

DRIVE WHEEL SPRING AND SUSPENSION MECHANISM

FIELD OF INVENTION

- 5 The invention relates to a drive wheel suspension system for use in robotics, mechatronics and wheel vehicle.

BACKGROUND OF THE INVENTION

- 10 The most typical and common types of robot wheel suspension mechanisms are as depicted in **Figs. 1 & 2**. These types of designs are complicated, bulky, and not suitable for use in the direct-drive motor wheel system. This is because such designs require the combination of 'link-and-joint' assembly in order to achieve only vertical movements for the wheel shaft axle on uneven surface. Any twisting or misalignment
15 of the wheel shaft axle will affect the accuracy of the wheel odometry reading. Similar designs of such suspension mechanisms can also be found in **Figs. 3 to 7** which share the same problems.

- Fig. 8** depicts another design of the suspension mechanism which is disclosed by a
20 China Patent CN206106867U. This patent provides a robot vehicle suspension system which includes a support frame, a connecting rod assembly, a horizontal arm assembly and a damper. The support frame, connecting rod assembly and horizontal assembly are linked together to form a parallelogram assembly. The damper is positioned in a vertical manner within the parallelogram assembly, two ends of the
25 damper are respectively connected to the support frame and the connecting rod assembly. Nevertheless, this design only ensures that the wheel moves perpendicularly with reference to the support frame. It does not solve the problem of wheel off-set.

Accordingly, it would be desirable to provide an enhanced design for the robot wheel suspension mechanism to ensure both, perpendicular movement and no wheel off-set. This invention provides such a mechanism and system thereof.

SUMMARY OF INVENTION

The invention provides a suspension system for a land vehicle, the system comprises an axle for receiving a vehicle wheel, a bearing plate for supporting the axle and the associated wheel; a pair of spaced apart linear bearings located inside a box frame; wherein the bearing plate is guided to reciprocate in a plane containing the pair of spaced apart linear bearings, such that the axis of the axle during any such movement remains parallel to the axis of the axle prior to that movement; and a sliding guide linear bearing means located parallel to the pair of spaced apart linear bearings, wherein the sliding guide linear bearing means is provided to resist an axial thrust directable along the axis of the axle or the displaced axis of the axle. In addition, means are provided to damp the reciprocal movement of the axle. The axis can be common to a pair of axles which are constrained for movement in a similar manner and the damping means may comprise an adjustable gas spring. Such land vehicle is preferably but not limited to a robotic vehicle.

In one embodiment of the invention, the axle may include a first support means to facilitate its reciprocal movement such that the axle remains in the plane containing the axis of the axle and the axis of the axle during any such movement remains parallel to the axis of the axle prior to that movement. Preferably, the first support means comprises a bearing plate which is carried by a pair of spaced linear bearings and is connected to the damping means.

In another embodiment of the invention, the axle may include a second support means to absorb axial thrust during its reciprocal movement and to facilitate the reciprocal movement. Preferably, the second support means comprises a pair of spaced sliding guides with surfaces against which the bearing plate slides during reciprocal movement of the axle.

One skilled in the art will readily appreciate that the invention is well adapted to carry out the objects and obtain the ends and advantages mentioned, as well as those inherent therein. The embodiments described herein are not intended as limitations on the scope of the invention.

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BRIEF DESCRIPTION OF THE DRAWINGS

For the purpose of facilitating an understanding of the invention, there is illustrated in the accompanying drawing the preferred embodiments from an inspection of which
10 when considered in connection with the following description, the invention, its construction and operation and many of its advantages would be readily understood and appreciated.

Fig. 1 illustrates a first example of a typical and common robot wheel
15 suspension mechanism [PRIOR ART].

Fig. 2 illustrates a second example of a typical and common robot wheel suspension mechanism [PRIOR ART].

20 Fig. 3 illustrates an embodiment of the wheel suspension mechanism disclosed by the Patent document US2010013685 [PRIOR ART].

Fig. 4 illustrates an embodiment of the wheel suspension mechanism disclosed by the Patent document CN204955959U [PRIOR ART].

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Fig. 5 illustrates an embodiment of the wheel suspension mechanism disclosed by the Patent document US2818273 [PRIOR ART].

Fig. 6 illustrates an embodiment of the wheel suspension mechanism

disclosed by the Patent document US5454585 [PRIOR ART].

- Fig. 7 illustrates an embodiment of the wheel suspension mechanism disclosed by the Patent document US7959174 [PRIOR ART].
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- Fig. 8 illustrates an embodiment of the wheel suspension mechanism disclosed by the Patent document CN206106867U [PRIOR ART].
- Fig. 9 is a first perspective diagram illustrating a robot wheel suspension mechanism which embodies therein the principle features of the invention.
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- Fig. 10 illustrates a second perspective diagram of the robot wheel suspension mechanism.
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- Fig. 11 illustrates a pair of the robot wheel suspension mechanisms aligned on a common axis.
- Fig. 12 illustrates a perspective view of the robot wheel suspension mechanism in operation on a flat surface.
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- Fig. 13 illustrates a front view of the robot wheel suspension mechanism in operation on the flat surface.
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- Fig. 14 illustrates a perspective view of the robot wheel suspension mechanism in operation on a protruded surface.
- Fig. 15 illustrates a front view of the robot wheel suspension mechanism in operation on the protruded surface.

Fig. 16 illustrates a side view of robot wheel suspension mechanism in operation on the protruded surface.

5 Fig. 17 illustrates a perspective view of the robot wheel suspension mechanism in operation on a depressed surface.

Fig. 18 illustrates a front view of the robot wheel suspension mechanism in operation on the depressed surface.

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Fig. 19 illustrates a side view of robot wheel suspension mechanism in operation on the depressed surface.

DETAILED DESCRIPTION OF THE INVENTION

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The invention will now be described in greater detail, by way of example, with reference to the drawings.

20 **Figs. 9 & 10** show a preferred embodiment of a suspension system **100**. The suspension system **100** is preferably used in the application of mobile robots. However, it should be understood that the suspension system **100** can also be applied to any other types of land vehicles which require high accuracy of data detection.

25 As shown in the **Figs. 9 & 10**, the suspension system **100** comprises a generally rectangular frame **101** having a pair of linear bearings **106** extended in a substantially vertical manner from a top end to a bottom end of the frame **101**, the linear bearings **106** are spaced apart from each other and respectively passes through each side of a bearing plate **102** so that the bearing plate **102** can be carried to move upwardly or downwardly along the linear bearings **106** to form a reciprocal movement **109**. An

axle **103** is provided to receive a wheel **110** on one end and the other end is connected
 a motor **104** to form a drive assembly for rotating the wheel **110**. The bearing plate
102 has a centre through hole for the drive assembly to pass through. Preferably, the
 motor **104** is positioned at one side of the bearing plate **102** and the axle **103** is
 5 positioned at the opposite side of the bearing plate **102**. The axle has a flange portion
 rotatably fitted into the centre through hole so that the axle **103** and the motor **104** can
 reciprocate vertically with the bearing plate **102**.

A damper such as a gas spring **105** is mounted on top of the frame **101**, having a
 10 linkage protrudes downwardly to connect a top portion of the bearing plate **102**. The
 gas spring **105** can be preloaded and adjusted to provide a constant force to maintain
 the position of the axle **103** on a common axis **108**. When the axle **103** is positioned
 on the common axis **108**, its axis is also aligned with the common axis **108**. In
 addition, the gas spring **105** also damps any external forces that act onto the axle **103**
 15 when the vehicle is in operation, especially when the vehicle is moving on an uneven
 surface **112, 114**.

The pair of linear bearings **106** ensure the linear reciprocation **109** of the axle **103** is
 constrained to move in a plane and is further constrained such that the axis **113** of the
 20 displaced axle **103** remains parallel to the common axis **108**. As such, the
 configuration can prevent the axle **103** from twisting, misalignment and wheel off-set.
 The suspension system is also further provided with a pair of sliding guides **107**
 extended vertically from the top to bottom of the frame **101**, one at each side of the
 bearing plate **102** to absorb axial thrust that acts towards the axle **103** when the
 25 vehicle is moving on an uneven surface **112, 114**. Each sliding guide **107** can be
 engaged with a sliding member that can slide along its respective sliding guide **107**
 and the bearing plate can be connected to the sliding members such that the sliding
 guides **107** can function as the linear bearings **106**. As shown in **Fig. 11**, the common
 axis **108** is also common to a pair of opposing axles **103** which are constrained for

movement in a similar manner.

- Figs 11 & 12** show an exemplary of the suspension system **100**. Preferably, the suspension systems **110** are mounted on a base **111** of a robotic vehicle. In operation,
- 5 when the robotic vehicle is moving on a flat ground surface, the axis of the opposing axles **103** are aligned on the common axis **108**. On the other hand, when one wheel of the robotic vehicle is moving on an uneven surface **112, 114**, the axle of which the wheel is linked moves in a manner such that the displaced axle **103** remains parallel to the common axis **108**. The uneven surface **112, 114** may include a protruded surface
- 10 **112** as shown in **Figs. 14 to 16**, which the axis **113** of the displaced axle **103** is positioned above the common axis **108**. The uneven surface **112, 114** may also include a depressed surface **114** as shown in **Figs. 17 to 19**, which the axis **113** of the displaced axle **103** is positioned below the common axis **108**.
- 15 The major benefit of the suspension system **100** is that it is compact and the traction force is adjustable. Furthermore, the configuration of the suspension system **100** is simple and suitable for use in mobile robot using direct motor differential wheel drive method.
- 20 The present disclosure includes as contained in the appended claims, as well as that of the foregoing description. Although this invention has been described in its preferred form with a degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangements of parts may be
- 25 resorted to without departing from the scope of the invention.

CLAIMS:

1. A suspension system for a land vehicle comprising:
 - an axle for receiving a wheel;
 - a bearing plate for supporting the axle and the associated wheel;
 - a pair of spaced apart linear bearings located inside a frame that is configured in a shape of a box;

wherein the bearing plate is guided to reciprocate in a plane containing the pair of spaced apart linear bearings when the wheel is displaced relative to a ground on which the land vehicle is operable to traverse, such that a displaced axis of the axle during wheel displacement is parallel to an axis of the axle prior to the wheel displacement as constrained by the bearing plate and the pair of spaced apart linear bearings and as supported by the box frame; and

a sliding guide linear bearing means located parallel to the pair of spaced apart linear bearings, wherein the sliding guide linear bearing means is provided to resist an axial thrust directable along the axis of the axle or the displaced axis of the axle.
2. The suspension system according to claim 1, wherein the sliding guide linear bearing means comprises first and second sliding guides extending vertically from a top to a bottom of the frame, the first and second sliding guides are located at opposing sides of the bearing plate.
3. The suspension system according to claim 1 or 2, further comprising:
 - a damping means to dampen the reciprocating displacement of both the axle and the wheel, wherein the damping means comprises an adjustable gas spring.
4. The suspension system according to claim 3, wherein the adjustable gas spring is connectable directly to the bearing plate and lies in the plane of reciprocation of the bearing plate.

5. The suspension system according to claim 3 or 4, wherein the adjustable gas spring provides a traction to the wheel according to adjustment of the gas spring.

6. The suspension system according to any one of claims 1-5, further comprising:
a second axle located opposite but in axial alignment with the axle, wherein the second axle and an associated wheel are also configured for reciprocating displacement in a plane containing an associated pair of spaced apart linear bearings.

7. A mobile vehicle with a suspension system, wherein the suspension system of the mobile vehicle comprises:

a bearing plate supporting both an axle and an associated wheel, with the bearing plate being constrained to reciprocate in a plane containing a pair of spaced apart linear bearing means located inside a box frame whilst the wheel is operable to traverse on a ground, so that error of odometry caused by wheel displacement is minimised during traverse of the mobile vehicle; and

a sliding guide linear bearing means located parallel to the pair of spaced apart linear bearing means, wherein the sliding guide linear bearing means is provided to resist an axial thrust directable along an axis of the axle or a displaced axis of the axle during wheel displacement.

8. The mobile vehicle according to claim 7, wherein the sliding guide linear bearing means comprises first and second sliding guides extending vertically from a top to a bottom of the frame, the first and second sliding guides are located at opposing sides of the bearing plate.

9. The mobile vehicle according to claim 7 or 8, wherein the suspension system of the mobile vehicle further comprises:

a damping means to dampen the reciprocating displacement of both the axle and the wheel, wherein the damping means comprises an adjustable gas spring.

10. The mobile vehicle according to claim 9, wherein the adjustable gas spring is connectable directly to the bearing plate and lies in the plane of reciprocation of the bearing plate.

11. The mobile vehicle according to claim 10, wherein the adjustable gas spring provides a traction to the wheel according to adjustment of the gas spring.

12. The mobile vehicle according to any one of claims 7-11, wherein the suspension system of the mobile vehicle further comprises:

a second axle located opposite but in axial alignment with the axle, wherein the second axle and an associated wheel are also configured for reciprocating displacement in a plane containing an associated pair of spaced apart linear bearing means.