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(54) **Low-deck articulated rail vehicle, particulary a tram**

Gelenkiges Niederflur- Schienenfahrzeug, insbesondere eine Strassenbahn

Véhicule ferroviaire articulé à plancher surbaissé, en particulier un tram

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Description

Field of technology

[0001] The invention deals with an arrangement of a low-deck tram car for passenger transport, designed particularly for municipal transport.

The Current State of technology

[0002] Low-deck trams are manufactured with low decks most through the vehicle length, while the height in the range of 350÷450 mm over the rail top may be considered standard and the minimum standard passing width is 600 mm. To keep the deck height at this standard level bogies of these trams are usually equipped with broken axle beams with independently mounted pairs of wheels with common geometrical axis of rotation. These axle beams with independently mounted wheels substitute the standard wheel sets, i.e. pairs of wheels pressed on common axles, and enable passing the floor at the low-deck level even between wheels.

[0003] However where rotable bogies are used, the wheels and the bogie bearing structure between the wheels restrict the passenger space when they turn around the vertical axis towards the vehicle body, that the width X of the passenger space is insufficient at the part over the bogie, thus smaller than standard, see Fig. 1.

[0004] If a low-deck vehicle consists of more sections (cars), where a non-rotable bogie is attached under each odd section, the width Y of the low-deck pass through the vehicle extends to the standard level see (Fig. 2), for instance with driving bogie according to GB 22898877. However it is at the expense of higher wheel wear, as only low bogie rotation around the vertical axis towards the particular vehicle body is possible (approx. 3°) in this instance. This leads to increased forces between the vehicle body and the bogie, and between the wheels and the rails, as most of the rotating movements of the section over the bogie are captured at the contact with the rail. These vehicles have moreover lower number of wheel sets (pairs) than vehicles with high deck level because of lower number of sections and thus also bogies and so the vertical load on one wheel set is higher, which is inconvenient for the operation.

[0005] The passing width for passengers may be enlarged, while the mounting of the vehicle body on bogies remains rotable, by locating the pivoting point of the vehicle body to the vertical centre of the wheel set (pair of opposite wheels). Location of vehicle bodies of adjacent sections of a tram on a single bogie this way enables relative enlargement of the passing width for passengers. However efforts for maintaining low deck level also over the bogies brings space problems, where the bogie cannot be equipped for example by double spring suspension, or these bogies are not equipped with driving mechanisms (patent IT 21163 A/84), or may be equipped with driving mechanisms, but then there is not enough space for disc brakes and the bogie only has block brakes (patent IT1216453). In a two-car vehicle only the middle bogie may be solved this way. The end bogies are rotable with the deck higher by approx. 200 mm.

The Principle of the Invention

[0006] The above disadvantages are removed by low-deck articulated rail vehicle according to claim 1. The vehicle consists of articles having a body and a chassis, arranged in configuration consisting of at least two cars or extended by at least one middle car that is equipped with one rotatable end bogie arranged under both the front part of the first vehicle body of the car configuration and under the rear parts of the last vehicle body of the car configuration, and by at least one middle bogie for two adjacent vehicle bodies of the car configuration to be rotatably mounted on the middle bogie, while each of the adjacent vehicle bodies is mounted on the middle bogie in it's each separate bearing point, while there are drives and brakes located at the outer sides of wheels with respect to the vehicle longitudinal axis.

[0007] The bogie arrangement allows the elements of primary and secondary springing to be located in the space between the pairs of independently mounted wheels, and the drives and brakes on the outer side of the wheel in relation to the vehicle longitudinal axe. Thanks to this arrangement the deck over the bogies may also be kept in the standard low level, which is only slightly higher than the rest of the passenger space floor, while both the parts of the floor are connected with a barrier free transition part of slightly elevated ramps, while the passing width of the vehicle remains standard. Connection of the individual sections of the body with the bogies is based on the principle that the pivot points of both of the adjacent bodies of the vehicle on the middle bogie is always geometrically located on the vertical axe going through the centre of rotation of the common rotation axis of one pair of the wheels, and the pivot point of the end bogie is vertically situated on the lengthwise axis of the bogie relatively close (approx. 1/3 of the bogie wheel base) to the centre of the common rotation axis of the pair of wheels more distant from the vehicle end, which minimizes the relative transversal movement of the appropriate wheels against the vehicle body during rotation around the vertical axis going through the pivot point of the middle bogie, and possibly through the point of attachment of the vehicle body on the appropriate end bogie, which enables just a small restriction of the passing width W of the vehicle then is usual for other vehicles with rotable bogies, i.e. the W dimension remains at the standard width over the middle bogies and is close to the standard width over the end bogies.

[0008] For the end bogies under the front and rear parts of vehicle this advantage only applies to the pairs of wheels closer to the centre of the vehicle, the outer parts show higher range of movement against the vehicle

body, however these pairs of wheels do not restrict the passenger space as they move under the driver's cabin at the front and under conveniently arranged seats at the back, for example arranged into an arch over the space where the outer pair of wheels moves (see Fig. 7). The passage width Z to the driver's cabin or to the seats at the back will remain acceptable, adequate to the intensity of passenger move at these areas.

[0009] Each section of the vehicle body mounted on the middle bogie is mounted by means of a bearing, which may be solved as an axial bearing or a tilting spherical bearing arranged on a cradle, while both the cradles on each middle bogie are connected by a rod transferring longitudinal forces between the sections. The rod arrangement and its attachment to the cradles enable the adjacent sections to move mutually along the longitudinal and transversal axes within the directional and vertical guiding of the rails. If spherical bearings are used for attachment of the body sections on the cradles, both the cradles may form a single solid unit, as the mutual movements of the sections around the longitudinal and transversal axes will be enabled in the spherical bearings. The longitudinal forces from the vehicle body sections to the bogie are transmitted by a rod connecting each of the cradles of the middle bogie with the frame of the middle bogie.

[0010] At the end bogies the body is mounted on the bogie by means of a bearing and a cradle with shifted mounting of the vehicle body against the springing sets and thus against the bogie centre. An axial ball bearing is for example used here for attachment of the vehicle body section, as it is capable of transferring the moment caused by eccentric load on the cradle.

[0011] The arrangement of both the bogie types according to the invention will enable a low deck to be kept all through the vehicle length at the standard level, even over the bogies, while the floor is stepless, only with ramps with gradual elevation of maximum 1 : 10, while the passing width of the vehicle over the middle bogies remains at least standard and over the end bogies is 70 % of the standard width, while the vehicle shows very good driving properties thanks to the use of primary and secondary springing, and the vehicle shows very good driving properties and minimum wear of wheels and rails, thank to the rotable mounting of the vehicle body on the bogies, which is unusual for low-deck vehicles, and the wheels of all the bogies may be driven and braked by disc brakes.

Summary of the figures in the drawing

[0012] The solution of the invention is illustrated in enclosed drawings, where Fig. 3 shows a two-car three-bogie configuration, Fig 4 shows a three-car four-bogie configuration, Figs. 5, 6 and 7 show arrangement of the vehicle over the bogies and Figs. 8 and 9 show mounting of the cars on the bogies.

Example of the invention application

[0013] The low-deck rail vehicle, particularly a tram car illustrated in Fig. 3 is arranged in two-car configuration with sections A and B and three bogies.

[0014] The vehicle in Fig. 4. is extended by one section and has four bogies.

[0015] The articulated tram vehicle shown in Fig. 3 is equipped with the first end rotable bogie 1 under the front part of section A and the second end bogie 1 under the rear part of section B and one middle bogie 2 under the articulation - link between sections A and B of the vehicle, while both the adjacent ends of the bodies - sections A and B of the vehicle are rotably mounted on the middle bogie, each in a separate mounting point 3.

[0016] The location of the bogies is illustrated in Figures 8 and 9. Bogies 1 and 2 are arranged in such a position that the elements of primary and secondary springing 5 are located in the space between the pairs of separately mounted wheels of the bogie, and drives and brakes (motors, gear boxes, disc and track brakes) 6 are located on the outer side of the wheel (in relation to the vehicle longitudinal axe).

[0017] Thanks to this arrangement the deck over the bogies may also be kept in the standard low level, which is only slightly higher than the rest of the passenger space floor, while both the parts of the floor are connected with a barrier free transition part by slightly elevated ramps, while the passing width of the vehicle remains standard.

[0018] Connection of the individual sections of the body with the bogies is based on the principle that the pivot point 3 of the middle bogie 2 is always geometrically located on the vertical axe going through the centre of rotation of the common rotation axis of one pair of the wheels, and the pivot point 4 of the end bogie 1 is vertically situated on the lengthwise axis of the bogie relatively close (approx. 1/3 of the bogie wheel base) to the centre of the common rotation axis of the pair of wheels more distant from the vehicle end, which minimizes the relative transversal movement of the appropriate wheels against the vehicle body during rotation around the vertical axis going through the pivot point 3 and possibly through the point 4 of attachment of the vehicle body on the appropriate bogie, which enables just a smaller restriction of the passing width W and Z of the vehicle, then is usual for other vehicles with rotable bogies, while the W dimension remains at the standard passing width of the vehicle.

[0019] For the end bogies 1 under the front and rear parts of vehicle this advantage only applies to the pairs of wheels closer to the centre of the vehicle, the outer parts show higher range of movement against the vehicle body - however these pairs of wheels do not restrict the passenger space as they move under the driver's cabin at the front and under conveniently arranged seats at the back. The seats in the back part of the vehicle are arranged into arch shape over the space where the outer pair of wheels of the bogie 1 moves, see Fig. 7. The width Z of the passage to the driver's cabin or to the seats at

the back will remain acceptable, adequate to the intensity of passenger frequency at these areas.

[0020] Each section of the vehicle body mounted on the middle bogie 2 is mounted by means of a bearing 7, which may be solved as an axial ball bearing or a tilting spherical bearing arranged on a cradle 8, see Fig. 8, while both the cradles 8 on the middle bogie 1 are connected by a longitudinal rod 9 transferring longitudinal forces between the vehicle sections. The rod 9 arrangement and its attachment to the cradles 8 enable the adjacent section to move mutually along the longitudinal and transversal axes within the directional and vertical guiding of the rails. If spherical bearings are used for attachment of the body sections on the cradles, both the cradles may form a single solid unit, as the mutual movements of the sections around the longitudinal and transversal axes will be enabled in the spherical bearings 7. The longitudinal forces from the vehicle body sections to the bogie are transmitted by a rod 10 connecting each of the cradles 8 of the middle bogie 2 with the frame 11 of the middle bogie 2.

[0021] At the end bogies 1 the appropriate section of the vehicle body is mounted on the bogie by means of a bearing 14 and a cradle 12 with longitudinally shifted mounting of the body 4 against the secondary springing sets 13 and thus against the bogie centre. An axial ball bearing 14 is used at the end bogies 1 for attachment of the vehicle body section, as it is capable of transferring the moment caused by eccentric load on the cradle.

[0022] The arrangement of both the bogie types of a low-deck articulated rail vehicle, particularly a tram, according to the invention will enable a low deck 15 to be kept all through the vehicle length at the standard level usual for low-deck trams, even over the bogies, while the floor is stepless, only with ramps with gradual elevation of maximum 1 : 10, while the passing width of the vehicle over the middle bogies remains at least standard and over the end bogies 1 is 70 % of the standard width, while the vehicle shows very good driving properties thanks to the use of primary and secondary springing, and the vehicle shows very good driving properties and minimum wear of wheels and rails, thank to the rotable mounting of the vehicle body on the bogies, which is unusual for low-deck vehicles. The wheels of all the bogies may be driven and braked by disc brakes.

Industrial applicability

[0023] The solution according to the invention is applicable for low-deck rail vehicles, particularly for trams designed mainly for municipal transport.

Claims

1. Low-deck articulated rail vehicle, particularly a tramway vehicle, in either a two cars (A, B) with three bogies (1, 2) configuration or extended by at least one car and at least one bogie, wherein the low-deck articulated rail vehicle is equipped with one rotatable end bogie (1) arranged under each of the front and rear end of the rail vehicle, and by at least one middle bogie (2) between two adjacent cars, while each of the adjacent cars is rotatably connected through its own pivot point (3) with the at least one middle bogie (2), the low-deck articulated rail vehicle further comprising primary and secondary suspensions (5), pairs of individually mounted wheels, drives, disc brakes and track brakes (6), wherein the drives, the disc brakes and the track brakes are located at the outer sides of the individually mounted wheels with respect to the rail vehicle longitudinal axis, and the primary and secondary suspensions (5) are located in the space between the pairs of individually mounted wheels, which allows the floor to be at low standard level, whereby low floor standard level is in the range of 350 mm to 450 mm above the rail, and wherein over the bogies, the level is slightly elevated compared to the rest of the passenger space, whereby the floor levels of the rail vehicle are connected with a barrier free transition consisting of gradually elevated ramps, whereby standard passing width of the vehicle is met, and whereby minimal standard passing width is 600 mm.

2. Low-deck articulated rail vehicle, particularly a tram, according to claim 1, **characterized by the fact** that connection of each section of the vehicle body is based on the principle that the pivot point (3) of the connection of the sections with the middle bogie (2) is geometrically located on the vertical axis going through the centre of the common axis of rotation of one pair of bogie wheels and the pivot point (4) of the end bogie (1) is situated on the longitudinal axis of the bogie, relatively close, approximately 1/3 of the bogie wheel base to the centre of the common axis of the pair of bogie wheels more distant form the vehicle end.

3. Low-deck articulated rail vehicle, particularly a tram, according to clam 1 **characterized by the fact** that each section of the vehicle body is mounted on the middle bogie (2) by means of bearing (7) arranged on one cradle (8) of the bogie, whereby both the cradles on each middle bogie are mutually connected with a longitudinal rod (9), which transfers longitudinal forces between adjacent sections of the vehicle, whereby the arrangement of the rod (9) and its attachment to the cradles (8) enable the adjacent section of the vehicle to move mutually around the longitudinal and transversal axes within the directional and vertical guiding of rails, whereby the longitudinal forces from the vehicle sections to the bogie are transferred by a rod (10) always connecting one of the cradles (8) of the middle bogie (2) with the frame (11) of this middle bogie (2).

4. Low-deck articulated rail vehicle, particularly a tram, according to claims 1 and 2, **characterized by the fact** that the vehicle body is attached to the end bogie (1) by means of a bearing (14) and a longitudinally asymmetrical cradle (12), with the body (4) longitudinally shifted against the secondary springing (13), or to the centre of the end bogie (1), whereby the bearing (14) is capable of transferring also the moment caused by the eccentric load of the cradle (13).

5. Low-deck articulated rail vehicle, particularly a tram, according to claim 3, **characterized by the fact** that the beaing (7) is an axial ball-bearing.

6. Low-deck articulated rail vehicle, particularly a tram, according to claim 3, **characterized by the fact** that the bearing (7) is a tilting spherical one and the cradles (8) of both the wheel sets of the middle bogie (2) form a single solid unit.

7. Low-deck articulated rail vehicle, particularly a tram, according to claim 4, **characterized by the fact** that the bearing (14) is an axial ball bearing.

Patentansprüche

1. Niederflur-Gelenk-Schienenfahrzeug, insbesondere die Straßenbahn, angeordnet entweder als zwei Wagen (A, B) mit drei Fahrwerken (1, 2), oder verlängert um mindestens einen Wagen und um mindestens ein Fahrwerk, wobei das Niederflur-Gelenk-Schienenfahrzeug immer mit einem seitlichen Drehgestell (1), angeordnet unter jedem vorderen und hinteren Ende des Fahrzeugkastens, und mit mindestens einem Mittelfahrwerk (2) zwischen zwei entsprechenden Wagen ausgestattet ist, wobei jeder dieser Wagen mit mindestens einem Mittelfahrwerk (2) mittels eines eigenen Drehpunkts (3) gelenkig verbunden ist, das Niederflur-Gelenk-Schienenfahrzeug umfasst weiterhin Primär- und Sekundärfederung (5), ein Paar unabhängig gelagerte Räder, Antriebe, Scheiben- und Schienenbremsen (6), wobei Antriebe, Scheiben- und Schienenbremsen an äußeren Seiten vom Paar der unabhängig gelagerten Räder zu Längsachse des Schienenfahrzeugs gelagert sind, und die Primär- und Sekundärfederung (5) liegt im Bereich zwischen dem Paar der separat gelagerten Räder, wodurch der Fahrzeugboden auf niedrigem Standardniveau beibehalten wird, wobei das niedrige Standardniveau zwischen 350 mm bis 450 mm über der Schiene beträgt, wobei oberhalb des der Fahrgestelle das Niveau leicht etwas höher gegenüber dem Fahrgastraum liegt, wobei beide Fahrzeugböden durch einen barrierefreien Übergang verbunden sind, bestehend aus allmählich steigenden Rampen, wobei eine Standardübergangsbreite erreicht wird, und wobei die Standardübergangsbreite 600 mm beträgt.

2. Niederflur-Gelenk-Schienenfahrzeug, insbesondere die Straßenbahn, nach Anspruch 1., **dadurch gekennzeichnet, dass** die Verbindung von jedem Gelenk des Fahrzeugkastens mit dem Fahrwerk so ausgeführt ist, das der Drehpunkt (3) der Verbindung der Kastengelenke mit dem Mittelfahrwerk (2) immer geometrisch an der Vertikalachse liegt, die durch die Mitte der gemeinsamen Drehachse eines Paars der Räder des Fahrwerks führt, und der Drehpunkt der Lagerung (4) des seitlichen Fahrwerks (1) ist an der Längsachse des Fahrwerks relativ nahe platziert, ca. 1/3 des Radstands des Fahrwerks, der Mitte der geneinsamen Drehachse eines Paars der Räder, weiter entfernt von der Frontseite des Fahrzeugs.

3. Niederflur-Gelenk-Schienenfahrzeug, insbesondere die Straßenbahn, nach Anspruch 1., **dadurch gekennzeichnet, dass** jedes Glied des Fahrzeugkastens am Mittelfahrwerk (2) mittels Lager (7) gelagert ist, angeordnet an einer Wiege (8) dieses Fahrwerks, wobei beide Wiegen in jedem Mittelfahrwerk miteinander durch eine Längszugstange (9) verbunden sind, die die Längskräfte zwischen benachbarten Gliedern des Fahrzeugs überträgt, wobei die Anordnung der Zugstange (9) und deren Befestigung an den Wiegen (8) den benachbarten Gliedern des Fahrzeugs eine gegenseitige Bewegung um die Längs- und Querachse im Rahmen der Richtungs- und Höhenführung der Schiene ermöglicht, während die Längskräfte von Fahrzeugkästen auf das Fahrwerk durch die Zugstange (10) übertragen werden, die immer eine der Wiegen (8) des Mittelfahrwerks (2) mit dem Rahmen (11) dieses Mittelfahrwerks (2) verbindet.

4. Niederflur-Gelenk-Schienenfahrzeug, insbesondere die Straßenbahn, nach Anspruch 1 und 2., **dadurch gekennzeichnet, dass** bei seitlichen Fahrwerken (1) der Fahrzeugkasten auf diesem Fahrwerk mittels eines Lagers (14) und längs asymmetrischer Wiege (12) mit Drehpunkt der Lagerung (4) des Fahrzeugkastens gelagert wird, längs gelagert / verschoben gegenüber den Federsätzen der Sekundärfederung (13) resp. der Mitte des seitlichen Fahrwerks (1), wobei das Lager (14) in der Lage ist, auch den Moment zu übertragen, der durch die Belastung der exzentrisch gelagerten Wiege (12) gegenüber der Mitte dieses seitlichen Fahrwerks (1) verursacht wird.

5. Niederflur-Gelenk-Schienenfahrzeug, insbesondere die Straßenbahn, nach Anspruch 3., **dadurch gekennzeichnet, dass** das Lager (7) als Axialwälzlager gebildet wurde.

6. Niederflur-Gelenk-Schienenfahrzeug, insbesonde-

re die Straßenbahn, nach Anspruch 3., **dadurch gekennzeichnet, dass** das Lager (7) als Kippkugellager gebildet wurde und die Wiegen (8) beider Radsätze des Mittelfahrwerks (2) eine feste Einheit bilden.

7. Niederflur-Gelenk-Schienenfahrzeug, insbesondere die Straßenbahn, nach Anspruch 4., **dadurch gekennzeichnet, dass** das Lager (14) als Axialwälzlager gebildet wurde.

Revendications

1. Véhicule ferroviaire articulé à plancher bas, en particulier de tramway, agencé soit comme un véhicule à deux voitures (A, B) avec trois bogies (1, 2), soit étant rallongé par au moins une voiture et au moins un bogie, ledit véhicule ferroviaire articulé à plancher bas étant toujours équipé d'un bogie (1) d'extrémité pivotant disposé en dessous de chaque extrémité avant et arrière de la caisse du véhicule, et d'au moins un bogie (2) central situé entre deux voitures respectives, chacune des voitures respectives étant reliée de manière pivotante par l'intermédiaire de son centre de rotation (3) à au moins un bogie central (2), le véhicule ferroviaire articulé à plancher bas comprend en outre des suspensions (5), primaire et secondaire, une paire de roues montées de façon indépendante, des actionneurs, des freins (6) à disque et des freins de voie, les actionneurs, les freins à disque et les freins de voie étant situés sur les côtés extérieurs des paires de roues montées de façon indépendante par rapport à l'axe longitudinal du véhicule ferroviaire et les suspensions (5), primaire et secondaire, sont placées dans la zone entre les paires de roues montées de façon indépendante ce qui maintient le plancher du véhicule au niveau bas standard, le niveau bas standard étant situé à une hauteur de 350 mm à 450 mm au-dessus du rail, et au-dessus des bogies, le niveau étant légèrement élevé par rapport au reste de l'espace voyageur, les deux planchers du véhicule étant reliés par un passage sans obstacle constitué de rampes montantes progressivement, la largeur standard de passage dans le véhicule étant atteinte et la largeur de passage minimale standard dans véhicule étant de 600 mm.

2. Véhicule ferroviaire articulé à plancher bas, en particulier de tramway, selon la revendication 1, **caractérisé en ce que** la liaison de chaque section de la caisse du véhicule avec le bogie est réalisée de telle sorte que le centre de rotation (3) de l'assemblage des sections de caisse avec le bogie central (2) soit toujours géométriquement sur l'axe vertical passant par le centre de l'axe de rotation commun d'une paire de roues de bogie et le centre de rotation du logement (4) du bogie (1) d'extrémité est situé sur l'axe longitudinal du bogie et est relativement proche, environ 1/3 de l'écartement du bogie, du centre de l'axe de rotation commun d'une paire de roues du bogie plus éloignée de l'avant du véhicule.

3. Véhicule ferroviaire articulé à plancher bas, en particulier de tramway, selon la revendication 1, **caractérisé en ce que** chaque section de la caisse du véhicule est montée sur le bogie central (2) au moyen d'un palier (7) disposé sur un berceau (8) de ce bogie, les deux berceaux, dans chaque bogie central, étant reliés par une bielle longitudinale (9) transmettant les forces longitudinales entre les sections voisines du véhicule, l'agencement de la bielle (9) et sa fixation aux berceaux (8) permettant aux sections voisines du véhicule de se mouvoir autour de l'axe longitudinal et l'axe transversal dans les limites de la direction et de la hauteur des rails, tandis que les forces longitudinales des caisses du véhicule agissant sur le bogie sont transmises par une bielle (10) reliant toujours un des berceaux (8) du bogie central (2) au châssis (11) de ce bogie central (2).

4. Véhicule ferroviaire articulé à plancher bas, en particulier de tramway, selon les revendications 1 et 2, **caractérisé en ce que** dans le cas des bogies d'extrémité (1), la caisse du véhicule est montée sur ce bogie au moyen d'un palier (14) et d'un berceau (12) à asymétrie longitudinale avec un centre de rotation du logement (4) de la caisse du véhicule, disposé/déplacé longitudinalement par rapport aux ensembles de ressorts de la suspension secondaire (13) ou par rapport au centre du bogie d'extrémité (1); le palier (14) étant capable de transmettre même un couple provoqué par la charge du berceau (12) monté de manière excentrique par rapport au centre de ce bogie d'extrémité (1)

5. Véhicule ferroviaire articulé à plancher bas, en particulier de tramway, selon la revendication 3, **caractérisé en ce que** le palier (7) est conçu comme un roulement axial.

6. Véhicule ferroviaire articulé à plancher bas, en particulier de tramway, selon la revendication 3, **caractérisé en ce que** le palier (7) est conçu comme un roulement à billes inclinable et les berceaux (8) des deux paires de roues du bogie central (2) forment une unité rigide.

7. Véhicule ferroviaire articulé à plancher bas, en particulier de tramway, selon la revendication 4, **caractérisé en ce que** le palier (14) est conçu comme un roulement axial.

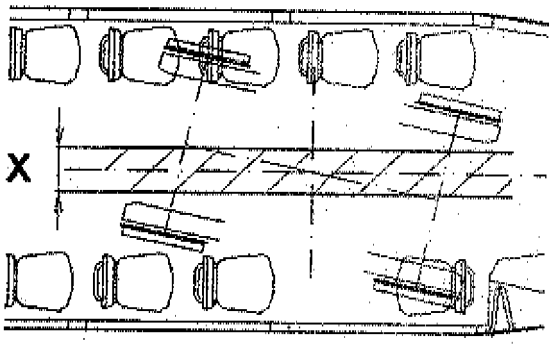

Fig. 1

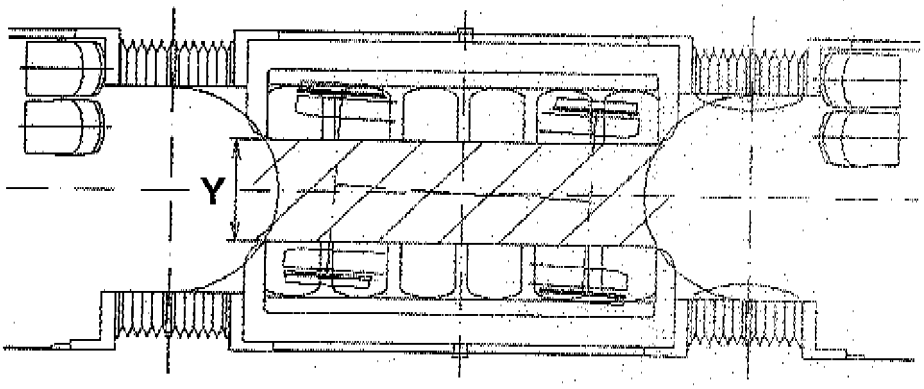

Fig. 2

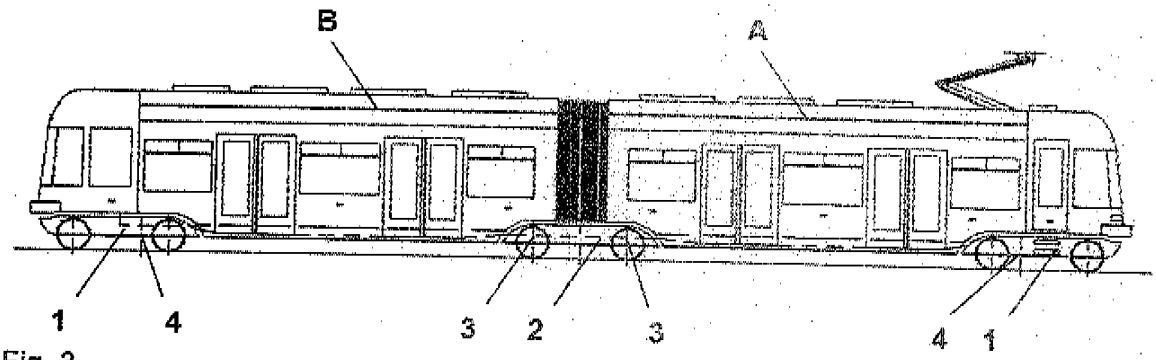

Fig. 3

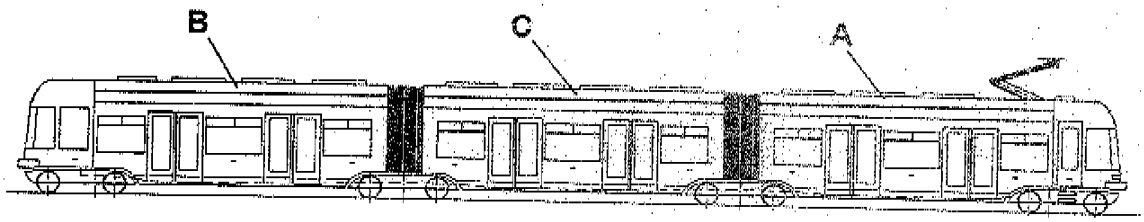

Fig. 4

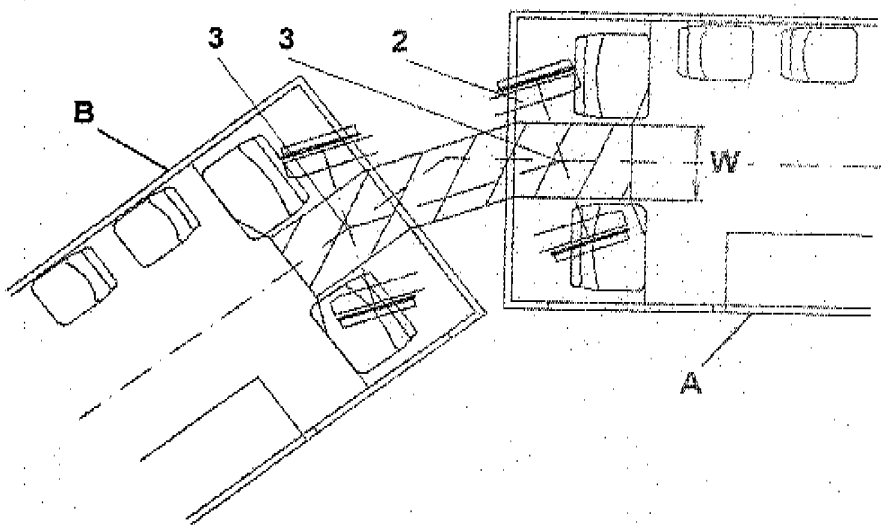

Fig. 5

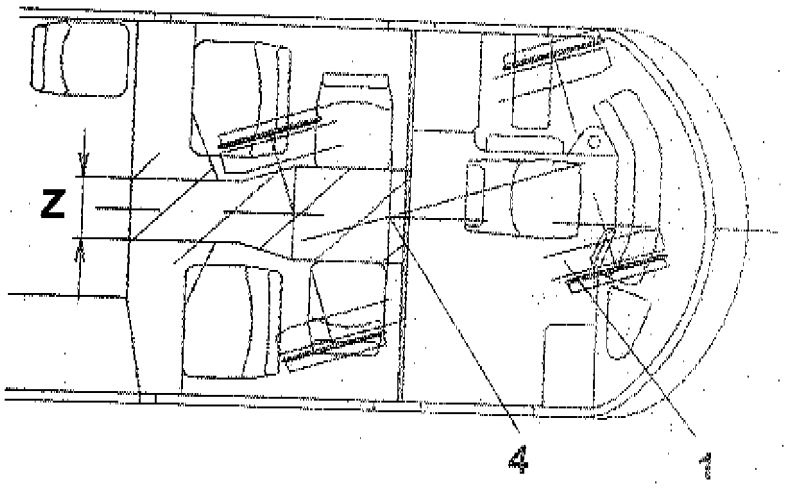

Fig. 6

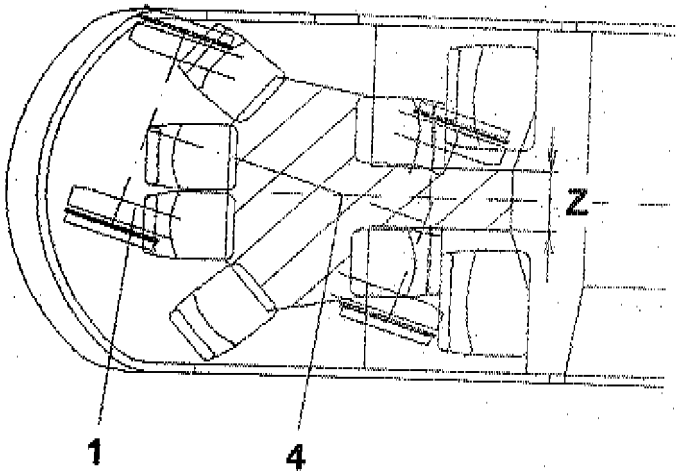

Fig. 7

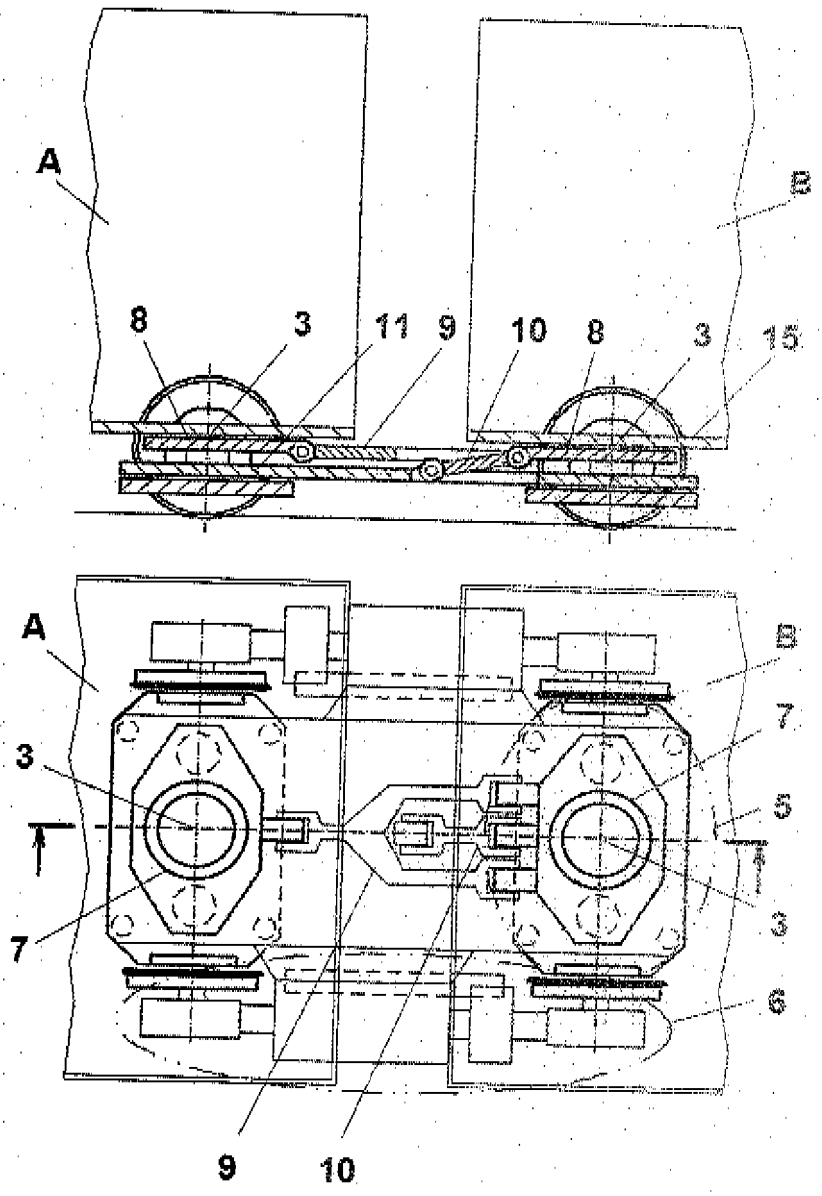

Fig. 8

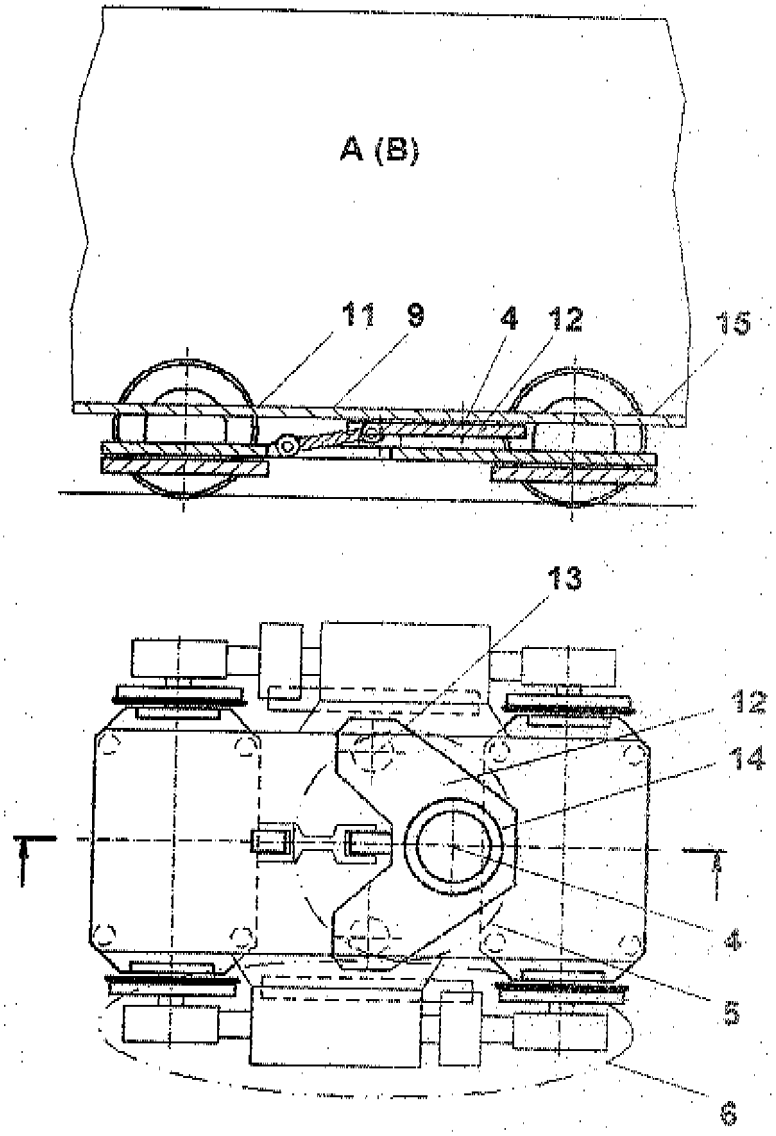

Fig. 9

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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