 51, the front lower cross part 52a1 and the rear lower cross part 52a2 are formed of the same steel.

10 [0071]

A lower middle bearing 521 that is provided at a middle portion in the left-and-right direction of the vehicle body frame 21, and a lower left bearing 522 and a lower right bearing 522 that are provided at or near leftmost and rightmost portions in the left-and-right direction of the vehicle body frame 21 are provided in each of the pair of front lower cross part 52a1 and rear lower cross part 52a2 of the lower cross portion 52. These lower middle bearings 521, as well as the lower left bearings 522 and the lower right bearings 522 are provided so that a lower middle axis M4, a lower left axis M5 and a lower right axis M6 that are respective turning centers of the bearings are parallel to one another. Additionally, the lower middle axis M4, the lower left axis M5 and the lower right axis M6 are also provided so as to be parallel to the upper middle axis M1, the upper left axis M2 and the upper right axis M3. In addition, in relation to their positions in the left-and-right direction of the vehicle body frame 21, the lower left bearing 522 and the lower right bearing 522 are set to be in

the same positions as the upper left bearing 512 and the upper right bearing 512, respectively, in relation to the left-and-right direction of the vehicle body frame 21 with the vehicle 10 resting in the upright state.

[0072]

- 5 The lower cross portion 52 is mounted on the headstock 211 via the lower middle bearings 521 in a position that lies below the upper cross portion 51 in relation to the up-and-down direction of the vehicle body frame 21. This allows the lower cross portion 52 to be supported on the headstock 211 so as to turn about the lower middle axis M4.

10 [0073]

- The lower cross portion 52 is connected to a lower portion of the left side portion 53 and a lower portion of the right side portion 54 via the lower left bearings 522 and the lower right bearings 522, respectively. This allows the lower cross portion 52 to turn about the lower left axis M5 and the lower right axis M6 relative to the left side portion 53 and the right side portion 54, respectively.

[0074]

In this embodiment, the lower cross portion 52 is made up of a combination of the two parts. That is, the lower cross portion 52 includes:

- 20 the part 52a2 that supports the lower portion of the right side portion 54 at the right end portion thereof via the lower right bearing 522 so as to turn about the lower right axis M6 that is parallel to the upper right axis M3 and supports the lower portion of the left side portion 53 at the left end portion thereof via the lower left bearing 522 so as to turn about the lower left axis M5

that is parallel to the upper left axis M2, that is supported on the vehicle body frame 21 at the middle portion thereof via the lower middle bearing 521 so as to turn about the lower middle axis that is parallel to the upper middle axis and that lies behind the headstock 211, and

5 the part (the part that is made up of the constituent parts denoted by reference numeral 52a1 and reference numeral 52b) that supports the lower portion of the right side portion 54 at the right end portion thereof via the lower right bearing 522 so as to turn about the lower right axis M6 that is parallel to the upper right axis M3 and supports the lower portion of the left side portion
10 53 at the left end portion thereof via the lower left bearing 522 so as to turn about the lower left axis M5 that is parallel to the upper left axis M2 and that is supported on the vehicle body frame 21 at the middle portion thereof via the lower middle bearing 521 so as to turn about the lower middle axis that is parallel to the upper middle axis.

15 [0075]

In this way, the upper cross portion 51 is supported on the headstock 211 so as to turn about the upper middle axis M1 that lies above the left front wheel 31 and the right front wheel 32 in relation to the up-and-down direction of the vehicle body frame 21. The lower cross portion 52 is supported on the
20 headstock 211 so as to turn about the lower middle axis M4 that lies above the left front wheel 31 and the right front wheel 32 and lies below the upper middle axis M1 in relation to the up-and-down direction of the vehicle body frame 21. In this embodiment, with the vehicle resting in the upright state, the upper cross portion 51 and the lower cross portion 52 are disposed in whole above

the left front wheel 31 and the right front wheel 32 in relation to the up-and-down direction of the vehicle body frame 21.

[0076]

Thus, by being configured in the way described above, the link
5 mechanism 50 can operate within a plane that contains the left side portion 53 and the right side portion 54. It is noted that the link mechanism 50 is mounted on the headstock 211. Because of this, even though the steering shaft 60 turns in association with the turn of the handlebar 23, the link mechanism 50 is not turned relative to the vehicle body frame 21.

10 [0077]

Fig. 4 is a sectional view showing an upper portion of the link
mechanism 50 as seen from a side of the vehicle with the vehicle resting in the upright state. As shown therein, in this embodiment, a lower surface C of the upper cross portion 51 is situated between an upper surface A of the front
15 lower cross part 52a1 that constitutes a front portion of the lower cross portion 52 and an upper surface B of the rear lower cross part 52a2 that constitutes a rear portion of the lower cross portion 52 in relation to the front-and-rear direction of the vehicle body frame 21. An upper front middle supporting portion 511FS is provided on the headstock 211 and this upper front middle
20 supporting portion 511FS supports the upper cross portion 51 so as to turn about the upper middle axis M1 via the upper middle bearing 511. A lower front middle supporting portion 521FS and a lower front middle supporting portion 521BS are provided on the headstock 211, and these lower front middle supporting portion 521FS and the lower front middle supporting portion 521BS

support the lower cross portion 52 so as to turn about the lower middle axis M4 via the lower middle bearings 521.

[0078]

Although the link mechanism 5 with the vehicle resting in the upright
5 state is shown in Fig. 4, the positional relationship just described above will be maintained even though the link mechanism 5 is actuated to operate as the vehicle body leans as will be described later. To be specific, even though the link mechanism 5 is actuated to operate, the lower surface C of the upper cross portion 51 is still situated between the upper surface A of the front lower
10 cross part 52a1 that constitutes the front portion of the lower cross portion 52 and the upper surface B of the rear lower cross part 52a2 that constitutes the rear portion of the lower cross portion 52 in relation to the front-and-rear direction of the vehicle frame body 21.

In other words, the link mechanism 5 is provided so that a front end of
15 the upper cross portion 51 and a front end of the lower cross portion 52 are situated in different positions in the direction of the upper right axis M3.

[0079]

(Brackets)

As shown in Fig. 2, the first bracket 335 is provided at a lower portion
20 of the left side portion 53. The first bracket 335 is connected to the left shock absorber 33. The first bracket 335 is mounted so as to turn relative to the left side portion 53. The tie-rod 6 is also mounted on the first bracket 335 so as to turn relative thereto. A turning axis around which the first bracket 335 and the left side portion 53 turn relative to each other and a turning axis around which

the first bracket 335 and the tie-rod 6 turn relative to each other are parallel to a direction in which the left side portion 53 extends (the left steering axis N1).

[0080]

The second bracket 336 is provided at a lower portion of the right side
5 portion 54. The second bracket 336 is connected to the right shock absorber
34. The second bracket 336 is mounted so as to turn relative to the right side
portion 54. The tie-rod 6 is also mounted on the second bracket 336 so as to
turn relative thereto. A turning axis around which the second bracket 336 and
the right side portion 54 turn relative to each other and a turning axis on which
10 the second bracket 336 and the tie-rod 6 turn relative to each other are parallel
to a direction in which the right side portion 54 extends (the right steering axis
N2).

[0081]

(Steering Shaft)

15 The steering shaft 60 is supported on the vehicle body frame 21
between the left side portion 53 and the right side portion 54 in the left-and-
right direction of the vehicle body frame 21. An upper end portion of the
steering shaft 60 is provided above the lower middle axis M4 in the up-and-
down direction of the vehicle body frame 21. The steering shaft 60 can turn
20 about a middle steering axis Z that extends in the up-and-down direction of the
vehicle body frame 21. The handlebar 23 is provided at the upper end portion
of the steering shaft 60. The tie-rod 6 (an example of a turning transmission
mechanism) transfers a turn of the steering shaft 60 that corresponds to an

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operation of the handlebar 23 to the right shock absorber 34 and the left shock absorber 33.

[0082]

When the steering shaft 60 turns as the handlebar 23 turns, the tie-rod
5 6 moves in the left-and-right direction of the vehicle body frame 21. Then, the first bracket 335 turns about the turning axis on which the first bracket 335 turns relative to the left side portion 53 as the tie-rod 6 moves so. This moves a connecting portion 52b where the first bracket 335 connects to the left shock absorber 33 in the left-and-right direction of the vehicle body frame 21, and the
10 left front wheel 31 turns about the second turning axis 312.

[0083]

In this way, the first bracket 335 transfers the turn of the handlebar 23 to the left front wheel 31. Similarly, the second bracket 336 transfers the turn of the handlebar 23 to the right front wheel 32.

15 [0084]

<Leaning of Vehicle Body>

Fig. 5 is an overall front view of the vehicle 1 of which the vehicle body is caused to lean at an angle T to the left in relation to a perpendicular direction from the state shown in Fig. 2. When the vehicle 1 is caused to lean in relation
20 to the perpendicular direction, the link mechanism 5 is actuated to operate.

[0085]

As this occurs, the upper cross portion 51 and the lower cross portion 52 are translated horizontally in the left-and-right direction while the direction in which they extend is kept parallel to the road surface G . The upper cross

portion 51 and the lower cross portion 52 turn about the upper left axis M2 and the lower left axis M5, respectively, relative to the left side portion 53. Additionally, the upper cross portion 51 and the lower cross portion 52 also turn about the upper right axis M3 and the lower right axis M6, respectively, relative to the right side portion 54.

[0086]

In this way, when the vehicle is seen from the front, with the vehicle resting in the upright state, the upper cross portion 51, the lower cross portion 52, the left side portion 53, the right side portion 54 form a rectangle, and when the vehicle is caused to lean, the link mechanism 5 operates so that the rectangle changes to a parallelogram as the vehicle is caused to lean further.

In the following description, an area where the upper cross portion 51, the lower cross portion 52, the left side portion 53 and the right side portion 54 move when the link mechanism 5 is actuated to operate may be referred to as a movable range of the link mechanism 5 from time to time.

[0087]

In this embodiment, the link mechanism 50 operates so that a left end of the upper cross portion 51 moves further horizontally leftwards than a left end of the lower cross portion 52. When the link mechanism 50 operates in this way, the left shock absorber 33 and the right shock absorber 34 lean in relation to the perpendicular direction. When the vehicle 1 leans to the left in relation to the perpendicular direction in the way described above, the state of the vehicle 1 changes from the state shown in Fig. 2 to the state shown in Fig. 5.

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[0088]

The vehicle 1 according to this embodiment can be turned by causing the vehicle body to lean in the left-and-right direction while the vehicle 1 is running. Additionally, the directions of the left front wheel 31 and the right front
5 wheel 32 can also be changed by operating the handlebar 23.

[0089]

<Rigidity of Cross Portions and Method for Measuring the Same>

Next, the rigidity of the upper cross portion 51 and the lower cross portion 52 will be described. In the following description, the rigidity of the
10 upper cross portion 51 and the lower cross portion 52 (hereinafter, when both the cross portions do not have to be discriminated from each other, the upper cross section 51 and the lower cross section 52 will be referred to simply as a cross portion) mean the difficulty in deflecting that the cross portions have when a force is exerted on the cross portions.

15 [0090]

The left front wheel 31 and the right front wheel 32 of the vehicle 1 are supported independently of each other. Because of this, there are situations in which forces that are different in magnitude are exerted on the left front wheel 31 and the right front wheel 32 at different timings. For example, when the
20 brakes are applied or the vehicle 1 rides over irregularities or undulations on the road surface, an external force is transferred to the link mechanism 5. As this occurs, there are situations in which forces that are different in magnitude or direction are exerted on the upper cross portion or the lower cross portion. Additionally, there are situations in which forces are exerted on the upper cross

portion of the lower cross portion at different timings. Further, as those occur, there are situations in which the upper cross portion or the lower cross portion is twisted. To deal with these situations, the right side portion 54, the left side portion 53, the upper cross portion 51 and the lower cross section 52 of the
5 vehicle 1 of this embodiment each have high rigidity to maintain the smooth operation of the link mechanism 5.

[0091]

The right side portion 54, the left side portion 53, the upper cross
portion 51 and the lower cross portion 52 that make up the link mechanism 5
10 are each formed highly rigid to enhance the function to turn smoothly and the function to transfer loads. This eventually enlarges external shapes of the right side portion 54, the left side portion 53, the upper cross portion 51 and the lower cross portion 52. Additionally, this results in enlargement of the link mechanism 5 that is made up of those portions that are so enlarged. Further,
15 the movable range of the link mechanism 5 is also expanded further. The vehicle that includes the vehicle body frame 21 that can lean and the two front wheels 31, 32 includes on the periphery of the steering shaft 60 the large link mechanism 5 that moves as the vehicle body frame 21 leans. Because of this, in the vehicle including the vehicle body frame 21 that can lean and the two
20 front wheels 31, 32, on-board components need to be provided so that the on-board components do not interfere with the movable range of the link mechanism 5. This requires the enhancement of the degree of freedom in designing the link mechanism 5 in the vehicle 1 that includes the vehicle body frame 21 that can lean and the two front wheels 31, 32.



Firstly, the inventor of this patent application has analyzed in detail the function of the link mechanism 5. The link mechanism 5 has the function to enable the right side portion 54 or the left side portion 53 to turn smoothly relative to the upper cross portion 51 and the lower cross portion 52 and the
5 function to enable the upper cross portion 51 and the lower cross portion 52 to turn smoothly relative to the vehicle body frame 21. Additionally, the link mechanism 5 has the function to transfer loads borne by the right side portion 54 or the left side portion 53 to the vehicle body frame 21.

This analysis has found out that the upper cross portion 51 and the
10 lower cross portion 52 are twisted by the loads borne by the link mechanism 5. The analysis has found out that the twisting of the upper cross portion 51 occurs along an upper center axis 51C (refer to Fig. 6) that passes through a center of the upper right bearing 512 of the upper cross member 51 in relation to the direction of the upper right axis M3 and a center of the upper left bearing
15 512 of the upper cross member 51 in relation to the direction of the upper left axis M2. The analysis also has found out that the twisting of the lower cross portion 52 occurs along a lower center axis 52C (refer to Fig. 7) that passes through a center between the upper right bearings 522 of the lower cross member 52 in relation to the direction of the lower right axis M6 and a center
20 between the lower left bearings 522 of the lower cross member 52 in relation to the direction of the lower left axis M5.

Then, various cross portions that are different in torsional rigidity about the upper center axis 51C and in torsional rigidity about the lower center axis 52C have been studied. The results of the study have found out that even

though the torsional rigidity of the upper cross portion 51 that includes the piece of part that is supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof is made to differ from the torsional rigidity of the

5 lower cross portion 52 that includes the piece of part that is supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof, in the event that the torsional rigidity of the lower cross portion 52 that includes the piece of

10 part that is supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof is made higher than the torsional rigidity of the upper cross portion 51 that includes the piece of part that is supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof, the smooth

15 operation of the link mechanism is easy to be maintained. It is considered that this is attributed to the fact that a difference between a distance between an axle of the right front wheel 32 and the upper right bearing 512 that lies between the upper cross portion 51 and the right side portion 54 and a distance between the axle of the right front wheel 32 and the lower right

20 bearings 522 that lie between the lower cross portion 52 and the right side portion 54 differs from a difference between a distance between an axle of the left front wheel 31 and the upper left bearing 512 that lies between the upper cross portion 51 and the left side portion 53 and a distance between the axle of the left front wheel 31 and the lower left bearings 522 that lie between the

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lower cross portion 52 and the left side portion 53. The distance between the axle of the right front wheel 32 and the lower right bearings 521 that lie between the lower cross portion 51 and the right side portion 54 is shorter than the distance between the axle of the right front wheel 32 and the upper right bearing 512 that lies between the upper cross portion 51 and the right side portion 54. The distance between the axle of the left front wheel 31 and the lower left bearings 522 that lie between the lower cross portion 52 and the left side portion 53 is shorter than the distance between the axle of the left front wheel 31 and the upper left bearing 512 that lies between the upper cross portion 51 and the left side portion 53. It is considered that these facts affect the smooth operation of the link mechanism 5.

According to the vehicle of this embodiment, the torsional rigidity of the lower cross portion 52 that includes the piece of part that is supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof is made higher than the torsional rigidity of the upper cross portion 51 that includes the piece of part that is supported on the side portions at the right end portion and the left end portion thereof and that is supported on the vehicle body frame at the middle portion thereof. Therefore, the smooth operation of the link mechanism 5 is easy to be maintained. Moreover, the upper cross portion 51 and the lower cross portion 52 are each made to include the piece of part that is supported on the side portions 53, 54 at the right end portion and the left end portion thereof and that is supported on the headstock 211 at the middle portion thereof, and the torsional rigidity of the upper cross portion 51 is made

to differ from the torsional rigidity of the lower cross portion 52. Therefore, it is possible to enhance the degree of freedom in designing the link mechanism 5.

[0092]

The rigidity of the cross portions of the link mechanism 5 includes a rigidity component that is attributed to the shape, thickness, material and the like of the cross portion itself and a rigidity component that is attributed to the type, size and the like of the upper middle bearing 511 or the lower middle bearings 521. Then, it is possible to know the rigidity of the cross portions based on displacements of the cross portions that are measured as will be described below. It is shown that the smaller a displacement, the larger the rigidity.

[0093]

Fig. 6 shows schematic drawings showing how to measure rigidity of the upper cross portion 51 with the lower cross portion 52 removed. (a) in Fig. 6 is a perspective view of an upper portion of the link mechanism 5, and (b) in Fig. 6 is a plan view of the upper portion of the link mechanism 5. Fig. 7 shows schematic drawings showing how to measure rigidity of the lower cross portion 52 with the upper cross portion removed. (a) in Fig. 7 is a perspective view of the upper portion of the link mechanism 5, and (b) in Fig. 7 is a plan view of the upper portion of the link mechanism 5.

[0094]

As shown at (a) in Fig. 6, the lower cross portion 52 is removed from the headstock 211. In this state, the upper middle bearing 511, the upper left

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bearing 512 and the upper right bearing 512 are kept mounted in the upper cross portion 51.

An upper right displacement X1 of the upper cross portion 51 is measured which results when a rearward test force F1 in the direction of the lower right axis M6 is exerted on the lower front right supporting portion 522FS in such a state that the lower cross portion 52 is removed which includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof while the upper cross portion 51 is kept mounted which includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof. In the same state, an upper left displacement X2 of the upper cross portion 51 is measured which results when a force that is the same in magnitude and direction (a rearward direction in the direction of the lower left axis M5) as the test force F1 is exerted on the upper left supporting portion 522FS.

[0095]

When the rearward test force F1 in the direction of the lower right axis M6 is exerted on the lower front right supporting portion 522FS, as has been described above, the upper cross portion 51 is twisted about the upper center axis 51C. Then, as shown at (b) in Fig. 6, as seen from the top thereof in the up-and-down direction of the vehicle body frame 21, a front edge of an upper surface of the upper cross portion 51 moves to the front in the front-and-rear direction of the vehicle body frame 21. This forward movement of the front edge of the upper surface at the right end portion of the upper cross portion 51

in the front-and-rear direction of the vehicle body frame 21 is measured as the upper right displacement X1. Similarly, when the rearward force in the direction of the lower left axis M5 that is the same in magnitude as the test force F1 is exerted on the lower front left supporting portion 522FS, the upper cross portion 51 is twisted about the upper center axis 51C. Then, as seen from the top thereof in the up-and-down direction of the vehicle body frame 21, the front edge of the upper surface of the upper cross portion 51 moves to the front in the front-and-rear direction of the vehicle body frame 21. This forward movement of the front edge of the upper surface at the left end portion of the upper cross portion 51 in the front-and-rear direction of the vehicle body frame 21 is measured as an upper left displacement X2.

[0096]

Next, as shown in Fig. 7, the upper cross portion 51 is removed from the headstock 211. The lower middle bearings 521, the lower left bearings 522, and the lower right bearings 522 are kept mounted in the lower cross portion 52. A lower right displacement X3 of the lower cross portion 52 is measured which results when a force that is same in magnitude and direction (rearward in the direction of the upper right axis M3) as the test force F1 is exerted on the upper front right supporting portion 512FS in such a state that the upper cross portion 51 is removed which includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof while the lower cross portion 52 is kept mounted which includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof. In the

same state, a lower left displacement X4 of the lower cross portion 52 is measured which results when a force that is the same in magnitude and direction (rearward in the direction of the upper left axis M2) as the test force F1 is exerted on the upper left supporting portion 512FS.

5 [0097]

When the force that is the same in magnitude and direction as the test force F1 is exerted on the upper front right supporting portion 512FS, as has been described above, the lower cross portion 52 is twisted about the lower center axis 52C. Then, as shown at (b) in Fig. 7, as seen from the top thereof
10 in the up-and-down direction of the vehicle body frame 21, a front edge of a lower surface of the lower cross portion 52 moves to the front in the front-and-rear direction of the vehicle body frame 21. This forward movement of the front edge of the lower surface at the right end portion of the lower cross portion 52 in the front-and-rear direction of the vehicle body frame 21 is measured as the
15 lower right displacement X3.

Similarly, when the force that is the same in magnitude and direction as the test force F1 is exerted on the upper front left supporting portion 512FS, the lower cross portion 52 is twisted about the lower center axis 52C. Then, as seen from the top thereof in the up-and-down direction of the vehicle body
20 frame 21, the front edge of the lower surface of the lower cross portion 52 moves to the front in the front-and-rear direction of the vehicle body frame 21. This forward movement of the front edge of the lower surface at the left end portion of the lower cross portion 52 in the front-and-rear direction of the vehicle body frame 21 is measured as a lower left displacement X4.

[0098]

The test force is exerted only on either the left end portion or the right end portion of the upper cross portion 51 and the lower cross portion 52 as either of the lower front right supporting portion 522FS and the lower front left supporting portion 522FS or either of the upper front right supporting portion 512FS and the upper front left supporting portion 512FS. By doing so, a force that is exerted on the upper cross portion 51 and the lower cross portion 52 when the brakes are applied or the vehicle rides over irregularities or undulations on the road surface is mocked.

10 [0099]

When the upper right displacement X1, the upper left displacement X2, the lower right displacement X3 and the lower left displacement X4 are measured in the way described above, in the vehicle 1 of this embodiment, the upper right displacement X1 and the upper left displacement X2 of the upper cross portion 51 are equal to each other, and the lower right displacement X3 and the lower left displacement X4 of the lower cross portion 52 are equal to each other. The upper right displacement X1 of the upper cross portion 51 is larger than the lower right displacement X3 of the lower cross portion 52. The upper left displacement X2 of the upper cross portion 51 is larger than the lower left displacement X4 of the lower cross portion 52. Additionally, a shape of the upper cross portion 51 is smaller than a shape of the lower cross portion 52. Additionally, a volume of the upper cross portion 51 is smaller than a volume of the lower cross portion 52.

[0100]

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In the vehicle 1 of this embodiment, a thickness in a front-and-rear direction and a thickness in an up-and-down direction of the upper cross portion 51 are equal to corresponding thicknesses of the front lower cross part 52a1 and the rear lower cross part 52a2 that make up the lower cross portion 52, and the same bearing is adopted for the upper middle bearing 511 and the lower middle bearings 521.

[0101]

Additionally, the upper cross portion 51 does not have a member that corresponds to the connecting portion 52b of the lower cross portion 52. Further, the upper middle bearing 511 disposed only ahead of the headstock 211. In contrast with this, the lower middle bearings 521 are provided both at a front and rear sides of the headstock 211. Since the lower cross portion 52 is supported by the lower middle bearings 521 at two locations in the front-and-rear direction, the displacements X_1 , X_2 may be larger than twice the displacements X_3 , X_4 , respectively.

[0102]

In addition, by adopting any one of the following configurations (1) to (3), the displacements X_1 , X_2 of the upper cross portion 51 become larger than the displacements X_3 , X_4 of the lower cross portion 52. (1) The upper cross portion 51 is made larger than the front lower cross part 52a1 that constitutes the front portion of the lower cross portion. (2) The upper middle bearing 511 of the upper cross portion 51 is made larger than the lower middle bearings 521 of the lower cross portion 52. (3) The upper middle bearing 511 of the upper cross portion 51 is made up of a plurality of bearings.

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[0103]

In the description made above, the rearward test force F1 is exerted on the lower front right supporting portion 522FS, the lower front left supporting portion 522FS, the upper front right supporting portion 512FS and the upper front left supporting portion 512FS. However, a forward test force F1 may be exerted on the lower front right supporting portion 522FS, the lower front left supporting portion 522FS, the upper front right supporting portion 512FS and the upper front left supporting portion 512FS. In the event that test forces that act in opposite directions in relation to the front-and-rear direction are exerted on the upper cross portion 51 and the lower cross portion 52, the aforesaid longitudinal loads that are exerted on the cross portions when the brakes are applied or the vehicle rides over the irregularities on the road surface can be mocked.

[0104]

15 <Functions and Advantages>

According to the vehicle of this embodiment, the movable range of the link mechanism 5 can be changed from a simple shape like a rectangular parallelepiped to an irregular shape by making the shape of the upper cross portion 51 that includes the piece of part that supports the right side portion 54 and the left side portion 53 and that is supported on the vehicle body frame 21 differ from the shape of the lower cross portion 52 that includes the piece of part that supports the right side portion 54 and the left side portion 53 and that is supported on the vehicle body frame 21. This can enhance the degree of freedom in designing the periphery of the steering shaft 60. As a result of this,

even though various on-board components that differ in size and the link mechanism 5 are disposed on the periphery of the steering shaft 60, it is possible to restrict the enlargement of the periphery of the steering shaft 60. Moreover, although the ratio of assignments of the load transferring function that are allocated between the upper cross portion 51 that includes the piece of part and the lower cross portion 52 that includes the piece of part is changed by making the shape of the upper cross portion 51 differ from the shape of the lower cross portion 52, it is easy to maintain the smooth operation of the link mechanism 5.

Consequently, in the vehicle that includes the vehicle body frame 21 that can lean and the two front wheels 31, 32, it is possible to restrict the enlargement in size of the construction on the periphery of the steering shaft 60 that lies above the two front wheels 31, 32 while maintaining the function of the link mechanism 5.

[0105]

Specifically, the upper cross portion 51 is made up of the single plate-shaped member, and as shown in Fig. 4, no member of the link mechanism 5 is provided at a rear upper portion of the link mechanism 5. This enables an upper portion of the space where the link mechanism 5 operates (the movable range of the link mechanism) to be smaller than the movable range of the link mechanism of Patent Document 1. Then, the vehicle body frame or accessories can be disposed in the space defined in the rear upper portion of the link mechanism 5. Alternatively, the front cover 221 may be designed to be simply smaller in size by an area corresponding to the rear upper space to

thereby enhance the external design thereof. Here, the accessories include a hydraulic unit of an ABS (Antilock Brake System), headlamp, horn, turn signals, radiator, battery, anti-theft device, brake hose, brake wire, fasteners for brake hose and brake wire, body cover, various meters, and the like.

5 [0106]

Therefore, a member of the vehicle body frame is designed to be large or an additional member is disposed in the space defined at the rear upper portion of the link mechanism 5 in the space defined at the front portion of the vehicle, whereby it is possible to enhance the rigidity of the vehicle.

10 Alternatively, the rear upper space can be made use of as space where indicators such as a speedometer, and accessories such as lamps and a main switch are disposed or stowage space. By doing so, positions where to dispose equipment at the front portion of the vehicle can freely be designed. Additionally, it is also possible to improve the external design.

15 [0107]

Further, to express the configuration described above in a different way, according to the embodiment, the lower cross portion 52 is made up of the front lower cross part 52a1 and the rear lower cross part 52a2 that are disposed so as to hold the headstock 211 therebetween, and the upper cross
20 portion 51 is made up of the single plate-shaped member. Then, the shape of the lower cross portion 52 is made larger than the shape of the upper cross portion 51. Namely, the lower cross portion 52 is formed large by making use of the space on the periphery of the lower portion of the link mechanism 5, and

the rigidity of the lower cross portion 52 is made larger than the rigidity of the upper cross portion 51.

In this way, in this embodiment, the rigidity of the link mechanism 5 is made unbalanced between the upper portion and the lower portion of the link mechanism 5. Since the lower cross portion 52 bears most of the rigidity that is required on the link mechanism 5, compared with the design concept of sharing equally the rigidity required on the link mechanism 5 between the upper portion and the lower portion of the link mechanism 5, the upper cross portion 51 can be formed smaller in shape than the lower cross portion 52 by forming the upper cross portion 51 of the single plate-shaped portion. This allows the upper portion of the link mechanism 5 to be formed small, and therefore, the space defined on the periphery of the upper portion of the link mechanism 5 can easily be made use of as the space where the vehicle body frame and the accessories are disposed. Alternatively, the space can easily be made use of to enhance the external design of the vehicle.

[0108]

In particular, the indicators and the vehicle body frame are disposed densely behind the headstock 211 in many cases. In this respect, this embodiment where no member of the upper cross portion 51 is provided on the headstock 211 is preferable since the space can be made effective use of for other applications. For example, the front frame 212 can be connected directly to the headstock 211 without interposing a support member or the like therebetween, thereby making it possible to enhance the rigidity of the front frame 212 and the headstock 211.

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Additionally, the upper cross portion 51, the lower cross portion 52, the left side portion 53 and the right side portion 54 of the link mechanism 5 are turnably supported by the bearings. This enhances the rigidity of the link mechanism 5.

5 [0109]

In the vehicle according to the embodiment, the upper right displacement X1 of the upper cross portion 51 is larger than the lower right displacement X3 of the lower cross portion 52, and the upper left displacement X2 of the upper cross portion 51 is larger than the lower left displacement X4
10 of the lower cross portion 52. Additionally, the shape of the upper cross portion 51 is smaller than the shape of the lower cross portion 52.

[0110]

According to the vehicle of this embodiment, the shape of the upper cross portion 51 that includes the piece of part that supports the right side
15 portion 54 and the left side portion 53 and that is supported on the vehicle body frame 21 is easy to be made smaller than the shape of the lower cross portion 52 that includes the piece of part that supports the right side portion 54 and the left side portion 53 and that is supported on the vehicle body frame 21. In other words, changing easily the shape the link mechanism enhances the
20 degree of freedom in designing the link mechanism. Additionally, this enables the movable range of the link mechanism 5 to be changed from the simple shape like a rectangular parallelepiped to a shape in which an upper portion is small. This can enhance the degree of freedom in designing an upper peripheral portion of the steering shaft 60. The ratio of the assignment of the

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load transferring function allocated to the upper cross portion 51 of which the shape is made smaller is reduced, while the ratio of the assignment of the load transferring function allocated to the lower cross portion 52 of which the shape is made larger is increased, and therefore, the balance between rigidity and shape is easy to be controlled. This can enhance the degree of freedom in designing the upper peripheral portion of the steering shaft 60. As a result of this, even though various on-board components having different sizes and the link mechanism 5 are disposed on the periphery of the steering shaft 60, it is possible to restrict the enlargement in size of the periphery of the steering shaft 60. Consequently, in the vehicle that includes the vehicle body frame that can lean and the two front wheels, it is possible to enhance the degree of freedom in designing the link mechanism while maintaining the function of the link mechanism. Additionally, in the vehicle that includes the vehicle body frame 21 that can lean and the two front wheels 31, 32, it is possible to restrict further the enlargement in size of the peripheral construction of the steering shaft 60 that lies above the two front wheels 31, 32 while maintaining the function of the link mechanism 5.

[0111]

When referred to herein, the shape of the upper cross portion 51 means a shape that is defined by the outer shape of the upper cross portion 51, and the shape of the lower cross portion 52 means a shape that is defined by the outer shape of the lower cross portion 52. 翻訳不要 翻訳不要 The outer shape of the upper cross portion 51 means an outer edge of an area that is defined by a surface of the upper cross portion 51 that makes up a movable

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range of the upper cross portion 51 when the link mechanism 5 operates. The outer shape of the lower cross portion 52 means an outer edge of an area that is defined by a surface of the lower cross portion 52 that makes up a movable range of the lower cross portion 52 when the link mechanism 5 operates.

5 For example, surfaces that defines outlines of the left and right end portions of the upper cross portion 51 when seen in the direction of the upper middle axis M1 make up left and right surfaces of the movable range of the upper cross portion 51. Because of this, the surfaces that define the outlines of the left and right end portions of the upper cross portion 51 when seen in the
10 direction of the upper middle axis M1 affect the shape of the upper cross portion 51. On the contrary to this, wall portions that define through holes that are provided in the upper cross portion 51 to dispose the upper middle bearing 511, the upper right bearing 512 and the upper left bearing 512 are not surfaces that make up the movable range of the upper cross portion. Thus, the
15 wall portions that define the through holes do not affect the shape of the upper cross portion 51. In addition to these wall portions, surfaces of recess portions that are provided simply with a view to reducing the weight of the upper cross portion 51 and that do not affect the movable range of the upper cross portion 51 do not affect the shape of the upper cross portion 51.

20 [0112]

<Modified Example>

Thus, while the invention has been described heretofore by the use of the embodiment thereof, the technical scope of the invention is not limited by the scope that is descriptively defined in the embodiment. It is obvious to those

skilled in the art to which the invention pertains that various alterations or improvements can be made to the embodiment.

For example, the shape of the upper cross portion 51 can be made to differ from the shape of the lower cross portion 52 as long as the displacement

5 X1 is equal to the displacement X2, the displacement X3 is equal to the displacement X4, the displacement X1 is larger than the displacement X3, and the displacement X2 is larger than the displacement X4. Therefore, the volume of the upper cross portion 51 may be the same as or different from the volume of the lower cross portion 52, provided that the displacement X1 is

10 equal to the displacement X2, the displacement X3 is equal to the displacement X4, the displacement X1 is larger than the displacement X3, and the displacement X2 is larger than the displacement X4. Alternatively, the weight of the upper cross portion 51 may be the same as or different from the weight of the lower cross portion 52 as long as the displacement X1 is equal to

15 the displacement X2, the displacement X3 is equal to the displacement X4, the displacement X1 is different from the displacement X3, the displacement X2 is different from the displacement X4, and the shape of the upper cross portion 51 is different from the shape of the lower cross portion 52. Alternatively, the material of the upper cross portion 51 may be the same as or different from the

20 material of the lower cross portion 52 as long as the displacement X1 is equal to the displacement X2, the displacement X3 is equal to the displacement X4, the displacement X1 is different from the displacement X3, the displacement X2 is different from the displacement X4, and the shape of the upper cross portion 51 is different from the shape of the lower cross portion 52.

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[0113]

For example, in the embodiment described above, there is described as an example formed of the same material and having the different shapes so that the displacement X1 is larger than the displacement X3 and that the displacement X2 is larger than the displacement X4. However, the approach to making the displacement X1 larger than the displacement X3 and the displacement X2 larger than the displacement X4 is not limited to that described in the embodiment. For example, the lower cross portion 52 may be formed of a material having a Young's modulus that is larger than that of the material of the upper cross portion 51. By this approach, too, it is easy that the displacements X1, X2 of the upper cross portion 51 are larger than the displacements X3, X4 of the lower cross portion 52. This can enhance the degree of freedom in designing the periphery of the steering shaft 60.

[0114]

In addition, in the embodiment described above, the plate members having the same shape are described as the upper cross portion 51 is made up of the one plate member, and the lower cross portion 52 is made up of the two plate members. However, the approach to giving the different shapes to the upper and lower cross portions is not limited thereto. For example, a configuration may be adopted in which the upper cross portion 51 is made up of one plate member and the lower cross portion 52 is made up of one member having an I-shaped cross section (whose sectional area is the same as that of the plate member). By adopting this configuration, the displacements

X1, X2 of the upper cross portion 51 can be made larger than the displacements X3, X4 of the lower cross portion 52.

[0115]

In addition to this, as the approach to giving the different shapes to the upper cross portion 51 and the lower cross portion 52, it is possible to adopt a means for giving different sectional areas or sectional shapes to the upper and lower cross portions or a means for providing or not providing a reinforcement rib to enhance the rigidity thereof. By adopting this configuration, the displacement X1 can be made larger than the displacement X3, and the displacement X2 can be made larger than the displacement X4. It is noted that when referred to herein, the description that the shapes of the upper cross portion and the lower cross portion differ means that a difference in shape that does not affect largely the rigidity of the cross sections is not included in the difference in shape that is referred to above. The materials, weights or volumes of the upper cross portion and the lower cross portion may differ as long as the shape of the upper cross portion differs from the shape of the lower cross portion.

[0116]

In this invention, the upper cross portion and the lower cross portion may be formed of the same material have different shapes. By forming one of the upper cross portion and the lower cross portion so as to have a larger shape than that of the other in order to ensure the rigidity of the one, it is easy to enhance the degree of freedom in designing the link mechanism.

[0117]

In the vehicle according to the invention, the shape of the upper cross portion may be the same as or different from the shape of the lower cross portion. The material of the upper cross portion may be the same as or different from the material of the lower cross portion. The volume of the upper cross portion may be the same as or different from the volume of the lower cross portion. Alternatively, in the upper and lower cross sections, the shapes may be the same while the materials and volumes are different, the materials may be the same while the shapes and volumes are different, or the volumes may be the same while the shapes and materials are different. Thus, various combinations may be adopted. The upper cross portion and the lower cross portion should be different in at least one of shape, material and volume so that the displacement X1 and the displacement X2 are equal, the displacement X3 and the displacement X4 are equal, the displacement X1 is larger than the displacement X3, and the displacement X2 is larger than the displacement X4.

According to the vehicle of the invention, it is possible to enhance both the degree of freedom in designing the link mechanism and the degree of freedom in designing the peripheral space of the link mechanism. This restricts the enlargement in size of the front portion of the vehicle. Additionally, this can make small in size the front portion of the vehicle.

For example, by using a material having higher rigidity than that of the material used for the cross portion having the smaller displacement for the cross portion having the larger displacement, the shape of the cross portion having the larger displacement can be made smaller in size to thereby enhance further the degree of freedom in designing the peripheral space of the cross portion

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having the larger displacement. This restricts the enlargement in size of the front portion of the vehicle. Additionally, this can make small in size the front portion of the vehicle.

[0118]

5 In the embodiment described above, as an example in which the rigidity of the upper cross portion 51 is made to differ from that of the lower cross portion 52, the rigidity of the lower cross portion 52 is set to be larger than the rigidity of the upper cross portion 51. Although the rear upper space of the link mechanism 5 is described as being used for other applications
10 including the application in which accessories are disposed in the space by setting the rigidity of the lower cross portion in that way, the invention is not limited thereto. For example, a configuration may be adopted in which a front upper space of the link mechanism 5 can be made use of for other applications by providing a single upper cross portion 51 behind the headstock 211. This
15 restricts the enlargement in size of the front portion of the vehicle. Additionally, this can make small in size the front portion of the vehicle.

 In addition, a configuration may be adopted in which the link mechanism 5 is constructed upside down compared with the construction described in the embodiment. In other words, a configuration may be adopted
20 in which an upper cross portion 51 has two cross parts, that is, a front upper cross part and a rear upper cross part that are provided so as to hold the headstock 211 from the front and rear therebetween, while a single lower cross portion 52 is provided only either before or behind the headstock 211. As this occurs, either a front lower portion or a rear lower portion of the link

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mechanism 5 can be used for other applications. This restricts the enlargement in size of the front portion of the vehicle. Additionally, this can make small in size the front portion of the vehicle.

[0119]

5 Additionally, in the embodiment described above, while the link mechanism 5 is described as including the upper cross portion 51 and the lower cross portion 52, the invention is not limited thereto. For example, as the link mechanism, a link mechanism may be adopted which is configured to have three or more cross portions such as a link mechanism including an upper
10 cross portion, a lower cross portion and a middle cross portion that is provided between the upper cross portion and the lower cross portion.

[0120]

 In addition, in the embodiment described above, while the upper cross portion 51 and the lower cross portion 52 are described as being mounted on
15 the headstock 211 that turnably supports the steering shaft 60, the invention is not limited thereto. For example, the upper cross portion 51 and the lower cross portion 52 may be mounted on a location that extends upwards and forwards from the front frame 212 or a member that is mounted on the front frame 212 so as to extend upwards and forwards.

20 [0121]

 Additionally, while the front lower cross part 52a1 and the rear lower cross part 52a2 that are provided at the front and rear of the lower cross portion 52 are described as being connected individually to the left side portion 53 and the right side portion 54 via the lower left bearings 522 and the lower

right bearings 522, the invention is not limited thereto. Only either of the front lower cross part 52a1 and the rear lower cross part 52a2 may be connected to the left side portion 53 and the right side portion 54. However, the front lower cross part 52a1 and the rear lower cross part 52a2 that are provided at the
5 front and rear of the lower cross portion 52 are preferably connected individually to the left side portion 53 and the right side portion 54, thereby making it easy to enhance the rigidity of the lower cross portion 52. By adopting this configuration, it is possible to enhance both the degree of freedom in designing the link mechanism and the degree of freedom in
10 designing the peripheral space of the link mechanism. This restricts the enlargement in size of the front portion of the vehicle. Additionally, this can make small in size the front portion of the vehicle.

[0122]

In the embodiment described above, as shown in Fig. 4, the lower
15 cross portion 52 includes the front lower cross part 52a1 and the rear lower cross part 52a2 that are connected, respectively, to the front and rear of the headstock 211 in such a way as to hold the headstock 211 therebetween in the front-and-rear direction of the vehicle body frame 21. Additionally, the upper cross portion 51 is provided only at the front of the headstock 211 in relation to
20 the front-and-rear direction of the vehicle body frame 21. By adopting this configuration, it is possible to enhance both the degree of freedom in designing the link mechanism and the degree of freedom in designing the peripheral space of the link mechanism. This restricts the enlargement in size of the front

portion of the vehicle. Additionally, this can make small in size the front portion of the vehicle. However, the invention is not limited thereto.

[0123]

For example, as shown in Fig. 8, a configuration may be adopted in which an upper cross portion 51A includes a front upper cross part 51A1 and a rear upper cross part 51A2 that are individually connected to a headstock 211 in such a way as to hold the headstock 211 therebetween in a front-and-rear direction of a vehicle body frame 21.

An upper front middle supporting portion 511FS and an upper rear middle bearing 511BS are provided on the headstock 211 to support the upper cross portion 51 so as to turn about the upper middle axis M1 via upper middle bearings 511.

A lower front middle supporting portion 521FS and a lower front middle supporting portion 521BS are provided on the headstock 211, and these lower front middle supporting portion 521FS and the lower front middle supporting portion 521BS support the lower cross portion 52 so as to turn about the lower middle axis M4 via the lower middle bearings 521.

Although not shown, in the embodiment shown in Fig. 8, an upper front right supporting portion 512FS is provided on a right side portion 54 to support the upper cross portion 51 so as to turn about an upper right axis M3 via an upper right bearing 512. A lower front right supporting portion 522FS is provided on the right side portion 54 to support the lower cross portion 51 so as to turn about a lower right axis M6 via a lower right bearing 522.

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An upper front left supporting portion 512FS is provided on a left side portion 53 to support the upper cross portion 51 so as to turn about an upper left axis M2 via an upper left bearing 512. A lower front left supporting portion 522FS is provided on the left side portion 53 to support the lower cross portion 51 so as to turn about a lower left axis M5 via a lower left bearing 522.

An upper rear right supporting portion 512BS is provided on the right side portion 54 to support the upper cross portion 51 so as to turn about the upper right axis M3 via an upper right bearing 512. A lower rear right supporting portion 522BS is provided on the right side portion 54 to support the lower cross portion 51 so as to turn about the lower right axis M6 via a lower right bearing 522.

An upper rear left supporting portion 512BS is provided on the left side portion 53 to support the upper cross portion 51 so as to turn about the upper left axis M2 via an upper left bearing 512. A lower rear left supporting portion 522BS is provided on the left side portion 53 to support the lower cross portion 51 so as to turn about the lower left axis M5 via a lower left bearing 522.

As this occurs, the front upper cross part 51A1 is set so as to be larger than the rear upper cross part 51A2. By adopting this configuration, compared with a case where the front upper cross part 51A1 is formed substantially as large as the rear upper cross part 51A2, it is possible to enhance the degree of freedom in designing the location where a front frame 212 is connected to the headstock 211. By adopting this configuration, it is possible to enhance both the degree of freedom in designing the link mechanism and the degree of freedom in designing the peripheral space of the link mechanism. This restricts

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the enlargement in size of the front portion of the vehicle. Additionally, this can make small in size the front portion of the vehicle. Also in the configuration shown in Fig. 8, it is set so that an upper right displacement X1 and an upper left displacement X2 are equal to each other, a lower right displacement X3 and a lower left displacement X4 are equal to each other, the upper right displacement X1 is larger than the lower right displacement X3, and the upper left displacement X2 is larger than the lower left displacement X4.

In the embodiment shown in Fig. 8, a shape of the upper cross portion 51A is smaller than a shape of the lower cross portion 52A.

10 [0124]

In the vehicle shown in Fig. 8, the vehicle body frame 21 includes the headstock 211 that supports the upper cross portion 51A and the lower cross portion 52A so as to turn. A shape of the front upper cross part 51A1 that lies ahead of the headstock 211 and a shape of the rear upper cross part 51A2 that lies behind the headstock 211 in relation to the direction of the upper right axis M3 are different from each other. Specifically, the shape of the front upper cross part 51A1 is larger than that of the rear upper cross part 51A2.

According to the vehicle of the invention that includes the vehicle body frame 21 that can lean and the two front wheels 31, 32, the shape of the front portion of the upper cross portion 51 that lies ahead of the link supporting portion is made to differ from the shape of the rear portion of the upper cross portion 51 that lies behind the link supporting portion, and therefore, it is possible to enhance the degree of freedom in designing the link mechanism. Additionally, this enables the movable range of the link mechanism 5 to be

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changed from the simple shape like a rectangular parallelepiped to a shape in which an upper rear portion is smaller than other areas. This can enhance the degree of freedom in designing the rear peripheral space of the upper cross portion 51. As a result of this, even though various on-board parts having
5 different sizes and the link mechanism 5 are disposed on the periphery of the steering shaft 60, it is possible to restrict further the enlargement of the periphery of the steering shaft 60. By adopting this configuration, it is possible to enhance both the degree of freedom in designing the link mechanism and the degree of freedom in designing the peripheral space of the link mechanism.
10 This restricts the enlargement in size of the front portion of the vehicle. Additionally, this can make small in size the front portion of the vehicle.

[0125]

In the vehicle according to the embodiment, the vehicle body frame 21 includes the headstock 211 that turnably supports the upper cross portion 51
15 and the lower cross portion 52. A shape of a front lower cross part 52a1 that lies ahead of the headstock 211 and a shape of a rear lower cross part 52a2 that lies behind the headstock 211 in relation to the direction of the lower right axis M6 are different from each other. Specifically, the front lower cross part 52a1 is larger than the rear lower cross part 52a2.

20 According to the vehicle of the invention that includes the vehicle body frame 21 that can lean and the two front wheels 31, 32, the shape of the front portion of the lower cross portion 52 that lies ahead of the link supporting portion is made to differ from the shape of the rear portion of the lower cross portion 52 that lies behind the link supporting portion, and therefore, it is

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possible to enhance the degree of freedom in designing the link mechanism while maintaining the function of the link mechanism. Additionally, this enables the movable range of the link mechanism 5 to be changed from the simple shape like a rectangular parallelepiped to a shape in which a lower rear portion is smaller than other areas. This can enhance the degree of freedom in designing the space on the periphery of the rear portion of the lower cross portion 52. As a result of this, even though various on-board parts having different sizes and the link mechanism 5 are disposed on the periphery of the steering shaft 60, it is possible to restrict further the enlargement of the periphery of the steering shaft 60. By adopting this configuration, it is possible to enhance both the degree of freedom in designing the link mechanism and the degree of freedom in designing the peripheral space of the link mechanism. This restricts the enlargement in size of the front portion of the vehicle. Additionally, this can make small in size the front portion of the vehicle.

15 [0126]

In the vehicle according to this embodiment, the upper cross portion 51 includes the piece of front upper cross part 51A1 that lies ahead of the headstock 211 in the direction of the upper right axis M3 and the piece of rear upper cross part 51A2 that lies behind the headstock 211 in the same direction.

20 According to the vehicle of this embodiment that includes the vehicle body frame 21 that can lean and the two front wheels 31, 32, since the upper cross portion 51 includes the piece of front upper cross part 51A1 that lies ahead of the headstock 211 and the piece of rear upper cross part 51A2 that lies behind the headstock 211, it is easy to control the balance between rigidity

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and shape in the upper cross portion 51. This can enhance the degree of freedom in designing the link mechanism, while maintaining the function of the link mechanism. This can enhance the degree of freedom in designing the lower peripheral portion of the steering shaft 60. This can enhance the degree of freedom in designing the peripheral space of the lower cross portion 52. As a result of this, even though various on-board parts having different sizes and the link mechanism 5 are disposed on the periphery of the steering shaft 60, it is possible to restrict further the enlargement of the periphery of the steering shaft 60. By adopting this configuration, it is possible to enhance both the degree of freedom in designing the link mechanism and the degree of freedom in designing the peripheral space of the link mechanism. This restricts the enlargement in size of the front portion of the vehicle. Additionally, this can make small in size the front portion of the vehicle.

[0127]

Alternatively, in the vehicle according to this embodiment, a material of the upper cross portion 51 may be different from a material of the lower cross portion 52. The material of the upper cross portion 51 or the material of the lower cross portion 52 is changed from the other, and therefore, a controlling range of the balance between rigidity and shape can be expanded. This can enhance the degree of freedom in designing the link mechanism, while maintaining the function of the link mechanism. Additionally, in the event that the upper cross portion 51 whose rigidity is smaller than that of the lower cross portion 52 is formed from a material having high rigidity, the shape of the upper cross portion 51 can be made small. As a result of this, it is possible to

enhance the degree of freedom in designing the periphery of the steering shaft 60. As a result of this, even though various on-board parts having different sizes and the link mechanism 5 are disposed on the periphery of the steering shaft 60, it is possible to restrict further the enlargement of the periphery of the steering shaft 60.

Consequently, in the vehicle that includes the vehicle body frame 21 that can lean and the two front wheels 31, 32, it is possible to restrict further the enlargement in size of the peripheral construction of the steering shaft 60 that lies above the two front wheels 31, 32 while maintaining the function of the link mechanism 5.

[0128]

<Different Modified Example>

Fig. 9 is a front view of a vehicle according to a different modified example of the invention. Fig. 10 is a plan view of the vehicle according to the different modified example of the invention. In the figures, E denotes an upper right bearing 512 and a fastening member (a bolt), C denotes an upper middle bearing 511 and a fastening member (a bolt), D denotes an upper left bearing 512 and a fastening member (a bolt), H denotes a lower right bearing 522 and a fastening member (a bolt), F denotes a lower middle bearing 521 and a fastening member (a bolt), and G denotes a lower left bearing 522 and a fastening member (a bolt).

In this modified example, in an upper cross portion 51 and a lower cross portion 52, a middle portion lies above a right end portion and a left end portion when seen from the front of the vehicle. When seen from the front, the

upper cross portion 51 and the lower cross portion 52 are curved. The upper cross portion 51 and the lower cross portion 52 have different shapes when seen from the front. The upper cross portion 51 is smaller than the lower cross portion 52 when seen from the front. The upper cross portion 51 and the lower cross portion 52 have different volumes. The volume of the upper cross portion 51 is smaller than that of the lower cross portion 52. Additionally, a relationship among a displacement X1, a displacement X2, a displacement X3 and a displacement X4 is the same as that described in Figs. 1 to 7.

In this different modified example, the middle portion of the lower cross portion lies further forwards in a front-and-rear direction of the vehicle than the right end portion and the left end portion of the lower cross portion. In the lower cross portion, a thickness of the middle portion in the front-and-rear direction of the vehicle is larger than those of the right end portion and the left end portion of the lower cross portion. The thickness of the right end portion of the lower cross portion in the front-and-rear direction of the vehicle is equal to that of the left end portion thereof. In this way, the balance of rigidity and shape between the upper cross portion and the lower cross portion is easy to be controlled. Consequently, it is possible to enhance the degree of freedom in designing the link mechanism while maintaining the function of the link mechanism in the vehicle that includes the vehicle body frame that can lean and the two front wheels.

[0129]

Additionally, a link supporting portion (a headstock) may be made up of a piece of part or a plurality of parts. In the case of the link supporting portion

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being made up of a plurality of parts, the parts may be joined together through welding, bonding or the like. Alternatively, the parts may be joined together with fastening members such as bolts, rivets or the like.

[0130]

- 5 The upper cross portion may include an upper front cross member that is made up of a piece of part, an upper rear cross member that is made up of a piece of part and a connecting member that is provided between the upper front and rear cross members and that is made up of a plurality of parts. In the case of the link supporting portion being made up of a plurality of parts, the
- 10 parts may be joined together through welding, bonding or the like. Alternatively, the parts may be joined together with fastening members such as bolts, rivets or the like.

[0131]

- The lower cross portion may include a lower front cross member that is
- 15 made up of a piece of part, a lower rear cross member that is made up of a piece of part and a connecting member that is provided between the lower front and rear cross members and that is made up of a plurality of parts. In the case of the link supporting portion being made up of a plurality of parts, the parts may be joined together through welding, bonding or the like.
- 20 Alternatively, the parts may be joined together with fastening members such as bolts, rivets or the like.

[0132]

 Additionally, the right side portion and the left side portion may each be made up of a piece of part or a plurality of parts. In the case of the link

supporting portion being made up of a plurality of parts, the parts may be joined together through welding, bonding or the like. Alternatively, the parts may be joined together with fastening members such as bolts, rivets or the like. The right side portion and the left side portion may each include a portion that is disposed ahead of the upper cross portion or the lower cross portion in the front-and-rear direction of the vehicle body frame and a portion that is disposed behind the upper cross portion or the lower cross portion in the front-and-rear direction of the vehicle body frame. The upper cross portion or the lower cross portion may be disposed between the portions that are disposed at the front of the right side portion and the left side portion and the portions that are disposed at the rear of the right side portion and the left side portion.

[0133]

When rearward forces in the direction of rotational axes of the bearings are exerted at least on the supporting portions, the displacement X1 and the displacement X2 of the cross portion should be equal to each other, the displacement X3 and the displacement X4 of the cross portion should be equal to each other, the displacement X1 should be larger than the displacement X3, and the displacement X2 should be larger than the displacement X4. When forward forces in the direction of the rotational axes of the bearings are exerted on the supporting portions, the displacements of the cross portions may be different.

[0134]

In the description made above, the forward movement of the front edge of the right end portion of the upper surface of the upper cross portion 51 in the

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front-and-rear direction of the vehicle body frame 21 is described as being measured as the upper light displacement X1, the forward movement of the front edge of the left end portion of the upper surface of the upper cross portion 51 in the front-and-rear direction of the vehicle body frame 21 is described as being measured as the upper left displacement X2, the forward movement of the front edge of the right end portion of the lower surface of the lower cross portion 52 in the front-and-rear direction of the vehicle body frame 21 is described as being measured as the lower right displacement X3, and the forward movement of the front edge of the left end portion of the lower surface of the lower cross portion 52 in the front-and-rear direction of the vehicle body frame 21 is described as being measured as the lower left displacement X4. However, in relation to the measuring method of the displacements X1 to X4, the invention is not limited thereto.

For example, a forward movement of the front edge of the right end portion of the upper surface of the upper cross portion 51 in the front-and-rear direction of the vehicle body frame 21 may be measured as the upper light displacement X1, a forward movement of the front edge of the left end portion of the upper surface of the upper cross portion 51 in the front-and-rear direction of the vehicle body frame 21 may be measured as the upper left displacement X2, a forward movement of a rear edge of the right end portion of the lower surface of the lower cross portion 52 in the front-and-rear direction of the vehicle body frame 21 may be measured as the lower right displacement X3, and a forward movement of a rear edge of the left end portion of the lower

surface of the lower cross portion 52 in the front-and-rear direction of the vehicle body frame 21 may be measured as the lower left displacement X4.

Alternatively, the upper right displacement X1 may be measured as a forward movement in the front-and-rear direction of the vehicle body frame 21 of the front edge of the upper surface of the upper cross portion 51 in a position that is spaced by an arbitrary distance D away from the upper right axis M3 in relation to the left-and-right direction of the vehicle body frame 21 as seen from the top in the up-and-down direction of the vehicle body frame 21. The upper right displacement X2 may be measured as a forward movement in the front-and-rear direction of the vehicle body frame 21 of the front edge of the upper surface of the upper cross portion 51 in a position that is spaced by an arbitrary distance D away from the upper left axis M2 in relation to the left-and-right direction of the vehicle body frame 21 as seen from the top in the up-and-down direction of the vehicle body frame 21. The lower right displacement X3 may be measured as a forward movement in the front-and-rear direction of the vehicle body frame 21 of the front edge of the lower surface of the lower cross portion 52 in a position that is spaced by an arbitrary distance D away from the lower right axis M6 in relation to the left-and-right direction of the vehicle body frame 21 as seen from the top in the up-and-down direction of the vehicle body frame 21. The lower left displacement X4 may be measured as a forward movement in the front-and-rear direction of the vehicle body frame 21 of the front edge of the lower surface of the lower cross portion 52 in a position that is spaced by an arbitrary distance D away from the lower left axis M5 in

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relation to the left-and-right direction of the vehicle body frame 21 as seen from the top in the up-and-down direction of the vehicle body frame 21.

Alternatively, a rear movement of a front edge of a right end portion of a lower surface of the upper cross portion 51 in the front-and-rear direction of the vehicle body frame 21 may be measured as the upper light displacement X1, a rearward movement of a front edge of a left end portion of the lower surface of the upper cross portion 51 in the front-and-rear direction of the vehicle body frame 21 may be measured as the upper left displacement X2, a forward movement of the front edge of the right end portion of the lower surface of the lower cross portion 52 in the front-and-rear direction of the vehicle body frame 21 may be measured as the lower right displacement X3, and a forward movement of the front edge of the left end portion of the lower surface of the lower cross portion 52 in the front-and-rear direction of the vehicle body frame 21 may be measured as the lower left displacement X4.

Additionally, the displacements X1 to X4 may be measured by a combination of the methods that are described above. For example, a forward movement of the front edge of the right end portion of the upper surface of the upper cross portion 51 in the front-and-rear direction of the vehicle body frame 21 may be measured as the upper light displacement X1, a forward movement of the front edge of the left end portion of the lower surface of the upper cross portion 51 in the front-and-rear direction of the vehicle body frame 21 may be measured as the upper left displacement X2, a rearward movement of a rear edge of a right end portion of an upper surface of the lower cross portion 52 in the front-and-rear direction of the vehicle body frame 21 may be measured as

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the lower right displacement X3, and a forward movement of the front edge of the left end portion of the lower surface of the lower cross portion 52 in the front-and-rear direction of the vehicle body frame 21 may be measured as the lower left displacement X4.

5 [0135]

Alternatively, the upper right displacement X1 and the upper left displacement X2 can be measured as a rotational angle about the upper center axis 51C at an arbitrary point on the upper cross portion 51 as seen from the left-and-right direction of the vehicle body frame 21. The lower right
10 displacement X3 and the lower left displacement X4 can be measured as a rotational angle about the lower center axis 52C at an arbitrary point on the lower cross portion 52 as seen from the left-and-right direction of the vehicle body frame 21.

For example, the upper right displacement X1 can be measured as a
15 rotational angle of an upper front edge about the upper center axis 51C that is formed by the upper surface and a front surface of the upper cross portion 51. The upper left displacement X2 can be measured as a rotational angle of the upper front edge about the upper center axis 51C that is formed by the upper surface and the front surface of the upper cross portion 51. The lower right
20 displacement X3 can be measured as a rotational angle of an upper front edge about the lower center axis 52C that is formed by the upper surface and a front surface of the lower cross portion 52. The lower left displacement X4 can be measured as a rotational angle of the upper front edge about the lower center

axis 52C that is formed by the upper surface and the front surface of the lower cross portion 52.

The upper right displacement X1 can be measured as a clockwise rotational angle of the upper front edge of the upper cross portion 51 about the upper center axis 51C as seen from the right of the vehicle body frame 21. The upper left displacement X2 can be measured as a counterclockwise rotational angle of the upper front edge of the upper cross portion 51 about the upper center axis 51C as seen from the left of the vehicle body frame 21. The lower right displacement X3 can be measured as a counterclockwise rotational angle of the upper front edge of the lower cross portion 52 about the upper center axis 52C as seen from the right of the vehicle body frame 21. The lower left displacement X4 can be measured as a clockwise rotational angle of the upper front edge of the lower cross portion 52 about the lower center axis 52C as seen from the left of the vehicle body frame 21.

Alternatively, the upper right displacement X1 can be measured as a counterclockwise rotational angle of the upper front edge of the upper cross portion 51 about the upper center axis 51C as seen from the right of the vehicle body frame 21. The upper left displacement X2 can be measured as a clockwise rotational angle of the upper front edge of the upper cross portion 51 about the upper center axis 51C as seen from the right of the vehicle body frame 21. The lower right displacement X3 can be measured as a counterclockwise rotational angle of the upper front edge of the lower cross portion 52 about the upper center axis 52C as seen from the right of the vehicle body frame 21. The lower left displacement X4 can be measured as a

counterclockwise rotational angle of the upper front edge of the lower cross portion 52 about the lower center axis 52C as seen from the right of the vehicle body frame 21.

The displacements X1 to X4 may be measured by various
5 combinations of the methods described above. For example, the upper right displacement X1 can be measured as a clockwise rotational angle of the front upper edge of the upper cross portion 51 about the upper center axis 51C as seen from the right of the vehicle body frame 21. The upper left displacement X2 can be measured as a counterclockwise rotational angle of the upper front
10 edge of the upper cross portion 51 about the upper center axis 51C as seen from the left of the vehicle body frame 21. The lower right displacement X3 can be measured as a clockwise rotational angle of the upper front edge of the lower cross portion 52 about the upper center axis 52C as seen from the left of the vehicle body frame 21. The lower left displacement X4 can be measured
15 as a clockwise rotational angle of the upper front edge of the lower cross portion 52 about the lower center axis 52C as seen from the left of the vehicle body frame 21.

Additionally, targets of which rotational angles are to be measured are not limited to the upper front edges of the cross portions. Rotational angles at
20 arbitrary points that are seen from the sides of the vehicle body frame 21 can be measured as the displacements X1 to X4.

[0136]

In the embodiments described above, the right side portion 54, the left side portion 53 and the headstock 211 are provided in positions that are

superposed one on another when the vehicle body frame 21 is seen from the sides thereof. However, when the vehicle body frame 21 is seen from the side thereof, the headstock 211 may be provided in a different position from positions where the right side portion 54 and the left side portion 53 are
5 provided in relation to the front-and-rear direction. Additionally, slant angles of the right side portion 54 and the left side portion 53 in relation to the up-and-down direction of the vehicle body frame 21 may differ from a slant angle of the headstock 211.

[0137]

10 The vehicle according to the invention is a vehicle that includes the vehicle body frame 21 that can lean and the two front wheels 31, 32. The number of rear wheels is not limited to one, and hence, may be two. Whether or not the vehicle includes the body cover that covers the vehicle body frame 21 is not a matter of question. As to the power source, an electric motor may
15 be used in place of the engine.

[0138]

When referred to in relation to the "direction," and the "member" in the invention, the term "along" also includes a case where the direction and the member are inclined within the range of ± 40 degrees. When referred to in
20 relation to the "direction" in the invention, the term "extend" also includes a case where the direction is inclined within the range of ± 40 degrees.

[0139]

The upper middle axis M1 and the lower middle axis M4 may be referred to as a middle axis as a general term therefor. The upper cross portion

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51 and the lower cross portion 52 may be referred to as a cross portion as a general term therefor. The right side portion 54 and the left side portion 53 may be referred to as a side portion as a general term therefor.

[0140]

5 In the invention, the link mechanism 5 may include further a cross portion in addition to the upper cross portion 51 and the lower cross portion 52. The upper cross portion 51 and the lower cross portion 52 are so called only from their relative positional relationship in the up-and-down direction. The upper cross portion 51 does not imply an uppermost cross portion in the link
10 mechanism 5. The upper cross portion may mean a cross portion that is positioned lower than an uppermost cross portion but is positioned upper than a different cross portion. The lower cross portion does not imply a lowermost cross portion in the link mechanism. The lower cross portion may mean a cross portion that is positioned upper than a lowermost cross portion but is
15 positioned lower than a different cross portion. In addition, the cross portion may include three parts that are a piece of part having a middle portion that is supported on the vehicle body frame, a right portion that supports the right side portion and a left portion that supports the left side portion and a pair of right cross part and left cross part that are divided laterally in the left-and-right
20 direction. In this way, the upper cross portion and the lower cross portion may each include a plurality of parts as long as they still have the link function. The link mechanism only has to include the upper cross portion and the lower cross portion.

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Additionally, in the embodiment, while the lower cross portion 52 is described as being made up of the two parts that are the flat plate-shaped rear lower cross part 52a2 and the part that includes integrally the flat plate-shaped front lower cross part 52a1 and the connecting portions 52b that connects the part 52a1 and the rear lower cross part 52a2 together. For example, by preparing the flat plate-shaped rear lower cross part 52a2, the flat plate-shaped front lower cross part 52a1, and the two connecting portions 52b as four independent parts, the lower cross portion 52 may be made up of these four parts.

10 [0141]

It is preferable that the test forces are exerted with the vehicle fixed in the upright state. The forward direction in relation to the direction of the lower right axis means a direction that is parallel to the lower right axis and that is directed from the rear portion of the vehicle to the front portion of the vehicle.

15 The rearward direction in relation to the direction of the lower right axis means a direction that is parallel to the lower right axis and that is directed from the rear portion of the vehicle to the front portion of the vehicle. The upper right axis, the lower right axis, the upper left axis and the lower left axis are parallel to one another. Because of this, the forward direction in relation to the direction

20 of the upper right axis, the forward direction in relation to the direction of the lower right axis, the forward direction in relation to the upper left axis and the forward direction in relation to the lower left axis are the same in direction. The rearward direction in relation to the direction of the upper right axis, the rearward direction in relation to the direction of the lower right axis, the

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rearward direction in relation to the upper left axis and the rearward direction in relation to the lower left axis are the same in direction.

[0142]

The test forces may be exerted directly on the supporting portions of
5 the side portions. Additionally, the test forces may be exerted on portions other than the supporting portions, which are portions on the side portions that lie on the upper right axis, the upper left axis, the lower right axis and the lower left axis. The test forces may be exerted on the supporting portions or the side portions by way of portions other than the side portions.

10 [0143]

When referred to in this invention, the description reading "the shape looks different" means that the shape of a certain part looks different when the part is seen in such a state that it is mounted on the vehicle. For example, the shape of a rectangular parallelepiped standing alone is construed as being
15 different from the shape of the same rectangular parallelepiped when it is mounted on the vehicle with its posture turned through 90 degrees.

[0144]

The terms and expressions that are used herein are used to describe the embodiments of the invention and hence should not be construed as
20 limiting the scope of the invention. It should be understood that any equivalents to the characteristic matters that are shown and described herein should not be excluded and that various modifications made within the scope of claims to be made later are permitted.

[0145]

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The invention can be embodied in many different forms. The disclosure herein should be recognized as providing the embodiments of the principle of the invention. Based on the understanding that the preferred embodiments that are described and/or illustrated herein are not intended to limit the invention thereto, several embodiments are described and illustrated herein.

[0146]

Several illustrated embodiments of the invention are described herein. The invention is not limited to the various preferred embodiments that are described herein. The invention can include every embodiment that includes equivalent elements, modifications, deletions, combinations (for example, combinations of the characteristics of the various embodiments), improvements and/or alterations that those skilled in the art to which the invention pertains can think of. Matters limited by claims should be construed widely based on terms that are used in the claims and should not be limited to the embodiments described in this description or the prosecution of this patent application. Those embodiments should be construed as non-exclusive. For example, in this disclosure, such terms as "preferable" and "good" are non-exclusive terms and mean that "it is preferable but does not limit the invention thereto" and "it is good but does not limit the invention thereto," respectively.

[0147]

This patent application is based on Japanese Patent Application No. 2012-277219 filed on December 19, 2012, Japanese Patent Application No. 2012-277220 filed on December 19, 2012, and Japanese Patent Application

No. 2013-138484 filed on July 1, 2013, the entire contents of which are incorporated herein by reference.

Description of Reference Numerals

[0148]

- 5 1: vehicle
 - 3: front wheel
 - 5: link mechanism
 - 21: vehicle body frame
 - 23: handlebar
- 10 31: left front wheel
 - 32: right front wheel
 - 33: left shock absorber
 - 34: right shock absorber
 - 51: upper cross portion
- 15 52: lower cross portion
 - 53: left side portion
 - 54: right side portion
 - 511: upper middle bearing
 - 512: upper left bearing, upper right bearing
- 20 521: lower middle bearing
 - 522: lower left bearing, lower right bearing
 - 60: steering shaft
 - 335: first bracket
 - 336: second bracket

M1: upper middle axis

M2: upper left axis

M3: upper right axis

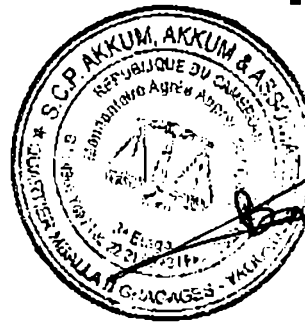
M4: lower middle axis

5 M5: lower left axis

M6: lower right axis

N1: left steering axis

N2: right steering axis



[Claim 1]

A vehicle that is driven by power from a power source comprising:

a left front wheel and a right front wheel that are disposed side by side

5 in a left-and-right direction as seen from a front of the vehicle and that are steerable;

a right shock absorbing device that supports the right front wheel at a lower portion thereof and that absorbs an upward displacement of the right front wheel in an up-and-down direction of the vehicle body frame;

10 a left shock absorbing device that supports the left front wheel at a lower portion thereof and that absorbs an upward displacement of the left front wheel in the up-and-down direction of a vehicle body frame;

a link mechanism including:

a right side portion that supports an upper portion of the right
15 shock absorbing device so as to turn about a right steering axis that extends in the up-and-down direction of the vehicle body frame;

a left side portion that supports an upper portion of the left shock absorbing device so as to turn about a left steering axis that is parallel to the right steering axis;

20 an upper cross portion that includes a piece of part that supports an upper portion of the right side portion at a right end portion thereof so as to turn about an upper right axis that extends in a front-and-rear direction of the vehicle body frame via an upper right bearing, that supports an upper portion of the left side portion at a left end portion thereof so as to turn about

an upper left axis that is parallel to the upper right axis via an upper left bearing and that is supported on the vehicle body frame at a middle portion thereof so as to turn about an upper middle axis that is parallel to the upper right axis and the upper left axis via an upper middle bearing; and

5 a lower cross portion that includes a piece of part that supports a lower portion of the right side portion at a right end portion thereof so as to turn about a lower right axis that is parallel to the upper right axis via a lower right bearing, that supports a lower end portion of the left side portion at a left end portion thereof so as to turn about a lower left axis that is parallel to the
10 upper left axis via a lower left bearing and that is supported on the vehicle body frame at a middle portion thereof so as to turn about a lower middle axis that is parallel to the upper middle axis via a lower middle bearing;

 a steering shaft that is supported on the vehicle body frame between the right side portion and the left side portion in a left-and-right direction of the
15 vehicle body frame, of which an upper end portion is provided above the lower middle axis in the up-and-down direction of the vehicle body frame and that is turnable about a middle steering axis that extends in the up-and-down direction of the vehicle body frame;

 a handlebar that is provided at the upper portion of the steering shaft;
20 and

 a turning transmission mechanism that transfers a turn of the steering shaft according to an operation of the handlebar to the right shock absorbing device and the left shock absorbing device, wherein

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with the lower cross portion removed that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof and the upper cross portion mounted that includes the piece of part that is supported at the right end
5 portion and the left end portion thereof and that is supported at the middle portion thereof, an upper right displacement of the upper cross portion that results when a forward or rearward test force in relation to the direction of the lower right axis is exerted on a lower right supporting portion of the right side portion where the lower cross member is supported and an upper left
10 displacement of the upper cross portion that results when a force that is the same in magnitude and direction as the test force is exerted on a lower left supporting portion of the left side portion are equal to each other,

with the upper cross portion removed that includes the piece of part that is supported at the right end portion and the left end portion thereof and
15 that is supported at the middle portion thereof and the lower cross portion mounted that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof, a lower right displacement of the lower cross portion that results when a force that is the same in magnitude and direction as the test
20 force is exerted on an upper right supporting portion of the right side portion where the upper cross member is supported and a lower left displacement of the lower cross portion that results when a force that is the same as in magnitude and direction as the test force is exerted on an upper left supporting

portion of the left side portion where the upper cross member is supported are equal to each other,

the upper right displacement of the upper cross portion is larger than the lower right displacement of the lower cross portion, and

5 the upper left displacement of the upper cross portion is larger than the lower left displacement of the lower cross portion.

[Claim 2]

The vehicle according to Claim 1, wherein

a shape of the upper cross portion that includes the piece of part that is
10 supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof is different from a shape of the lower cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof.

15 [Claim 3]

The vehicle according to Claim 2, wherein

a shape of the upper cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof is smaller than a shape of the lower
20 cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof.

[Claim 4]

The vehicle according to Claim 1, wherein

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a volume of the upper cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof is different from a volume of the lower cross portion that includes the piece of part that is supported at the right end
5 portion and the left end portion thereof and that is supported at the middle portion thereof.

[Claim 5]

The vehicle according to Claim 4, wherein

a volume of the upper cross portion that includes the piece of part that
10 is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof is smaller than a volume of the lower cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof.

15 [Claim 6]

The vehicle according to any one of Claims 1 to 5, wherein

a material of the upper cross portion that includes the piece of part that is supported at the right end portion and the left end portion and that is supported at the middle portion is identical to a material of the lower cross
20 portion that includes the piece of part that is supported at the right end portion and the left end portion and that is supported at the middle portion.

[Claim 7]

The vehicle according to any one of Claims 1 to 5, wherein

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a material of the upper cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof is different from a material of the lower cross portion that includes the piece of part that is supported at the right end
5 portion and the left end portion thereof and that is supported at the middle portion thereof.

[Claim 8]

The vehicle according to any one of Claims 1 to 7, wherein
the vehicle body frame includes:

10 a link supporting portion that turnably supports the upper cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof and the lower cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the
15 middle portion thereof, and

a shape of a front portion of the upper cross portion that lies ahead of the link supporting portion in the direction of the upper right axis differs from a shape of a rear portion of the upper cross portion that lies behind the link supporting portion.

20 [Claim 9]

The vehicle according to any one of Claims 1 to 8, wherein
the vehicle body frame includes:

a link supporting portion that turnably supports the upper cross portion that includes the piece of part that is supported at the right end portion and the

left end portion thereof and that is supported at the middle portion thereof and the lower cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof, and

- 5 a shape of a front portion of the lower cross portion that lies ahead of the link supporting portion in the direction of the lower right axis differs from a shape of a rear portion of the lower cross portion that lies behind the link supporting portion.

[Claim 10]

- 10 The vehicle according to any one of Claims 1 to 9, wherein
the vehicle body frame includes a link supporting portion that turnably supports the upper cross portion that includes the piece of part that is supported at the right end portion and the left end portion and that is supported at the middle portion and the lower cross portion that includes the piece of part
15 that is supported at the right end portion and the left end portion and that is supported at the middle portion, and

- the upper cross portion includes a piece of upper front part that lies ahead of the link supporting portion in the direction of the upper right axis, that is supported at the right end portion and the left end portion and that is
20 supported at the middle portion and a piece of upper rear part that lies behind the link supporting portion in the direction of the upper right axis, that is supported at the right end portion and the left end portion and that is supported at the middle portion.

[Claim 11]

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The vehicle according to any one of Claims 1 to 10, wherein

the vehicle body frame includes a link supporting portion that turnably supports the upper cross portion that includes the piece of part that is supported at the right end portion and the left end portion and that is supported
5 at the middle portion and the lower cross portion that includes the piece of part that is supported at the right end portion and the left end portion and that is supported at the middle portion, and

the lower cross portion includes a piece of lower front part that lies ahead of the link supporting portion in the direction of the lower right axis, that
10 is supported at the right end portion and the left end portion and that is supported at the middle portion and a piece of lower rear part that lies behind the link supporting portion in the direction of the lower right axis, that is supported at the right end portion and the left end portion and that is supported at the middle portion.

15 [Claim 12]

The vehicle according to any one of Claims 1 to 7, wherein

the vehicle body frame includes a link supporting portion that turnably supports the upper cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is
20 supported at the middle portion thereof and the lower cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof, and

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the upper cross portion or the lower cross portion is provided only either ahead of or behind the link supporting portion and is not provided both ahead of and behind the link supporting portion.

[Claim 13]

5 The vehicle according to any one of Claims 1 to 11, wherein

a front end of the upper cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof and a front end of the lower cross portion that includes the piece of part that is supported at the right end
10 portion and the left end portion thereof and that is supported at the middle portion thereof are provided in different positions in relation to the direction of the upper right axis.

[Claim 14]

The vehicle according to any one of Claims 1 to 11, wherein

15 a rear end of the upper cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof and a rear end of the lower cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion
20 thereof are provided in different positions in relation to the direction of the upper right axis.

[Claim 15]

The vehicle according to any one of Claims 1 to 14, wherein

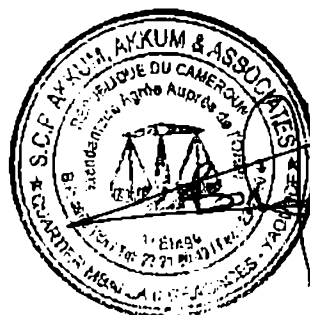
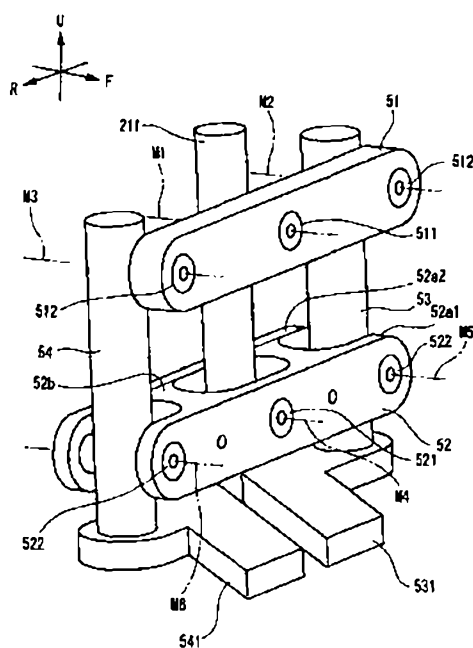
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the vehicle body frame includes a link supporting portion that turnably supports the upper cross portion that includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof and the lower cross portion that
5 includes the piece of part that is supported at the right end portion and the left end portion thereof and that is supported at the middle portion thereof, and
the link supporting portion turnably supports the steering shaft.

Abstract

An object of the invention is to provide a vehicle including a vehicle body frame that can lean and two front wheels that can enhance the degree of freedom in designing a link mechanism while maintaining the function of the link mechanism.

There is provided a vehicle 1 that includes a vehicle body frame that can lean and a right front wheel and a left front wheel and in which an upper cross portion and a lower cross portion of a link mechanism 5 each include a piece of part that is supported on side portions at a right end portion and a left end portion thereof and that is supported on a vehicle body frame at a middle portion thereof. In the vehicle 1, an upper right displacement X_1 and an upper left displacement X_2 that result when a rearward test force is exerted individually on a lower right supporting portion and a lower left supporting portion that support the lower cross portion 52 with the lower cross portion 52 removed are larger than a lower right displacement X_3 and a lower left displacement X_4 that result when a force that is the same in magnitude and direction as the forces exerted on the lower right and left supporting portions is exerted individually on an upper right supporting portion and a upper left supporting portion that support the upper cross member 51 with the upper cross portion 51 removed.



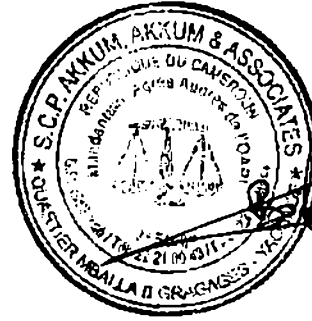


FIG. 1

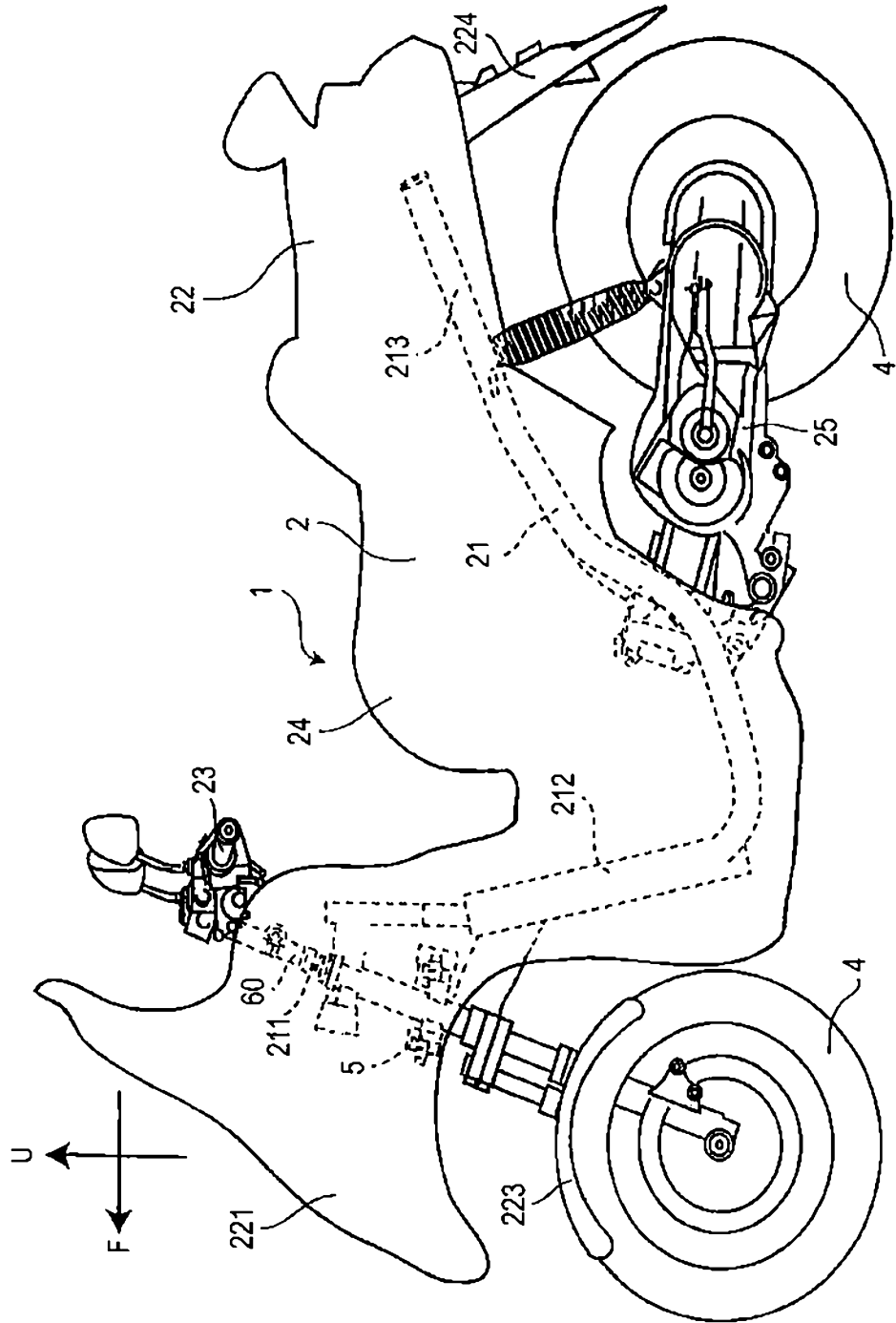
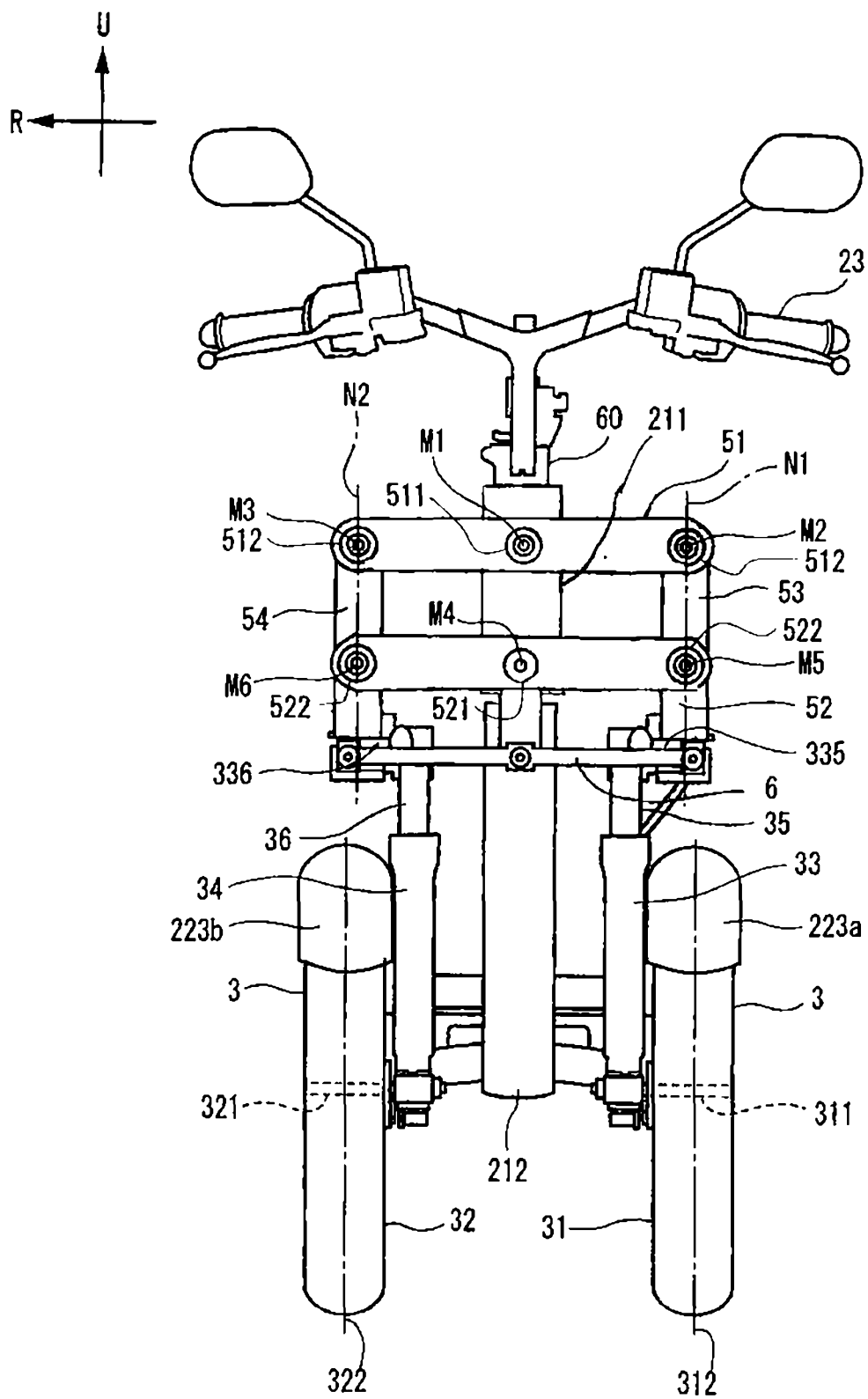


FIG. 2



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FIG. 3

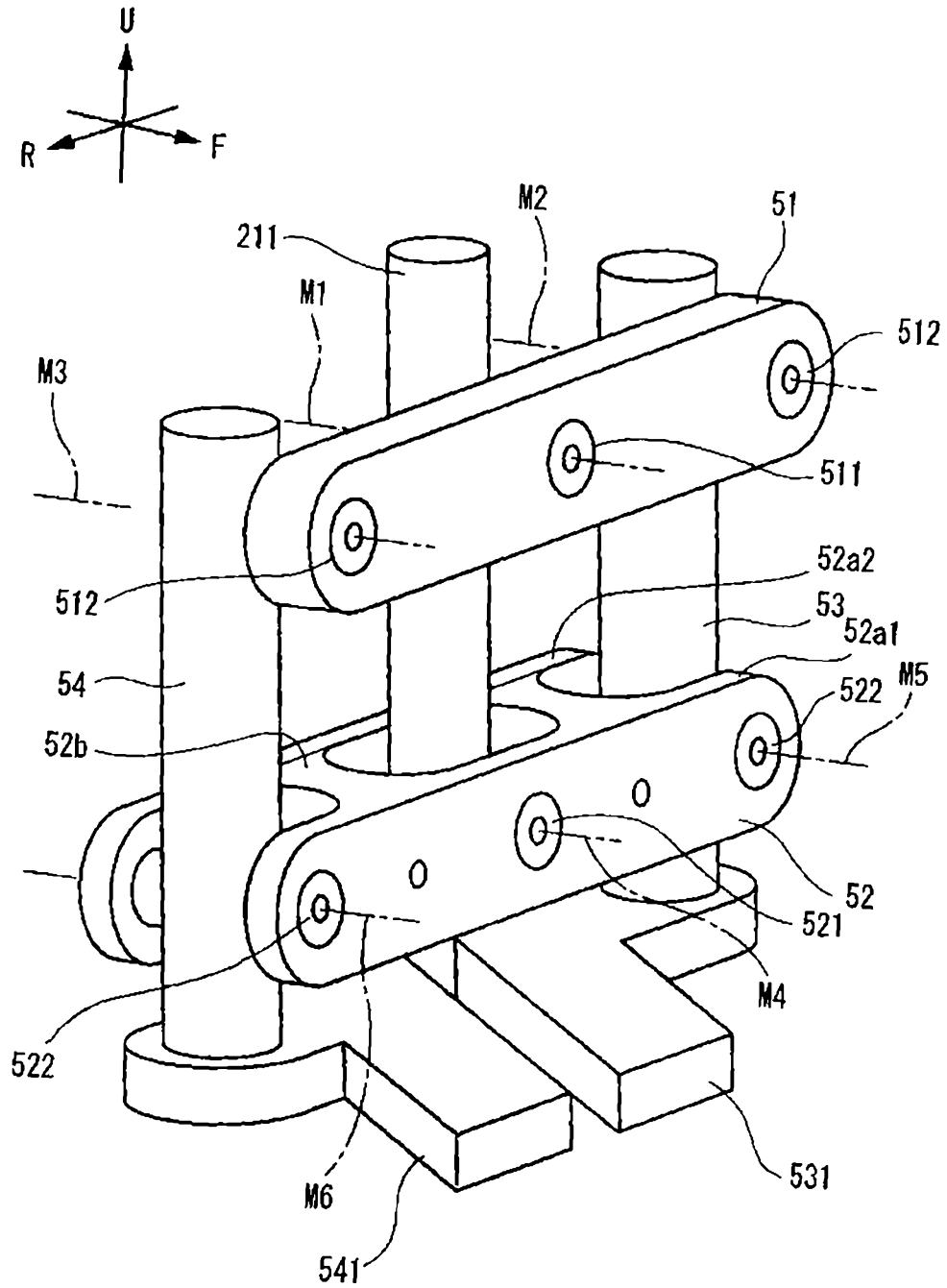


FIG. 4

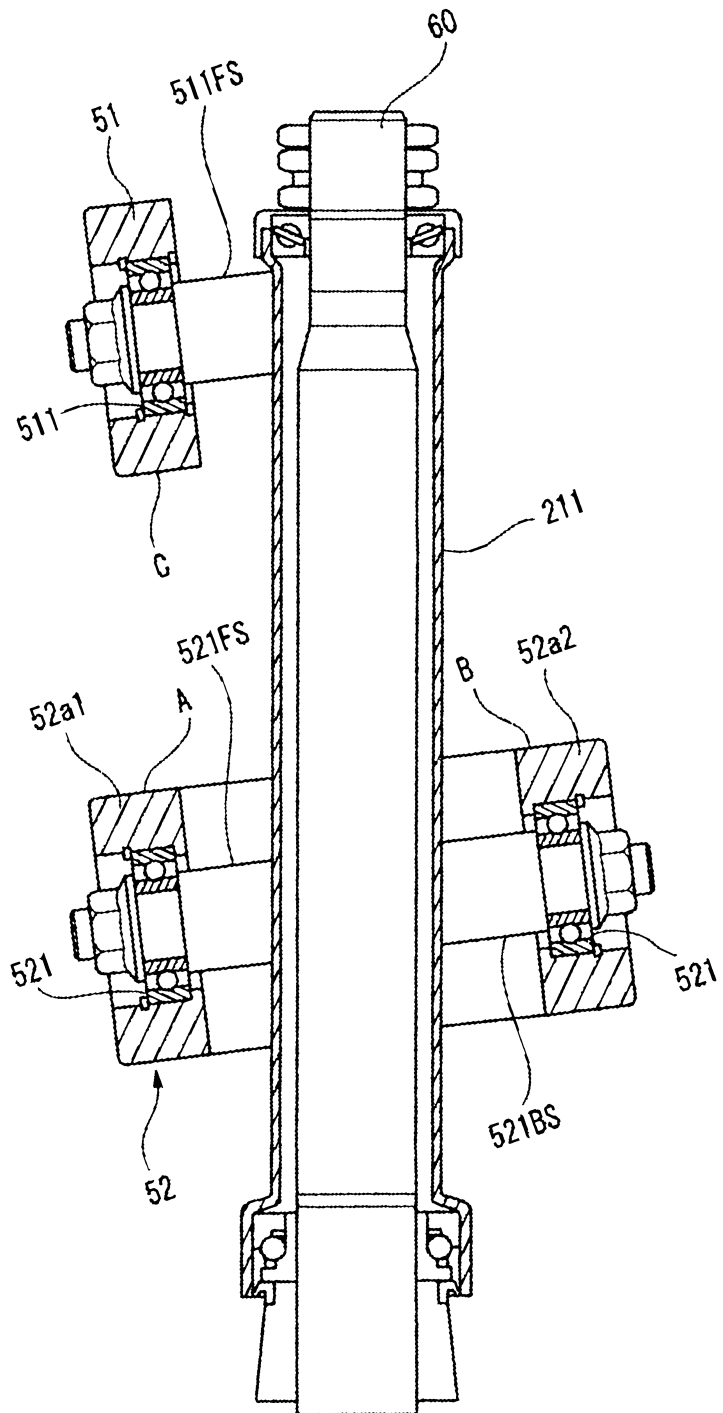
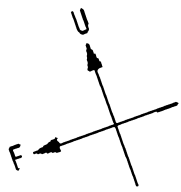
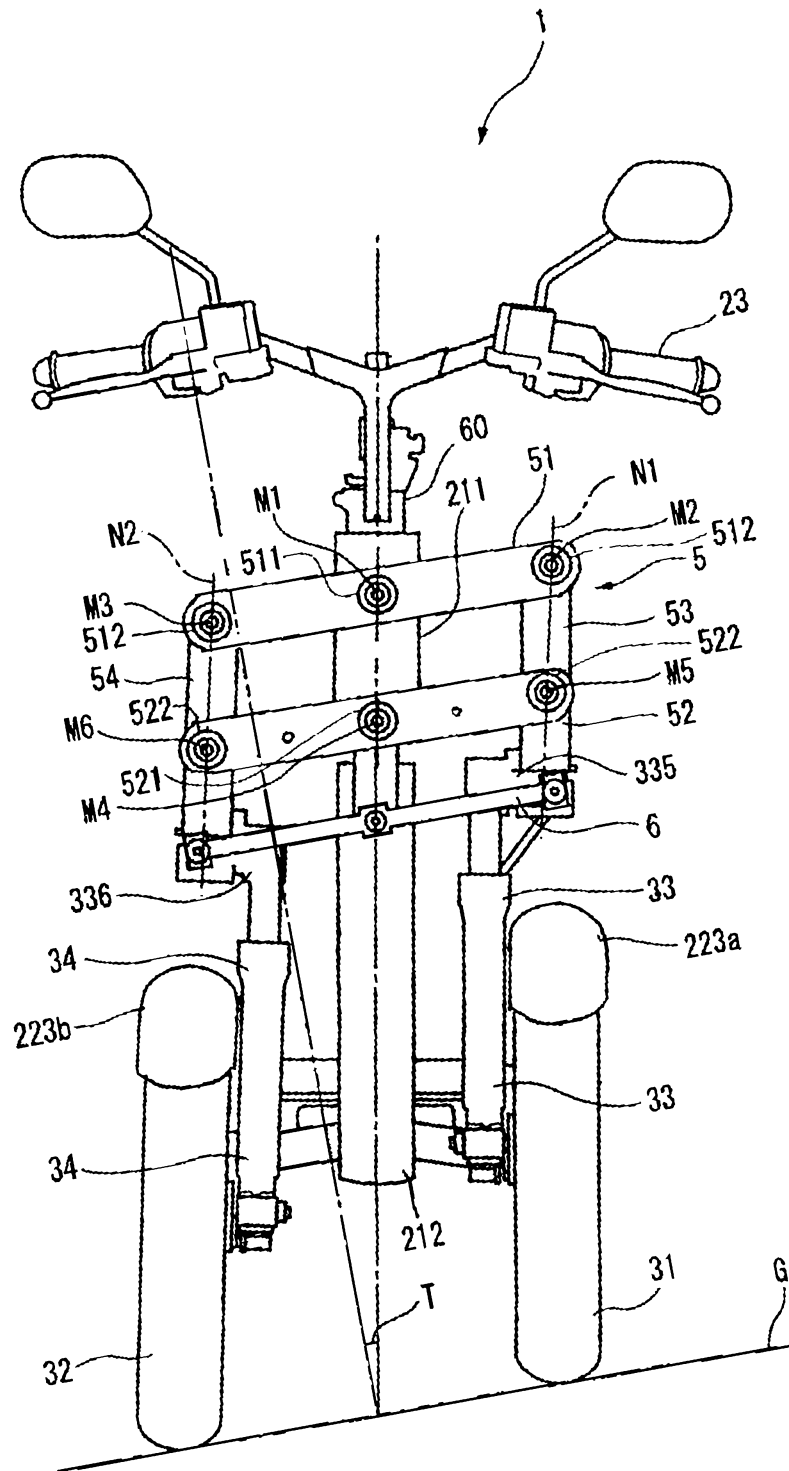
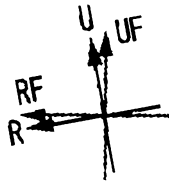
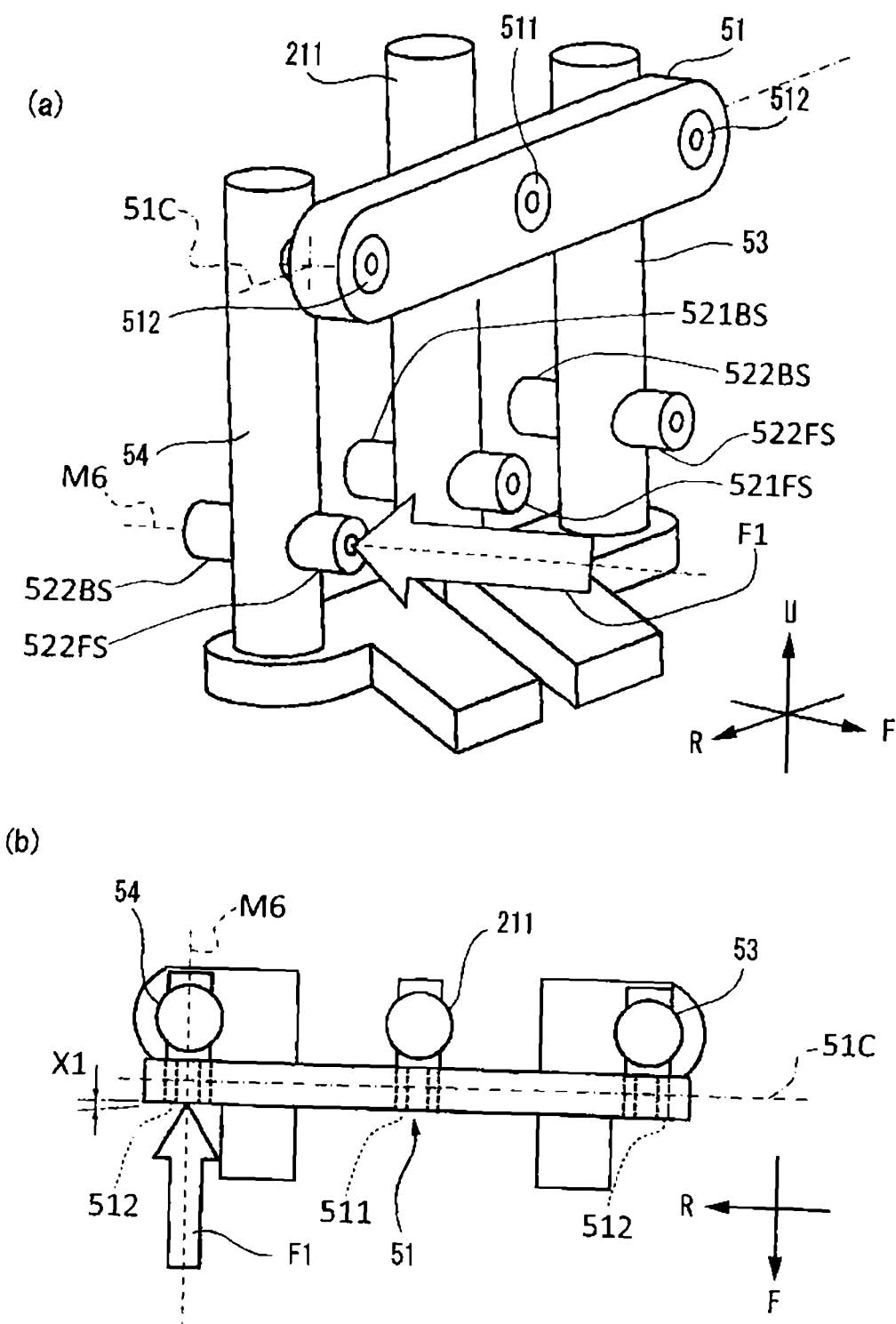


FIG. 5



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FIG. 6



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FIG. 8

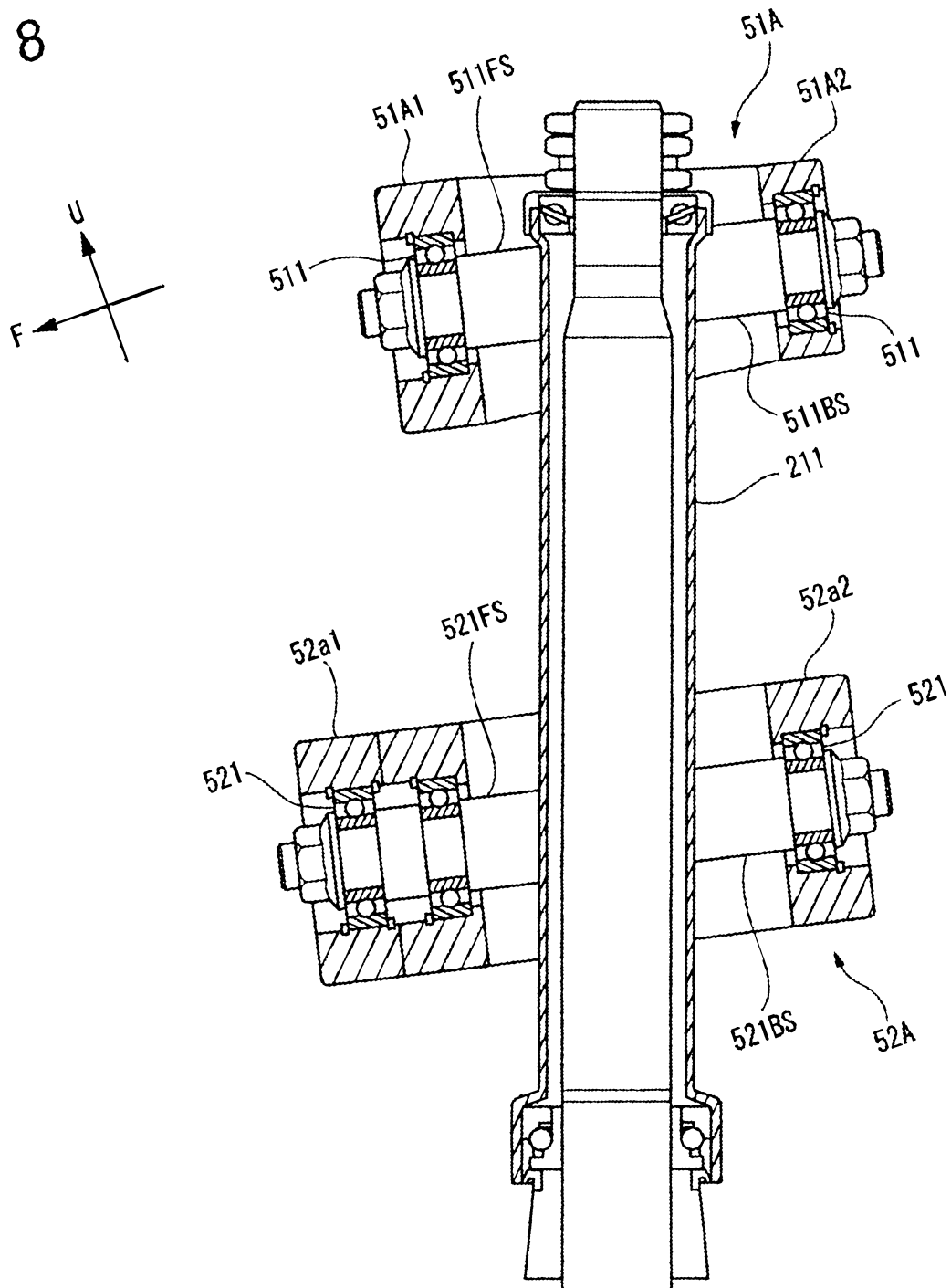
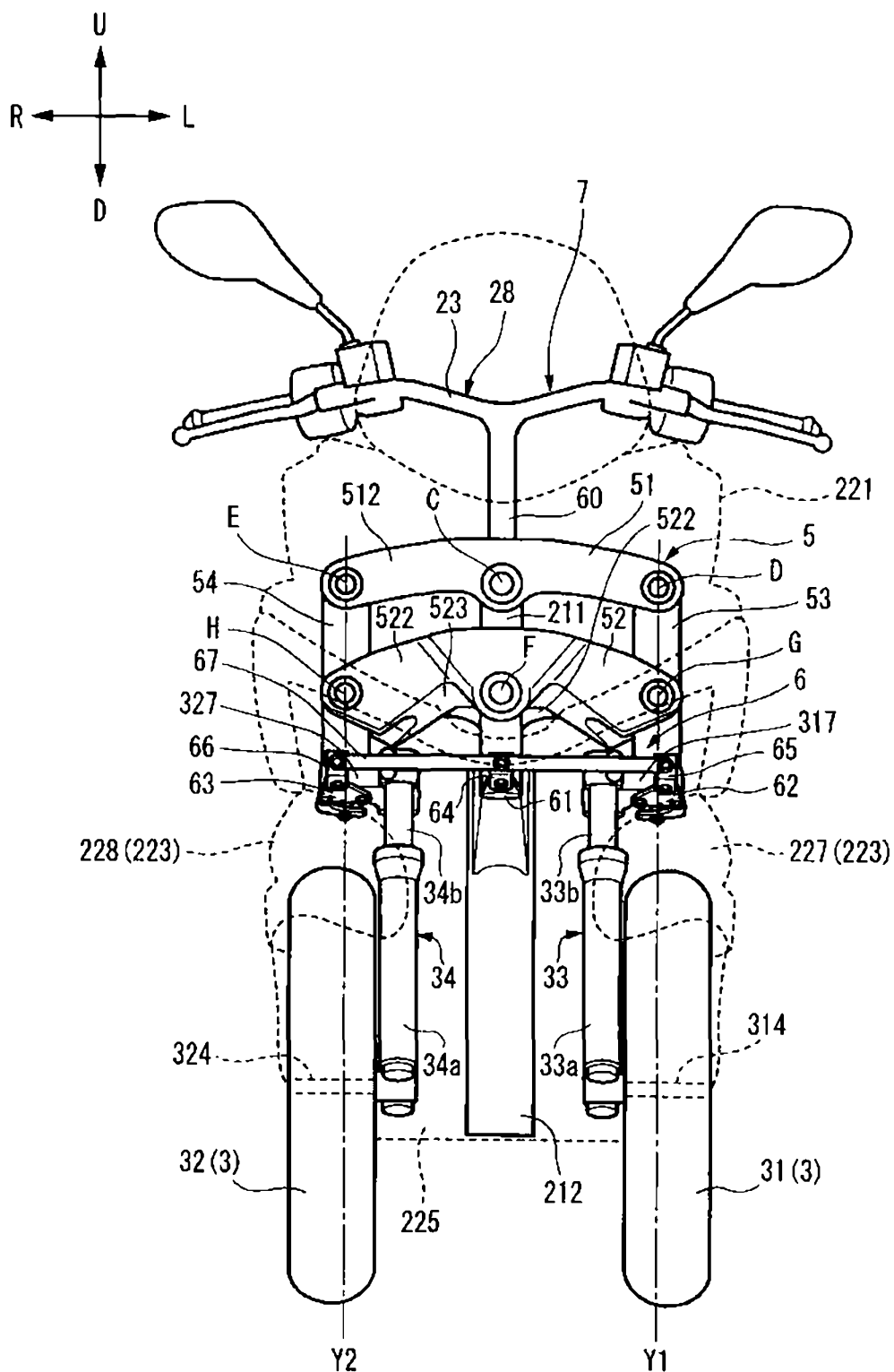


FIG. 9



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FIG. 10

