United States Patent [19]

Hennings

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[54] **TWO RAIL SUSPENSION RAILWAY WITH A LINEAR MOTOR**

[75] Inventor: **Walter Hennings**, Kirchen/Sieg, Germany

[73] Assignee: **Arn. Jung Lokomotivfabrik GmbH**, Jungenthal bei Kirchen, Germany

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[52] **U.S. Cl.** ..... **104/148 LM**, 104/94

[51] **Int. Cl.** **B60l 13/00**

[58] **Field of Search** ..... 104/148 LM, 94; 310/12, 310/13

[56] **References Cited**

UNITED STATES PATENTS

3,557,704	1/1971	English	104/148 LM
3,611,944	10/1971	Reder	104/148 LM
3,618,529	11/1971	Bertin	104/148 LM
3,696,752	10/1972	Bourg	104/94
3,707,924	1/1973	Barthalon et al.	104/148 LM

FOREIGN PATENTS OR APPLICATIONS

760,521	6/1967	Canada	104/148 LM

OTHER PUBLICATIONS

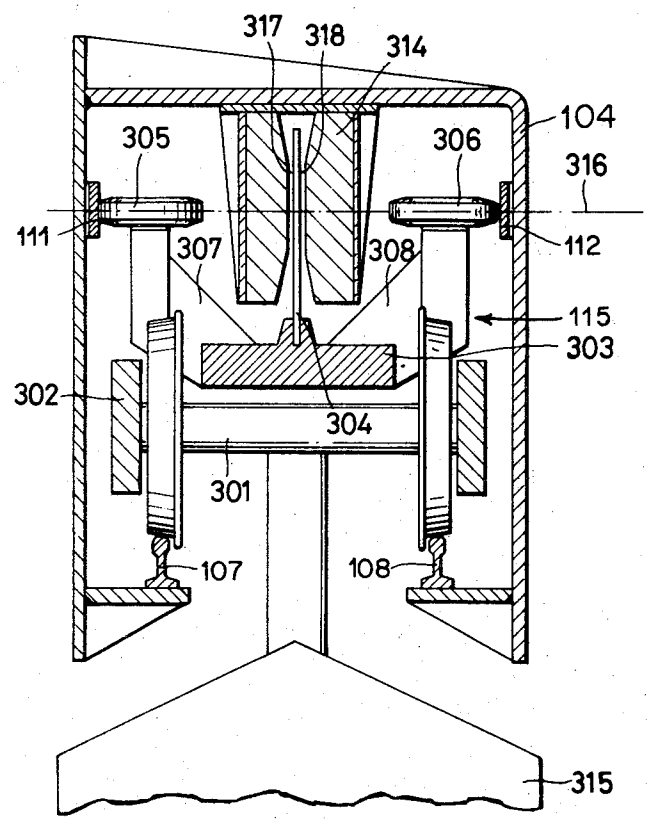
Poloujadoff, Linear Induction Machines, IEEE Spectrum, March 1971, p. 81.

Primary Examiner—M. Henson Wood, Jr.
Assistant Examiner—George H. Libman
Attorney, Agent, or Firm—Woodhams, Blanchard and Flynn

[57] **ABSTRACT**

A suspended carriage railway system having a linear motor. There is provided for such a system fixed supporting means for mounting a spaced pair of tracks. An undercarriage is supported on said track and in turn supports an intermediate frame. One part of linear motor means is mounted on the fixed supporting means and the other part thereof is mounted on the intermediate frame. Said frame is related to the undercarriage for sidewise relative movement with respect thereto but is rigidly guided by lateral rails against sidewise movement with respect to the fixed supporting means. Thus the intermediate frame is held accurately against sidewise movement and the linear motor means mounted on said intermediate frame and the fixed supporting means are held accurately against sidewise movement with respect to each other. This makes possible a minimum spacing of the linear motor components while permitting the undercarriage structure to move sidewardly in response to clearance between the supporting wheels and the rails. The railway carriages are suspended from the undercarriage means.

11 Claims, 8 Drawing Figures



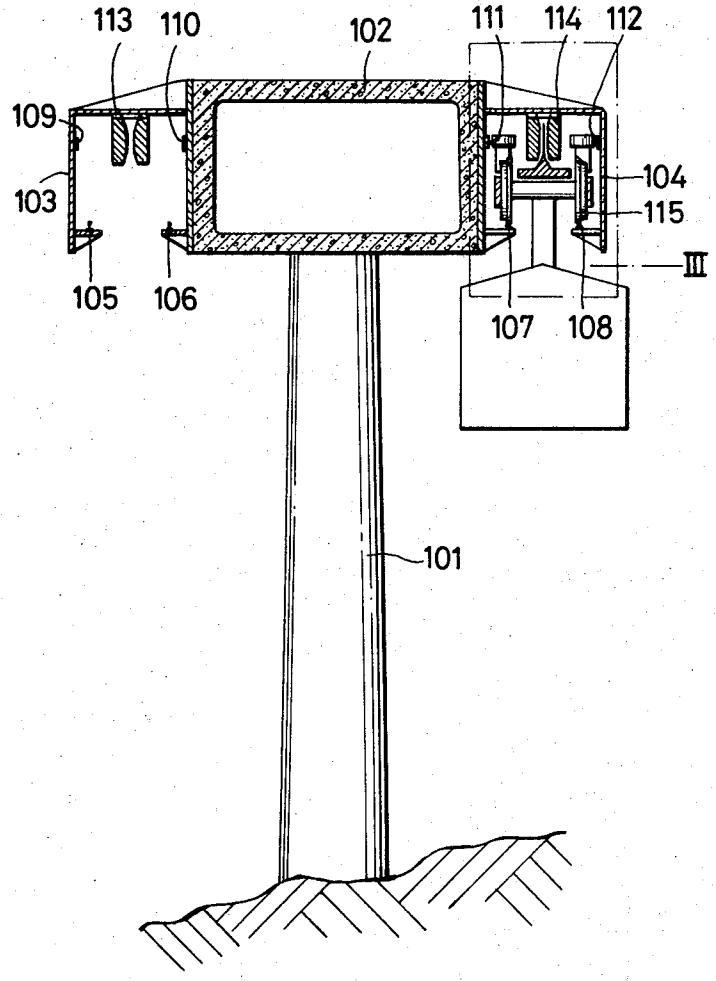


Fig. 1

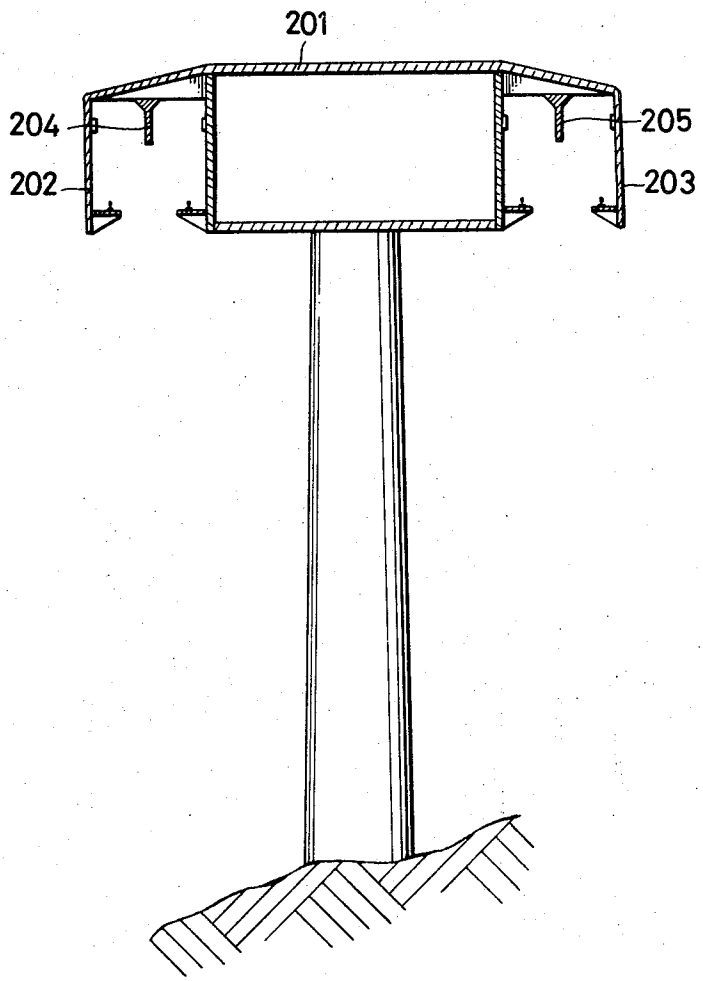
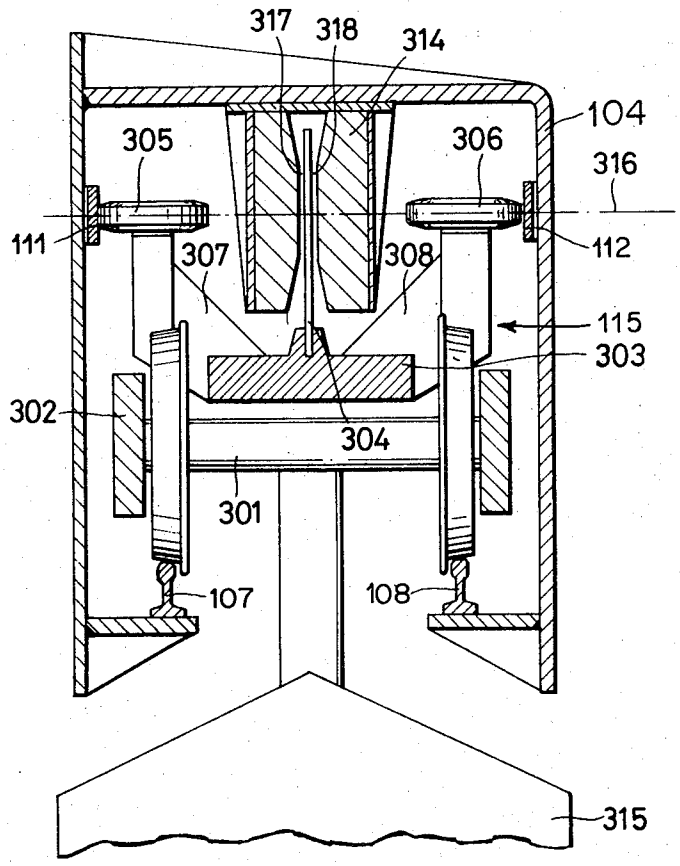


Fig. 2


317
318
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104
305
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316
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315

Fig. 3

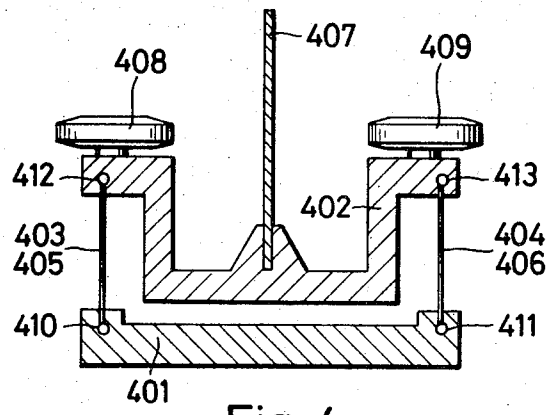
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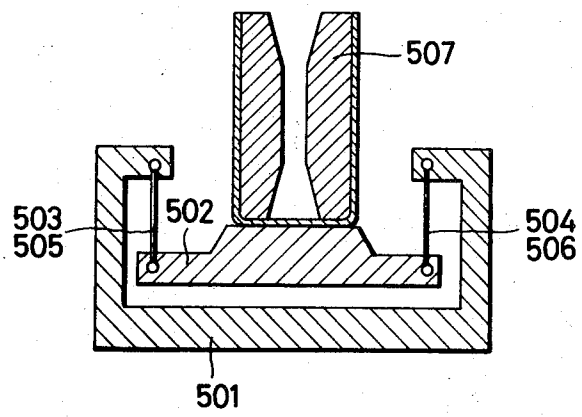
Fig. 4


507
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501

Fig. 5

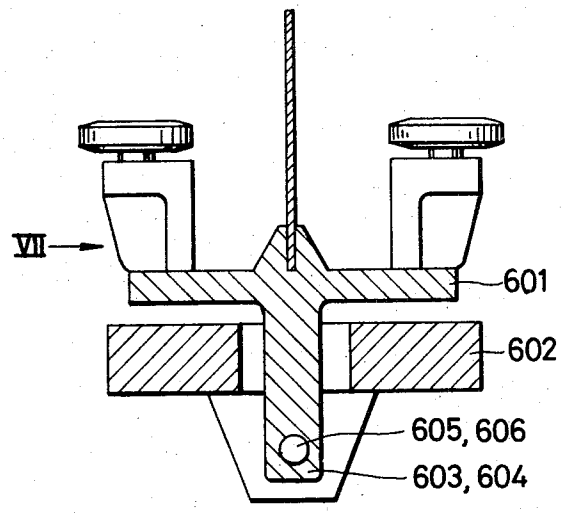
VII
601
602
605, 606
603, 604

Fig. 6

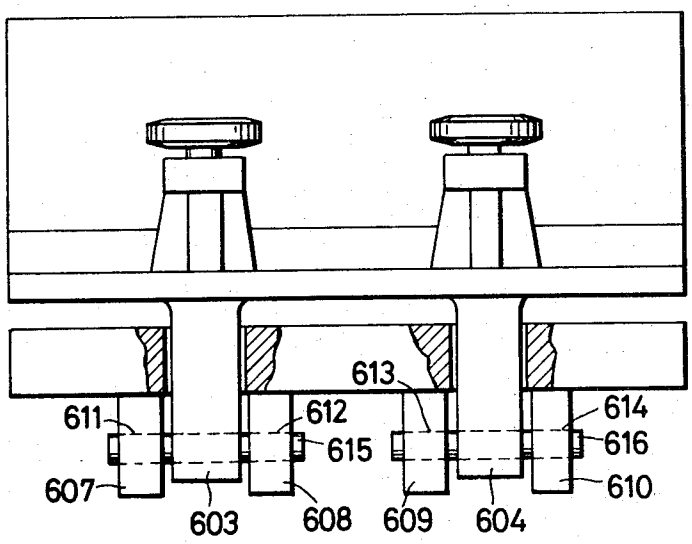
613
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Fig. 7

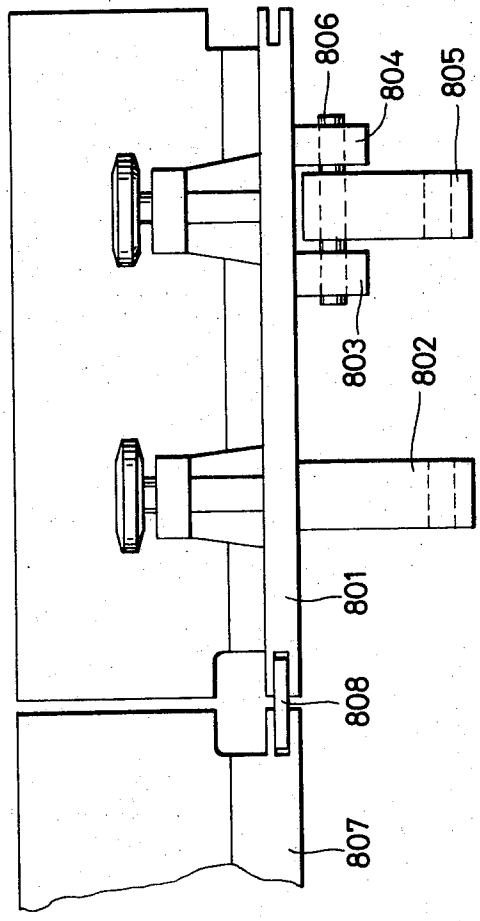

Fig. 8

TWO RAIL SUSPENSION RAILWAY WITH A LINEAR MOTOR

The invention relates to a two rail suspension track with rails which are secured on a track carrier and it further relates to carriages including undercarriage frames, wherein on each of the track carrier and on the undercarriages there is secured respectively the inductor or the reaction rail of a linear induction motor.

In the case of such track, the inductor is built preferably in a double comb construction with two oppositely positioned combs. The reaction rail runs free of contact in the gap between the two combs. In driving vehicles with linear induction motors, there exists the problem of guiding the parts of the linear motors which are moved with the carriages with respect to the parts of the linear motors which are fixedly installed in the track with sufficient accuracy that the gap between the two combs of the inductors can be held as small as possible. The effectiveness of the drive is improved as the gap is made smaller.

For the construction of a suspension track, it is further important that favorable provision be made for the manufacture of the track and the carriages and also for the driving thereof and for maintenance.

The suspension system consists of the track and the train. The track comprises a main carrier which is supported by supports and also comprises the track carrier which is connected to the main carrier and has been mentioned above. For below ground suspension tracks, the track carriers can be suspended on the tunnel supports. The track carriers can also be constructed as self-supporting main carriers which is particularly advantageous in the case of single rail tracks.

Each train consists of at least one carriage, but usually of several connected carriages, wherein either all carriages or only a portion thereof are driven by linear induction motors. The carriages consist of the undercarriage (frame, wheel sets, axial bearings, possibly springs), the driving mechanism and the suspension load (carriage box, retainers, hose connectors). The undercarriages can be constructed as rigid frame undercarriages with two or more axles or also as unitary frame undercarriages, in which for example, a carriage box is suspended on a two-axle undercarriage. It is also possible to use single axle rod drawn undercarriages.

There exists two different possibilities for the types of carriages with linear induction motors. It is possible to place the inductor fixedly into the track and to secure the reaction rail on the carriages. It is however, also possible to install the inductors in the carriage and to place the reaction rail along the track. Which one of these two possibilities is the most advantageous in a given instance depends, aside from the construction of the carriages, on the load of the track, the inclination thereof and other factors. The present invention permits the use of both systems.

Normal railroad wheels have proven to be very successful in cases of higher speeds for wheel supported carriages. A set of such wheels centers itself in the track primarily due to the conical running surfaces. The rolling resistance of such wheel sets with metal wheels on steel rails is particularly small. The wheel sets undergo, however, certain lateral movements in the rail. The lateral play between wheel sets and rail increases with time due to the wear of wheel flange and rail. Lateral movements of a carriage running on normal railroad wheel sets are thus greater than if permitted by the economically useable gap widths of linear induction motors. For installing linear motors for the drive of carriages with railroad wheel sets, special measures are required to achieve as small gap widths as possible.

The basic purpose of the invention is to construct a double rail suspension track of the type mentioned above in such a manner that the part of the linear induction motor which is connected to the undercarriage remains aligned accurately with respect to the stationary part even if the undercarriage frame moves laterally relative to the running tracks.

This purpose is achieved according to the invention by arranging the inductor or the reaction rail on swingable frames which are connected pivotally with the undercarriage frames and providing that the swingable frames are guided for adjusting the parts of the induction motor with respect to one another on the track carrier.

If, in a track so constructed, the undercarriage, and therewith, also the undercarriage frame, moves laterally relative to the track, the swingable frame maintains its central position with respect to the right and left guide track since it can move laterally with respect to the undercarriage frame and under the control of its guide, is maintained in the center. Thus, lateral movements of the undercarriage frame do not result in lateral shifting of the reaction rail (or the inductor). They also do not change the vertical position of the reaction rail. Same is also true if in place of the reaction rail, an inductor is secured on the swingable frame. Such inductor would also not be subjected to a lateral shifting and the gap between the inductor combs will be maintained in the correct position. Thus, in both cases, no position changes occur between the parts of the linear motors which parts are connected to the carriage and which parts are secured on the track carrier so that very small gaps can be maintained between the inductor combs.

The vehicle frame can, however — for example, in the case of obstacles positioned on the track — take on a position which is inclined with respect to the horizontal line. The swingable frame is then also inclinedly positioned and the position of the reaction rail also differs slightly from the vertical position. The inclined position requires an enlargement of the gap width between the comb of the inductors. This gap enlargement, can however, be kept small if according to a further development of the invention the guide track is positioned in the center of the vertical dimension, or approximately in the center of the vertical dimension of the inductors. Thus, in all normally occurring inclined positions of the wheel sets and of the undercarriage frame, the necessary gap width can be maintained small.

In the preferred embodiment of the invention, guide rollers are supported for guiding on the swingable rames which guide rollers are rotatable about vertical axes and which guide rollers cooperate with the track carrier. Guide rollers have the advantage that sliding friction is avoided. Nevertheless, different guide means, such as sliding shoes, are also possible. The swingable suspension can be effected in different ways. One possibility is to connect the swingable frame, the undercarriage frame, to several parallel swingable supports which in the normal position are advantageously positioned vertically. In place of the swingable supports

it is also possible to provide suspended pendulum-like linkages.

A further possibility for the swingable suspension of parts of the linear motors which parts moved together with the carriage, is to provide a swingable frame which at a point vertically spaced from the guide plane is supported rotatably in the undercarriage frame. At a lateral shifting of the undercarriage in the rail, the axis of rotation is then also shifted laterally. At the height of the guide plane there occurs, however, no lateral shifting of the swingable frame since it is here laterally guided. The lateral shifting of the point of rotation effects an inclined position of the pendulum. This inclined position becomes smaller and the greater becomes the vertical distance between the point of rotation and the guide plane. In order to minimize the inclined position, and thus also minimize the required gap width in the inductor, the point of rotation for the pendulum must be positioned as high as possible, which normally improves the structural aspects of a deep positioning of the axis of rotation. The arrangement of the guide plane at the level of the center of the inductors further improves this swingable arrangement.

The driving forces for the drive of the carriage are produced as forces between the inductor and the reaction rails. Since the space between the individual inductors — regardless of whether secured on the track or on the carriages — will in many cases be larger than a carriage length, traction forces must also be transferred between the individual carriages. The traction forces must, furthermore, be transmitted from the swingable frame of the carriage to the undercarriage frame. This latter force transmission can be done through known structural elements, for example, pressure rollers, hingedly mounted tension or compression rods or slide surfaces.

The transmission of traction force between the individual carriages can be done by a hinged connection of the undercarriage frame of the individual carriages. The hinge connection can be constructed elastically or it is possible to install an additional elastic structural part between the undercarriage frames. Such a connection of the carriages through the undercarriage frames is normally suitable if the inductors are moveable with the carriages, particularly if not all carriages are provided with inductors.

If the inductors are installed in the track and the reaction rails are mounted in the carriages, it can be advantageous, particularly, if the spacing of the inductors is substantially greater than the length of the individual carriages — to transmit the traction forces between the individual carriages by a hinge connection of the swingable frame.

This hinge connection can also be constructed elastically. Such a connection of a swingable frame has the advantage that between swingable frames and undercarriage frames of a carriage only a relatively small longitudinal force must be transmitted, namely, the traveling and acceleration resistance of an individual carriage. Accordingly, the structural part for transmission of these forces can be satisfied by a lighter construction. Also, in this manner, the vertical distance between the center of these inductors and the connection of the carriages can be maintained small so that the rotational movement which results from this distance and the traction force becomes small.

In order to balance out small irregularities of the guide tracks, it is advantageous if the guide rollers themselves are somewhat resilient. This can be accomplished by providing said rollers with elastic running surfaces or by supporting the rollers in such a manner that they are pressed against the running surfaces by springs. However, the possible shifting movements must be limited to fixed stops so that the necessary guiding characteristics are maintained.

The track carriers consist advantageously of rectangular boxes which are open in downward direction, which boxes are, for example, of rolled profiles, or can be welded together from plates. The track carrier then supports the tracks in the lower zone of said boxes. The inner surfaces of the side walls serve as running surfaces for the guide rollers, whereby for reasons of manufacturer tolerances, it is possible to provide special guide tracks which are secured on the side walls. All parts of the undercarriages and the drive are positioned for protection within the track area. Nevertheless, all parts which are positioned in the track carrier are easily accessible through the lower opening for installation, operation and repairs.

Exemplary embodiments of the invention are illustrated in the drawings, in which:

FIG. **1** is a cross-sectional view of a two rail track according to the invention in which the inductors are parts of the track structure,

FIG. **2** is a corresponding cross-sectional view whereby, however, the reaction rails are a part of the track structure,

FIG. **3** is a section of FIG. **1**, which section is enlarged with respect to FIG. **1**, in the zone of the dash-dotted box III of FIG. **1**,

FIG. **4** is a cross-sectional view of an undercarriage frame and a swingable frame wherein the swingable frame is suspended by swingable supports,

FIG. **5** is a cross-sectional view of an undercarriage frame and a swingable frame wherein the swingable frame is suspended by suspension linkages,

FIG. **6** is a cross-sectional view of an undercarriage and a swingable frame wherein the swingable frame is supported pivotally about a low positioned axis.

FIG. **7** is a view of the undercarriage frame and swingable frame in direction of the arrow VII of FIG. **6** and

FIG. **8** is a side view of a swingable frame which is supported corresponding to a further embodiment of the invention and showing a coupling between two successive swingable frames.

In the embodiment according to FIG. **1**, the support columns **101** carry a main support **102** which is in this embodiment manufactured of concrete. The main support **102** is constructed as a box support with rectangular closed torsion-stiff cross section. Track housings **103** and **104** are mounted laterally on the main support **102**, which track housings are welded together of sheet-metal plates and rolled sections and carry tracks **105** to **108**, guide rails **109** to **112** and inductors **113** and **114** of linear motors. A carriage **115** is illustrated on the right track.

FIG. **2** illustrates a cross-sectional view of an alternative embodiment of the railway line. The main support **201** and the track housings **202** and **203** are here united to a common support which is welded together from sheet metal plates and rolled sections. In place of the

inductors, in this exemplary embodiment the reaction rails **204** and **205** are secured on the track housings.

FIG. **3** illustrates the cross-sectional view which has already been shown in FIG. **1** of frame carriage **115** in an enlarged scale. The cross-sectional plane lies approximately in the zone of a wheel set. The wheel set **301** is supported in the undercarriage frame **302.** A swingable frame **303** is swingably mounted in a manner which is not illustrated in FIG. **3** onto the undercarriage frame **302.** The swingable rame **303** carries a reaction track **304** and guide rollers **305** and **306** on lateral arms **307** and **308.**

Tracks **107, 108,** guide tracks **111** and **112** and inductors **314** of the linear motors are mounted on the track housing **104.** The suspended load **315** is suspended in a manner which is not illustrated in detail on the undercarriage frame.

The guide rollers **305** and **306** are positioned with their wheel planes in a horizontal plane which is indicated by the dash-dotted line **316.** Said plane is, as can be easily seen from FIG. **3,** approximately in the midzone of the linear motor **304**/314.

FIG. **4** illustrates a connection between the undercarriage frame and the swingable frame by means of swingable supports. To connect the undercarriage frame **401** and the swingable frame **402** three or more, preferably four swingable supports **403** to **406** are provided, whereby the swingable supports **403** and **404** are positioned in the cross-sectional plane and the swingable supports **405** and **406** are positioned in a plane which is provided behind the drawing plane. The swingable frame **402** carries a reaction rail **407** and the guide rollers **408** and **409.** Two or more guide rollers, for example four guide rollers, can be supported on a swingable frame.

The pivot axes **410** to **413,** with which the swingable supports **403** to **406** are hinged to the undercarriage frame **401** or on the swingable frame **402,** are advantageously constructed so that they permit the swingable supports to pivot only about axes which are parallel to the direction of travel, namely perpendicular to the drawing plane. By this arrangement, the swingable frame, seen in FIG. **4,** can in this embodiment swing only to the left and to the right. It can be permitted to swing forwardly and rearwardly only if additional guide means are provided. However, in place of the axes **410** to **413,** universal joints could also be used, and in such case it will be necessary to provide means which prevent, or at least limit, the back and forward swing of the swingable frame.

FIG. **5** illustrates an embodiment in which a swingable frame **502** is suspended on an undercarriage frame **501** by means of suspended pendulum-like linkages **503** to **506.** In this embodiment an inductor **507,** rather than the reaction track is mounted on the swingable frame **502.** The guide rollers which are connected to the swingable frame and which lie in a different cross-sectional plane are not illustrated in FIG. **5.**

FIGS. **6** and **7** illustrate a further variation for mounting a swingable frame **601** on an undercarriage frame **602.** The swingable frame **601** has two downwardly extending arms **603** and **604** in which horizontal bores **605** and **606** are provided which extend parallel to the longitudinal direction of the carriage. The undercarriage frame has also several downwardly extending arms **607** to **610** in which bores **611** to **614** which are also parallel to the direction of travel are provided. The swingable frame **601** and the carriage frame **602** are hingedly connected by pins **615** to **616.**

The support of the wheel sets on the undercarriage frame, the mounting of the suspended load on the undercarriage frame, the coupling of the carriages together and the structural elements for transmitting the tractive forces between swingable frame and undercarriage frame are not illustrated in FIGS. **4** to **7.**

FIG. **8** illustrates a swingable frame **801** which is similarly constructed as the swingable frame **601** according to FIGS. **6** and **7** and a part of a second swingable frame **807.** Instead of two equally long depending hangers as they are used in the embodiment according to FIGS. **6** and **7,** the swingable frame **801** according to FIG. **8** has a long hanger **802** and two shorter hangers **803** and **804.**

The hanger **802** is connected to the undercarriage frame in the same manner as in the embodiment according to FIGS. **6** and **7.** Between the hangers **803** and **804** and a not illustrated undercarriage frame, there is inserted a swingable support **805** which is hinged to the hangers **803** and **804** by the pin **806.** Through this type of hinge the swingable frame can be slightly inclined relative to the undercariage frame in direction of travel.

The two swingable frames **801** and **807** are connected by a link **808.**

By the support of the swingable frame corresponding to FIGS. **4** and **5,** same moves substantially only horizontally during a swing motion. Thus, they swing about a pivot point which lies at infinity. However, in the embodiment according to FIGS. **6** to **8,** the swinging takes place about a real pivot axis so that upon the occurrence of swinging motion, a small inclination of the swingable frame occurs. Same is however small in the case of the relatively small normally used angles of swinging.

The guide rollers are in all embodiments in a horizontal plane corresponding to the plane **316** in FIG. **3,** namely, they are at a height which corresponds to the middle vertical zone of the induction motors. It is easily understood that through this a particularly good guide is achieved. However, the invention includes also embodiments in which the guide rollers or other guide means are arranged in a different relative vertical position with respect to the inductor motors. In the case of a suspension of the swingable frame in such a manner that they pivot about a real pivot axis (FIGS. **6** to **8**), it is basically advantageous if the horizontal plane in which the guide rollers or other guide means are positioned to lie at as large a vertical a spacing as possible from the pivot axis. In the case of the given guide clearance, the swing will be maintained at a small value. Holding such swing to a relatively small magnitude is the condition that makes possible the effective minimizing of the air gap between the stationary and the movable parts of the linear motor. These gaps are identified by reference numerals **317** and **318** in FIG. **3.**

I claim:

1. A suspended carriage railway system, comprising:

means defining a track mounted on an elongated support structure, said support structure having an inverted U-shaped cross section;

a vehicle having first and second vertically spaced carriage members, one of said first and second carriage members having one of an inductor and a re-

action rail of a linear induction motor secured thereto, the other of said inductor and said reaction rail being mounted on said support structure, the free ends of the legs of the U being turned inwardly to define a support for said other of said carriage members;

a pair of horizontally spaced guide rails separate from said track means and mounted on an inwardly facing side of said U for guiding said one of said first and second carriage members along said support structure to accurately maintain the spacing between said inductor and said reaction rail, said guide rails extending coextensively along said support structure and with said track means, said track means guiding said other of said carriage members; and

connecting means for connecting said first and second carriage members together, said connecting means consisting solely of a plurality of parallel and normally vertically aligned connecting supports connected to and extending between said first and second carriage members, said connecting supports including means for facilitating a free, relative lateral movement between said first and second carriage members due to lateral variations in the positioning of said other of said carriage members relative to said track means.

2. The improvement according to claim **1,** wherein said one of said carriage members is positioned above said other of said carriage members.

3. The improvement according to claim **1,** wherein said other of said carriage members includes a pair of extensions along the sides thereof and which extend upwardly to a position above said one of said carriage members; and

wherein said plurality of said connecting supports extend between each of said pair of extensions and said one of said carriage members.

4. The improvement according to claim **1,** wherein said means for facilitating a lateral movement comprises pivot means secured between the ends of each of said connecting supports and said first and second carriage members.

5. The improvement according to claim **4,** wherein the axes of said pivot means extends parallel to the direction of travel of said vehicle.

6. The improvement according to claim **5,** wherein said guide means comprises means defining a second track mounted on said support structure, said track also defining a plane and guide roller means rotatably secured to said one of said carriage members and engaging and being guided by said second track means; and

wherein said pivot axes are vertically spaced from said plane.

7. The improvement according to claim **6,** wherein said plane intersects the approximate midpoint of said one of said inductor and said reaction rail.

8. The improvement according to claim **6,** wherein said second track means is mounted on a pair of horizontally spaced vertical side walls of said support structure; and

wherein said guide roller means secured to said one of said carriage members is rotatable about a vertical axis of rotation.

9. The improvement according to claim **8,** wherein said guide roller means consists of a plurality of guide rollers having a resiliently flexible characteristic thereby defining resilient flexibility transversely to the direction of travel.

10. The improvement according to claim **9,** wherein said guide rollers have a rubber running surface.

11. The improvement to claim **1,** wherein said track means comprise a pair of horizontally spaced and parallel rails engaged by wheel means rotatably secured to said other of said carriage members.

* * * * *