RAILWAY CAR ROLL STABILIZING BOGIE

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FOREIGN PATENTS OR APPLICATIONS

A suspension for a high-speed railway vehicle comprises between the body and the bogie chassis a bolster platform which is connected to the body by a pivot allowing the free rotation of the bogie in the curves, in combination with springs. Moreover, the bolster platform is connected to a transom of the bogie chassis by an articulated trapezium, with springs ensuring the stability. The body can thus orientate itself in the direction of the centrifugal force in the curves without loss of the stability. The articulations of the trapezium are situated very low, which reduces to a minimum the dynamic transfers to the axles.

18 Claims, 10 Drawing Figures
Fig. 3.

Fig. 4.
Fig. 5.

Fig. 6.
RAILWAY CAR ROLL STABILIZING BOGIE

BACKGROUND OF THE INVENTION

The invention relates to the suspensions, of the tilting type, applicable more especially to railway vehicles intended to travel at very high speed on existing track.

In general, railway tracks are given a cant in their curves with a view to compensating for the effects of centrifugal force.

These cants are calculated for a predetermined maximum speed.

For this speed, the gravitational forces in conjunction with the centrifugal forces have a resultant in a direction normal to the track. The same goes for the passengers of the vehicles, the resultant of the forces applied being also perpendicular to the seats and to the floor: they therefore do not undergo any continuous lateral force, and this constancy of their "apparent vertical" ensures their optimum comfort.

The same does not hold if the running speeds differ from the predetermined maximum speed, which is generally the case.

At low speeds (for example with heavy goods trains), the centrifugal forces are very weak and the components of gravitational forces introduced by the cant in the centrifugal direction pull the material and the track towards the inside of the curve. This is one of the reasons why the transverse cant slopes of the tracks have been limited to the generally accepted maximum values, in other words an angle of 6° approximately.

Conversely, if in accordance with the present tendencies towards the increase in the speeds of fast trains, the predetermined speeds are exceeded in the curves, the centrifugal forces increase and are only partially compensated by the existing cants. This fact is not troublesome from the point of view of the tracks which, by virtue of symmetry, allow without discrimination forces of the same order towards the inside or towards the outside.

However, the situation of the rolling stock is different, since the presence of non-compensated centrifugal forces involves the appearance not only of transverse accelerations felt by the travellers, but also of a rocking torque applied to the suspension and which imposes on it an inconvenient tilt angle directed outwardly, that is to say in the wrong direction. This situation therefore appears undesirable and one has sought to remedy it by the following reasoning.

Any running speed (however high it may be) in a curve, it is always possible, through the condition of equilibrium defined above, to find a corresponding value of "optimum" cant, which would make the running speed a new basic speed. The difference between this optimum cant and the existing cant represents the "insufficiency of cant" which it is a question of compensating. (One can thus show, in particular, that to an "overspeed" of 41 percent — which doubles the centrifugal forces — there corresponds an insufficiency of cant equal to the existing cant.)

This being so, since there is no question of modifying the existing cant, the solution to the problem is evident: the insufficiency of cant has to be compensated by the rolling stock and, more especially — since the wheels have to preserve contact with the rails — by the suspended portion of the vehicles. It is accordingly sufficient to compel the median plane of the bodies to have, in relation to the normal to the transverse slope of the track, angles of tilt equal to the angular insufficiency of cant and directed towards the inside of the curve.

Various arrangements have been conceived to this end.

DESCRIPTION OF THE PRIOR ART

Thus it is that one has proposed to suspend the body of a vehicle about a longitudinal axis passing above the center of gravity, so that the body is oriented naturally in the transverse direction according to the resultant of the weight and of the transverse forces applied. This solution, ideal in itself, poses considerable problems of bulk.

It has also been proposed to connect a vehicle body to a bogie with the aid of oblique connecting rods defining, in the transverse plane of the bogie, a deformable articulated trapezium, the shorter base of which (at the upper portion) is integral with the bogie and the large base of which (at the lower portion) is integral with the body, the said connecting rods thus being loaded in tension by the weight of the body. This connection constitutes a transverse suspension of the stable "bifilar" type, with restoration by gravity, but examination of the geometry of the system shows that this restoration is necessarily too high since, under a given centrifugal force, the angle of tilt of equilibrium is always less than its optimum value, all the more so as the transverse force is itself greater. This device therefore contributes only an imperfect solution to the problem posed.

One can also envisage other solutions based on closed loop servo-control of the angle of tilt of the body by a control system receiving, amongst other input information, that relating to the value of the transverse force of semi-continuous character applied to the vehicle. The reliability of such systems is no longer, nowadays, debatable and their cost can be reduced to reasonable limits. However, these solutions require the use of a large source of mechanical energy.

OBJECTS OF THE INVENTION

It is an object of the invention to provide a suspension system, allowing the aforesaid disadvantages to be obviated.

Particular objects of the invention are to ensure: a. tilting, compensating insufficiencies of cant by angles of tilt of the body capable of at least reaching the maximum values allowed for the angles of cant of the tracks; b. vertical suspension of body insensitive to transverse dynamic forces; c. a lowered longitudinal attachment of the chassis of bogies to the bodies of the vehicles; d. insensitivity of the equilibrium of the body to the action of lateral winds; e. freedom of pivoting of the bogies facilitating their entry into curves; f. and in a preferred embodiment, the insensitivity of the vertical suspension to the dynamic transfers of load due to longitudinal acceleration or deceleration.

It takes account in particular of two important points concerning the dynamics of railway vehicles travelling at high speed.

The first, relating to the attachment of the bogies to the vehicle bodies, requires that the points of application to bogie chassis of the longitudinal resultants of inertia of the body (upon acceleration or upon braking)
be situated at a level as close as possible to that of the rails, so as to reduce to a minimum the dynamic transfers of vertical loads between axles of the bogie.

The second concerns the effects of the lateral winds (gusts) on the transverse equilibrium of vehicles, which are frequently empty. It is appropriate that the suspension connections of these vehicles be conceived in such a way that the transverse aerodynamic thrusts (generally applied in the vicinity of half the height of the lateral surface of the body) have as small effects as possible on the suspensions both lateral (swaying, drift), and vertical (undesirable rolls or tilt angles).

SUMMARY OF THE INVENTION

In order to satisfy more especially these desiderata, the invention consists, principally, in suspensions of vehicles of the type in question comprising, as is known, on each carriage or bogie whether or not provided with a relatively rigid primary suspension a bolster, which will also be referred to as, an intermediate element or a platform between the bogie chassis and vehicle body, and connected to these latter by connection systems, in arranging these systems in such a way that the one interposed between bolster platform and body comprises, on the one hand, a kinematic connection suited to ensure only freedom of vertical translation and freedom of rotation about an axis for the displacement of the bogie and, on the other hand, a resilient connection for bearing the vertical loads, and that the connection system between platform and bogie chassis comprises, on the one hand, a kinematic connection arranged so as to allow the platform and the body to move in rotation, in relation to the chassis, in a transverse plane itself articulated about a median transverse axis of the chassis and situated at the base of this latter, and, on the other hand, an elastic connection suited to generate in the plane of the platform transverse components counter-balancing the components of gravity generating instability. The bogie chassis which includes side frames and a connecting transom will also be referred to as the lower frame.

In particular, the kinematic connection between platform and bogie chassis will be constituted essentially by an articulated trapezium system, with the large base on the chassis and the bogie small base on the platform, the lateral sides of the trapezium being articulated, at their base, on a median bottom traverse of the chassis, by articulations of the type with swivel joint or universal joint.

Such an assembly, completed advantageously by the various arrangements explained hereinafter, enables suspensions to be realised which meet the various desiderata referred to above. In particular, stability is constantly ensured, whatever may be the forces of the lateral wind or the centrifugal force, and this, respectively, due to the geometric properties of the platform/chassis connection, and by means of the resilient restoring means provided at the base of the chassis. On the other hand, due to the fact that the stresses due to acceleration or decelerations are transferred to the median transverse axis arranged at the base of the chassis, which axis will be arranged as low as possible, below the plane of the axes of the wheels, the said stresses will entail, between axles of each bogie, only transfers of load which are very reduced and capable also of being transmitted from the body to the bogies in such a way that the vertical suspension of the body remains insensitive to the dynamic effects of these accelerations or decelerations.

BRIEF DESCRIPTION OF THE DRAWINGS

In the attached drawings, which are, of course, given by way of example:

FIGS. 1 and 2 show diagrammatically and respectively in elevation and semi-section and in partial side view, a railway vehicle having bogies which may have a relatively stiff primary suspension, and provided with a suspension system in accordance with the invention.

FIGS. 3 and 4 show similarly, respectively in plan view and in side view, portions being broken away, another embodiment of the invention.

FIG. 5 shows in plan a variant of the embodiment of FIG. 3;

FIG. 6 shows in section, on a larger scale, a connection element of the assembly of FIG. 5;

FIGS. 7 and 8 show respectively and partially, in elevation and in side view, an assembly similar to that of FIGS. 1 and 2, but of another embodiment;

FIG. 9 shows in partial elevation an assembly similar to that of FIGS. 3 or 5 and 4, but according to a further embodiment;

FIG. 10, finally, shows diagrammatically a vehicle provided with suspensions in accordance with the invention, according to the embodiments of FIGS. 3, 4 and 5.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The drawings show suspensions between a body I of a railway vehicle, and one of its bogie trucks. The bogie chassis, also referred to as the lower frame includes side frames 2 and a connecting transom 11. An intermediate movable element or bolster 3, which will also be called a "platform," is connected to the body and the chassis respectively by two connection assemblies or connection stages, namely: the upper stage E₂ between body and platform, and the lower stage E₁ between platform and bogie chassis.

Each of the stages E₁ and E₂ comprises, co-acting in parallel:

a "kinematic connection" device, defining geometrically the relative mobilities of the elements in question, and

a "resilient connection" device controlling, through springs, the equilibrium of the stresses brought into play in accordance with at least one of the aforesaid relative mobilities.

The two connection stages have distinct main functions:

the upper stage E₂ ensures the function of guided vertical suspension of the body and the pivotal freedom of the bogie;

the lower stage E₁ ensures the function of pendular transverse suspension of the body and the hunting of the bogie.

The two stages co-operate through their kinematic connections in the function of effecting longitudinal attachments between body and bogie.

The two stages perform the following functions: as regards the upper stage E₂, the kinematic connection keeps the platform and the body parallel one to the other and allows between them only a freedom of vertical translation (sus-
pension) and a freedom of rotation about their common vertical median axis (bogie pivoting), while the resilient connection transmits the whole of the static and dynamic vertical loads from the body to the platform (suspension) while tolerating limited tangential relative displacements upon the pivoting of the bogie.

The kinematic connection of the lower stage \( E_2 \) allows the platform to move, in relation to the bogie chassis, in a transverse plane itself articulated about a median transverse axis situated at the bottom portion of the chassis, this latter mobility permitting hunting of the bogie.

The mobility in the transverse plane will be defined essentially, as shown in FIGS. 1 and 2, by the deformation of a trapezium having articulated rigid elements whose small base is formed by the platform \( E_3 \), the large base formed by the bogie chassis, and whose sides are constituted by two connecting elements 6, comparable (in projection onto the plane of the movement) to two oblique connecting rods converging (in the state of rest and on a horizontal track) at a point such as \( I \) of the median plane of symmetry of the body, the altitude of which point is advantageously situated, as a result of suitable choice of the proportions of the articulated trapezium substantially at the level of half the height of the lateral surface of the body so as virtually to cancel any movement of rocking under the action of a thrust of lateral wind \( F_t \).

This mobility finds expression, for any transverse excursion \( GG' \) of the center \( G \) of the platform \( E_3 \) in relation to its mean position, in a tilting of this platform — and therefore of the body which is fastened to it — about a longitudinal axis, a tilting whose angular value defines the angle of tilt \( \gamma \) of the body.

It will be noted immediately that the tilting body suspension thus far realized is unstable when, as is the case here, the force of gravity is directed from top to bottom. To any divergence of the center of the platform \( E_3 \) in relation to its mean position of equilibrium (or metastable) position illustrated in solid lines in FIG. 1, there corresponds in effect the application to this platform of an unbalanced torque, increasing with this divergence and directed in the direction of its increase. This is a negative restoration force. It can be seen moreover in FIG. 1, where a displaced position (shown in broken lines) has the effect of causing the center of gravity \( G \) to drop to the position \( G' \).

It is the main role of the resilient means of the lower stage \( E_2 \) to re-establish the equilibrium of the suspension by developing, between the bogie chassis and the platform \( E_3 \), systems of stresses whose moments along the platform counterbalance the components of gravity which create the unbalancing torque.

Thus, through the presence of this resilient restorability, the stability of the assembly is maintained, without however opposing the momentary angular deviation under the effect of the centrifugal force, the resilient means only intervening and only being calculated to counterbalance the component of gravity resultant from tilting.

Some practical forms of embodiment, solely of course by way of example, will now be described in more detail.

Constitution of the upper stage \( E_2 \).

As regards first of all the kinematic connection, one can have recourse for example, in accordance with the simplest embodiment, illustrated in FIGS. 1 and 2, as well as 7 and 8, to a central pivot 4, integral with the bottom of the body 1, co-operating for vertical sliding and for pivotal motion with a coaxial socket bearing 5, integral with the platform 3.

Appropriate lubrication of this connection should be arranged to minimize the effects of sliding friction of the behaviour of the vertical suspension. The sleeve bearing 5 could instead be connected to the platform 3 with the aid of known resilient elements (such as those described in French Pat. No. 1,272,175 of 12th August 1960) allowing a great flexibility in the axial direction of slide of the pivot, at the same time as a very great rigidity with regard to any radial or conical forces.

Other embodiments, shown in FIGS. 3 to 6, as well as 9 and 10 and which eliminate sliding, consists in connecting the platform 3, at its center in an articulated manner, to a vertical pivot 18 carried at 17 by the said platform and traversing a clevis or the like 19 integral with at least one arm 20 mounted in an oscillating manner on the body, at a suitable distance \( b \) from the median transverse axis of the bogie.

In particular, a triangular disposition may be used, comprising two arms of this type converging on the aforesaid pivot and articulated about axes 21a, 21b, which are also convergent, or else a bipod single assembly 20 such as that of FIG. 3 may be used with interpolation of resilient bushes at the articulations.

Such an articulated triangle assembly has the effect of keeping the pivotal axis 18 in the median body plane while allowing it — as well as the platform 3 — angular movement in relation to the bottom of the body 1, in the longitudinal median plane, very close to the vertical translation tangent to the position of equilibrium.

A variant, shown in FIGS. 5 and 6, consists in having recourse to a single arm 20, arranged in the vertical median plane of the body and articulated at 21, in combination with transverse stays 20 substantially horizontal in the mean position of rest and articulated at their ends respectively to the body 1 and to the central arm 20 with the aid of appropriate clevises 51, the said stays 20 being provided with a limited longitudinal extensibility obtained for example through the incorporation at their terminal articulations of elastic bushes such as 52 (FIG. 6).

In order to ensure the parallelism of the body 1 and of the platform 3 in the transverse plane, this suspension having an oscillating arm advantageously includes an anti-roll device, arranged for example in the following manner (FIGS. 3 to 5 and 9).

Articulated to the body 1, symmetrically at 22a, 22b, is a strong tubular transverse anti-roll bar 23, integral at each of its ends with levers 24, which are substantially horizontal and have terminal clevises 24a and 24b, situated (in the absence of deflection) in the vertical median transverse plane of the bogie chassis and of the platform 3. The clevises 24a and 24b are connected respectively to pivot pins 25a and 25b mounted at the ends of the platform 13 by substantially vertical connecting rods 26, articulated to the said clevises and pivot pins.

The anti-roll bar 23, thus made insensitive by the initial verticality of the connecting rods 26, to the displacements \( \beta \) of the bogie, opposes very effectively
the relative transverse inclinations of the platform 3 and of the body 1 and limits to negligible values the undesirable angles of tilt due to the non-compensated centrifugal forces and to the action of lateral wind.

As regards now the resilient connection means of the upper stage E₂, it is constituted for example by vertical suspension springs 7 (FIG. 1) inserted between body 1 and platform 3 and the choice of which is arbitrary (helical springs, pneumatic springs, etc.) as well as their arrangement (number, spacing, etc.). Always equally loaded, they have to satisfy only one special requirement which is to tolerate the tangential relative displacements of their support surfaces corresponding to the maximum displacements δm of the bogies (typically 6°).

Constitution of the lower stage E₁

First of all the kinematic connection consists essentially in the aforementioned trapezoid.

In the first embodiment, shown in FIGS. 1 and 2, the lower stage comprises two identical inverted rigid triangles 6 disposed symmetrically on either side of the longitudinal vertical median plane of equilibrium at rest of the bogie chassis and of the platform 3. The triangles 6 are articulated at their upper base portions on two longitudinal pins 8 integral with the platform 3 and, by their lower apices, which carry universal joints 9 — having a swivel joint, for example, — on to cooperating support surfaces 10 — for example cups — integral with the bogie chassis and situated as low as possible — for example at the ends, adjacent to the longerons, of a lower transverse or transom 11 forming the large base of the transverse suspension trapezoid.

The triangles 6 thus transmit to the bogie chassis the vertical loads of the body 1 and of the platform 3 under compression stresses.

They also transmit the longitudinal stresses of inertia acting on these same elements upon braking (and upon acceleration if the bogie is a motor bogie).

Thus if fL is the total inertia force at the center of gravity of the vehicle in the event of braking, a force J/2 is applied to each swivel joint 9 at a distance h from the permanent way. Under these conditions, if L is the spacing of the front and rear wheel axles, one has for the increase in load dZ on the front axle, the formula:

\[ + dZ = \frac{(J/2) \ h}{L} \]

As h is small, it can be seen that the suspension in accordance with the invention gives rise to only small differences of adhesion load between the axles of the bogie under the effect of the braking.

In another embodiment (preferable, it would seem, by virtue of possible difficulties in construction and maintenance of the swivel joints 9), the function of the universal joint is divided into two orthogonal rotations. For example, in the embodiments shown in FIGS. 4 and 7 to 9, the lower transverse 11, instead of being integral with the bogie chassis, is connected to this latter, in the vicinity of the longerons, by two elastic articulations 13 capable of transmitting to the said longerons the vertical and transverse loads emanating from the body 1 and from the platform 3 but provided furthermore, about their common longitudinal axis (traverse to the bogie chassis) with angular elastic mobility to allow hunting of the bogie. To the traverse 11, thus freed for pivoting about its longitudinal axis and at the locations of the ends of the large base of the suspension trapeze, there are rigidly fastened two pins 14, which are parallel and identical (save in length) to the pins 8 of the platform 3. On one side and the other, are pivoted a variant 6a of the triangle 6, modified for this purpose, in the form of a braced side-beam, ball joint 9 of the lower apices of the triangles 6 in FIG. 1 being simply replaced by the articulations co-operating with the pins 14.

This embodiment offers the advantage of combining in a single subassembly all the elements of the transverse kinematic connection and of facilitating the mounting thereof, the articulation blocks 13 being able to be slipped easily between the longerons of the chassis 2 and held in position before fixing.

The resilient connection which the lower stage E₁ comprises is arranged, for example, in the following manner.

In principle, any system of springs — such as that schematized at 12 in FIG. 1 — acting in the plane of transverse suspension and bearing respectively on the chassis and on the platform 3 is capable — when suitably dimensioned — of applying to the said platform transverse forces opposing the negative restoring force due to the unbalancing torque due to gravity.

In preferred embodiments, those spring devices will be chosen which, in addition to exerting the desired transverse restoration forces, are capable of exerting in a permanent manner, upward thrusts on the platform 3, whose values can thus diminish the gravitational loads applied to the triangles 6 or cross-braced side-beams 6c and to their articulations.

In a first embodiment (FIGS. 7 and 8), applicable more especially to the case where the lower traverse 11 is endowed with freedom for pivotal movement, two pins 14a are mounted on either side of the central portion of this traverse, parallel to the end pins 14, and on these pins 14a are articulated the lower ends of two pairs of telescopic sliding connecting rods 15, the upper ends of which are, in their turn, articulated on the pins 8 of the platform 3, between the articulations of the side beams 6c. Each end of the sliding connecting rods 15 is provided with a plate 16. A helical spring 12 is mounted on each rod between the two plates, the said spring being in a state of prestressed compression in the mean position of the system. The connecting rods 16 therefore exert equal oblique thrusts on the pins 8. The horizontal components of these thrusts on each side counter-balance one another but their components F in the direction of the planes of the side beams 6c, are directed upwardly against the loads exerted by gravity.

It can be seen furthermore that to any transverse displacement of the platform 3, from its median position of symmetry, there corresponds an extension (and therefore a reduction in thrust) of the pair of sliding connecting rods 15 situated on the side of this displacement and a shortening (and therefore an increase in thrust) of the other pair. The components of these thrusts, acting transversely on the platform 3, are added algebraically and, for a suitable choice of the characteristics of the springs 12, create the desired compensating resilient restoration.

Another embodiment of resilient restoration (shown in FIG. 9), effecting a reduction in the static loads applied to the triangles 6 or side beams 6c, uses — still in a symmetrical arrangement and in the transverse plane of suspension — rubber or rubber-metal elements 27, of substantially prismatic shape, whose bearing sur-
faces, which may be bonded to rigid plates 28, are secured to the surfaces with which they co-operate, these surfaces facing each other respectively on the bottom of the platform 3 and on the traverse 11. Suitably orientated and initially dimensioned so as to be prestressed in compression on assembly in their position of equilibrium, these elements are subjected, upon transverse displacements of the platform 3, to normal and, more importantly, to tangential deformations. The resilient resistance to shearing of these elements plays a major role in obtaining the transverse restoring forces counter-balancing the unbalancing torque due to gravity.

One of the advantages of this solution, in addition to its simplicity, is the automatic contribution, through elastomeric hysteresis, of an appreciable damping of swaying oscillation which can affect the body, more especially in the transitory conditions separating two stable successive values of the angles of tilt or in the case of transverse shocks due to the track.

Where the platform is pivotally connected, to at least one arm or system of arms 20 (as in FIGS. 3 to 5), articulated at one end to the body 1, a suitable geometrical arrangement is preferably chosen whereby any tendency of the body 1 to incline forwards or rearwards under the action of a deceleration or of an acceleration is avoided.

For this purpose, it is sufficient, as is easily demonstrated, and as is known in the matter of connections of sets of wheels for road vehicles, for the transverse plane AB (FIG. 10) passing through the transverse articulation 9 or 13 of the aforesaid trapezia on the traverse 11 (Point A, FIG. 10) and through the articulation 21 of the arm or arms 20 (Point B, FIG. 10), to pass also through the center of gravity G of the body 1.

If E/2 is half the distance between the two bogies and b the horizontal distance between the traverse 11 and the articulation 21, while h, h₁ and H designate respectively the heights above the rail of the articulations 9 or 13, 21 and of the center of gravity G, it is then necessary that

\[ b/(E/2) = (h₁ - h)/(H - h) \]

CONCLUSION

In the embodiments described above, simple means ensure the required stability, while allowing the body to orientate itself suitably under the effect of the centrifugal force, when the speeds exceed the basic value corresponding to the cant of the track. Furthermore, the general suspension of the body is insensitive to the actions of the accelerations or accelerations and to that of the lateral winds.

As is self-evident, and as emerges moreover already from the foregoing, the invention is in no way restricted to those of its modes of application, nor to those of its embodiments, of its various parts, having been more especially envisaged; it embraces, on the contrary, all the variants thereof. In particular:

the maximum value of the transverse excursion of the platform 3 could be limited, the intervention of a progressive stop 29 (FIG. 9) acting for example between the platform 3 and the longitudinal of the chassis, elastomers could be used for the various articulations between rigid elements;

and resilient restoration forces generated on pivoting of the adhered elastomeric articulations can be used as auxiliary restoration forces towards the mean position of the co-operating elements.

I claim:

1. A suspension system for supporting at least a portion of a vehicle body on a bogie, comprising:
   a lower frame including side frames supported on wheel axles of the bogie and a transom extending from one side frame to the other and rigidly connected to said side frames,
   a bolster located above the lower frame and a vehicle body mounted on the bolster.
   first mechanical connection means for interconnecting said bolster and said lower frame, said first mechanical connection means comprising an articulated system pivotally connected to the lower frame and the bolster, the instantaneous center of rotation of which articulated system is situated at a higher level than the level of the center of gravity of the body, such that tilting movement from an upper right position of said bolster relative to said lower frame transversely of the vehicle frame lowers the center of gravity of the vehicle body,
   first resilient means interconnecting said lower frame and said bolster for exerting on said bolster a resilient restoring force opposing instability of the body due to lowering of the center of gravity of the body during tilting movement of the body around said center of rotation away from a vertical line through the center of the lower frame,
   a second mechanical connection between said bolster and said body including means for limiting movement between said bolster and said body to relative vertical displacement and relative rotation about a substantially vertical axis,
   and a second resilient means interconnecting the bolster and the body for resiliently transmitting weight loads between the body and the bolster.

2. A suspension system in accordance with claim 1, in which the first mechanical connection comprises an articulated trapezium transverse of the vehicle body, with the large base on the lower frame and the small base on the bolster, the inclined sides of the trapezium being articulated, at their lower ends, on the transom of the lower frame by articulations of the type having a swivel or universal joint.

3. A suspension system according to claim 2, in which the sides of the trapezium converge towards a point situated substantially on the level of half the height of the lateral surface of the vehicle body.

4. A suspension system according to claim 2, in which each side of the trapezium is arranged in the form of a triangle whose upper base is pivoted on the bolster and is parallel to the longitudinal vertical median plane of the vehicle body, while the lower apex is articulated on the transom of the lower frame.

5. A suspension system according to claim 4, in which the lower apex of each triangle comprises a swivel joint mounted in a cup carried by the transom of the lower frame.

6. A suspension system in accordance with claim 4, in which the lower apex of the triangle comprises a fork articulated to the transom of the lower frame.

7. A suspension system according to claim 1, in which said second mechanical connection between said body and said bolster includes a vertical pivot pin cooperating with a sleeve carried by the bolster.
8. A suspension system according to claim 1, in which said second mechanical connection comprises at least one arm articulated at one end to the body and at the other end to the bolster by a pivot traversing this latter.

9. A suspension system according to claim 8, wherein the first mechanical connection comprises two arms articulated to the body by spaced articulations incorporating resilient sleeves.

10. A suspension system according to claim 8, in which the arm is articulated on the body about a single axis, and is stayed by two symmetrical stays each articulated at one end to the body and at the other to the bolster and provided with slight longitudinal extensibility.

11. A suspension system according to claim 8, and further comprising an anti-roll device.

12. A suspension system according to claim 8, wherein the vehicle body is a railway car and wherein the extension of the plane passing through the transverse axis of rotation of the lower frame relative to the bolster and through the axis of articulation of the arm relative to the body also passes through the center of gravity of the vehicle body.

13. A suspension system according to claim 1, in which said first resilient means comprises springs arranged so as to allow limited relative movements in rotation of the bolster relative to the body.

14. A suspension system according to claim 1, in which said second resilient means comprises springs interposed obliquely to said bolster.

15. A suspension system according to claim 14, in which said springs are pre-compressed, so as to give rise, in the transverse direction of the bolster, to a resultant force which, being zero in the central position of the body relative to the bolster, increases as the body and bolster move transversely from their central position of equilibrium, to thus create a restoring force opposing such movement.

16. A suspension system according to claim 14, in which said springs number at least two, and are interposed between the transom of the lower frame in the proximity of its center, and two points of attachment arranged adjacent the ends of the bolster.

17. A suspension system according to claim 14, in which said springs are constituted by rubber masses.

18. A suspension system according to claim 1, wherein the median transverse axis of the lower frame, about which the bolster can in effect pivotally tilt, is arranged below the axes of the wheels of the lower frame, in the vicinity of the track, so as to limit the size of the longitudinal rocking torque of the lower frame under the action of forces of acceleration or of deceleration.