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(54) **RUNNING GEAR UNIT FOR A RAIL VEHICLE**

(57) The present invention relates to a running gear unit for a rail vehicle, comprising a running gear frame unit (104), a traverse unit (109), and a suspension unit (106), in particular, a secondary suspension unit. The running gear frame unit (104) is configured to be supported on at least one wheel unit and defines a longitudinal direction, a transverse direction and a height direction. The traverse unit (109) is configured to support a wagon body (101.1) unit of the rail vehicle. The suspension unit (106) suspends the traverse unit (109) to the running gear frame unit (104). The suspension unit (106) comprises at least one spring unit (110) and at least one pendulum unit (111) arranged kinematically in series in

a force flux between the running gear frame unit (104) and the traverse unit (109). The at least one pendulum unit (111) has a first end section with a first articulation (111.3) associated to the running gear frame unit (104) and a second end section with a second articulation (111.4) associated to the traverse unit (109). The first articulation (111.3) and the second articulation (111.4) allow relative motion between the running gear frame unit (104) and the traverse unit (109) in the transverse direction and/or in the longitudinal direction by a pendulum motion of the pendulum unit (111). The first articulation (111.3) and/or the second articulation (111.4) is formed by the at least one spring unit (110).

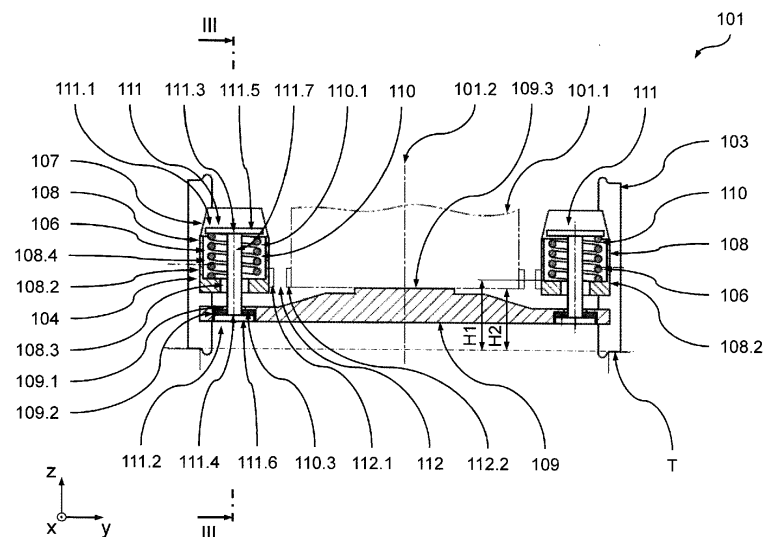


Fig. 2

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a running gear unit for a rail vehicle, comprising a running gear frame unit, a traverse unit, and a suspension unit, in particular, a secondary suspension unit. The running gear frame unit is configured to be supported on at least one wheel unit and defines a longitudinal direction, a transverse direction and a height direction. The traverse unit is configured to support a wagon body unit of the rail vehicle. The suspension unit suspends the traverse unit to the running gear frame unit. The suspension unit comprises at least one spring unit and at least one pendulum unit arranged kinematically in series in a force flux between the running gear frame unit and the traverse unit. The at least one pendulum unit has a first end section with a first articulation associated to the running gear frame unit and a second end section with a second articulation associated to the traverse unit. The first articulation and the second articulation allow relative motion between the running gear frame unit and the traverse unit in the transverse direction and/or in the longitudinal direction by a pendulum motion of the pendulum unit. The present invention further relates to a rail vehicle comprising such a running gear unit.

[0002] In order to ensure good riding comfort for the passengers in such a rail vehicle, the secondary suspension typically has to provide a certain amount of lateral deflection between the running gear and the supported wagon body. More precisely, good passenger riding comfort typically requires a secondary suspension which is comparatively soft in the transverse direction.

[0003] In many known bogie designs, the wagon body is supported on the running gear frame via springs (typically helical springs) immediately arranged between the running gear frame and the wagon body. Such designs have the disadvantage that the springs, when deflected in a direction transverse to the longitudinal spring axis, are fairly rigid in the transverse direction, which is undesired in terms of riding comfort. Attempts to solve this problem are known, for example, from WO 2006/021360 A1, where a laminated rubber metal spring is interposed between the helical spring and the running gear frame in order to provide a sufficient amount of lateral softness of the secondary suspension.

[0004] However, such solutions require additional components and further building space, which is typically strongly limited in modern rail vehicle running gears. Moreover, irrespective of the number of components of the secondary suspension, this approach with the bolster sitting on top of the running gear frame has its disadvantages in vehicles where a low floor wagon body is required. This is due to the fact that, in such cases, the bolster has to have a generally U-shaped design, where the shanks of the bolster have to pass the longitudinal beams of the running gear frame (in the height direction)

in order to have the (transversely centrally located) base of the bolster at a sufficiently low height level for such a low floor wagon body. Apparently, such a design strongly limits the transverse dimension of the wagon body available between the shanks of the bolster.

[0005] Another approach to provide lateral softness of the secondary suspension is followed in generic running gear units as they are known in the art, for example, from the so-called Minden Deutz bogies (e.g. their MD36 and MD50 series). Typically, such running gear units have a traverse unit in the form of a bolster suspended to the running gear frame via two pendulums per running gear side. The bolster carries the secondary suspension, typically in the form of helical springs, which support the wagon body. This design is advantageous in terms of riding comfort, since relative motion between the running gear frame and the supported wagon body in the transverse direction is possible via the pendulum motion of the pendulums without requiring deflection of the spring units of the secondary suspension in this transverse direction (i.e. typically without requiring noticeable deflection of the helical springs transverse to their longitudinal spring axis). One problem however, with these running gears is the fact that they require a considerable amount of building space for the individual suspension components, such building space, as mentioned, typically being fairly limited in a modern running gear for rail vehicles.

SUMMARY OF THE INVENTION

[0006] Thus, it is the object of the present invention to provide a running gear unit as described above, which does not show the disadvantages described above, or at least shows them to a lesser extent, and which, in particular, facilitates a more space-saving configuration relaxing the building space constraints within the running gear.

[0007] The above objects are achieved starting from a rail vehicle unit according to the preamble of claim 1 by the features of the characterizing part of claim 1.

[0008] The present invention is based on the technical teaching that a more space-saving configuration relaxing the building space constraints within the running gear can be accomplished, if the spring unit also integrates the function of one of the articulations on the pendulum unit.

[0009] This may be done by linking the pendulum unit in such a manner to the spring unit that the pendulum moment causing the pendulum motion is immediately introduced into the spring unit. On a straight level track, this pendulum moment acts on the spring unit in a direction transverse to the height direction, such that it causes an uneven load on the spring unit in the height direction. The spring unit (which is arranged in such a manner that its primary support is provided in the height direction) may easily respond to such an uneven load in the height direction by uneven deflection in the height direction, thereby generating or defining, respectively the tilt or pen-

dulum motion of the pendulum unit.

[0010] Hence, for example, even with conventional coil springs, the longitudinal elasticity of the spring unit (i.e. the elasticity of the spring unit along the spring unit longitudinal axis) is used to provide one of the tilt axes of the pendulum and, hence, the lateral excursion of the wagon body with respect to the running gear frame unit.

[0011] It will be appreciated that, using the same spring unit as in a conventional configuration with the traverse sitting on top of a spring unit supported by the running gear frame unit, the transverse rigidity of this coupling between the wagon body and the running gear frame unit is way softer compared to this conventional design. Moreover, this transverse rigidity may be easily adjusted by the effective pendulum length of the pendulum unit (i.e. the effective distance between the centers of rotation of the first and second articulation).

[0012] Overall, the functional integration of the tilt axis of one of the articulations within the spring unit, on the one hand, leads to an advantageous reduction of the number of components required for the suspension unit and, apparently, already for this reason reduces the building space required and overall cost.

[0013] Moreover, the functional integration of the articulation within the spring unit greatly facilitates achieving a nested design where the pendulum unit is at least partially received within a space provided by the spring unit. Hence, an even more compact and space-saving design may be achieved.

[0014] Hence, according to one aspect, the present invention relates to a running gear unit for a rail vehicle, comprising a running gear frame unit, a traverse unit, and a suspension unit, in particular, a secondary suspension unit. The running gear frame unit is configured to be supported on at least one wheel unit and defines a longitudinal direction, a transverse direction and a height direction. The traverse unit is configured to support a wagon body unit of the rail vehicle. The suspension unit suspends the traverse unit to the running gear frame unit. The suspension unit comprises at least one spring unit and at least one pendulum unit arranged kinematically in series in a force flux between the running gear frame unit and the traverse unit. The at least one pendulum unit has a first end section with a first articulation associated to the running gear frame unit and a second end section with a second articulation associated to the traverse unit. The first articulation and the second articulation allow relative motion between the running gear frame unit and the traverse unit in the transverse direction and/or in the longitudinal direction by a pendulum motion of the pendulum unit. The first articulation and/or said second articulation is formed by said at least one spring unit.

[0015] It will be appreciated that the running gear frame unit, typically, is a running gear frame defining first and lateral sides of the running gear, while the traverse unit typically is a bolster or the like extending between one lateral side and the other lateral side of the running gear to support the wagon body. However, any other desired

configuration may be selected in the context of the present invention.

[0016] As mentioned above, the functional integration of the articulation within the spring unit may be obtained in any suitable way. Preferably, to do so, the at least one pendulum unit is connected to the at least one spring unit in such a manner that a pendulum moment causing the pendulum motion is introduced into the spring unit. This causes uneven deflection on the spring unit which results in the desired tilt or pendulum motion, respectively. Preferably, the spring unit defines a support direction for supporting the traverse unit on the running gear frame unit, and the at least one pendulum unit is connected to the at least one spring unit in such a manner that the pendulum moment is arranged transverse to the support direction, in particular, perpendicular to the support direction. By this means a particularly efficient configuration making use of the primary rigidity of the spring unit in its support direction is achieved (rather than using the secondary rigidity transverse to the support direction, which, in many cases, is undesirably higher than this primary rigidity).

[0017] It will be appreciated that the advantages of the functional integration of the articulation within the spring unit in terms of the reduction of the required number of components may be achieved with any desired and suitable arrangement of the components of the suspension unit. Hence, for example, a configuration may be chosen where two pendulum elements of the pendulum unit are located on opposite sides of the spring unit. Preferably, as mentioned above, a nested arrangement is selected, wherein the pendulum unit defines a pendulum longitudinal direction, and the at least one spring unit defines a pendulum receptacle, which extends along the pendulum longitudinal direction and receives at least a part of the pendulum element. For example, in such a case, the pendulum unit may be located in a receptacle formed by an interstice or gap between two spring elements of the spring unit.

[0018] Moreover, such a solution is particularly advantageous and yields particularly space-saving configurations, if a spring element of the spring unit itself provides such a receptacle. Hence, with certain embodiments of the invention, the at least one spring unit comprises a spring element and the receptacle is an internal receptacle of the spring element extending through the spring element. With certain embodiments, the at least one spring unit may comprise a coil spring element, the receptacle then being defined by an inner circumference of the coil spring element. With further variants, the at least one spring unit comprises a rubber spring element, in particular a laminated rubber metal spring element, the receptacle then being defined by an axial aperture within the rubber spring element. Any of these variants yields particularly space-saving configurations, since the pendulum unit extends through a space confined by the spring unit, which otherwise would typically be unused.

[0019] Basically, any desired and suitable setup may

be used for the pendulum unit, which guarantees that the tilt axis of one of the first and second articulations is defined and provided by the spring unit. With certain preferred embodiments, the pendulum unit has a pendulum element extending between the first end section and the second end section, and the first end section and/or the second end section forms a first contact section contacting the at least one spring unit. By this means, very simple configuration may be achieved for the functional integration of the articulation within the spring unit.

[0020] Preferably, the first contact section is rigidly connected to the pendulum element, such that a simple and direct introduction of the pendulum moment (causing the pendulum motion) into the spring unit is achieved. Basically, any desired and suitable geometric design of the contact section may be selected. Typically, with fairly simple to implement designs, the first contact section extends in a direction transverse to a pendulum longitudinal axis of the pendulum element. Moreover, a fairly simple and compact configuration is achieved, if the first contact section is a substantially plate shaped element.

[0021] It will be appreciated that the other articulation of the pendulum unit may also be designed in any desired and appropriate way providing compensation of the necessary tilt between the pendulum unit and the component linked to it (i.e. the running gear frame unit or the traverse unit). Hence, preferably, the end section of the pendulum unit located opposite to the first contact section comprises an articulation unit forming part of one of the first articulation and the second articulation, the articulation unit contacting one of the running gear frame unit and the traverse unit.

[0022] For example, a conventional rotational link, such as a simple hinge element or a ball link element, may be used for the articulation at the other end of the pendulum unit. With other embodiments, however, the articulation unit comprises at least one resilient element. Hence, at this end as well, the resilient component may be used to define the tilt axis at the other articulation. With certain robust and simple to implement embodiments, the at least one resilient element may be a rubber spring element, in particular a laminated rubber metal spring element. Here again, the tilt compensation may be achieved by uneven elastic deformation of the rubber spring element.

[0023] With other embodiments, however, a similar articulation concept is used at both ends of the pendulum unit. Hence, in these cases, the at least one resilient element may be at least one spring element of the at least one spring unit. This yields the same articulation functionality at both ends of the pendulum unit.

[0024] With preferred embodiments, the articulation unit comprises a second contact section of the pendulum unit contacting the at least one resilient element. Again, in a manner similar to the configuration at the other end of the pendulum unit, the second contact section may be rigidly connected to the pendulum element, thereby yielding a very simple and robust design. Furthermore, the

second contact section may again extend in a direction transverse to a pendulum longitudinal axis of the pendulum element. Moreover, the second contact section, again may be a substantially plate shaped element, which leads to a very simple design.

[0025] It will be appreciated that there are several ways of arranging the spring unit in the force flux between the traverse unit and the running gear frame unit. With certain embodiments, the at least one spring unit is arranged, in the force flux, between the running gear frame unit and the pendulum unit. In addition or as an alternative, the at least one spring element may be arranged, in the force flux, between the pendulum unit and the traverse unit. It will be appreciated that, in particular, both variants may be combined, either on different lateral sides of the running gear frame unit but also for the same side of the running gear frame unit. In particular, they may be combined with one single pendulum element (i.e. yielding a configuration with two spring units linked to the pendulum unit).

[0026] It will be appreciated that any desired and suitable arrangement of the spring unit may be chosen. For example, the spring unit may be under tensile load in the rest state of the running gear unit on a straight level track. Preferably, the at least one spring unit is arranged such that, in a rest state with the traverse unit suspended to the running gear frame standing unit on a straight level track, the at least one spring element is under compressive load. This yields a particularly robust and simple to implement configuration.

[0027] It will be appreciated that the present invention may be implemented in the context of wagon body support systems of any desired support rigidity. Typically, the spring rigidity of the at least one spring element, in the pendulum longitudinal direction, is a function of the overall mass to be supported and/or the desired transverse rigidity of the suspension (which again is a function of the pendulum length along the pendulum longitudinal direction). Preferably, the at least one spring element, in the pendulum longitudinal direction, has a spring rigidity, which ranges from 0.1 kN/mm to 1 kN/mm, preferably from 0.15 kN/mm to 0.4 kN/mm, more preferably from 0.2 kN/mm to 0.3 kN/mm. By this means particularly beneficial dynamic behavior of the running gear unit may be achieved.

[0028] It will be further appreciated that any desired and suitable connection of the suspension unit to the running gear frame unit and/or the traverse unit may be chosen. This may be done, in particular, as a function of the overall building space available, the individual spatial and/or design requirements for the respective vehicle etc.

[0029] With particularly, compact, robust yet lightweight designs, the at least one spring unit is at least partially received, in particular substantially fully received, within a receptacle of the running gear frame unit. In addition or as an alternative, the at least one spring unit is at least partially received, in particular substantially fully received, within a receptacle of the traverse unit.

Such receptacles, for example, may be provided in a very simple manner by the internal space available with running gear frame or traverse designs using generally box shaped components.

[0030] Compactness of the design may be further increased in a beneficial manner with embodiments, where the at least one pendulum unit extends through an aperture within the running gear frame unit and/or the at least one pendulum unit extends through an aperture within the traverse unit.

[0031] It will be appreciated that the pendulum unit may have any desired and suitable fixed length along its pendulum longitudinal axis. Preferably, however, the pendulum unit defines a pendulum longitudinal direction and a pendulum length along the pendulum longitudinal direction between a center of rotation of the first articulation and a center of rotation of the second articulation. In these cases, the pendulum unit may comprise a length adjustment device configured to adjust the pendulum length. Such a solution has a great advantage that the rigidity of the suspension system in the transverse direction and/or the longitudinal direction may be adjusted via the adjustment of the pendulum length. Furthermore, the adjustment may also be used for compensating wheel wear (i.e. readjusting the entry-level into the wagon body after the wheels of the running gear have worn to a certain extent).

[0032] It will be appreciated that any desired concept may be used for achieving the length adjustment of the pendulum length. With fairly simple configurations, the length adjustment device comprises a screw connection. Furthermore, the length adjustment device may be implemented at any desired and suitable location within the pendulum unit. Preferably, the length adjustment device is located in an end section of the pendulum unit, thereby yielding particularly simple and easy access to the length adjustment device.

[0033] It will be appreciated that the pendulum length is selected as a function of the rigidity of the suspension system to be achieved in the transverse direction and/or longitudinal direction and/or the overall mass of the suspended components. With preferred embodiments, showing particularly beneficial dynamic behavior in terms of running stability and riding comfort, the pendulum length ranges from 50% to 300%, preferably from 100% to 250%, more preferably from 150% to 200%, of a length of the at least one spring unit along the pendulum longitudinal direction. It will be appreciated in this context that pendulum lengths below 100% of the length of the at least one spring unit can be achieved, since the center of rotation of the first and second articulation can eventually be even located within the space confined by the at least one spring unit.

[0034] It will be appreciated that, typically, the excursion between the running gear frame unit and the traverse unit has to be limited to a certain extent. This limitation may be provided by the elastic counterforce of the spring unit. Preferably, however, limitation is provided by at least

one hard stop unit, the hard stop unit limiting relative motion between the running gear frame unit and the traverse unit in the transverse direction and/or the longitudinal direction. Any desired configuration may be selected for the hard stop unit. For example, the hard stop unit may act between the pendulum unit and either of the running gear frame unit or the traverse unit. Preferably, the hard stop unit comprises a first hard stop element connected to the running gear frame unit, the first hard stop element preferably being configured to cooperate with a second hard stop element connected to a wagon body supported by the traverse unit.

[0035] It will be appreciated that the present invention may be used in the context of any desired running gear frame designs. For example it may be used in the context of generally rectangular running gear frame units or generally H-shaped running gear units, but also any other desired frame design may be selected. With certain embodiments, the running gear frame unit comprises at least one longitudinal beam section extending in the longitudinal direction, the at least one spring unit and the at least one pendulum unit being connected to a support section of the longitudinal beam section. The support section may be arranged at any desired location in the longitudinal direction of the running gear frame unit. With certain particularly simple embodiments, the support section is a longitudinally central section of the running gear frame unit.

[0036] It will be appreciated that, with the present invention, particularly low levels of the floor within the wagon body may be realized. This is particularly the case with certain embodiments, where the support section, in a rest state on a straight level track, defines a first height level in the height direction and the traverse unit defining a second height level in the height direction, the second height level being lower than the first height level. Preferably, the first height level is defined by an interface between the spring unit and the running gear frame unit and the second height level is defined by a support interface of the traverse unit configured to support the wagon body.

[0037] It will be appreciated that it may eventually be sufficient to realize the support concept according to the present invention only on one lateral side of the running gear, whereas on the other lateral side of the running gear, a different suspension concept is followed. Preferably, however, the suspension concept is used on both lateral sides of the running gear unit. Hence, with preferred embodiments, the running gear frame unit, in the transverse direction, has a first lateral side and a second lateral side, the at least one spring unit being a first spring unit and the at least one pendulum unit being a first pendulum unit located at the first lateral side of the running gear frame unit. Here, the suspension unit further comprises at least one second spring unit and at least one second pendulum unit arranged kinematically in series in a force flux between the running gear frame unit and the traverse unit and located at the second lateral side of the running

gear frame unit.

[0038] As outlined above, preferably, the second spring unit and the second pendulum unit are at least substantially functionally and/or geometrically symmetric with respect to the first spring unit and the first pendulum unit. It should be noted here that functionally symmetric means that, while geometric deviations may exist, the same functionality is provided at both lateral sides of the running gear frame unit.

[0039] It will be appreciated that any desired arrangement of the pendulum longitudinal axes may be realized on both lateral sides of the running gear frame unit. Hence, with certain embodiments, the first pendulum unit has a first longitudinal axis and the second pendulum unit has a second longitudinal axis, each longitudinal axis being defined by a center of rotation of the first articulation and a center of rotation of the second articulation of the pendulum unit. In one case, the first pendulum unit and the second pendulum unit are arranged such that the first longitudinal axis and the second longitudinal axis are substantially parallel in a rest state on a straight level track. Such a solution has the advantage that, in case of identical pendulum length and identical location of the respective corresponding articulations in the height direction, the pendulum motion is neutral in terms of rolling motion of the wagon body.

[0040] With other embodiments, however, the first pendulum unit and the second pendulum unit are arranged such that the first longitudinal axis and the second longitudinal axis are mutually inclined in a rest state on a straight level track. With such a solution, a wagon body tilting system may be implemented, where the wagon body undergoes rolling motion upon deflection of the traverse unit with respect to the running to frame unit in the transverse direction.

[0041] The present invention further relates to a rail vehicle with a wagon body supported on a running gear unit according to the invention.

[0042] Further embodiments of the present invention will become apparent from the dependent claims and the following description of preferred embodiments which refers to the appended figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0043]

- Figure 1 is a schematic side view of a part of a preferred embodiment of a rail vehicle according to the present invention with a preferred embodiment of a running gear unit according to the present invention;
- Figure 2 is a schematic sectional view of the running gear unit of Figure 1 along line II-II of Figure 1;
- Figure 3 is a schematic sectional view of the running gear unit of Figure 2 along line III-III of Figure

2 in a rest state.

- Figure 4 is a schematic sectional view of the running gear unit of Figure 2 along line III-III of Figure 2 in a deflected state.
- Figure 5 is a schematic sectional view of a part of a further preferred embodiment of the running gear according to the invention.
- Figure 6 is a schematic sectional view of a part of a further preferred embodiment of the running gear according to the invention.
- Figure 7 is a schematic sectional view of a part of a further preferred embodiment of the running gear according to the invention.
- Figure 8 is a schematic sectional view of a part of a further preferred embodiment of the running gear according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

First Embodiment

[0044] With reference to Figures 1 to 4 a first preferred embodiment of a rail vehicle 101 according to the present invention comprising a preferred embodiment of a running gear unit 102 according to the invention will now be described in greater detail. In order to simplify the explanations given below, an xyz-coordinate system has been introduced into the Figures, wherein (on a straight, level track T) the x-axis designates the longitudinal direction of the rail vehicle 101, the y-axis designates the transverse direction of the rail vehicle 101, while the z-axis designates the height direction of the rail vehicle 101 (the same, of course, applies for the running gear 102). It will be appreciated that all statements made in the following with respect to the position and orientation of components of the rail vehicle, unless otherwise stated, refer to a static situation with the rail vehicle 101 standing on a straight level track under nominal loading.

[0045] The vehicle 101 is a low floor rail vehicle such as a tramway or the like. The vehicle 101 comprises a wagon body 101.1 supported by a suspension system on the running gear unit in the form of a bogie 102. The running gear unit 102 comprises two wheel units in the form of wheel sets 103 supporting a running gear frame unit in the form of a running gear frame 104 via a primary spring unit 105. The running gear frame 104 supports the wagon body 101.1 via a suspension unit in the form of a secondary suspension unit 106 (also referred to as a secondary spring unit).

[0046] The running gear frame 104 has a frame body 107 comprising two longitudinal beams 108 and a transverse linking unit (not shown in greater detail) providing a structural connection between the longitudinal beams

108 in the transverse direction. Each longitudinal beam 108 has two free end sections 108.1 and a central support section 108.2. A traverse unit in the form of a bolster or traverse 109 is connected to the central support section 108.2, while the free end sections 108.1 of the longitudinal beams 108 form a primary suspension interface 110 for primary suspension devices of the primary suspension unit 105 connected to the associated wheel unit 103. In the present example, a compact and robust rubber-metal-spring is used for the respective primary spring device.

[0047] As can be seen, in particular, from Figure 2, the bolster 109 supports the wagon body 101.1, while the traverse 109 extends between the left and right lateral side of the running gear 102 and is suspended to the running gear frame 104 via the secondary suspension unit 106. To this end, the secondary suspension unit 106, on each lateral side of the running gear 102, comprises a spring unit 110 and a pendulum unit 111 arranged kinematically in series in a force flux between the running gear frame 108 and the traverse 109.

[0048] The spring unit 110 and the pendulum unit 111 on the left and right side of the running gear (in the rest state) are substantially symmetric with respect to the central longitudinal plane 101.2 (parallel to the xz plane). Hence, in the following, mainly the configuration on one lateral side will be described in greater detail in only.

[0049] As can be seen from Figure 2 to 4, each pendulum unit 111 has a first end section 111.1 and a second end section 111.2. A first articulation 111.3 associated to the running gear frame 104 is located at the first end section 111.1, while a second articulation 111.4 associated to the traverse 109 is located at the second end section 111.2. The first articulation 111.3 and the second articulation 111.4 allow relative motion between the traverse 109 (and, hence, the wagon body 101.1 supported on the traverse 109) and the running gear frame 104 in the transverse direction (y-axis) and in the longitudinal direction (x-axis) by a pendulum motion of the pendulum unit 111. Particularly the relative motion in the transverse direction is important for ensuring riding comfort for the passengers in the wagon body 101.1.

[0050] As can be seen particularly well from Figure 2 and 3, the respective spring unit 110 comprises a simple helical spring element 110.1 made from suitable spring steel. It will be appreciated, however, that with other embodiments of the invention, any other suitable type of spring made of any other material or material combination will for such a secondary spring function may be used. Moreover, any combination of such spring elements may be selected. In particular, a nested (typically concentric) arrangement of two or more helical springs may be selected as needed.

[0051] Furthermore, the respective pendulum unit is formed by a generally plate shaped first contact element 111.5, a generally plate shaped second contact element 111.6 and a pendulum element 111.7. The pendulum element 111.7 is rigidly connected to the two contact el-

ements 111.5 and 111.6. The pendulum element 111.7 defines a pendulum axis 111.8, which (in the rest state as shown in Figure 2 and 3) is substantially parallel to the height direction (z-axis).

[0052] The first contact element 111.5 is a circular element that extends transverse to the pendulum longitudinal axis 111.8. It will be appreciated however that, with other embodiments, any other type of contact element may be selected. In particular, two or more support arms or the like may radially extend from the pendulum element 111.7 towards the circumference of the spring element 110.1.

[0053] The first contact element 111.5 contacts the upper end of the spring element 110.1 over its entire circumference, such that reliable contact is obtained under any load conditions. It will be appreciated that any desired connection between the first contact element 111.5 and the spring element 110.1 may be selected. In particular, a mere frictional connection may be sufficient in view of the contact load acting as a result of the weight of the wagon body 101.1. Preferably, however, at least one centering means, centering the first contact element 111.5 with respect to the spring element 110.1 (in the direction transverse to the pendulum longitudinal axis 111.8) is provided at the inner and/or outer circumference of the spring element 110.1 (such that a positive connection is realized between these components in this direction transverse to the pendulum longitudinal axis 111.8).

[0054] The pendulum element 111.7 is a generally rod shaped (typically cylindrical) element, which extends throughout the receptacle 110.2 defined by the inner circumference of the spring element 110.1, such that a particularly space-saving nested arrangement of the spring unit 110 and the pendulum unit 111 is obtained.

[0055] The pendulum element 111.7 further extends downwards through an aperture 108.3 within the respective longitudinal beam 108 of the running gear frame 104. Similarly, the pendulum element 111.7 further extends downwards through an aperture 109.1 in the traverse 109. Before reaching the second contact element 111.6, the pendulum element 111.7 extends downwards through a central aperture 110.4 of a resilient element 110.3.

[0056] The resilient element 110.3, on its lower side, sits on the second contact element 111.6, while the traverse 109 contacts the upper side of the resilient element 110.3. In other words, the resilient element 110.3 is clamped between the traverse 109 and the second contact element 111.6. In the present example, the resilient element is a laminated rubber metal spring element. However, with other embodiments of the invention, any other type of resilient element (e.g. a conventional helical spring or one or more disc springs etc.) may be used to connect the second contact element 111.6 and the traverse 109.

[0057] The second contact element 111.6 again is a circular element that extends transverse to the pendulum longitudinal axis 111.8. The second contact element

111.6 contacts the lower end of the resilient element 110.3 over its entire circumference, such that reliable contact is obtained under any load conditions. It will be appreciated that, at this lower end of the pendulum unit 111 as well, any desired connection between the second contact element 111.6 and the resilient element 110.3 may be selected. Again, a mere frictional connection may be sufficient in view of the contact load acting as a result of the weight of the wagon body 101.1. Preferably, however, at least one centering means, centering the second contact element 111.6 with respect to the resilient element 110.3 (in the direction transverse to the pendulum longitudinal axis 111.8) is provided at the inner and/or outer circumference of the resilient element 110.3 (such that a positive connection is realized between these components in this direction transverse to the pendulum longitudinal axis 111.8). Similar applies for the connection between the resilient element 110.3 and the traverse 109.

[0058] As a consequence of the above configuration, in the present case, the wagon body 101.1 is suspended to the running gear frame 104 via the traverse 109 and the secondary suspension unit 106. More precisely, the force flux of the support force from the running gear frame 104 to the wagon body 101.1 goes from the support section 108.2 of the longitudinal beam 108 through the spring element 110.1 to the (upper) first contact element 111.5, the pendulum element 111.7, the (lower) contact element 111.6, the resilient element 110.3 and the traverse 109 into the wagon body 101.1. Hence, in the present example, the spring element 110.1 and the resilient element 110.3 are both under compressive load (in the rest state and, typically, under any normal operating condition of the vehicle).

[0059] As can be seen particularly well from Figure 3 and 4, in the present example, the first articulation 106.4 is formed by the spring unit 106.1. More precisely, the spring unit 106.1 doesn't only provide the resident support of the weight of the wagon body 101.1 but also integrates the function of the first articulation 106.4 by defining the upper tilt axis or upper center of rotation of the pendulum unit 106.2.

[0060] This functional integration of the first articulation 106.4 within the spring unit 106.1 is obtained the following way (see Figure 4). A transverse force TF introduced into the pendulum unit 111 via the traverse 109 results in a pendulum moment PM acting on the pendulum unit 111 at the level of the (upper) first articulation 111.3. The pendulum moment PM is arranged transverse to the support direction and the longitudinal spring axis 110.4, respectively, of the spring element 110.1. The (upper) first contact element 111.5 converts this pendulum moment PM into an uneven compression of the spring element 110.1 (in the direction of its longitudinal spring axis 110.4, respectively) over its circumference. As a consequence, the pendulum unit 111 is tilted about an (upper) first center of rotation or first tilt axis 111.9. Hence, a pendulum motion of the pendulum unit 111 is generated with any transverse deflection of the traverse 109 (supporting the

wagon body 101.1) and the running gear frame 104.

[0061] By this means a particularly efficient configuration making use of the primary rigidity of the spring element 110.1 along its support direction or longitudinal spring axis 110.4 is achieved (rather than using the secondary rigidity of the spring element 110.1 transverse to the support direction 110.4, which, typically, is undesirably higher than this primary rigidity).

[0062] It will be appreciated that, at the level of the (lower) second articulation 111.4 of the pendulum unit 111, a similar (highly functionally integrated) articulation concept is followed to provide compensation of the tilt between the pendulum unit 111 and the traverse 109 via the resilient element 110.3. Here again, the reaction moment to the transverse force TF is converted by the second contact element 111.6 into an uneven compression of the element 110.3 (in the direction of its longitudinal axis coinciding with the spring axis 110.4) over its circumference. As can be seen from Figure 4, this leads to a generally wedge shaped deformation of the resilient element 111.6 (with a wedge angle corresponding to the tilt angle of the pendulum unit 111). As a consequence, the tilt of the pendulum unit 111 is compensated at the level of the traverse 109 by a rotation about a (lower) second center of rotation or second tilt axis 111.10.

[0063] It will be appreciated that, with other embodiments of the invention, a conventional rotational link, such as a simple hinge element or a ball link element, may be used for the articulation 111.4 at the lower end of the pendulum unit 111.

[0064] As can be seen from Figure 2, the spring element 110.1 is substantially fully received within a receptacle 108.4 of the running gear frame 104, while the resilient element 110.3 is substantially fully received within a receptacle 109.2 of the traverse 109. In the present example, the receptacles 108.4 and 109.2 are provided in a very simple manner by the internal space available with running gear frame or traverse designs using generally box shaped components as it is the case for the present longitudinal beams 108 and the traverse 109. Such a configuration yields a particularly compact, robust yet lightweight design.

[0065] In the present embodiment, the spring element 110.1, in the pendulum longitudinal direction 111.8 (in the rest state) and the along its longitudinal spring axis 110.4, respectively, has a spring rigidity, which ranges from 0.1 kN/mm to 1 kN/mm, preferably from 0.15 kN/mm to 0.4 kN/mm, more preferably from 0.2 kN/mm to 0.3 kN/mm. By this means particularly beneficial dynamic behavior of the running gear 102 may be achieved.

[0066] As outlined above, the pendulum unit 111 may have any desired and suitable fixed effective length EL along its pendulum longitudinal axis 111.8 between the first center of rotation 111.9 and the second center of rotation 111.10. In the present example, however, the pendulum unit 111 comprises a length adjustment device as indicated by the dashed contour 111.11 in Figure 3. The length adjustment device 111.11 is configured to ad-

just the effective pendulum length EL. Adjustability of the effective length EL of the pendulum unit 111 has the great advantage that the rigidity of the suspension system in the transverse direction (y-axis) and/or the longitudinal direction (x-axis) may be adjusted via the adjustment of the effective pendulum length EL. Furthermore, the adjustment of the effective pendulum length EL may also be used for compensating wheel wear (i.e. for readjusting the height level of the wagon body after the wheels of the wheel sets 103 have worn to a certain extent).

[0067] The length adjustment device 111.11 is located at the lower, second end section 111.2 of the pendulum unit 111, thereby providing easy access for adjustment. The length adjustment device 111.11 comprises a simple screw connection (which may be secured against loosening by any suitable means) and may use spacer elements introduced between the (lower) second contact element 111.6 and the pendulum element 111.7.

[0068] It will be appreciated that the effective pendulum length EL is selected as a function of the rigidity of the suspension of the wagon body 101.1 to be achieved in the transverse direction (y-axis) and/or longitudinal direction (x-axis). In the present example, particularly beneficial dynamic behavior in terms of running stability and riding comfort is achieved in that the pendulum length ranges from 50% to 300%, preferably from 100% to 250%, more preferably from 150% to 200%, of a length of the at least one spring unit along the pendulum longitudinal direction.

[0069] As can be seen from Figure 2, relative excursion between the running gear frame 104 and the wagon body 101.1 (supported by the traverse 109) is limited to a certain extent. More precisely, this excursion limitation is provided by a hard stop unit 112. To this end, the hard stop unit comprises a first hard stop element 112.1 connected to the running gear frame 104, which cooperates with a second hard stop element 112.2 connected to the wagon body 101.1 supported by the traverse 109.

[0070] It will be appreciated that, typically, traction and braking forces acting in the longitudinal direction (x-axis) are transmitted between the running gear 102 and the wagon body 101.1 by suitable traction linkages (not shown). Hence, typically, the secondary suspension 106 will not have to transfer or take up a considerable amount of these traction and braking forces.

[0071] It will be appreciated that, in the present embodiment, due to the compact and space-saving suspension concept of the traverse 109 particularly low levels of the floor within the wagon body 101.1 may be realized. Here, the support section 108.2, in the rest state, defines a first height level H1 in the height direction (z-axis) and the traverse 109 defines a second height level H2 in the height direction, which is lower than the first height level H1. As can be seen from Figure 2, the first height level H1 is defined by the support interface between the spring element 110.3 and the support section 108.2, while the second height level H2 is defined by a support interface 109.3 of the traverse 109.

[0072] It will be appreciated that, apparently, the only limitation to the second height level H2 is the height dimension of the traverse 109 itself and the required ground clearance. Furthermore, it will be appreciated that, with the present suspension concept, apart from the lateral play that has to be provided for the lateral excursion of the wagon body 101.1 with respect to the running gear frame 104 (corresponding to twice the distance between the hard stop elements 112.1, 112.2), the entire space available in the transverse direction between the hard stop elements 112.1 of the respective longitudinal beam 108 may be taken by the wagon body 101.1. This allows a particularly spacious low floor passage for the passengers within the wagon body 101.1.

[0073] As can be seen from Figure 1, the wagon body 101.1 (more precisely, either the same part of the wagon body 101.1 also supported on the first running gear 102 or another part of the wagon body 101) is supported on a further, second running gear 113. The second running gear 113 is identical to the first running gear 102 in all the parts described above. However, while the first running gear 102 may be a driven running gear with a drive unit (not shown) mounted to the frame body 107, the second running gear 113 may be a non-driven running gear, having no such drive unit mounted to the frame body 107. Of course, each of the first and second running gear 102 and 113 may also be a driven or non-driven running gear

Second Embodiment

[0074] In the following, a second preferred embodiment of a running gear unit 202 according to the invention will now be described with reference to Figure 1, 4 and 5. The running gear 202 may simply replace the running gear 102 in Figure 1. The running gear 202 in its basic design and functionality largely corresponds to the rail vehicle 101 such that it is here mainly referred to the differences. In particular, identical components have been given the identical reference numeral, while like components are given the same reference numeral increased by the value 100. Unless explicitly deviating statements are given in the following, explicit reference is made to the explanations given above in the context of the first embodiment with respect to these components.

[0075] As can be seen from Figure 5, the only difference with respect to the first embodiment lies in the design of the suspension unit 206, more specifically, the design of the pendulum unit 211. Here, the pendulum unit 211 comprises two pendulum elements 211.9 connected by a common (upper) first contact element 211.5. The first contact element 211.5 again contacts the upper end of the spring element 110.1, which again is supported on the respective longitudinal beam 108. Here, the spring element 110.1 is located in a gap provided between the two pendulum elements 211.9 in the longitudinal direction (x-axis). Each pendulum element 211.9, at its lower end, is connected to the traverse 109 via a (lower) second contact elements 211.6 and an intermediate resilient el-

ement 110.3.

[0076] The functionality of the suspension unit 206 in the transverse direction (y-axis) is equivalent to the functionality of the suspension unit 106 of the first embodiment. In particular, the pendulum motion of the pendulum unit 211 with the tilt axes 211.9 and 211.10 is substantially identical to the pendulum motion as it has been described in the context of the first embodiment in particular with reference to Figure 4. Hence, insofar, reference is made to these explanations as given above.

[0077] One difference here is that this double pendulum element configuration is more rigid in the longitudinal direction (x-axis). This is due to the fact that a force acting exclusively in the longitudinal direction (e.g. a traction or braking force), due to the force frame formed by the traverse 109 and the pendulum unit 211, will not result in a correspondingly large pendulum moment about a transverse pendulum axis parallel to the transverse axis (y-axis). Hence, here, the spring element 110.3 will mainly experience shear loading, such that uses made of the secondary rigidity of the spring element 110.3 in a direction transverse to its spring longitudinal axis 110.4.

Third Embodiment

[0078] In the following, a third preferred embodiment of a running gear unit 302 according to the invention will now be described with reference to Figure 1, 4 and 6. The running gear 302 may simply replace the running gear 102 in Figure 1. The running gear 202 in its basic design and functionality largely corresponds to the rail vehicle 101 such that it is here mainly referred to the differences. In particular, identical components have been given the identical reference numeral, while like components are given the same reference numeral increased by the value 200. Unless explicitly deviating statements are given in the following, explicit reference is made to be explanations given above in the context of the first embodiment with respect to these components.

[0079] As can be seen from Figure 6, the only difference with respect to the first embodiment lies in the design of the suspension unit 306, more specifically, the design of the spring unit 310 and the pendulum unit 311. Here, the spring unit comprises two spring elements 310.1, while the pendulum unit 311 comprises one pendulum element 311.9 and an elongated (upper) first contact element 311.5. The first contact element 311.5 contacts the upper ends of the two spring elements 310.1, which are supported on the respective longitudinal beam 108. Here, the pendulum element 311.9 is located in a gap provided between the two spring elements 310.1 in the longitudinal direction (x-axis). The pendulum element 311.9, at its lower end, again is connected to the traverse 109 via a (lower) second contact elements 311.6 and an intermediate resilient element 110.3.

[0080] The functionality of the suspension unit 306 in the transverse direction (y-axis) is equivalent to the functionality of the suspension unit 106 of the first embodi-

ment. In particular, the pendulum motion of the pendulum unit 311 is substantially identical to the pendulum motion as it has been described in the context of the first embodiment in particular with reference to Figure 4. Hence, insofar, reference is made to these explanations as given above. Similar applies to the functionality of the suspension unit 306 in the longitudinal direction (x-axis), where the pendulum motion (about a pendulum axis parallel to the transverse axis) is achieved by deviating compression and individually uneven of the two spring elements 310.1.

Fourth Embodiment

[0081] In the following, a fourth preferred embodiment of a running gear unit 402 according to the invention will now be described with reference to Figure 1, 4 and 7. The running gear 402 may again simply replace the running gear 102 in Figure 1. The running gear 402 in its basic design and functionality largely corresponds to the rail vehicle 101 such that it is here mainly referred to the differences. In particular, identical components have been given the identical reference numeral, while like components are given the same reference numeral increased by the value 300. Unless explicitly deviating statements are given in the following, explicit reference is made to be explanations given above in the context of the first embodiment with respect to these components.

[0082] As can be seen from Figure 7, the only difference with respect to the running gear 102 of the first embodiment is the upside down arrangement of the suspension unit 406. More precisely, the spring element 110.1 of the spring unit 110 is located in a receptacle 409.2 of the traverse 409, while the resilient element 110.3 is located in a receptacle 408.4 of the longitudinal beam 408. Hence, the (upper) first contact element 411.5 of the pendulum unit 411 now contacts the resilient element 110.3, while the (lower) second contact element 411.6 of the pendulum unit 411 contacts the spring element 110.1.

[0083] Hence, in the present case, the force flux of the support force from the running gear frame 104 to the wagon body 101.1 goes from the support section 408.2 of the longitudinal beam 408 through the resilient element 110.3 to the (upper) first contact element 411.5, the pendulum element 411.7, the (lower) contact element 411.6, the spring element 110.1 and the traverse 409 into the wagon body 101.1. Hence, in the present example, the spring element 110.1 and the resilient element 110.3 again are both under compressive load (in the rest state and, typically, under any normal operating condition of the vehicle).

[0084] Otherwise the functionality of the suspension unit 406, in particular, its kinematics, is substantially identical to the functionality of the suspension unit 106 as it has been described above in the context of the first embodiment. Hence, insofar, reference is made to the explanations given above.

Fifth Embodiment

[0085] In the following, a fifth preferred embodiment of a running gear unit 502 according to the invention will now be described with reference to Figure 1, 4 and 8. The running gear 502 may again simply replace the running gear 102 in Figure 1. The running gear 502 in its basic design and functionality largely corresponds to the rail vehicle 101 such that it is here mainly referred to the differences. In particular, identical components have been given the identical reference numeral, while like components are given the same reference numeral increased by the value 300. Unless explicitly deviating statements are given in the following, explicit reference is made to be explanations given above in the context of the first embodiment with respect to these components.

[0086] As can be seen from Figure 8, the only difference with respect to the running gear 102 of the first embodiment is the design of the suspension unit 506, which is a combination of the first and fourth embodiment. More precisely, the spring unit 510 comprises an (upper) first spring element 510.1, which is located in a receptacle 508.4 of the longitudinal beam 508 (in a manner similar to the first embodiment). Furthermore, the spring unit 510 comprises a (lower) second spring element 510.3, which is located in a receptacle 509.2 of the traverse 509 (in a manner similar to the fourth embodiment). Hence, the (upper) first contact element 511.5 of the pendulum unit 511 now contacts the (upper) first spring element 510.1, while the (lower) second contact element 511.6 of the pendulum unit 511 contacts the (lower) second spring element 110.1.

[0087] Hence, in the present case, the force flux of the support force from the running gear frame 104 to the wagon body 101.1 goes from the support section 508.2 of the longitudinal beam 508 through the (upper) first spring element 510.1 to the (upper) first contact element 511.5, the pendulum element 511.7, the (lower) contact element 511.6, the (lower) second spring element 510.3 and the traverse 509 into the wagon body 101.1. Hence, in the present example, the first spring element 510.1 and the second element 510.3 again are both under compressive load (in the rest state and, typically, under any normal operating condition of the vehicle).

[0088] Otherwise the functionality of the suspension unit 506, in particular, its kinematics, is substantially identical to the functionality of the suspension unit 106 as it has been described above in the context of the first embodiment. Hence, insofar, reference is made to the explanations given above.

[0089] It will be appreciated that the first and second spring elements 510.1 and 510.3 are shorter (along their spring longitudinal axis 510.4) than the spring element 110.1. It will be appreciated that, especially in this case, with such axially shorter spring elements, the first and second spring elements 510.1 and 510.3 do not necessarily have to be helical spring elements as shown. In particular, they may be a rubber spring elements, e.g.

laminated rubber metal spring elements as it is indicated in Figure 8 by the dashed contours 510.5.

[0090] Although the present invention in the foregoing has only been described in the context of low-floor rail vehicles, it will be appreciated, however, that it may also be applied to any other type of rail vehicle in order to overcome similar problems with respect to a simple and space saving solution reducing the manufacturing effort.

Claims

1. A running gear unit for a rail vehicle, comprising

- a running gear frame unit (104; 204; 404; 504),
- a traverse unit (109; 209; 409; 509), and
- a suspension unit (106; 206; 306; 406; 506), in particular, a secondary suspension unit (106; 206; 306; 406; 506);
- said running gear frame unit (104; 204; 404; 504) being configured to be supported on at least one wheel unit and defining a longitudinal direction, a transverse direction and a height direction;
- said traverse unit (109; 209; 409; 509) being configured to support a wagon body (101.1) unit of said rail vehicle;
- said suspension unit (106; 206; 306; 406; 506) suspending said traverse unit (109; 209; 409; 509) to said running gear frame unit (104; 204; 404; 504);
- said suspension unit (106; 206; 306; 406; 506) comprising at least one spring unit (110; 210; 310; 410; 510) and at least one pendulum unit (111; 211; 311; 411; 511) arranged kinematically in series in a force flux between said running gear frame unit (104; 204; 404; 504) and said traverse unit (109; 209; 409; 509);
- said at least one pendulum unit (111; 211; 311; 411; 511) having a first end section with a first articulation (111.3; 211.3; 311.3; 411.3; 511.3) associated to said running gear frame unit (104; 204; 404; 504) and a second end section with a second articulation (111.4; 211.4; 311.4; 411.4; 511.4) associated to said traverse unit (109; 209; 409; 509);
- said first articulation (111.3; 211.3; 311.3; 411.3; 511.3) and said second articulation (111.4; 211.4; 311.4; 411.4; 511.4) allowing relative motion between said running gear frame unit (104; 204; 404; 504) and said traverse unit (109; 209; 409; 509) in said transverse direction and/or in said longitudinal direction by a pendulum motion of said pendulum unit (111; 211; 311; 411; 511);

characterized in that

- said first articulation (111.3; 211.3; 311.3; 411.3; 511.3) and/or said second articulation (111.4; 211.4; 311.4; 411.4; 511.4) is formed by said at least one spring unit (110; 210; 310; 410; 510).

2. The running gear unit according to claim 1, wherein

- said at least one pendulum unit (111; 211; 311; 411; 511) is connected to said at least one spring unit (110; 210; 310; 410; 510) in such a manner that a pendulum moment causing said pendulum motion is introduced into said spring unit (110; 210; 310; 410; 510);

- said spring unit (110; 210; 310; 410; 510), in particular, defining a support direction for supporting said traverse unit (109; 209; 409; 509) on said running gear frame unit (104; 204; 404; 504), said at least one pendulum unit (111; 211; 311; 411; 511) being connected to said at least one spring unit (110; 210; 310; 410; 510) in such a manner that said pendulum moment is arranged transverse to said support direction, in particular, perpendicular to said support direction.

3. The running gear unit according to claim 1 or 2, wherein

- said pendulum unit (111; 211; 311; 411; 511) defines a pendulum longitudinal direction, and said at least one spring unit (110; 210; 310; 410; 510) defines a pendulum receptacle (110.2; 310.2; 410.2; 510.2);

- said pendulum receptacle (110.2; 310.2; 410.2; 510.2) extending along said pendulum longitudinal direction and receiving at least a part of said pendulum unit (111; 211; 311; 411; 511), in particular at least a part of a pendulum element of said pendulum unit (111; 211; 311; 411; 511),

wherein

- said at least one spring unit (110; 210; 310; 410; 510), in particular, comprises a spring element (110.1; 310.1; 410.1; 510.1, 510.4) and said receptacle (110.2; 310.2; 410.2; 510.2) is an internal receptacle of said spring element (110.1; 310.1; 410.1; 510.1, 510.4) extending through said spring element (110.1; 310.1; 410.1; 510.1, 510.4)

and/or

- said at least one spring unit (110; 210; 310; 410; 510), in particular, comprises a coil spring element (110.1; 310.1; 410.1; 510.1), said re-

ceptacle (110.2; 310.2; 410.2; 510.2) being defined by an inner circumference of said coil spring element (110.1; 310.1; 410.1; 510.1).

and/or

- said at least one spring unit (510), in particular, comprises a rubber spring element (510.4), in particular a laminated rubber metal spring element (510.4), said receptacle being defined by an axial aperture within said rubber spring element (510.4).

4. The running gear unit according to any one of claims 1 to 3, wherein

- said pendulum unit (111; 211; 311; 411; 511) has a pendulum element (111.7; 211.7; 311.7; 411.7; 511.7) extending between said first end section and said second end section;

- said first end section and/or said second end section forming a first contact section (111.5; 211.5; 311.5; 411.5; 511.5) contacting said at least one spring unit (110; 210; 310; 410; 510);

- said first contact section (111.5; 211.5; 311.5; 411.5; 511.5), in particular, being rigidly connected to said pendulum element (111.7; 211.7; 311.7; 411.7; 511.7);

- said first contact section (111.5; 211.5; 311.5; 411.5; 511.5), in particular, being a substantially plate shaped element.

5. The running gear unit according to claim 4, wherein

- the end section of said pendulum unit (111; 211; 311; 411; 511) located opposite to said first contact section (111.5; 211.5; 311.5; 411.5; 511.5) comprises an articulation unit forming part of one of said first articulation (111.3; 211.3; 311.3; 411.3; 511.3) and said second articulation (111.4; 211.4; 311.4; 411.4; 511.4);

- said articulation unit contacting one of said running gear frame unit (104; 204; 404; 504) and said traverse unit (109; 209; 409; 509).

6. The running gear unit according to claim 5, wherein

- said articulation unit comprises at least one resilient element (110.3),

- said at least one resilient element (110.3), in particular, being a rubber spring element (110.3), in particular a laminated rubber metal spring element (110.3),

and/or

- said at least one resilient element (110.3), in particular, being at least one spring element (110.3) of said at least one spring unit (110; 210; 310; 410; 510).

7. The running gear unit according to claim 6, wherein

- said articulation unit comprises a second contact section (111.6; 211.6; 311.6; 411.6; 511.6) of said pendulum unit (111; 211; 311; 411; 511) contacting said at least one resilient element (110.3);
- said second contact section (111.6; 211.6; 311.6; 411.6; 511.6), in particular, being rigidly connected to said pendulum element (111.7; 211.7; 311.7; 411.7; 511.7);
- said second contact section (111.6; 211.6; 311.6; 411.6; 511.6), in particular, extending in a direction transverse to a pendulum longitudinal axis of said pendulum element (111.7; 211.7; 311.7; 411.7; 511.7);
- said second contact section (111.6; 211.6; 311.6; 411.6; 511.6), in particular, being a substantially plate shaped element.

8. The running gear unit according to any one of claims 1 to 7, wherein

- said at least one spring unit (110; 210; 310; 510) is arranged, in said force flux, between said running gear frame unit (104; 204; 504) and said pendulum element (111.7; 211.7; 311.7; 511.7)

and/or

- said at least one spring unit (410; 510) is arranged, in said force flux, between said pendulum element (411.7; 511.7) and said traverse unit (409; 509);

and/or

- said at least one spring unit (110; 210; 310; 410; 510) is arranged such that, in a rest state with said traverse unit (109; 209; 409; 509) suspended to said running gear frame unit (104; 204; 404; 504) on a straight level track, said at least one spring unit (110; 210; 310; 410; 510) is under compressive load,

and/or

- said at least one spring unit (110; 210; 310; 410; 510), in said pendulum longitudinal direction, has a spring rigidity, which ranges from 0.1 kN/mm to 1 kN/mm, preferably from 0.15 kN/mm

to 0.4 kN/mm, more preferably from 0.2 kN/mm to 0.3 kN/mm.

9. The running gear unit according to any one of claims 1 to 8, wherein

- said at least one spring unit (110; 210; 310; 410; 510) is at least partially received, in particular substantially fully received, within a receptacle (109.2; 209.2; 309.2; 409.2; 509.2) of said running gear frame unit (104; 204; 404; 504)

and/or

- said at least one spring unit (110; 210; 310; 410; 510) is at least partially received, in particular substantially fully received, within a receptacle (109.2; 209.2; 309.2; 409.2; 509.2) of said traverse unit (109; 209; 409; 509)

and/or

- said at least one pendulum unit (111; 211; 311; 411; 511) extends through an aperture within said running gear frame unit (104; 204; 404; 504)

and/or

- said at least one pendulum unit (111; 211; 311; 411; 511) extends through an aperture within said traverse unit (109; 209; 409; 509).

10. The running gear unit according to any one of claims 1 to 9, wherein

- said pendulum unit (111; 211; 311; 411; 511) defines a pendulum longitudinal direction and a pendulum length along said pendulum longitudinal direction between a center of rotation of said first articulation (111.3; 211.3; 311.3; 411.3; 511.3) and a center of rotation of said second articulation (111.4; 211.4; 311.4; 411.4; 511.4);

wherein

- said pendulum unit (111; 211; 311; 411; 511) comprises a length adjustment device (111.7) configured to adjust said pendulum length, said length adjustment device (111.7), in particular, comprising a screw connection and/or said length adjustment device (111.7), in particular, being located in an end section of said pendulum unit (111; 211; 311; 411; 511),

and/or

- said pendulum length ranges from 50% to 300%, preferably from 100% to 250%, more

preferably from 150% to 200%, of a length of said at least one spring unit (110; 210; 310; 410; 510) along said pendulum longitudinal direction.

11. The running gear unit according to any one of claims 1 to 10, wherein

- at least one hard stop unit (112; 412; 512) is provided, said hard stop unit (112; 412; 512) limiting relative motion between said running gear frame unit (104; 204; 404; 504) and said traverse unit (109; 209; 409; 509) in said transverse direction and/or said longitudinal direction;

- said hard stop unit (112; 412; 512), in particular, comprising a first hard stop element connected to said running gear frame unit (104; 204; 404; 504);

- said first hard stop element, in particular, being configured to cooperate with a second hard stop element connected to a wagon body (101.1) supported by said traverse unit (109; 209; 409; 509).

12. The running gear unit according to any one of claims 1 to 11, wherein

- said running gear frame unit (104; 204; 404; 504) comprises at least one longitudinal beam section extending in said longitudinal direction;

- said at least one spring unit (110; 210; 310; 410; 510) and the at least one pendulum unit (111; 211; 311; 411; 511) being connected to a support section of said longitudinal beam section;

- said support section, in particular, being a longitudinally central section of said running gear frame unit (104; 204; 404; 504);

- said support section, in a rest state on a straight level track, in particular, defining a first height level in said height direction and said traverse unit (109; 209; 409; 509) defining a second height level in said height direction, said second height level being lower than said first height level, said first height level, in particular, being defined by an interface between said spring unit (110; 210; 310; 410; 510) and said running gear frame unit (104; 204; 404; 504) and said second height level, in particular, being defined by a support interface of said traverse unit (109; 209; 409; 509) configured to support said wagon body (101.1).

13. The running gear unit according to any one of claims 1 to 12, wherein

- said running gear frame unit (104; 204; 404; 504), in said transverse direction, has a first lateral side and a second lateral side,

- said at least one spring unit (110; 210; 310; 410; 510) being a first spring unit (110; 210; 310; 410; 510) and said at least one pendulum unit (111; 211; 311; 411; 511) being a first pendulum unit (111; 211; 311; 411; 511) located at said first lateral side of said running gear frame unit (104; 204; 404; 504);

- said suspension unit (106; 206; 306; 406; 506) comprising at least one second spring unit (110; 210; 310; 410; 510) and at least one second pendulum unit (111; 211; 311; 411; 511) arranged kinematically in series in a force flux between said running gear frame unit (104; 204; 404; 504) and said traverse unit (109; 209; 409; 509) and located at said second lateral side of said running gear frame unit (104; 204; 404; 504);

- said second spring unit (110; 210; 310; 410; 510) and said second pendulum unit (111; 211; 311; 411; 511), in particular, being at least substantially functionally and/or geometrically symmetric with respect to said first spring unit (110; 210; 310; 410; 510) and said first pendulum unit (111; 211; 311; 411; 511).

14. The running gear unit according to claim 13, wherein

- said first pendulum unit (111; 211; 311; 411; 511) has a first longitudinal axis and said second pendulum unit (111; 211; 311; 411; 511) has a second longitudinal axis, each longitudinal axis being defined by a center of rotation of said first articulation (111.3; 211.3; 311.3; 411.3; 511.3) and a center of rotation of said second articulation (111.4; 211.4; 311.4; 411.4; 511.4) of said pendulum unit (111; 211; 311; 411; 511),

wherein

- said first pendulum unit (111; 211; 311; 411; 511) and said second pendulum unit (111; 211; 311; 411; 511) are arranged such that said first longitudinal axis and said second longitudinal axis are substantially parallel in a rest state on a straight level track;

or

- said first pendulum unit (111; 211; 311; 411; 511) and said second pendulum unit (111; 211; 311; 411; 511) are arranged such that said first longitudinal axis and said second longitudinal axis are mutually inclined in a rest state on a straight level track.

15. A rail vehicle with a wagon body (101.1) supported on a running gear unit according to any one of claims 1 to 14.

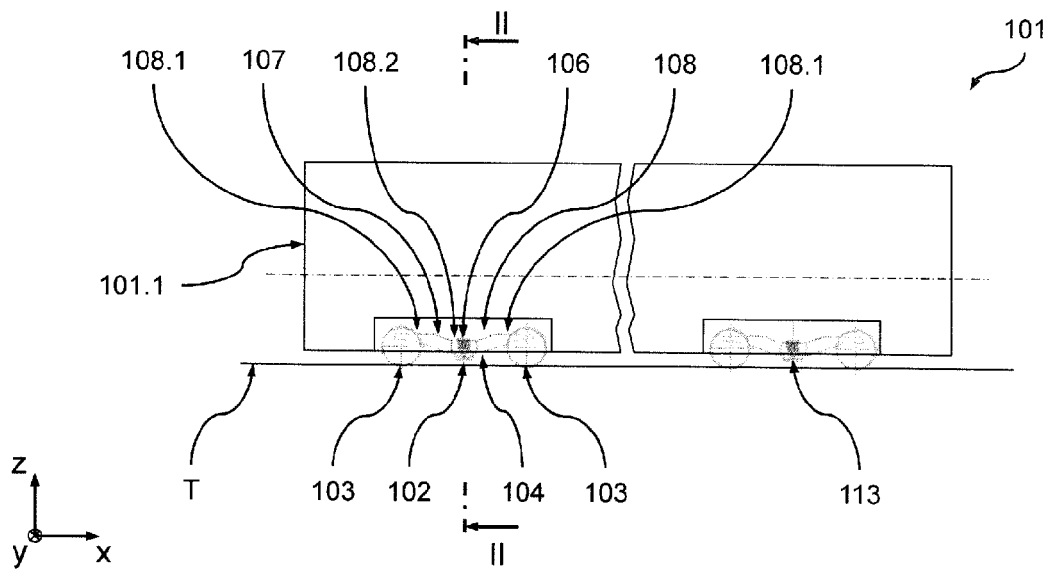


Fig. 1

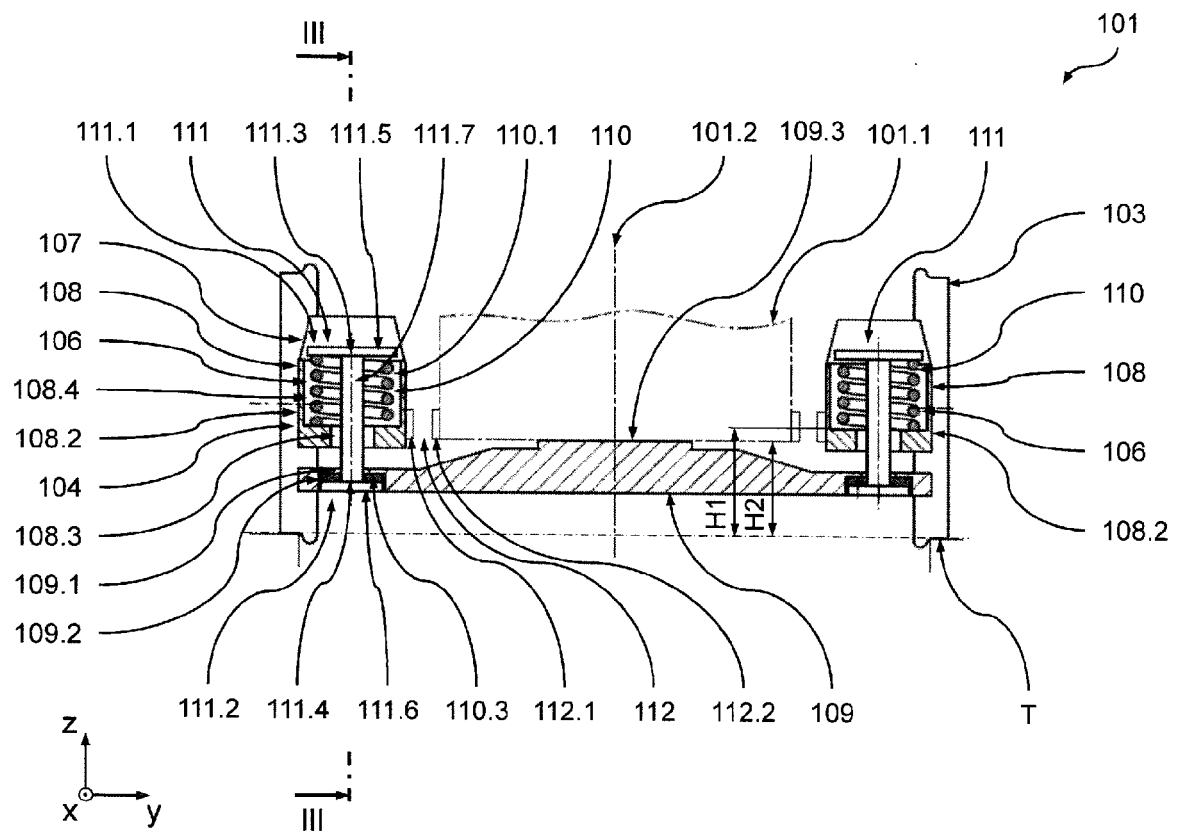


Fig. 2

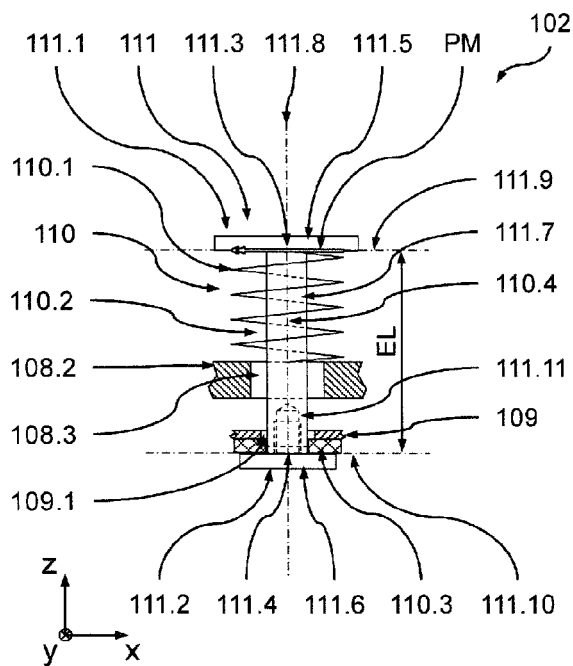


Fig. 3

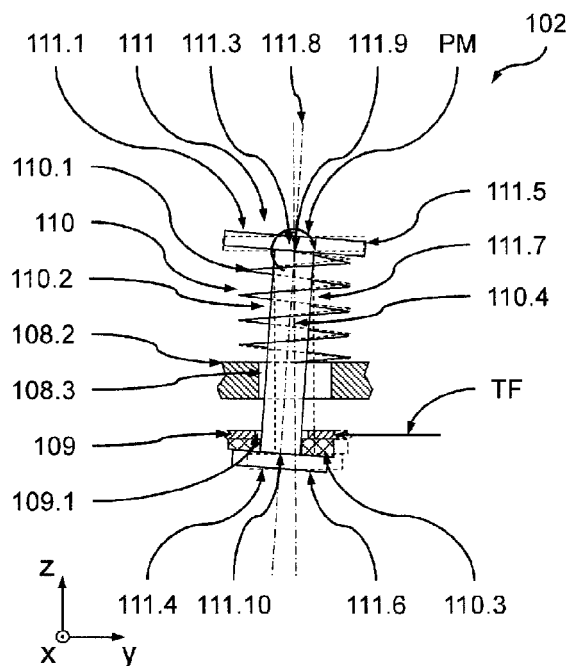


Fig. 4

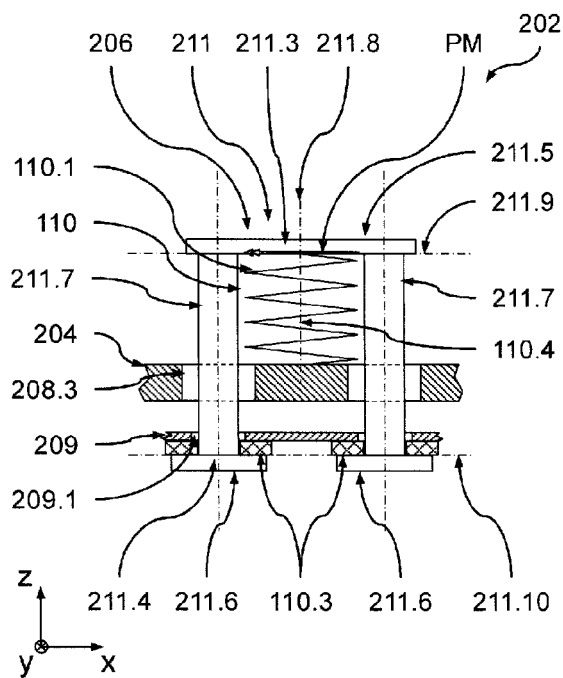


Fig. 5

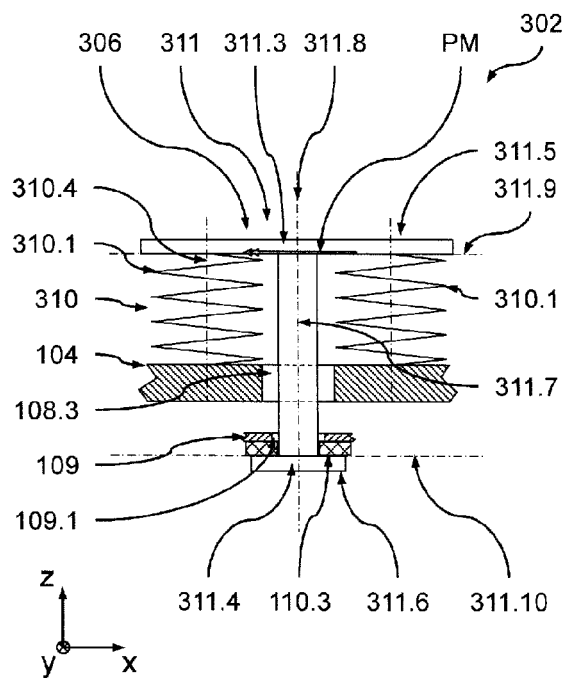


Fig. 6

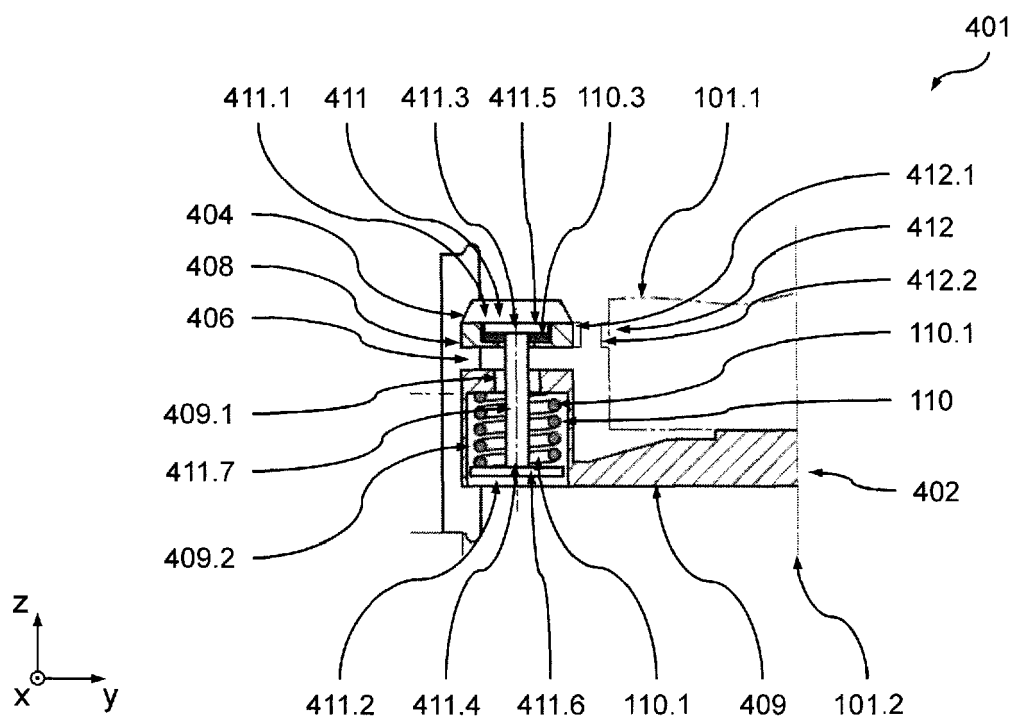


Fig. 7

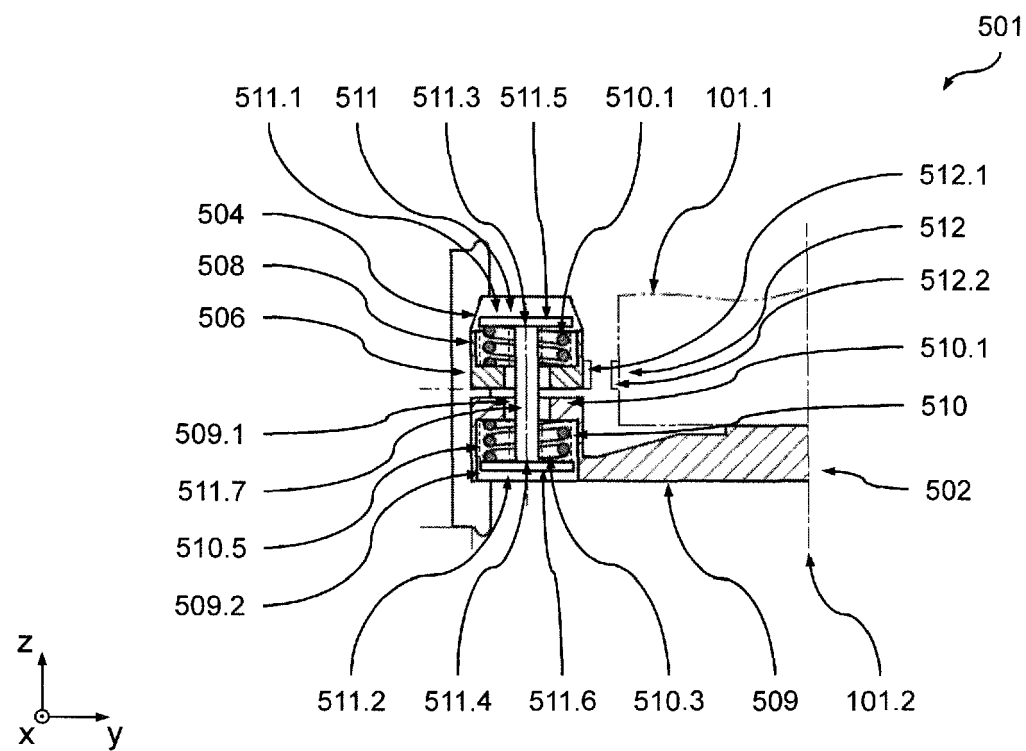


Fig. 8



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