Oct. 23, 1962 L. CHADENSON 3,059,591

SUSPENSION RAILWAY

Filed April 29, 1959 3 Sheets-Sheet 1

Fig. 1.

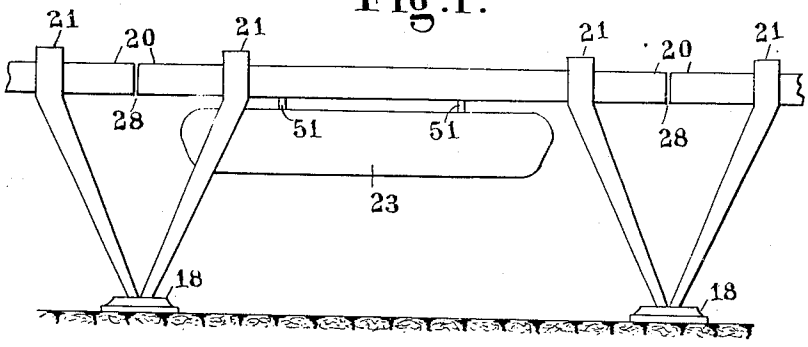
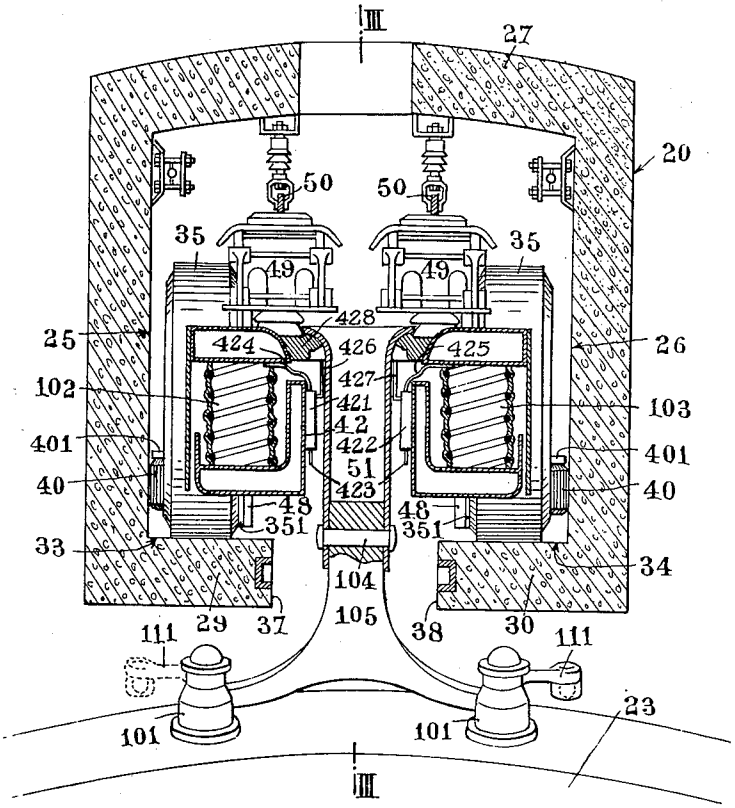


Fig. 2.

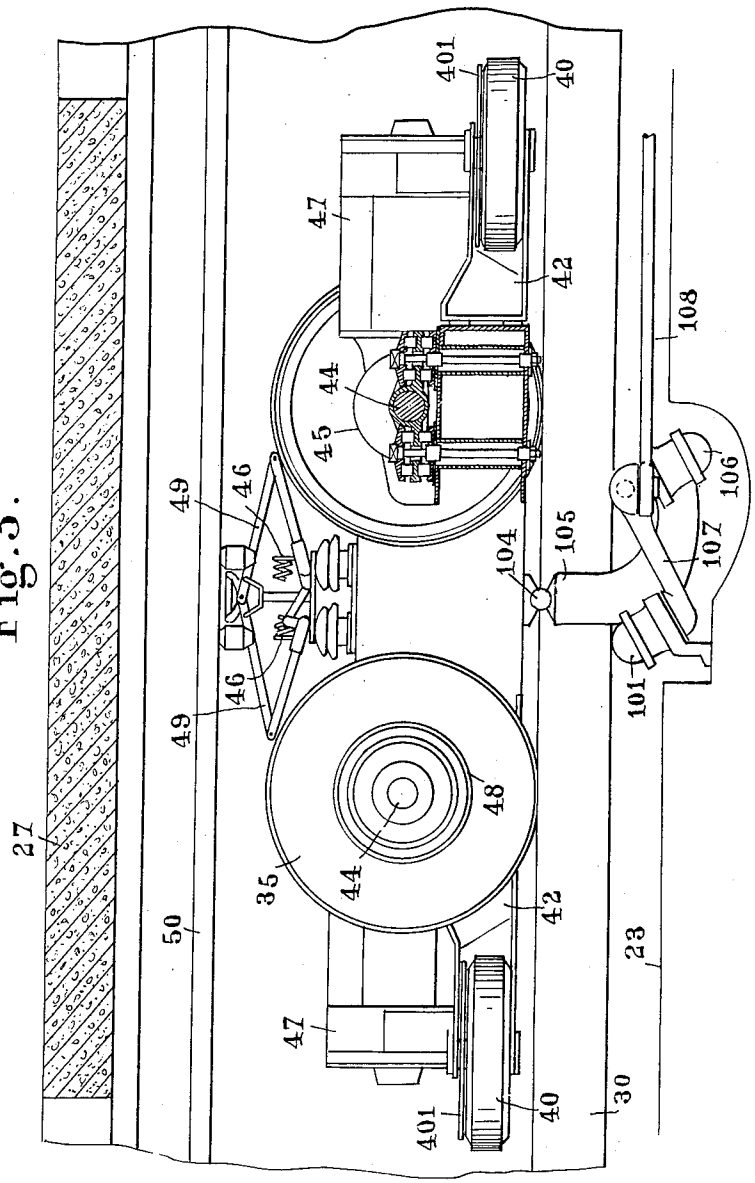


Oct. 23, 1962 L. CHADENSON 3,059,591

SUSPENSION RAILWAY

Filed April 29, 1959 3 Sheets-Sheet 2

Fig. 3.



Oct. 23, 1962 L. CHADENSON 3,059,591

SUSPENSION RAILWAY

Filed April 29, 1959 3 Sheets-Sheet 3

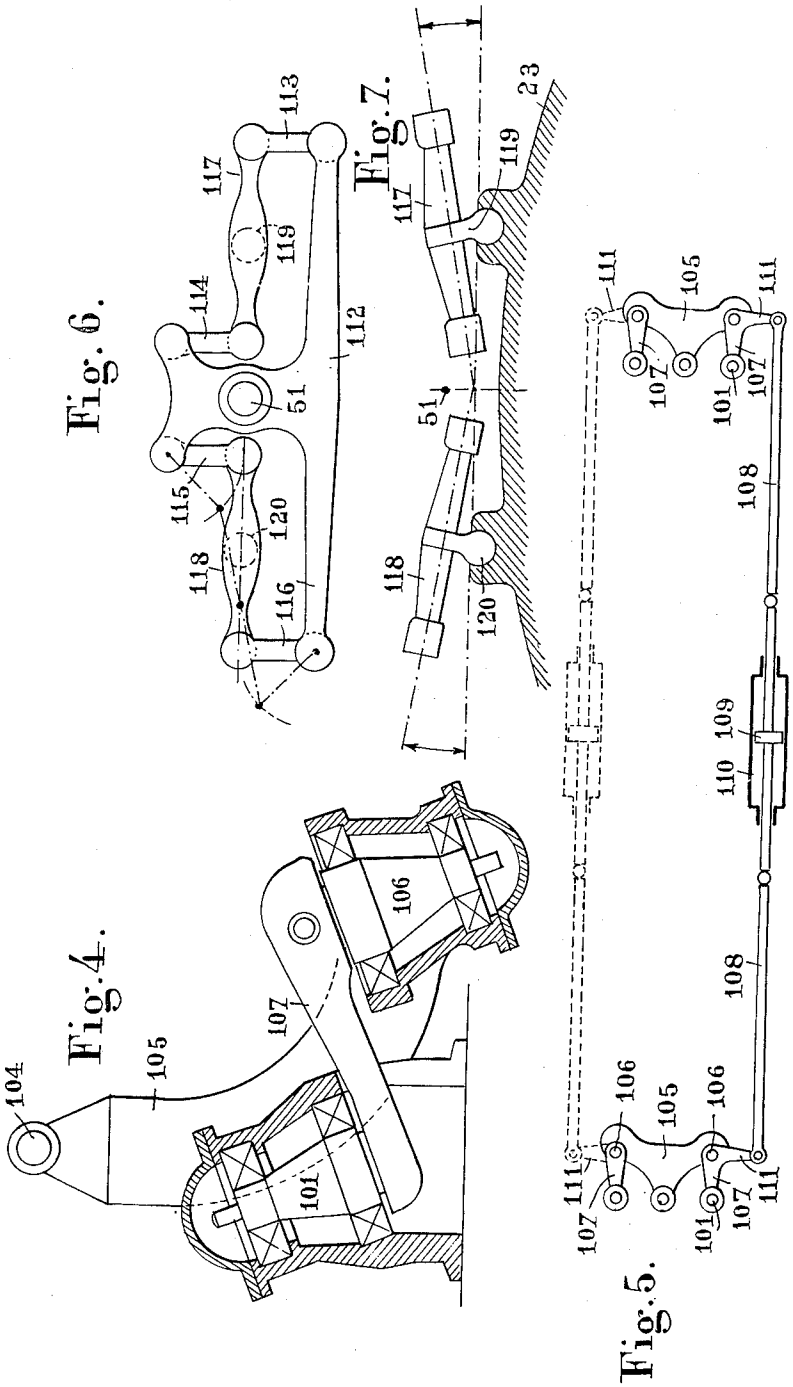


Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

United States Patent Office 3,059,591 Patented Oct. 23, 1962

3,059,591

SUSPENSION RAILWAY

Lucien Chadenson, Paris, France, assignor to Safege-Transport, Societe Anonyme, Paris, France

Filed Apr. 29, 1959, Ser. No. 809,672
Claims priority, application France Mar. 10, 1959
14 Claims. (Cl. 105—155)

In a prior U.S. Patent No. 2,825,291, the applicant described a suspension or overhead railway for urban or suburban lines, that is to say, a railway system wherein the bodies of the train-forming vehicles are disposed under the bogie-trucks and connected thereto through essentially vertical suspension members, the trucks themselves being carried by a track consisting of a substantially box-sectioned girder in which the trucks are enclosed, guided and adapted to travel, said suspension members extending through a longitudinal slot formed centrally of the lower portion of the box-sectioned girder.

The track lying normally well above the ground level may, if necessary, be arranged underground along predetermined sections.

The essential features of the suspension overhead railway described in the aforesaid patent may be summarized as follows:

(*a*) It is mounted on rubber-tyred wheels to reduce noise and improve the passengers' comfort, as well as to increase the wheel adherence (resulting in improved acceleration, deceleration and hill-climbing capacity).

(*b*) A single and same structure either metallic or made of pre-stressed concrete will provide the following four essential functions:

(1) It provides horizontal surfaces constituting the tracks engaged by the rolling carrier wheels of the vehicles;

(2) It provides vertical side surfaces acting as guide means to the vehicles of which the rubber-tyred carrier wheels cannot serve this purpose. The horizontal guide wheels are also rubber-tyred.

(3) Due to its vertical and/or horizontal surfaces it is adapted to transfer to said structure, in the form of torsional stresses of this structure, that fraction of the transverse disturbing efforts (such as throwing off centre the passenger load, and beam winds) which, as it is exerted on the bodies of the suspension vehicles, is not compensated by the maximum permissible transverse inclination of these bodies.

(4) It affords the construction of switching points for the tracks as conventional in railway switches, with the same safety, simplicity and efficiency requirements as in conventional railway systems.

(*c*) This single structure results in a shape particularly adapted to withstand not only flexural stresses exerted by vertical forces but also the torsional stresses mentioned hereinabove; furthermore, its cross-sectional dimensions may be as small as possible, the feature being necessary for not only reducing the initial cost of the system but also preserving aesthetic requirements of the town districts in which the line is to be constructed.

It is the essential object of this invention to provide an improved arrangement of the means for suspending the vehicles of this suspension railway from their bogie-trucks whereby the disturbing transverse forces transmitted by these suspension means to the box-sectioned girder are reduced without increasing the maximum transverse inclination of the vehicles as consistent with the passengers' comfort, that is, without interfering with the comfort of the railway users.

To this end and according to a first feature of this invention, the suspension means provided between the vehicle and each of its trucks are so arranged that the virtual centre of rotation of the vehicle in a transverse

plane lies above the truck, so that given a same transverse displacement of the vehicle which is brought about by transverse disturbing forces (such as lateral displacement of the load, beam winds, etc.) its angular inclination is inferior to that obtaining if it were simply suspended from the truck or from beneath the truck as shown in FIGS. 2 and 3 of my prior Patent No. 2,825,291, and remains inferior to a limit value consistent with the passengers' comfort.

This specific arrangement does not interfere with the inclination of the vehicle body which is caused by the centrifugal force when negotiating a curve, as the tracks are suitably canted along the curved portions of the railway system.

Although the transverse inclination of the vehicle bodies is thus limited to the maximum angle consistent with the passengers' comfort, it is nevertheless essential to give to these bodies the maximum possible transverse elongation consistent with the structure contemplated for the railway stock concerned, in order to compensate the greatest possible fraction of the torque created by the aforesaid transverse disturbing forces. This can be provided by a simple pendulum suspension designed to allow a transverse inclination of the suspension up to 6° or 7°. It can also be provided by means of a double pendulum suspension. To this end and according to another feature of this invention there is provided, in addition to the aforesaid primary suspension system permitting through the longitudinal slot of the box-girder a limited transverse inclination of the vehicle body about a virtual longitudinal axis being above the bogie-trucks a transverse-stability correcting device permitting beneath the box-girder an additional transverse displacement of the vehicle either by rotation with a relatively great radius of rotation, or by translation, with a view to absorb a complementary fraction of the transverse disturbing forces without appreciably increasing the inclination of the vehicle body.

In order to afford a clearer understanding of the features and advantages of this invention and of the manner in which the same may be carried out in the practice, reference will now be made to the accompanying drawings forming part of this specification and illustrating diagrammatically by way of example a typical form of embodiment thereof and the preferred double pendulum type suspension. In the drawings:

FIGURE 1 is a diagrammatical elevational view of the railway system of this invention;

FIGURE 2 is a cross-sectional view showing on a larger scale the box-sectioned girder constituting the track for the bogie-trucks, one of these trucks being shown in end view;

FIGURE 3 is a diagrammatical longitudinal section of the track, showing a bogie-truck and details of the suspension system of a vehicle;

FIGURE 4 is a part-sectional, part-elevational side view of a suspension system;

FIGURE 5 is a plan view of the suspension system with its relevant adjustment means;

FIGURES 6 and 7 are diagrammatical views showing an alternate form of embodiment of the suspension system as seen in plan view and in end view respectively.

The overhead or suspension railway system illustrated in FIG. 1 comprises a track consisting of a continuous series of sections **20** separated by expansion joints **28** and supported by gantry or tower structures **21** bearing on solid blocks **18**; the vehicles **23** are carried by suspension devices **51** anchored in turn on bogie-trucks within the track formed by the sections **20**.

The box-sectioned girder **20** comprises, as shown notably in FIG. 2, L-sectioned side members **25**, **26** of which the horizontal portions **29**, **30** constitute through

their upper surfaces 33, 34 the tracks engaged by the rolling carrier wheels 35 of the vehicle trucks. These surfaces 33, 34 are given in the curved portion of the track the necessary cant and formed with cant joining portions. The wheels 35 are rubber-tyred. The registering faces 37, 38 of said horizontal portions 29, 30 are at a constant relative spacing throughout the track length.

The cross-section of this track structure with its lower horizontal portions 29, 30, lateral walls 25, 26 and roof 27 is substantially box-shaped and therefore ensures a complete and reliable protection of the track-forming surfaces, bogie-trucks and electric conductors against weather conditions; furthermore, this shape is particularly suitable for resisting longitudinal vertical flexural stress, transverse torsional stress and longitudinal stress resulting from strong accelerations and brake applications. Finally, it reduces the structure of the overhead construction to a minimum.

As shown in FIG. 3, the bogie-trucks of the vehicle comprise a frame 42 on which a pair of axle shafts 44 are mounted. These shafts 44 are driven through reducing gears 45 provided endwise of the driving shafts (not shown) of electromotors 47. These motors 47 are energized through one or more current collectors 49 urged by springs 46 against current-feeding lines or rails 50 suspended from the roof 27 of the box-sectioned girder or secured on the inner sides 25 or 26 of this girder. All the controllers and other devices for controlling the operation of the electromotors, as well as the electric circuits are housed within the bodies 23 of the vehicles. Electric braking resistors, not shown, may be also located within the vehicle bodies or on the roof of the vehicles 23. The truck axles 44 are provided with brakes of the expanding-shoe type or disc-type 48.

Mounted for free rotation on vertical shafts at either end of the truck frame 42 are guide wheels 40 engaging the vertical inner surfaces 25, 26 of the girder in order to maintain the bogie-truck constantly centred on the track. These wheels 40 are also rubber-tyred.

The carrier wheels 35 and guide wheels 40 (the latter also acting for obvious reasons as stabilizing wheels) may be provided if desired with safety discs or rims 351, 401 contacting the relevant track-forming surfaces 33, 34 and 25, 26 in case of excessive overload or in case of accidental deflation of the relevant tyres. The disc or rims 351 may also act as brake disc in addition to or as a substitute for the discs or drums 48.

The truck frame 42 comprises a vertical suspension member 51 extending through the interval between the horizontal portions 29, 30 of the box-sectioned girder; this member 51 is anchored to the vehicle body 23 through suspension means to be described presently.

An elastic suspension system is provided between the truck frame 42 and the vertical suspension column or like member 51; this system may be of any known or conventional type, for example comprising metal springs, pneumatic or hydro-pneumatic means, or a combination of these known systems, means responsive to the variations in the load and transverse inclination of the vehicle bodies being provided and correcting automatically the level and position of the vehicle body in relation to the girder 20, notably along and near the departure and arrival platforms of stations. Adequate jointed couplings associated with damping devices are provided in the suspension system in order to enable the vehicle bodies to oscillate longitudinally and transversely in relation to the trucks.

The suspension system of the vehicles may be of the double pendulum type as illustrated in FIGS. 2 to 5 of the drawings. The suspension column 51 is resiliently supported by the truck frame 42 through a pair of rubber bellows 102, 103 inflated with compressed air by means of an apparatus, not shown, whereby the pressure obtaining in these bellows can be ascertained and controlled at will or automatically. For this purpose, a known arrangement may be provided which consists in valves 421 and 422, which are secured to the truck frame 42. Said valves receive compressed air from the main system 423 and send it through the flexible conduits 424, 425 to the bellows 102, 103. The valves are controlled by rods 426, 427 whose upper ends are fixed to a traverse 428 suspended from the bogie and whose lower ends ensure the operation of the valves so as to maintain the distance between the non-suspended parts 49 and suspended parts 428 of the chassis. The suspension column 51 associated with these bellows constitutes the first pendulum or primary suspension system in the assembly. The suspension column 51 is provided with a horizontal transverse pivot pin 104 of which the axis is substantially coincident with the plane 33, 34 engaged by the carrier wheel 35. Under this pivot pin 104 the suspension column 51 is replaced by an inclined transverse member 105 carrying on each side a pair of stub shafts 106 inclined to the vertical so that the theoretical axes of these shafts 106 intersect the vertical axis of the suspension column 51 at a suitable level above the bogie-truck and form therewith the first pendulum. Mounted on each stub shaft 106 by means of ball-bearings or like devices is an arm 107 supporting the body 23 of the vehicle through the medium of a pin 101. The assembly comprising the members 105, 106, 107 and 101 constitutes the second pendulum of the suspension system. One or either of the arms 107 of each bogie-truck of the vehicle 23 are provided with, or form an integral part of, bell-crank levers 111 coupled to each other through one or two connecting rods 108 parallel to the longitudinal axis of the vehicle body and extending above the roof of the vehicle. This or these rods 108 are provided in their intermediate portion with one or two pistons 109 slidably mounted in one or two cylinders 110 rigid with the roof of the vehicle body and filled with a suitable hydraulic fluid. Adequate means are provided whereby the movements of the second pendulum are controlled by or responsive to those of the first pendulum, dash pot means being associated therewith for controlling from the driver's cab of the vehicle the movements of the piston 109 in its cylinder 110 and therefore the movements of the connecting rod 108. Thus, the transverse equilibrium of the body may be controlled as required, notably for restoring the body to a proper vertical position before the vehicle enters a station.

The additional transverse elongation may result not only from a rotational movement but also from a movement of translation; the transverse-stability correcting device may be constructed notably according to the principle of Watt's parallel motion as illustrated diagrammatically in FIGS. 6 and 7 wherein the suspension member or column 51 has anchored thereto a member 112 from which are suspended through links 113, 114, 115 and 116 the members 117 and 118 carrying the vehicle body 23 by means of stub shafts 119 and 120. When the transverse-stability correcting device operates by translation a return effect by gravity may be obtained notably as shown in FIG. 7 by mounting two linkages connected in accordance with a parallelogram of Watt in downwardly convergent planes.

As a rule, the position of the aforesaid torsional centre of the box-sectioned girder represents the most favorable position for the virtual centres of rotation of the primary suspension and of the transverse-stability correcting device when the latter operates by rotation.

In all cases the transverse-stability correcting device has servo means associated therewith and may be provided with dampers. These servo means may comprise essentially a power device of hydraulic, pneumatic or electrical type which, by taking as a reference the apparent vertical of the vehicle consisting of the line perpendicular to the plane 33, 34, will cause the transverse displacement of the vehicle bodies and notably return them to their vertical position within the limits of their

maximum permissible transverse inclination. The servo action may also be controlled by taking as a reference the transverse torque created in the box-sectioned girder by the transverse disturbing forces. In any case this power device is also adapted to suppress any transverse oscillation of the body likely to interfere with the passengers' comfort.

In all cases the two suspension systems—front and rear—of a same body **23** are interconnected either mechanically (for example by means of the connecting link **108** already mentioned) or through the medium of a fluid actuating the power device (for example a hydraulic or pneumatic cylinder) mentioned in the preceding paragraph. Thus, any swaying of the vehicle bodies is avoided.

It would not constitute a departure from the spirit and scope of this invention to take advantage of the capacity of the box-sectioned girder **20** in order to resist torsional stresses by applying the reactions resulting from various transverse efforts to the outer faces of the vertical portions **25** or **26** or to the lower faces of the horizontal portions **29, 30**.

In case the guide-wheels are arranged within the box-sectioned girder, as shown in FIG. 2, the line switching arrangement already described in the aforesaid Patent No. 2,825,291 may be suitably modified.

What I claim is:

1. A suspension railway system of the character wherein elongated hollow girder means having a longitudinally extending slot along the bottom thereof provides trackway means, the combination including bogie truck means adapted to roll on said trackway means within the girder means, vehicle means adapted to be carried by said bogie truck means, and suspension means connected between said bogie truck means and said vehicle means, said suspension means including first support means movably connected with the bogie truck means for lateral movement with respect to the bogie truck means about a virtual axis substantially above the level of the slot in the girder means, said suspension means also including second support means movably connected with the first support means at a location below the level of the slot.

2. The invention as defined in claim 1, wherein said second support means is movable laterally with respect to said first support means.

3. The invention as defined in claim 1, wherein said bogie truck means is provided with yieldable cushioning means, and said suspension means is provided with pivotal mounting means to be supported on said cushioning means, said pivotal mounting means being centered about virtual pivots disposed above the trackway means.

4. The invention as defined in claim 1, wherein said second support means includes a member extending transversely with respect to the trackway means, the extremities of the transverse member having pivotal connections with the vehicle means.

5. The invention as defined in claim 3, wherein said yieldable cushioning means includes a pair of fluid-tight bellows disposed laterally on opposite sides of the suspension means.

6. The invention as defined in claim 5, wherein means is provided to regulate the pressure of fluid within each of said bellows.

7. The invention as defined in claim 2, wherein said second support means includes a member extending transversely with respect to the trackway means, and said movable connection with the vehicle means includes a pair of links, one end of each link being pivotally connected to the respective extremities of said transverse member, said links being downwardly inclined toward their respective other ends and being pivotally connected at said other ends to the vehicle means.

8. The invention as defined in claim 2, wherein said first support means includes a horizontally extending member disposed below the level of said slot in the girder means, and said second support means includes two levers having pivotal connections medially of their respective extremities with said vehicle means at laterally spaced locations, each of said levers being connected with said horizontal members by means of a pair of links, each said link having a pivotal connection at one end with a respective extremity of one of said levers, the other end of each said link having a separate pivotal connection with said horizontal member.

9. The invention as defined in claim 8, wherein said two links are disposed for pivotal movement in respective planes which are downwardly convergent toward the center of the vehicle means, whereby the influence of gravity tends to center the vehicle means with respect to the bogie means.

10. The invention as defined in claim 1, wherein said bogie truck means includes two load-carrying wheel mechanisms spaced longitudinally along said trackway means, said suspension means including first and second support means connected between each of said mechanisms and said vehicle means, and including equalizing means connected between the respective second support means to give lateral movement of each support means an equal value up to a predetermined limit.

11. The invention as defined in claim 10, wherein said equalizing means includes dashpot means to control said lateral movement of the second support means.

12. The invention as defined in claim 10, wherein each of said second support means includes a pivotally mounted bell crank lever and a longitudinally extending rod pivotally connected between said bell crank levers, and said equalizing means includes a cylinder fixed to the vehicle means and a piston disposed in said cylinder fixed to said rod, said cylinder being adapted to contain fluid to yieldably resist movement of the piston.

13. The invention as defined in claim 1, wherein said suspension means includes means to control the angular position of the vehicle means with respect to the bogie truck means about an axis extending parallel with the trackway means to facilitate entry of the vehicle means into a station.

14. The suspension railway system as defined in claim 1, wherein the interior of said hollow girder means is provided with spaced vertical faces, and said bogie truck means is provided with vertical pneumatic tire wheels in rolling engagement with said trackway means, and with horizontally arranged guide rolls in rolling engagement with the internal vertical faces of said hollow girder means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,043,357	Strauss	June 9, 1936
2,060,402	Strauss	Nov. 10, 1936
2,623,475	Fraser	Dec. 30, 1952
2,825,291	Chadenson	Mar. 4, 1958

OTHER REFERENCES

The Engineer, April 29, 1960, pages 755 to 757, 28 Essex St., Strand, London, W.C. 2.

Elements of Mechanism, pages 295 to 298, by Schwamb, Merrill, and James, John Wiley and Sons, Inc. (1921).