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(54) **Suspension system with controlled degrees of freedom**

(57) To couple a vehicle pod to a magnetic vehicle guidance system, a suspension system is provided which is arranged to couple certain degrees of freedom between the vehicle pod and the guidance system, and uncouple other degrees of freedom. More specifically, along a travel direction, forces are coupled between the guidance system and the vehicle, whereas the five other degrees of freedom are uncoupled. This uncoupling provides less disturbances to be transferred from the guidance system to the vehicle pod providing a smoother ride. The suspension system comprises one bogie on each side with a centre member provided between the bogies. The bogies have one translational and one rotational degree of freedom uncoupled relative to the centre member which may compensate for unevennesses in the guidance system.

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Title: Suspension system with controlled degrees of freedom

TECHNICAL FIELD

The present invention relates to the field of a suspension system for coupling a magnetically suspended vehicle pod in a vehicle guidance system, a magnetic levitation vehicle and a transportation system.

BACKGROUND

Magnetic levitation vehicles may be suspended from a magnetic track or supported on a magnetic track. To couple a vehicle pod of the magnetic levitation vehicle to the magnetic track a suspension may be used.

SUMMARY

The present invention aims to provide a suspension system for coupling a magnetically suspended vehicle pod in a vehicle guidance system with controlled degrees of freedom.

A first aspect provides a suspension system for coupling a magnetically suspended vehicle pod moving along a travel direction in a vehicle guidance system to said vehicle guidance system comprising a first guide at a first side, and a second guide at a second side. The suspension system comprises a first bogie provided at the first side, comprising a first magnetic suspension module arranged to engage with the first guide. The suspension system further comprises a second bogie provided at the second side, comprising a second magnetic suspension module arranged to engage with the second guide. The bogies preferably have an elongate shape, with length substantially parallel to an intended direction of movement of the pod. The suspension system further comprises an elongated centre member provided between the first bogie and the second bogie substantially parallel to the bogies. In the suspension system, the first bogie and the second bogie are connected to the centre member with a straight guide or quasi straight

guide mechanism, such that at least one of the bogies can each translate substantially in a suspension direction relative to the centre member. Furthermore, the straight guide or quasi straight guide mechanism allows a rotation of each of the bogies relative to the centre member around a lateral axis perpendicular to the travel direction.

This arrangement of the bogies and the centre member allows the centre member to remain in the same orientation even when one or both of the bogies alter their position in the suspension direction and/or rotate around the lateral axis perpendicular to the travel direction. Furthermore, the arrangement of the bogies and the centre member allow forces to travel between the first bogie and the second bogie in the direction of the lateral axis.

Such an alteration of the position of the bogies and/or such a rotation of the bogies may be caused by for example a change in a size of an air gap between a guide and a respective magnetic suspension module due to for example an unevenness in a guide.

Within this arrangement, translation of the bogies and the centre member in the direction of travel is restricted and rotation of the two bogies and the centre member relative to one another over a vertical axis is restricted as well. This does, on the other hand, not necessarily restrict rotation around the suspension axis of the arrangement of the bogies and the centre member relative to the vehicle.

Furthermore, translation of the bogies relative to one another over a horizontal axis, perpendicular to the direction of movement is restricted as well. By virtue of use of the quasi straight guide, a translation of at least two out of the bogies and the centre member relative to other will result in some horizontal translation, but such translation is restricted.

Furthermore, rotation of the bogies and the centre member around the travel direction is possible, but the angles of rotation will have the same signs and have the same order of magnitude or may even be

substantially the same (with a deviation of maximum 10%), by virtue of the (quasi) straight guides.

In an embodiment of the suspension system, each bogie comprises a suspension support, arranged to couple suspension forces between a vehicle pod attached to the suspension system and the bogie on which the suspension support is provided. As an option, each bogie comprises more than one suspension supports, wherein the suspension supports are provided at a distance from one another on a line substantially parallel to the travel direction, wherein the suspension supports are arranged to couple suspension forces between a vehicle pod attached to the suspension system and the bogie on which the suspension support is provided.

The suspension supports allow a weight caused by gravitational pull on the mass of the suspended vehicle pod to be coupled to the guides of the vehicle suspension system through the suspension.

Preferably, the suspension supports are provided substantially below one of the magnetic suspension modules. This prevents titling moments due to misaligned of the forces in the suspension direction on the suspension supports and the magnetic suspension modules.

In a preferred embodiment of the suspension system, the suspension supports are arranged as air springs. An air spring may be loaded under tension or under compression, and allows control in an extension direction of the air spring, which in use will be substantially equal to the suspension direction. An air spring substantially allows movement in the five other degrees of freedom between the vehicle pod and the bogie on which the air spring as the suspension support is provided, thus preventing over-constraining the connection between the vehicle pod and the suspension system.

A further embodiment of the suspension system further comprises four bar elements variable in length, which are at a proximal end attached by proximal joints to the centre member, the four bars at a distal end each

comprising a hinge, wherein the four distal joints define a rectangular plane corresponding to four attachment points on a vehicle pod arranged to be attached to the suspension system.

The distal joints and the proximal joints may be arranged as hinges which allow rotation over one axis, and constrain all other five degrees of freedom. Alternatively, the hinges may allow rotation over two or three axes, and constrain the other three degrees of freedom. In the latter case, the hinges may be arranged as spherical bearings, or ball-and-socket hinges.

The bar elements that are variable in length allow, when the vehicle pod is connected to the four distal joints, the suspension system to be translated over the substantially horizontal direction while the vehicle pod remains in substantially the same lateral position on said substantially horizontal direction.

Furthermore, the combination of the distal joints, proximal joints, and the variation of length of the bar elements allow a vehicle pod attached to the suspension system to remain in substantially the same orientation relative to the vehicle guidance system, while the suspension system rotates over the suspension direction.

The bar elements may be arranged as pistons, resilient elements arranged to change length when compressed and/or tensioned, or any other prismatic joint which allows a change of length in the elongation direction of the bar element.

In an embodiment, the suspension system further comprises a sliding element, wherein the sliding element is arranged to allow a sliding movement between the centre member and a vehicle pod attached to the sliding element over a sliding axis.

The sliding element may be rotatably attached to the centre member such that the sliding element can rotate relative to the centre

member around an axis parallel to the suspension direction. In use, the sliding axis will be substantially perpendicular to the travel direction.

The sliding element may be provided via a bushing, ball bearing, or any other tribologic connection in the centre member, which will allow the rotation of the sliding element relative to the centre member.

In an embodiment of the suspension system, the magnetic suspension modules comprise a plurality of magnets, such that a distance between a magnetic suspension module and a corresponding suspension guide may be controlled separately for at least two positions of the magnetic suspension module. This allows control of rotation of one or both of the bogies around one or both of the suspension direction and the substantially horizontal direction perpendicular to the suspension direction.

Each straight guide or quasi straight guide mechanism may be arranged as a parallelogram linkage comprising four bars, of which a first bar extends from a centre bogie joint provided on or near the centre of a bogie towards a top proximal joint provided on a proximal side of the centre member. A second bar extends from the centre bogie joint towards a top distal joint provided on a distal side of the centre member at a distance from the top proximal joint. A third bar extends from a proximal bogie joint provided on the bogie towards a bottom proximal joint provided on the proximal side of the centre member. A fourth bar extends from a distal bogie joint provided on the bogie towards a bottom distal joint provided on the distal side of the centre member at a distance from the bottom proximal joint. In the mechanism, the rotation of each of the bogies relative to the centre member around a lateral axis perpendicular to the travel direction is around the centre bogie joint comprised by the respective bogie.

A second aspect provides a magnetic levitation vehicle comprising a vehicle pod and a plurality of suspension systems according to the first aspect connected at or near the top or bottom of the vehicle pod. The

suspension system may be used to couple certain degrees of freedom between the vehicle pod and a vehicle guidance system.

A third aspect provides a transportation system comprising a magnetic levitation vehicle and a vehicle guidance system comprising a first guide at a first side, and a second guide at a second side.

DESCRIPTION OF THE FIGURES

The various aspects and embodiments thereof will now be discussed in conjunction with drawings. In the drawings:

Fig. 1A shows a suspended magnetic levitation vehicle;

Fig. 1B shows a supported magnetic levitation vehicle;

Fig. 2A shows a front view of a suspension system;

Fig. 2B shows a detailed view of part of the suspension system;

Fig. 3A shows part of an embodiment of the suspension system;

Fig. 3B shows a top view of part of an embodiment of the suspension system;

Fig. 3C shows a schematic top view of part of another embodiment of the suspension system;

Fig. 3D shows a schematic isometric view of part of the other embodiment of the suspension system;

Fig. 4 shows a top view of part of another embodiment of the suspension system; and

Fig. 5 shows a preferred embodiment of the suspension system.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Fig. 1A shows an embodiment of a magnetic levitation vehicle 400 comprising a vehicle pod 200, a first suspension system 410 and a second suspension system 420, both suspension systems according to any of the embodiments as described here-below. In the embodiment of Fig. 1A, the suspension systems are connected at or near the top of the vehicle pod 200

and are arranged to couple the magnetic levitation vehicle 400 to a vehicle guidance system 300. Fig. 1B shows an embodiment of the magnetic levitation vehicle 400 wherein the suspension systems are connected at or near the bottom of the vehicle pod 200. In Figs. 1A and 1B, the substantially horizontal direction 128 points into the paper.

The magnetic levitation vehicle 400 is arranged to be moved along a travel direction 102 whilst being either magnetically suspended from the vehicle guidance system 300 in Fig. 1A or magnetically supported by the vehicle guidance system 300 in Fig. 1B, wherein in both Figures the gravity is oriented opposite to a suspension direction 126.

Both the vehicle pod 200 and the vehicle guidance system 300 may be assumed to be substantially rigid bodies. A misalignment between the vehicle pod 200 and the vehicle guidance system 300 may thus be compensated by the suspension systems, preventing undesired strain on one or both of the vehicle pod 200 and the vehicle guidance system 300. The translation of the vehicle pod 200 along the travel direction 102 relative to the vehicle guidance system 300 may be left unconstrained to allow the vehicle pod 200 to travel in the vehicle guidance system 300 along the travel direction 102.

Fig. 2A shows a front view of an embodiment of a suspension system 100 for coupling the magnetically suspended vehicle pod 200 along the travel direction 102 (pointing out of the page) in the vehicle guidance system 300 to said vehicle guidance system 300. The vehicle guidance system 300 comprises a first guide 108 at a first side, and a second guide 110 at a second side. The vehicle guidance system 300 may comprise at the first side a first lateral guide 107 and at the second side a second lateral guide 109.

The suspension system 100 of the embodiment as shown in Fig. 2A comprises a first bogie 112 at the first side, which comprises a first magnetic suspension module 114 arranged to engage with the first guide

108. The suspension system 100 further comprises a second bogie 116 at the second side, comprising a second magnetic suspension module 118 arranged to engage with the second guide 110.

A magnetic suspension module arranged to engage with a guide implies that a magnetic force may be exerted between the suspension module and the guide. Such a force may be for example used for compensating gravity pulling on the magnetic suspension module. Between a magnetic suspension module and a respective guide, an air gap may be present.

As an option, the first bogie 112 may comprise at the first side a first lateral magnetic module 115 and the second bogie 116 at the second side a second lateral magnetic module 119. The first lateral magnetic module 115 is arranged to engage with the first lateral guide 107 and the second lateral magnetic module 119 is arranged to engage with the second lateral guide 109.

A lateral magnetic module arranged to engage with a lateral guide implies that a magnetic force may be exerted between the lateral magnetic module and the lateral guide. Such a force may for example be used for controlling a lateral position on a lateral axis 128 of the suspension 100 within the vehicle guidance system 300.

The suspension system 100 as shown in Fig. 2A further comprises an elongated centre member 120 provided between the first bogie 112 and the second bogie 116 substantially parallel to the bogies. Substantially parallel here implies that the bogies and the elongated centre member 120 are preferably oriented in the same direction, but a small deviation from being parallel may be allowed. The elongated centre member 120 is elongated in the travel direction 102.

In the suspension system 100, the first bogie 112 and the second bogie 116 are connected to the elongated centre member 120 with a first straight guide mechanism 122 and a second straight guide mechanism 124,

respectively, shown schematically in Fig. 2A. A straight guide mechanism, also known as a straight line mechanism, is defined as a mechanism which may be used to connect a first body to a second body such that the first body may be translated relative to the second body over a straight line. Here, the first body is one of the bogies and the second body is the elongated centre member 120.

A straight guide mechanism here may also be a quasi straight guide mechanism. A quasi straight guide mechanism, also known as a nearly straight line mechanism, is defined as a mechanism which may be used to connect a first body to a second body such that the first body may be translated relative to the second body over an approximately straight line, said approximately straight line often being more straight over a short section of the total stroke of the first body relative to the second body. With such quasi straight guide mechanisms, with the translation over the approximately straight line a smaller parasitic displacement of the first body towards the second body is associated. Because the translation over the approximately straight line will be relatively small, this parasitic displacement will be even smaller and may be allowable.

The connection by a straight guide mechanism allows each of the bogies to be translated substantially in the suspension direction 126 relative to the elongated centre member 120. This connection also allows the elongated centre member 120 to stay in substantially the same position in the suspension direction 126 when one or both of the bogies translates in the suspension direction 126, for example due to unevennesses in one or both of the first guide 108 and the second guide 110. The straight guide mechanisms couple forces in the travel direction 102 between the bogies and the elongated centre member 120.

In the suspension system 100, the straight guide mechanisms further allow a rotation of the respective bogie relative to the elongated

centre member 120 around the lateral axis 128 perpendicular to the travel direction 102.

Now referring to Fig. 2B, which shows the second side of an embodiment of the suspension system 100, wherein each bogie comprises an air spring 132 as a suspension support. As the suspension system 100 may be regarded symmetrical over the elongated centre member 120, for conciseness only the second side is shown in Fig. 2B.

The magnetically suspended vehicle pod 200 as shown in Fig. 2B comprises an extended support section 290. The extended support section 290 is arranged for connecting the vehicle pod 200 to a suspension support. In the embodiment of Fig. 2B, the vehicle pod 200 is supported via the extended support section 290 on a top side of the air spring 132, which causes the air spring 132 to be compressed by virtue of a gravitational force orientated opposite to the suspension direction 126 pulling on the vehicle pod 200. An embodiment of the suspension system 100 is also envisioned in which the extended support section 209 is provided below the air springs, thus putting the air spring 132 under tension by virtue of the gravitational force pulling on the air spring 132.

Each bogie may comprise more than one air spring 132, wherein in such embodiments of the suspension system 100, the air springs are provided at a distance from one another on a line substantially parallel to the travel direction 102, and the air springs are arranged to couple suspension forces between a vehicle pod 200 attached to the suspension system 100 and the bogie on which the air spring is provided.

Embodiments of bogies are envisioned comprising one air spring 132 per bogie, preferably provided at or near the centre of the bogies. Any other number of air springs per bogie is also envisioned as an option.

Preferably, the air springs are provided substantially below one of the magnetic suspension modules. This prevents undesired moments due to a misalignment of the force vectors of the forces between the guide and

respective magnetic suspension module, and the force of the vehicle pod on the air spring 132.

The suspension supports are preferably arranged as air springs, which may be used to control one degree of freedom: translation in the suspension direction 126. The two other translational degrees of freedom and the three rotational degrees of freedom are substantially unconstrained for small translations or rotations. In another embodiment, the suspension supports are arranged as pistons of which both ends are provided with a joint, such as a ball joint, such that it may provide similar or the same kinematic behaviour as an air spring.

The suspension supports may be controlled actively, or arranged as passive air springs with a specific desired stiffness and damping.

Fig. 3A shows an embodiment of a straight guide mechanism 122 between the first bogie 112 and the elongated centre member 120. A first bar 201 extends from a centre bogie joint 211 preferably provided on or near the centre of the first bogie 112 towards a top proximal joint 221 provided on a proximal side of the centre member 120. A second bar 202 extends from the centre bogie joint 211 towards a top distal joint 222 provided on a distal side of the centre member 120 at a distance from the top proximal joint 221. Alternatively, the top distal joint 222 and the top proximal joint 221 may be one dimensional hinges, allowing a hinging movement over an axis substantially parallel to the centre member 120. A third bar 203 extends from a proximal bogie joint 212 provided on the bogie 112 towards a bottom proximal joint 223 provided on the proximal side of the centre member 120. A fourth bar 204 extends from a distal bogie joint 213 provided on the bogie 112 towards a bottom distal joint 224 (not shown) provided on the distal side of the centre member 120 at a distance from the bottom proximal joint 223. Alternatively, the bottom proximal joint 223 and the bottom distal joint 224 may be one dimensional hinges, enabling a hinging movement over an axis substantially parallel to the centre member 120.

The rotation of the first bogie 112 relative to the elongated centre member 120 around the lateral axis 128 perpendicular to the travel direction 102 is allowed around the centre bogie joint 211.

Any of the bottom proximal joint 223, bottom distal joint 224, proximal bogie joint 212, distal bogie joint 213 may be arranged as ball joints, but alternatively may also be arranged as universal joints or hinges, as long as the allow rotation over an axis parallel to the elongation direction of the elongated centre member 120.

The centre bogie joint 211, the top proximal joint 221, and the top distal joint 222 may be arranged as ball joints that allow rotation over three degrees of freedom. Alternatively, one or more of these joints may be arranged as universal joints that allow rotation over two degrees of freedom.

Fig. 3B shows a top view of part of the suspension system 100 comprising the first bogie 112, elongated centre member 120, second bogie 116. Provided between the first bogie 112 and the elongated centre member 120 is the first straight guide mechanism 122, and provided between the second bogie 116 and the elongated centre member 120 is the second straight guide mechanism 124. Both straight guide mechanisms in this embodiment are arranged as the four bar parallelogram linkage as described here-above.

In the embodiment of the suspension system 100 as shown in Fig. 3A and 3B, the top and bottom proximal joints, and the top and bottom distal joints are positioned substantially above each other. Embodiments of the suspension system 100 are envisioned as well wherein the top and bottom proximal joints, and the top and bottom distal joints are not positioned substantially above each other. Furthermore, the third bar 203 and fourth bar 204 need not necessarily be positioned parallel to one another.

The straight guide mechanisms allow exchange of forces in the travel direction 102 between the bogies and the centre member through the

first bars 201 and second bars 202. The straight guide mechanisms further allow forces in the substantially horizontal direction 128 to travel between the first bogie 112,the second bogie 116, and the centre member 120.

In the embodiment of the suspension system 100 the first bar 201 and the second bar 202 are connected to the same centre bogie joint 211. Embodiments of the suspension system 100 wherein the first bar 201 and the second bar 202 are connected to separate joints on the bogie are envisioned as well, and may provide similar kinematics.

Fig. 3C shows a top view of part of an alternative embodiment of the suspension system 100 with the straight guide mechanism 122 provided between and connecting the first bogie 112 and the elongated centre member 120. The first bar 201 and second bar 202 are in this configuration connected to a middle centre member joint 218 which is preferably provided at or near the centre of the centre member 120. This embodiment may provided the similar desired kinematics which allows exchange of forces in the travel direction 102 between the bogies and the centre member through the first bars 201 and second bars 202, and further allow rotation of the first bogie 112 relative to the elongated centre member 120 around the lateral axis 128 perpendicular to the travel direction 102 and translation of the first bogie 112 relative to the elongated centre member 120 over the suspension direction 126.

The middle centre member joint 218 may be arranged as a ball joint, or may alternatively be arranged as a universal joint.

Fig. 3D shows yet another embodiment of part of the suspension system 100 wherein the straight guide mechanism 122 comprises three bar elements: a top bar element 205, the third bar element 203 and the fourth bar element 204. The top bar element 203 is at a proximal end attached to a top bogie joint 219 and extends towards top proximal joint 221. Again this embodiment may provide similar kinematics to that of the embodiments of Fig. 3A.

It will be appreciated that many different configurations and numbers of joints and bar elements may be used to provide the desired kinematics as discussed here-above. For example, mirroring the straight guide mechanisms over a plane spanned by the travel direction 102 and the substantially horizontal direction 128 gives useable straight guide mechanisms as well. Mirroring the embodiment of Fig. 3D over a plane spanned by the substantially horizontal direction 128 and the suspension direction 126 may indeed also provide the desired kinematics.

Furthermore, configurations are envisioned for the straight guide mechanisms wherein the bars differ in length, and the distance between the elongated centre member 120 and the respective bogie is different for the top joints and the bottom joints. In such a configuration, the bogie may, when translating relative to the centre member 120, rotate around an axis parallel to the travel direction 102.

Fig. 4 shows part of an embodiment of the suspension system 100, further comprising a first bar element 161, a second bar element 162, a third bar element 163 and a fourth bar element 164. For conciseness of the figure, the bogies and straight guide mechanisms have been omitted. The first bar element 161 is attached to the centre member 120 with a first proximal joint 165 and at a distal end comprises a first distal joint 171 arranged to be attached to a first attachment point 241 of the vehicle pod 200. Similarly, the second bar element 162 is attached to the centre member 120 with a second proximal joint 166 and at a distal end comprises a second distal joint 172 arranged to be attached to a second attachment point 242 of the vehicle pod 200. The third bar element 163 is attached to the centre member 120 with a third proximal joint 167 and at a distal end comprises a third distal joint 173 arranged to be attached to a third attachment point 243 of the vehicle pod 200. The fourth bar element 164 is attached to the centre member 120 with a fourth proximal joint 168 and at a distal end

comprises a fourth distal joint 174 arranged to be attached to a fourth attachment point 244 of the vehicle pod 200.

The bar elements are variable in length, and are preferably arranged as pistons but may also be arranged as any other prismatic joint or as air springs.

The proximal and distal joints may be hinges that are arranged to allow rotation of the respective ends of the bar elements around the suspension direction 126 but may also be arranged as ball joints which allow rotation of the respective ends of the bar elements around two or three axes of rotation. Hinges and ball joints in particular may also be embodied as cardan joints which allow rotation over two axes, and as any other spherical joint or spherical rolling joint, providing the same or similar functionality. Alternatively or additionally, the ball joint functionality may be provided by a material having resilient properties in all direction, including, but not limited to a rubber joint or a joint comprising another elastomer material. In case a hinge is preferred which has only one degree of freedom - a rotation around a single axis - this is specifically indicated as such, though this does not exclude any implementation in which further hinges may be implemented as hinges with a single degree of freedom.

The length of the bar elements may be controlled actively or may be passively controlled by the forces exerted on the bar elements. The bar elements may be provided with a specific damping and/or stiffness for improving dynamics of the suspension system 100. The bar elements may be resilient in their elongation direction, implying that a force may be used to compress or elongated the bar elements, and that after the force is removed the bar element return to a nominal length. This resilience may be the result of air present in a piston as a bar element, a spring element comprised by the bar element, a resilient material comprised by the bar element, a leaf spring, a plate spring, a ring spring, a coil spring, a torsion

spring, a rubber spring, a rubber-metal spring, an air spring, a swinging link arrangement, any other way, or any combination thereof.

The suspension system 100 as shown in Fig. 4 further comprises a sliding element 190 which is preferably rotatably attached to the elongated centre member 120. The sliding element 190 is arranged to be connected to the vehicle pod 200 to allow a sliding movement between the centre member 120 and the vehicle pod over a sliding axis 192. The sliding axis 192 will in use be generally oriented substantially parallel to the horizontal direction 128.

To allow rotation between the sliding element 190 and the centre member 120, a bushing 194 or bearing may be provided between the sliding element 190 and the centre member 120 which allows rotation around the suspension direction 126.

The rotation between the sliding element 190 and the centre member 120 may be actively controlled using for example a motor, or may be passive and may be provided with a desired stiffness and/or damping to improve dynamic behaviour of the suspension system 100.

With the arrangement of joints, bar elements and sliding element 190 as shown in Fig. 4, the orientation of the vehicle pod 200 may be maintained substantially constant even if the suspension system 100 translates over the lateral axis 128 and/or rotates around the suspension direction 126.

Although Fig. 4 shows four bar elements which are oriented parallel to the substantially horizontal direction 128, embodiments of the suspension system 100 comprising any number of bar elements oriented in any direction are envisioned as well.

The attachment points 241,242,243,244 of the vehicle pod 200 may be positioned as a square or rectangle, but may also be positioned differently, wherein the suspension system 100 has corresponding bar element lengths and orientations to correspond to the attachment points.

Furthermore, more or less than four attachment points may be provided, with a corresponding amount of bar elements.

Fig. 5 shows a preferred embodiment of a suspension system 100, comprising the four bar parallelogram linkages as straight guide mechanisms as shown in Figs. 3A and 3B, and the with joints connected bar elements and sliding element 190 of Fig. 4. With this suspension system 100, the orientation of a vehicle pod 200 attached to the distal joints 171,172,173,174 of the bar elements, the sliding element 190, and the suspension supports 132 may remain constant or substantially constant even if the suspension 100 at least one of rotates and/or translates over the suspension direction 126 and rotates and/or translates over the lateral axis 128.

In embodiments of the suspension system 100, at least one of the first magnetic suspension module 114 and the second magnetic suspension module 118, and the first lateral magnetic module 115 and second lateral magnetic module 119 may comprise a plurality of magnets. This allows distances between different magnets and the corresponding guide comprised by the vehicle guidance system 300 to be controlled separately. This in turn allows control of a rotation of a bogie around the suspension direction 126 for the lateral magnetic modules and a rotation of a bogie around the substantially horizontal direction 128 for the magnetic suspension modules.

Any of the joints in any of the embodiments of the suspension system may be arranged as spherical joints which allow rotation over all three axes of rotation. Also, universal joints that allow rotation over two axes of rotation may be used if it does not overconstrain or underconstrain the desired kinematics. Similarly, revolute joints or hinges may be used wherever this use does not overconstrain or underconstrain the desired kinematics.

In the embodiment of the suspension system 100 as shown in Fig. 5, the centre bogie joint 211 of the first bogie 112 and the centre bogie joint

(not shown) of the second bogie 116 are preferably arranged as spherical joints to compensate for torsion of the bars which are connected to said joints. Alternatively, an element providing a torsional degree of freedom may be comprised by the bar itself which allows torsion of a distal end of the bar relative to a proximal end of the bar.

To couple a vehicle pod to a magnetic vehicle guidance system, a suspension system is provided which is arranged to couple certain degrees of freedom between the vehicle pod and the guidance system, and uncouple other degrees of freedom. More specifically, along a travel direction, forces are coupled between the guidance system and the vehicle, whereas the five other degrees of freedom are uncoupled. This uncoupling provides less disturbances to be transferred from the guidance system to the vehicle pod providing a smoother ride. The suspension system comprises one bogie on each side with a centre member provided between the bogies. The bogies have one translational and one rotational degree of freedom uncoupled relative to the centre member which may compensate for unevennesses in the guidance system.

At least part of the various aspects and embodiments thereof may be summarised as follows:

1. Suspension system for coupling a magnetically suspended vehicle pod moving along a travel direction in a vehicle guidance system to said vehicle guidance system comprising a first guide at a first side, and a second guide at a second side, the suspension system comprising:

- a first bogie provided at the first side, comprising a first magnetic suspension module arranged to engage with the first guide;
- a second bogie provided at the second side, comprising a second magnetic suspension module arranged to engage with the second guide;
- an elongated centre member provided between the first bogie and the second bogie substantially parallel to the bogies;

wherein the first bogie and the second bogie are connected to the centre member with a straight guide or quasi straight guide mechanism, such that the bogies can each be translated substantially in a suspension direction relative to the centre member.

2. Suspension system according to embodiment 1, wherein the straight guide or quasi straight guide mechanisms allow a rotation of the respective connected bogie relative to the centre member around a lateral axis perpendicular to the travel direction.

3. Suspension system according to embodiment 1 or 2, wherein each bogie comprises a suspension support, arranged to couple suspension forces between a vehicle pod attached to the suspension system and the bogie on which the suspension support is provided.

4. Suspension system according to embodiment 3, wherein the suspension supports are each provided substantially below the magnetic suspension module of the respective bogie which comprises the suspension support.

5. Suspension system according to embodiment 3 or 4, wherein the suspension supports are arranged as air springs.

6. Suspension system according to any of the embodiments 3-5, wherein each bogie comprises more than one suspension supports, and wherein the suspension supports of each of the bogies are provided at a distance from one another on a line substantially parallel to the travel direction.

7. Suspension system according to any of the preceding embodiments, further comprising four bar elements variable in length, which are at a proximal end attached by proximal joints to the centre member, the four bars at a distal end each comprising a distal joint, wherein the four distal joints define a rectangular plane corresponding to four attachment points on a vehicle pod arranged to be attached to the suspension system.

8. Suspension system according to embodiment 7, wherein the bar elements are arranged as pistons.

9. Suspension system according to any of the preceding embodiments, further comprising a sliding element, wherein the sliding element is arranged to allow a sliding movement between the centre member and a vehicle pod attached to the sliding element over a sliding axis.

10. Suspension system according to embodiment 9, wherein the sliding element is rotatably attached to the centre member such that the sliding element can be rotated relative to the centre member around an axis parallel to the suspension direction.

11. Suspension system according to any of the previous embodiments, wherein the magnetic suspension modules comprise a plurality of magnets, such that a distance between a magnetic suspension module and a corresponding guide may be controlled separately for at least two positions of the magnetic suspension module.

12. Suspension system according to any of the previous embodiments, further comprising lateral magnet modules which comprise a plurality of magnets, such that a distance between a lateral magnet module and a corresponding lateral guide comprised by the vehicle guidance system may be controlled separately for at least two positions of the lateral magnet module.

13. Suspension system according to any of the previous embodiments, wherein each straight guide or quasi straight guide mechanism comprises a parallelogram linkage comprising four bars, of which:

- a first bar extends from a centre bogie joint provided on or near the centre of a bogie towards a top proximal joint provided on a proximal side of the centre member;

- a second bar extends from the centre bogie joint towards a top distal joint provided on a distal side of the centre member at a distance from the top proximal joint;

- a third bar extends from a proximal bogie joint provided on the bogie towards a bottom proximal joint provided on the proximal side of the centre member;

- a fourth bar extends from a distal bogie joint provided on the bogie towards a bottom distal joint provided on the distal side of the centre member at a distance from the bottom proximal joint;

wherein the rotation of each of the bogies relative to the centre member around a lateral axis perpendicular to the travel direction is around the centre bogie joint comprised by the respective bogie.

14. Magnetic levitation vehicle comprising a vehicle pod and a plurality of suspension systems according to any of the preceding embodiments connected at or near the top or bottom of the vehicle pod.

15. Transportation system comprising;

- a magnetic levitation vehicle according to embodiment 14; and

- a vehicle guidance system comprising a first guide at a first side, and a second guide at a second side.

In the description above, it will be understood that when an element such as layer, region or substrate is referred to as being "on" or "onto" another element, the element is either directly on the other element, or intervening elements may also be present. Also, it will be understood that the values given in the description above, are given by way of example and that other values may be possible and/or may be strived for.

Furthermore, the invention may also be embodied with less components than provided in the embodiments described here, wherein one component carries out multiple functions. Just as well may the invention be embodied using more elements than depicted in the Figures, wherein

functions carried out by one component in the embodiment provided are distributed over multiple components.

It is to be noted that the figures are only schematic representations of embodiments of the invention that are given by way of non-limiting examples. For the purpose of clarity and a concise description, features are described herein as part of the same or separate embodiments, however, it will be appreciated that the scope of the invention may include embodiments having combinations of all or some of the features described.

The word 'comprising' does not exclude the presence of other features or steps than those listed in a claim. Furthermore, the words 'a' and 'an' shall not be construed as limited to 'only one', but instead are used to mean 'at least one', and do not exclude a plurality.

A person skilled in the art will readily appreciate that various parameters and values thereof disclosed in the description may be modified and that various embodiments disclosed and/or claimed may be combined without departing from the scope of the invention.

It is stipulated that the reference signs in the claims do not limit the scope of the claims, but are merely inserted to enhance the legibility of the claims.

Conclusies

1. Ophangingsysteem voor koppelen van een magnetisch ondersteunde voertuiggondel welke in een reisrichting beweegt in een voertuiggeleidingssysteem aan het voertuiggeleidingssysteem omvattende een eerste geleider aan een eerste zijde en een tweede geleider aan een tweede zijde, het ophangingsysteem omvattende:

- een eerste bogie voorzien aan de eerste zijde, omvattende een eerste magnetische ophangingsmodule ingericht om samen te werken met de eerste geleider;
- een tweede bogie voorzien aan de tweede zijde, omvattende een tweede magnetische ophangingsmodule ingericht om samen te werken met de tweede geleider;
- een langgerekt middendeel voorzien tussen de eerste bogie en de tweede bogie in hoofdzaak parallel aan de bogies;

waarin de eerste bogie en de tweede bogie met een rechtgeleiding- of quasi-rechtgeleidingmechanisme zijn verbonden met het middendeel, zodanig dat de bogies elk in hoofdzaak in een ophangingsrichting getransleerd kunnen worden ten opzichte van het middendeel.

2. Ophangingsysteem volgens conclusie 1, waarin het rechtgeleiding- of quasi-rechtgeleidingmechanisme een rotatie mogelijk maakt van de respectievelijke verbonden bogie ten opzichte van het middendeel rond een laterale as loodrecht op de reisrichting.

3. Ophangingsysteem volgens conclusie 1 of 2, waarin elke bogie een ophangingssteun omvat, ingericht om ophangingskrachten te koppelen tussen een voertuiggondel verbonden aan het ophangingsysteem en de bogie waaraan de ophangingssteun is voorzien.

4. Ophangingsysteem volgens conclusie 3, waarin de ophangingssteunen elk in hoofdzaak onder de magnetische ophangingsmodule van de respectievelijke bogie welke de ophangingssteun omvat zijn voorzien.

5. Ophangingsysteem volgens conclusie 3 of 4, waarin de ophangingssteunen ingericht zijn als luchtveren.

6. Ophangingsysteem volgens een van de conclusies 3-5, waarin elke bogie meer dan een ophangingssteun omvat en waarin de ophangingssteunen van elk van de bogies op een afstand van elkaar zijn voorzien op een lijn welke in hoofdzaak parallel loopt aan de reisrichting.

7. Ophangingsysteem volgens een van de voorgaande conclusies, verder omvattende vier staafdelen die in lengte kunnen variëren, welke aan een proximaal uiteinde met proximale verbindingen verbonden zijn aan het middendeel, de vier staafdelen aan een distaal uiteinde omvattende een distale verbinding, waarin de vier distale verbindingen een rechthoekig vlak definiëren welke correspondeert met vier verbindingspunten op een voertuiggondel ingericht om te worden verbonden met het ophangingssysteem.

8. Ophangingsysteem volgens conclusie 7, waarin de staafelementen zijn uitgevoerd als zuigers.

9. Ophangingsysteem volgens een van de voorgaande conclusies, verder omvattende een glij-element, waarin het glij-element is ingericht om een glijbeweging over een glij-as mogelijk te maken

tussen het middendeel en een voertuiggondel verbonden met het glij-element.

10. Ophangingsysteem volgens conclusie 9, waarin het glij-element roteerbaar verbonden is met het middendeel zodanig dat het glij-element kan worden geroteerd ten opzichte van het middendeel rond een as parallel aan de ophangingsrichting.

11. Ophangingsysteem volgens een van de voorgaande conclusies, waarin de magnetische ophangingsmodules een veelvoud aan magneten omvatten, zodanig dat een afstand tussen een magnetische ophangingsmodule en een corresponderende geleider apart geregeld kan worden voor ten minste twee posities van de magnetische ophangingsmodule.

12. Ophangingsysteem volgens een van de voorgaande conclusies, verder omvattende laterale magneetmodules welke een veelvoud aan magneten omvatten, zodanig dat een afstand tussen een laterale magneetmodule en een corresponderende laterale geleider omvat door het voertuiggeleidesysteem apart geregeld kan worden voor ten minste twee posities van de laterale magneetmodule.

13. Ophangingsysteem volgens een van de voorgaande conclusies, waarin elk rechtgeleiding- of quasi-rechtgeleidingmechanisme een parallellogrammechanisme omvat, omvattende vier stangen, waarvan:

- een eerste staaf strekt vanaf een middelste bogieverbinding voorzien op of nabij het midden van een bogie naar een bovenste

proximale verbinding voorzien op een proximale zijde van het middendeel;

- een tweede staaf strekt vanaf de middelste bogieverbinding naar een bovenste distale verbinding voorzien op een distale zijde van het middendeel op een afstand van de bovenste proximale verbinding;
- een derde staaf strekt vanaf een proximale bogieverbinding voor op de bogie naar een onderste proximale verbinding voorzien op de proximale zijde van het middendeel;
- een vierde staaf strekt vanaf een distale bogieverbinding voorzien op de bogie naar een onderste distale verbinding voor op de distale zijde van het middendeel op een afstand van de onderste proximale verbinding;

waarin de rotatie van elk van de bogies ten opzichte van het middendeel rond een laterale as loodrecht op de reisrichting rond de middelste bogieverbinding omvat door de respectievelijke bogie is.

14. Magnetisch zweefvoertuig omvattende een voertuiggondel, en een veelvoud aan ophangingsystemen volgens een van de voorgaande conclusies verbonden aan of nabij de bovenkant of onderkant van de voertuiggondel.

15. Transportatiesysteem omvattende:

- een magnetisch zweefvoertuig volgens conclusie 14; en
- een voertuiggeleidingssysteem omvattende een eerste geleider aan een eerste zijde en een tweede geleider aan een tweede zijde.

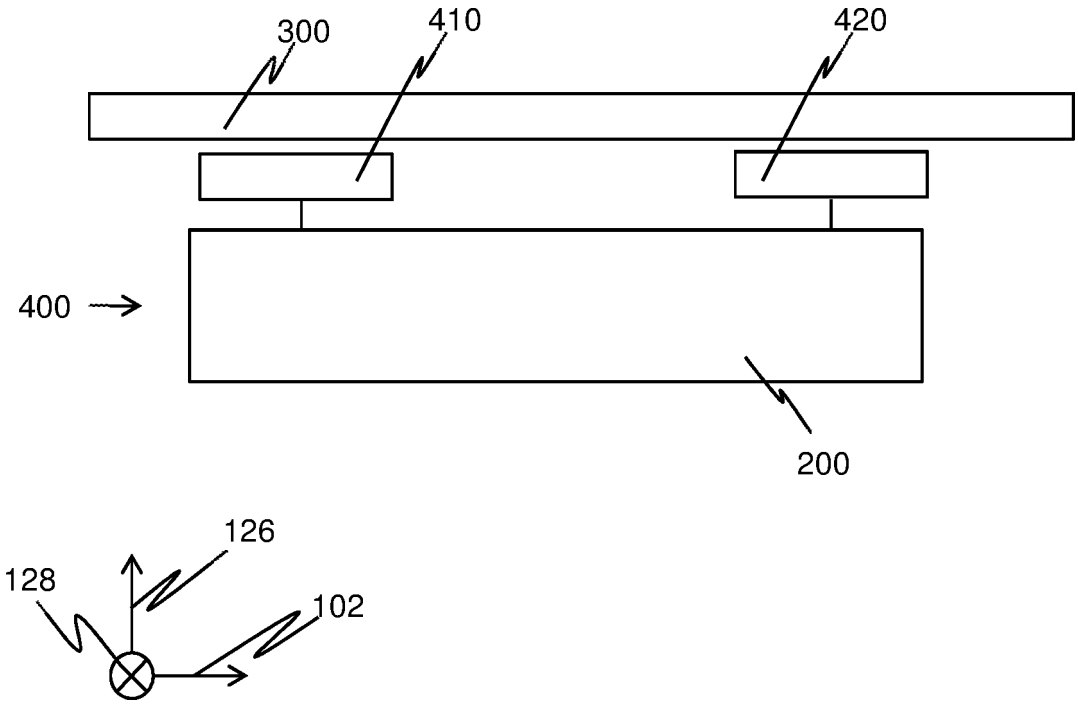

FIG 1A

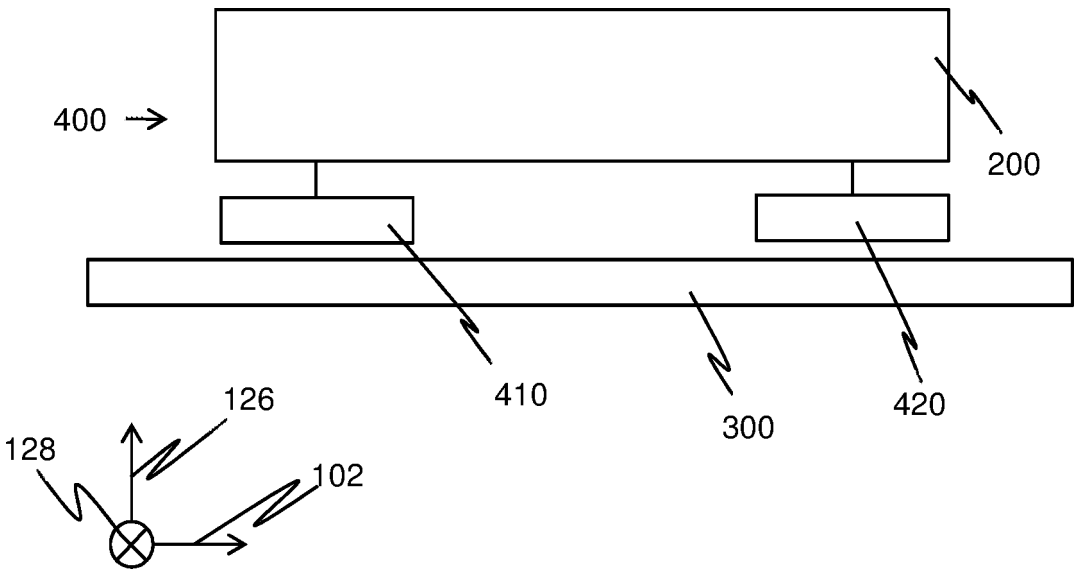

FIG 1B

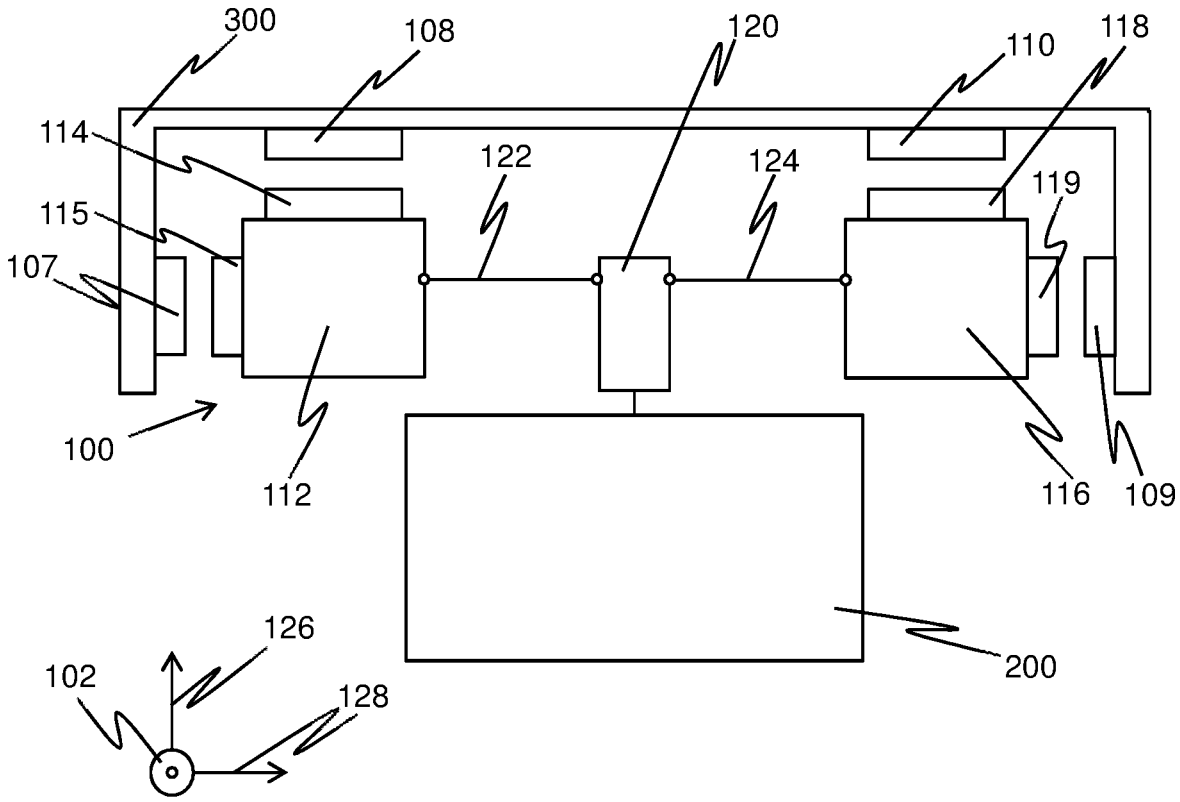
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FIG 2A

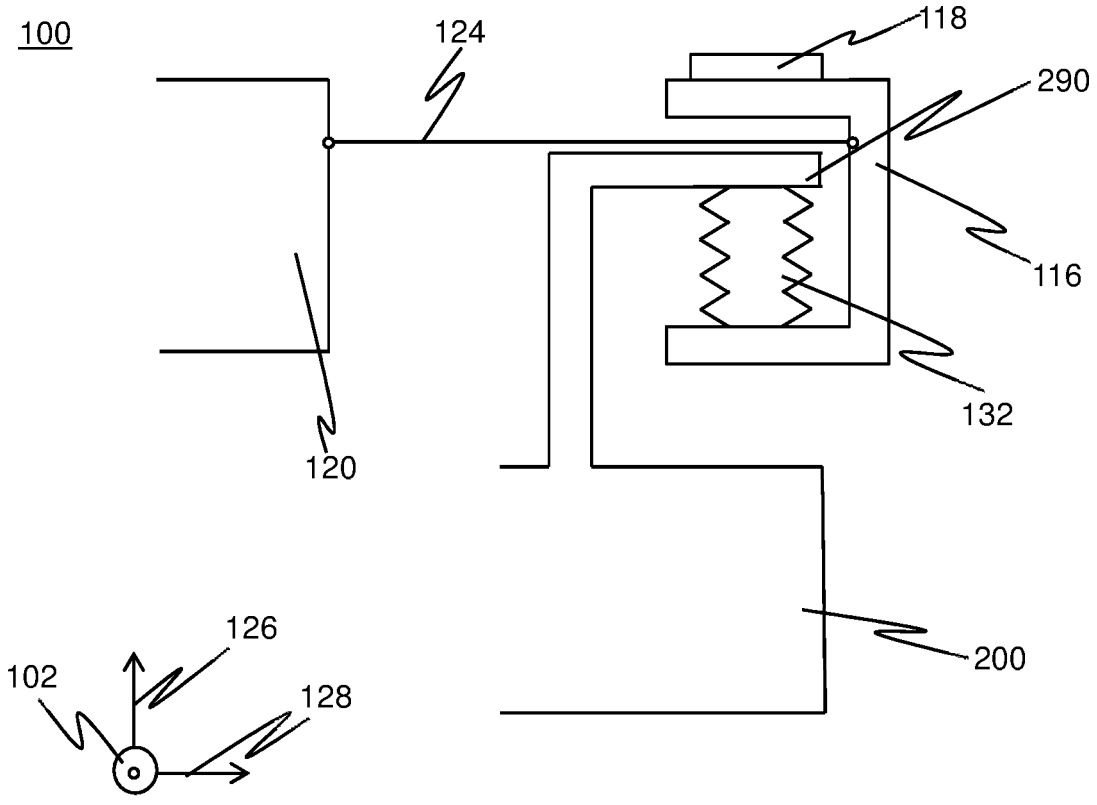
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FIG 2B

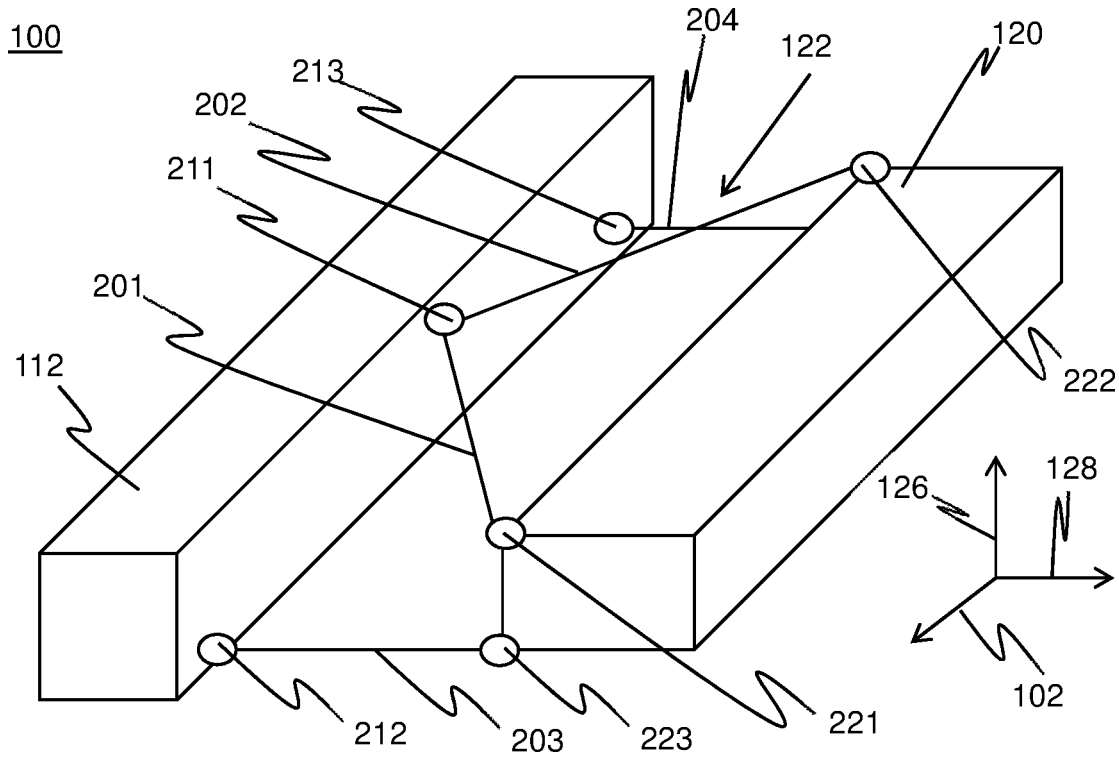
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FIG 3A

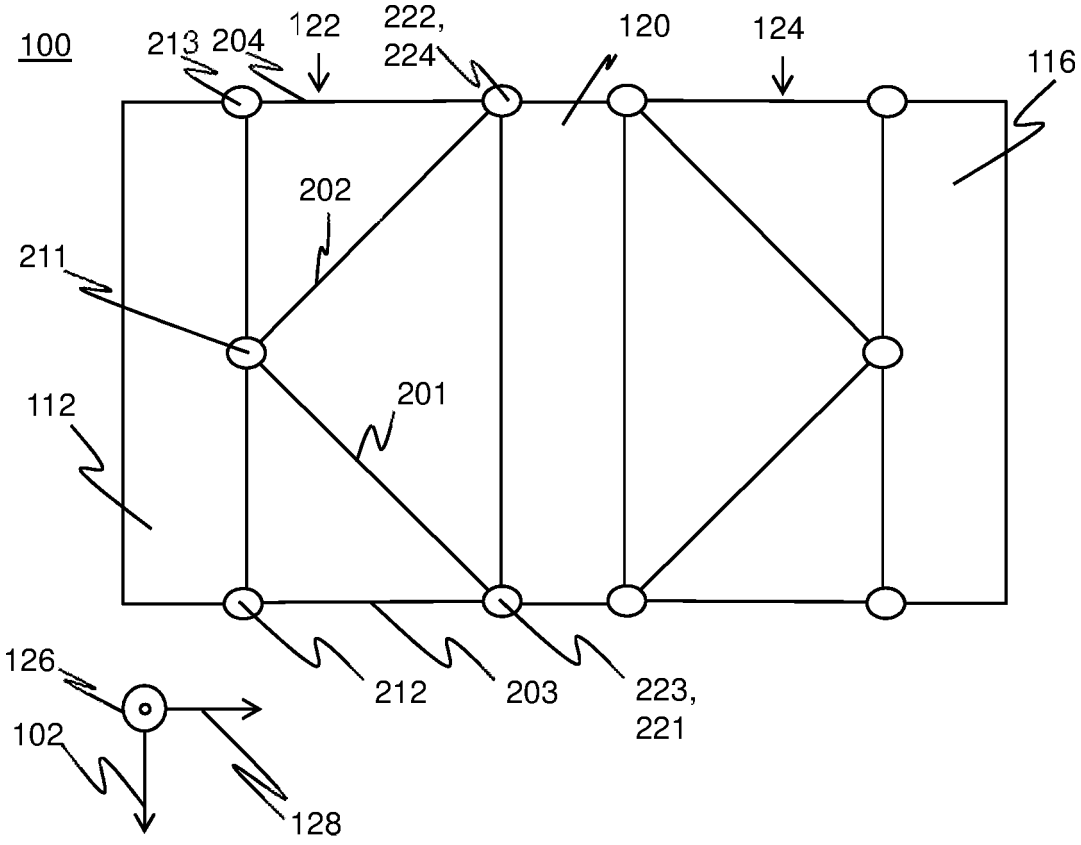
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FIG 3B

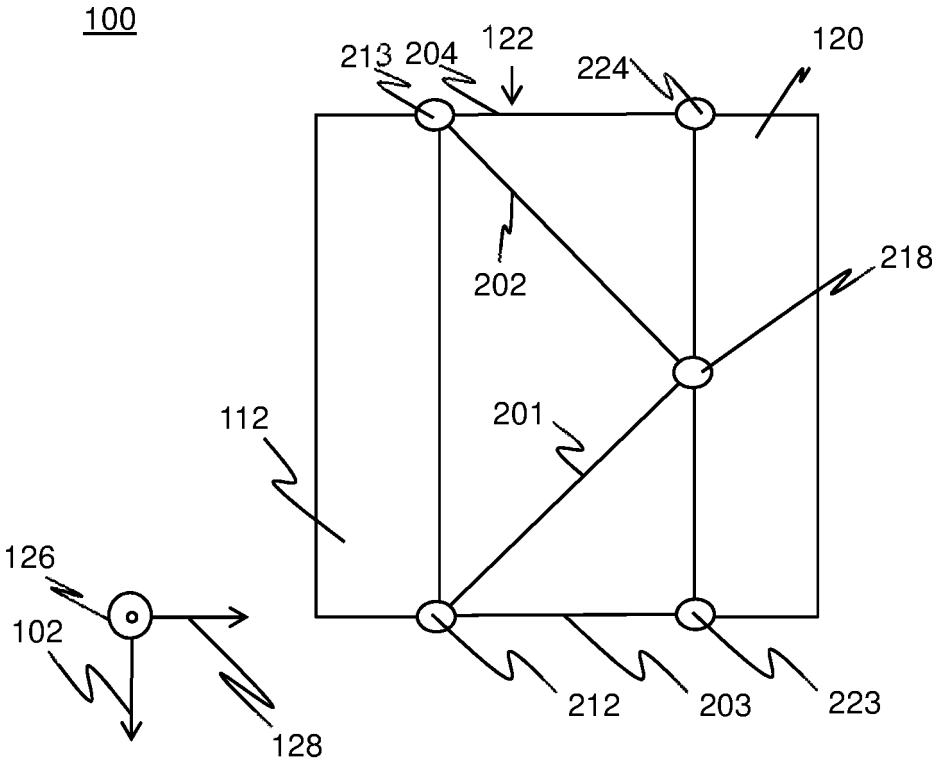
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FIG 3C

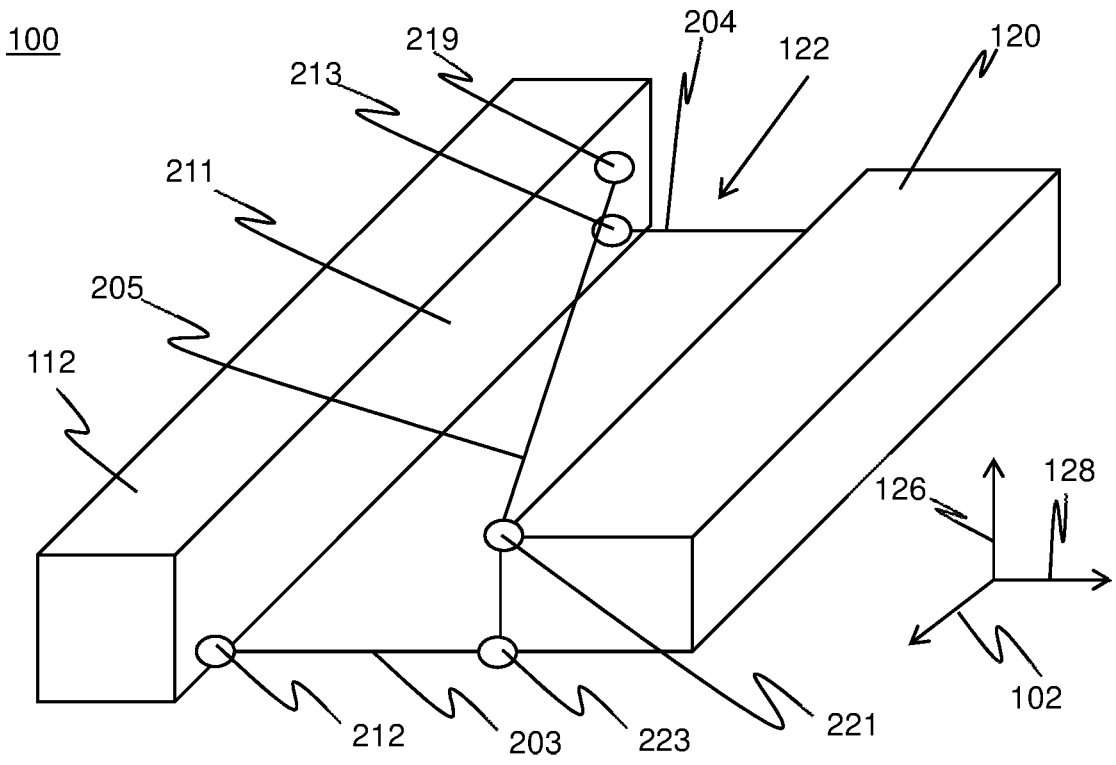
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FIG 3D

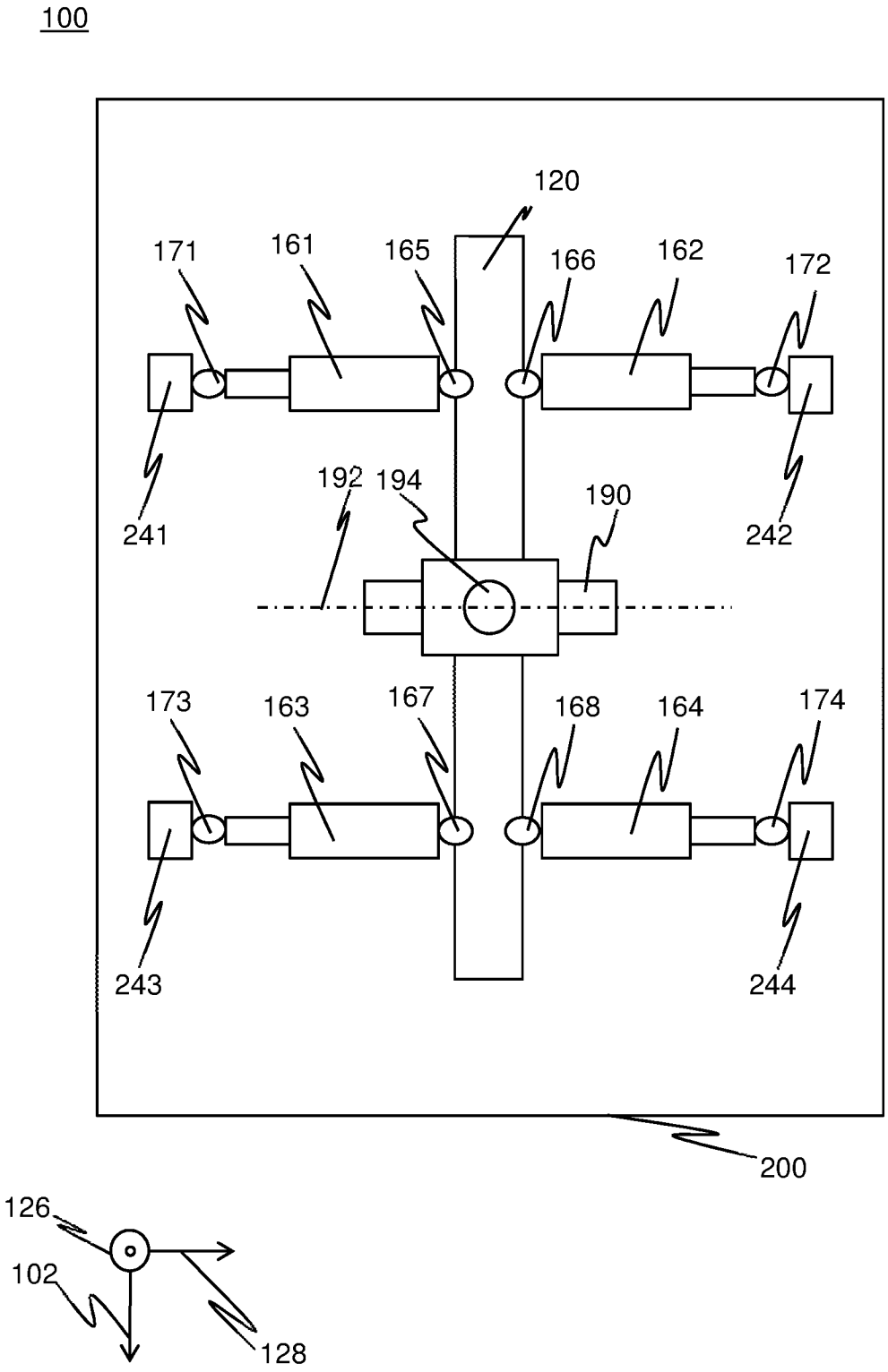
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FIG 4

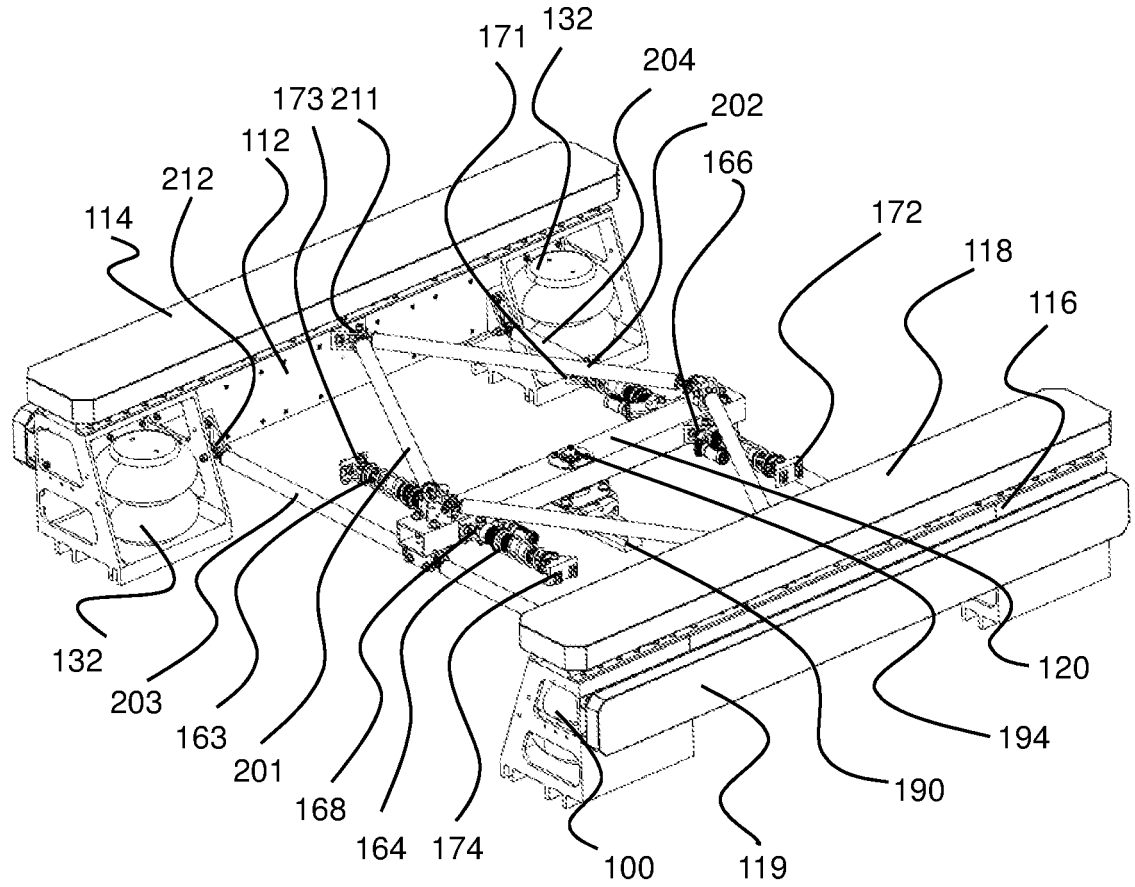
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FIG 5

SAMENWERKINGSVERDRAG (PCT)

RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE

IDENTIFICATIE VAN DE NATIONALE AANVRAGE	KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE
	P119398NL00
Nederlands aanvraag nr. **2021674**	Indieningsdatum **20-09-2018**
	Ingeroepen voorrangsdatum
Aanvrager (Naam) **Hardt IP B.V.**	
Datum van het verzoek voor een onderzoek van internationaal type **27-10-2018**	Door de Instantie voor Internationaal Onderzoek aan het verzoek voor een onderzoek van internationaal type toegekend nr. **SN72298**

I. CLASSIFICATIE VAN HET ONDERWERP (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)

Volgens de internationale classificatie (IPC)

B61B13/08;B61B3/02;B61F5/02

II. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte minimumdocumentatie

Classificatiesysteem	Classificatiesymbolen
IPC	**B61B;B61F**

Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

III. ☐	**GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES**	(opmerkingen op aanvullingsblad)
IV. ☐	**GEBREK AAN EENHEID VAN UITVINDING**	(opmerkingen op aanvullingsblad)

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2021674

A. CLASSIFICATIE VAN HET ONDERWERP
INV. B61B13/08 B61B3/02 B61F5/02
ADD.

Volgens de Internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC.

B. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte miminum documentatie (classificatie gevolgd door classificatiesymbolen)
B61B B61F

Onderzochte andere documentatie dan de mimimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden)
EPO-Internal, WPI Data

C. VAN BELANG GEACHTE DOCUMENTEN

Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
X A	US 3 937 148 A (SIMPSON PAUL A) 10 februari 1976 (1976-02-10) * figuren 5a, 5b * -----	1-6,11, 12,14,15 7-10,13
X	JP H04 243660 A (HITACHI LTD; HITACHI KASADO ENG KK) 31 augustus 1992 (1992-08-31) * figuren 1-3 * -----	1-6,14, 15
X	JP H05 8725 A (HITACHI LTD; HITACHI KASADO ENG KK) 19 januari 1993 (1993-01-19) * figuren 1-6 * -----	1-6,14, 15
A	US 4 280 412 A (MIHIROGI KIYOSHI) 28 juli 1981 (1981-07-28) * figuren 7, 8 * -----	1

☐ Verdere documenten worden vermeld in het vervolg van vak C.

☒ Leden van dezelfde octrooifamilie zijn vermeld in een bijlage

° Speciale categorieën van aangehaalde documenten

"A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft

"D" in de octrooiaanvrage vermeld

"E" eerdere octrooi(aanvrage), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven

"L" om andere redenen vermelde literatuur

"O" niet-schriftelijke stand van de techniek

"P" tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur

"T" na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvrage, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding

"X" de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur

"Y" de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht

"&" lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltooid	Verzenddatum van het rapport van het onderzoek naar de stand van de techniek van internationaal type
11 juni 2019	

Naam en adres van de instantie	De bevoegde ambtenaar
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Crama, Yves

Formulier PCT/ISA/201 (tweede blad) (Januari 2004)

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Informatie over leden van dezelfde octrooifamilie

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2021674

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)	Datum van publicatie
US 3937148 A	10-02-1976	GEEN	
JP H04243660 A	31-08-1992	JP 2633991 B2	23-07-1997
		JP H04243660 A	31-08-1992
JP H058725 A	19-01-1993	GEEN	
US 4280412 A	28-07-1981	AU 529258 B2	02-06-1983
		BR 7905444 A	20-05-1980
		CA 1153625 A	13-09-1983
		DE 2934169 A1	13-03-1980
		FR 2434066 A1	21-03-1980
		GB 2029347 A	19-03-1980
		IT 1122807 B	23-04-1986
		JP S5529676 A	03-03-1980
		JP S5817063 B2	04-04-1983
		US 4280412 A	28-07-1981

WRITTEN OPINION

File No.	Filing date *(day/month/year)*	Priority date *(day/month/year)*	Application No.
SN72298	20.09.2018		NL2021674

International Patent Classification (IPC)
INV. B61B13/08 B61B3/02 B61F5/02

Applicant
Hardt IP B.V.

This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the application
- ☐ Box No. VIII Certain observations on the application

	Examiner
	Crama, Yves

Application number

WRITTEN OPINION

NL2021674

Box No. I Basis of this opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material:

   ☐ a sequence listing

   ☐ table(s) related to the sequence listing

   b. format of material:

   ☐ on paper

   ☐ in electronic form

   c. time of filing/furnishing:

   ☐ contained in the application as filed.

   ☐ filed together with the application in electronic form.

   ☐ furnished subsequently for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes:	Claims	4, 7-10, 13
	No:	Claims	1-3, 5, 6, 11, 12, 14, 15
Inventive step	Yes:	Claims	7-10, 13
	No:	Claims	1-6, 11, 12, 14, 15
Industrial applicability	Yes:	Claims	1-15
	No:	Claims	

2. Citations and explanations

see separate sheet

WRITTEN OPINION

Box No. VII Certain defects in the application

see separate sheet

1 **Re Item V**

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

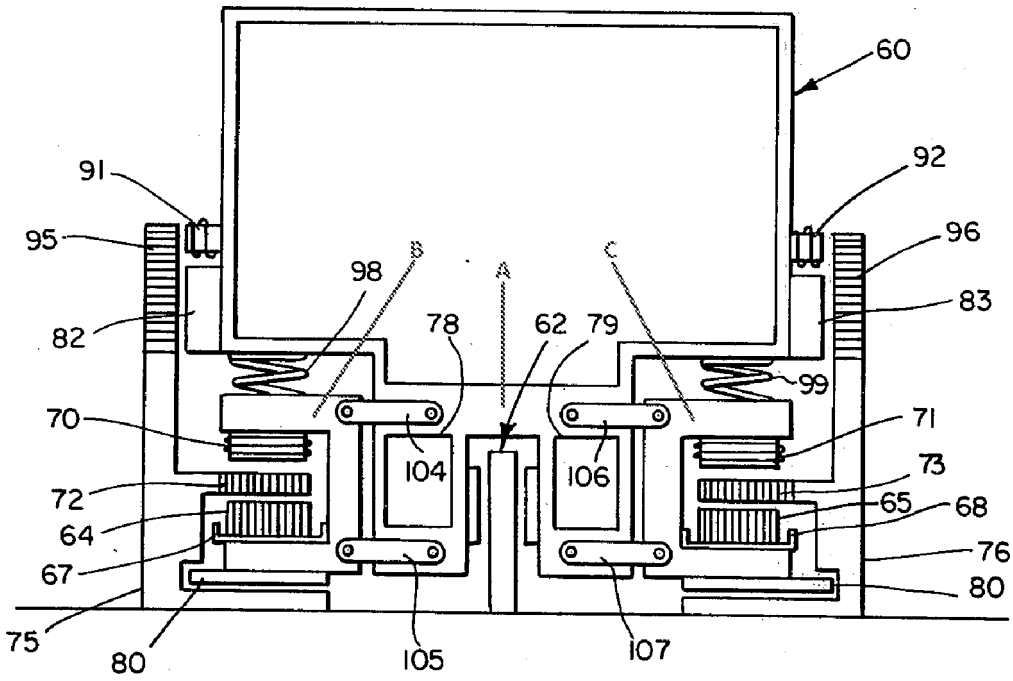
1.1 Reference is made to the following documents:

D1	US 3 937 148 A (SIMPSON PAUL A) 10 februari 1976 (1976-02-10)
D2	JP H04 243660 A (HITACHI LTD; HITACHI KASADO ENG KK) 31 augustus 1992 (1992-08-31)
D3	JP H05 8725 A (HITACHI LTD; HITACHI KASADO ENG KK) 19 januari 1993 (1993-01-19)
D4	US 4 280 412 A (MIHIROGI KIYOSHI) 28 juli 1981 (1981-07-28)

1.2 The present application does not meet the criteria of patentability, because the subject-matter of claim 1 is not new.

D1 discloses:

Ophangingsysteem voor koppelen van een magnetisch ondersteunde voertuiggondel [Fig. 5a, 5b (60)] welke in een reisrichting beweegt in een voertuiggeleidingssysteem [Fig. 5a (75) (76)] aan het voertuiggeleidingssysteem [Fig. 5a (75) (76)] omvattende een eerste geleider [Fig. 5a (72)] aan een eerste zijde en een tweede geleider [Fig. 5a (73)] aan een tweede zijde, het ophangingsysteem omvattende:
- een eerste bogie [See copy of Fig. 5a below (B)] voorzien aan de eerste zijde, omvattende een eerste magnetische ophangingsmodule [Fig. 5a (64) (70)] ingericht om samen te werken met de eerste geleider [Fig. 5a (72)];
- een tweede bogie [See copy of Fig. 5a below (C)] voorzien aan de tweede zijde, omvattende een tweede magnetische ophangingsmodule [Fig. 5a (65) (71)] ingericht om samen te werken met de tweede geleider [Fig. 5a (73)];
- een langgerekt middendeel [See copy of Fig. 5a below (A)] voorzien tussen de eerste bogie [See copy of Fig. 5a below (B)] en de tweede bogie [See copy of Fig. 5a below (C)] in hoofdzaak parallel aan de bogies;
waarin de eerste bogie [See copy of Fig. 5a below (B)] en de tweede bogie [See copy of Fig. 5a below (C)] met een rechtgeleiding- of quasi-rechtgeleidingmechanisme [Fig. 5a (104) (105) (106) (107)] zijn verbonden met het middendeel [See copy of Fig. 5a below (A)], zodanig dat de bogies elk in hoofdzaak in een ophangingsrichting getransleerd kunnen worden ten opzichte van het middendeel.



It is to be noted that the documents D2 and D3 also contain all the features of claim 1:

- D2, see figures 1-3: left and right bogie [6], elongated center member [3], quasi straight guide mechanism [7].
- D3, see figures 1, 2, 6: left and right bogie [4], elongated center member [5], quasi straight guide mechanism [9].

1.3 Dependent claims 2-6, 11, 12, 14, 15 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of novelty and/or inventive step:

1.3.1 The additional features of claim 2 are implicitly disclosed in D1-D3, as the quasi straight guides located at the front and the rear side of the bogie can move in opposite directions and therefore allow a limited rotation of the bogies around a lateral axis perpendicular to the travel direction.

1.3.2 The additional features of dependent claims 3, 5 and 6 are known from D1 [suspension support (98) (99) (100) (101) (102)] and/or D2 [suspension support (5)].

1.3.3 Regarding claim 4: given the configuration of the vehicle pod above the bogie in D1, D2 and D3, the suspension supports have been located above the magnetic suspension modules - however, installing these suspension

supports underneath the magnetic suspension modules appears to be but a slight constructional change of the suspension system as described in D1-D3, which would be obvious to the skilled person faced with the task of adapting this suspension to a hanging vehicle pod. Consequently, the subject-matter of claim 4 appears to lack an inventive step.

1.3.4 The additional features of dependent claims 11, 12, 14 and 15 are known from D1 [see magnets (64) (65) (82) (83) and vehicle pod (60)].

1.4 The combination of the features of dependent claims 7-10 and 13 is neither known from, nor rendered obvious by, the available prior art. The reasons are as follows: claims 7-10 describe a connection allowing the vehicle pod to move compared to the elongated center member; in D1, the center member is firmly fixed to the vehicle pod, while D2 and D3 only mention a body supporting spring without further details regarding the connection between the vehicle pod and the center member. Claim 13 describes a quasi straight guide connecting the bogies to the center member - even though D1, D2 and D3 do disclose similar quasi straight guides serving the same purpose, the skilled person would have no incentive to modify them in such a way that they would include the features of claim 13.

2 **Re Item VII**

Certain defects in the application

2.1 Independent claim 1 is not in the two-part form, which in the present case would be appropriate, with those features known in combination from the prior art being placed in the preamble and the remaining features being included in the characterising part.

2.2 The features of claims 1-15 are not provided with reference signs placed in parentheses.

2.3 The relevant background art disclosed in D1-D3 is not mentioned in the description, nor are these documents identified therein.