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(54) RAILWAY VEHICLES AND BOGIES

(71) We, BRITISH RAILWAYS BOARD, a public authority established under the provisions of the Transport Act 1962, of 222 Marylebone Road, London N.W.1., do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention relates to railway vehicles and is applicable not only to railway vehicles in which the vehicle body is supported on trucks or bogies, but also where the vehicle body is supported directly on wheel-sets, e.g. four-wheeled vehicles, and where a combination of bogies and wheel-sets may be used to support the body. The invention is also applicable to railway vehicles which are articulated together and where adjacent ends of two vehicles are carried on a single common bogie.

Existing designs of railway vehicles depend for their riding ability on the provision of stiffness and frictional or viscous restraint between the vehicle body and the wheel sets. Consequently because these parameter inhibit relative movement of the vehicle body and wheel-sets, high stability performance is obtained at the cost of an inferior performance in negotiating curves in the railway track.

In order to provide for good stabilisation of a vehicle at high speed, whilst permitting relatively free movement of the vehicle through curves in the railway track, an arrangement has been proposed for a railway vehicle, or bogie therefor, having at least two wheel-sets each with a live axle mounted in a respective pair of axle bearings, wherein at least one axle bearing of one wheel-set is elastically interconnected with at least one axle bearing of the other wheel-set through bracing means which serve no vertical load carrying function at least intermediate their connections to the axle bearings, said bracing

means providing bracing between the wheel-sets which produces high restoring forces when the wheel-sets have a parallel but misaligned disposition, and low restoring forces when the wheel-sets have an aligned but non-parallel disposition.

Such an arrangement has been described and claimed in our British Patent No. 1179723 and an object of this invention is to provide an advantageous construction of such an arrangement as well as various other improvements.

According to this invention there is provided a railway vehicle of the kind having at least two wheel-sets, each with a live axle mounted in a respective pair of axle bearings, at least one axle bearing of one wheel-set being elastically interconnected with at least one axle bearing of the other wheel-set through bracing means providing bracing between the wheel-sets, wherein said bracing means comprise a frame structure for each wheel-set which extends transversely of the vehicle and is rigidly connected between axles boxes housing said axle bearings of its respective wheel-set, said frame structures being shaped and arranged so as to be connected together by said elastic connection at a level which is below the axle height of the vehicle.

In one form, each frame structure may comprise a transversely arranged horizontally extending frame member of generally shallow V-form in plan rigidly connected at its ends to upwardly extending frame members which are in turn, rigidly connected to their respective axle boxes, the transverse frame members being connected via said elastic connection at their apices.

Preferably, said frame structures are connected via said elastic connection at a level well below said axle height and a bolster is accommodated within the space so provided between the wheel sets.

The bolster may be provided with side

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flanges which are supported via a secondary spring mounting (preferably "flexicoiling" springs) within the height of side frames for the vehicle, and the arrangement may be such that the line of action of the secondary spring mounting is substantially the same as that for a primary spring mounting between the side frames and respective axle boxes of the wheel-sets.

According to a feature of this invention the railway vehicle may have side frames which are connected to respective axle boxes via a primary spring mounting for restraining the axle boxes in pitch, in which case the plan-view stiffness of each said primary spring mounting is designed to be less than the lateral stiffness of said elastic connection.

In one form each primary spring mounting may comprise rubber pads which provide a required vertical/plan - view stiffness ratio.

According to a further feature of this invention, the case where the railway vehicle has side frames connected to respective axle boxes via a primary spring mounting, each said side frame is of fabricated construction comprising a bridge member of I-section from which a sub-frame depends, said bridge member and sub-frame defining a space therebetween into which respective side flanges of a bolster project, each said side flange being supported by the respective sub-frame via a secondary spring mounting.

Said space may house a combined vertical and lateral damping arrangement for the bolster comprising a pair of friction blocks which are loaded by a required amount by spring biasing means into contact with friction liners extending transversely between and fixed to the sub-frame of said side frames.

According to another feature of this invention, each axle box of the railway vehicle may be fabricated to provide a bearing support surface which is semi-circular or less for supporting a cartridge bearing, in which case the cartridge bearing is rigidly fixed in position by a part-circular strap appropriately fixed on the axle box and tightened down onto said cartridge bearing.

In a railway vehicle in accordance with the invention it is desirable for good curving that the wheel treads have a high effective conicity.

In order that the invention may be readily understood and further features made apparent, a railway bogie and two modifications thereof, constructed in accordance therewith, will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a side-view of the bogie.

Figure 2 is a plan view of the bogie.

Figure 3 is a view in half-section on the line III-III of Figure 2,

Figure 4 is an enlarged detail of an elastic connection for the cross-bracing,

Figure 5 is a half-section similar to Figure 3 showing a modified form of bolster,

Figure 6 is a fragmentary half-view similar to Figure 1 of a modified vertical damper arrangement.

Referring to Figures 1 to 3, the bogie comprises two wheel-sets 1, 2 each comprising wheel 3 mounted on live axles 4, (i.e. each axle is solidly connected to its wheels 3). The wheels shown in Figures 1 to 3 have high effective conicity, i.e. λ in the range 0.05 to 0.5 and preferably 0.2 to 0.3. The wheel-set 1 rotates in axle bearings 5, whilst the wheel-set 2 rotates in axle bearings 6. The axle bearings are located in this example, but not necessarily, at the two ends of the axles of their respective wheel-sets and each bearing location comprises a box 7 which is designed to provide a bearing support surface having an included angle of not more than 180° . By providing a bearing support surface 8 which is semi-circular (or slightly less than semi-circular), a cartridge bearing 9 may be readily located on said surface and rigidly fixed in position by a part-circular strap 10 (see Figure 1). Each strap may be tightened down onto its cartridge bearing 9 by the use of bolts 11 as shown in Figure 1, or by a suitable detachable coupling (e.g. a hook-shaped joint) at one end of the strap and a bolt at the other end.

The axle boxes 7 in this arrangement form an integral part of the cross-bracing. Thus the cross-bracing comprises two rigid framework structures 12, 13 which extend between the axle boxes 7 of each wheel-set 1, 2. In this embodiment each framework comprises a transverse frame member 14 of generally shallow V-form in plan, the ends of which are welded to upwardly inclined longitudinal frame members 15; these frame members are of suitable cross-section so that the structure is stiff both transversely and longitudinally (e.g. of box or I-section). The free ends of the members 15 of each structure are provided with flanges 16 by which they are rigidly attached to their respective axle boxes either by bolts as shown, or by welding, or any other stiff connection. Each transverse member 14 of each structure 12, 13 is provided at its apex with a connecting plate 14a by which the members are flexibly connected by any suitable arrangement restraining the wheel sets 1, 2 from relative linear displacements, but permitting the wheel-sets 1, 2 to move freely relative to each other with rotational displacements such as in the yaw sense (for negotiating curves), perhaps with a small restoring torque. The flexible connection must also permit limited amounts of differential roll and pitch between the structures 12 and 13 and hence their respective wheel-sets 1 and 2. For example, the connecting plates 14a may provide tongue and channel sections (see Figure 4), the tongue being connected to the walls of the channel via rubber

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pads 14b bonded thereto (see Figure 4). Alternative arrangements for such a connection include the use of a "spherilastic" bearing i.e. a universal joint with a flexible insert between the joint components, or by use of "flexural" steel. In this embodiment each structure 12, 13 includes a welded-in transversely extending strut 17 extending between respective frame members 15 in the plane of its respective V-frame member 14 or 15, as shown in Figures 1 and 2. The struts 17 improve the longitudinal stiffness of the cross-bracing.

It can be readily seen from Figure 1 that the transverse frame members 14 are supported well below the height of the axles 4 of the wheel-sets, due to the inclination of frame members 15. This is to provide adequate space to accommodate a bolster 18 (see Figure 3) between the main side frames 19 of the bogie. Each side frame 19 extends in the longitudinal direction of the bogie and is supported at its ends by the appropriate axle boxes 7 of the wheel sets 1 and 2, each end of each frame being flexibly connected to its respective axle box via pairs of rubber pads 20 which provide the primary spring mounting and which act to restrain the axle box in pitch. It should be noted here that the lateral stiffness of each of these pads 20 is less than the lateral stiffness of the flexible connection between the cross-bracing structures 12, 13 to ensure that lateral and longitudinal movements in use tend to be accommodated by the primary spring mounting with low resultant forces, i.e. the primary plan view suspension is of low stiffness. The rubber pads 20 may be in the form of laminated units incorporating steel plates 21 (as shown in Figure 1) in order to obtain an acceptable vertical/lateral stiffness ratio.

In Figure 1, the rubber pad/plate units are shown horizontal but they could be arranged to be inclined at a predetermined angle to the horizontal to produce a desired longitudinal/lateral stiffness relationship for the primary spring mounting. The arrangement of the axle boxes 7 and primary spring mounting is such that the rubber pads 20 of the latter are at a relatively small height above the axes of the wheel sets 1 and 2. Consequently, the line of action of these pads for lateral and longitudinal movement is relatively low down on the bogie. This feature, coupled with the space provided by the relatively low position of the transverse frames 14 of the cross-bracing arrangement, facilitates the use of so-called "flexicoiling" springs (i.e. coils springs which are designed to take up shear movement in addition to vertical movement) to provide a secondary spring mounting for vertical and lateral movements, since it is desirable, although not essential that the line of action of the flexicoiling springs is substantially the same

as that for the rubber pads 20 of the primary spring mounting.

Referring to the drawings, in particular Figures 1 and 3, it can readily be seen that a flexicoiling spring mounting 22 is provided on each side of the bogie at a central position between the wheel-sets 1 and 2 and each spring in the mounting is located at its lower end over a spigot 23 on a sub-frame part 24 of its side frame 19. The upper end of each spring is located over a further spigot 25 projecting from the underside of a side flange 26 of the bolster 18.

Each side frame 19 in this embodiment is constructed from steel plate (rather than a conventional casting) and comprises a bridge member 27 from which the sub-frame 24 depends. It will not be noted that the bridge member and sub-frame define a rectangular space 28 within which its associated flexicoiling springs 22 and flange 26 of the bolster 18 are located. The bridge member and sub-frame of each side frame are basically of I-section and, in order to ensure a satisfactory fatigue life, the dimensions of the I-sections vary according to the distribution of load to which it is subjected in use. The variation of the I-sections is shown particularly in Figure 1. It will also be noted from this figure that the sub-frame 24 is hung from the bridge member 19 and includes an I-section part 24a of constant section and two triangular fillet parts 24b. The webs of the fillet parts 24b are provided with aligned pairs of spaced rectangular recesses 29 which are adapted to support the ends of two brake beams 30; for this purpose each end of each brake beam is bifurcated to provide two spigot portions 30a and 30b which locate into and through their respective recesses 29 to rest on a reinforcing plate 31 attached to a respective said web and extending between the pair of recesses. This fixing arrangement has the advantage that, compared with the conventional single spigot fixing arrangement, it provides improved torsional restraint to the brake beams and also a more satisfactory distribution of load to the side frames 19. For clarity only a part of each brake beam 30 is shown by dash lines in Figure 2.

The design of the side frames enables the bolster 18 if desired to be fabricated using standard sections and plate (instead of the conventional cast construction), since no complicated profiles or cut-outs need to be formed in the bolster. The cross-section of the bolster included in Figure 3 is of conventional cast construction and has a vertical damper arrangement comprising a link 32 pivoted to each side of the bolster and frictionally engaged at its lower end by a part 33 carried by the sub-frame 24, a slot 34 being provided to limit the vertical extent of the damping movement. A similar arrangement 39 provides for lateral damping between the

bolster and the bridge members 27 of the side-frames. As shown in Figure 3, the central part 35 of the upper face of the bolster is strengthened and provided with a cast annular recess 36 for rotatably supporting the underframe 37 of the vehicle body via a mating annular ring 38.

Referring to Figure 5, a bolster 18 of fabricated construction is shown as an alternative to the case bolster of Figure 3. It will be noted that the construction includes an upper steel plate 40, onto the upper surface of which an annular ring 41 is located centrally and welded thereto to provide the annular recess 36. The steel plate is strengthened and made stiff by a dished lower plate 42 which is welded to the underside of the plate 40 which, in this embodiment, but not necessarily, leaves a projecting outer edge of the plate 40 which constitutes the side flange 26.

With the design of the side frames 19 as described above and because of the rectangular spaces 28 defined therein an alternative form of vertical damper arrangement to that described above with reference to Figure 3 has been proposed. Thus, referring to Figure 6, the damper arrangement comprises two vertical friction liners 43 extending transversely between and rigidly fixed to the sub-frame 24 of the two side frames 19, each liner being arranged to receive in frictional engagement therewith a friction block 44. The friction blocks 44 are urged into engagement with their respective liners by spring biasing means, 45, which may provide a predetermined loading to control the frictional effect, and hence the damping rate, of the arrangement. It will be seen from Figure 6 that the alternative damper arrangement can be made as an extremely compact unit and located in that part of the space 28 above the flexicoiling spring mounting 22.

WHAT WE CLAIM IS:-

1. A railway vehicle of the kind having at least two wheel-sets, each with a five axle mounted in a respective pair of axle bearings, at least one axle bearing of one wheel-set being elastically interconnected with at least one axle bearing of the other wheel-set through bracing means providing bracing between the wheel-sets, wherein said bracing means comprise a frame structure for each wheel-set which extends transversely of the vehicle and is rigidly connected between axle boxes housing said axle bearings of its respective wheel-set, said frame structures being shaped and arranged so as to be connected together by said elastic connection at a level, which is below the axle height of the vehicle.

2. A railway vehicle according to Claim 1, wherein each frame structure comprises a transversely arranged horizontally extending frame member of generally shallow V-form in plan rigidly connected at its ends to

upwardly extending frame members which are in turn, rigidly connected to their respective axle boxes, the transverse frame members being connected via said elastic connection at their apices.

3. A railway vehicle according to Claim 1 or Claim 2, wherein the frame structures are connected via said elastic connection at a level well below said axle height, and wherein a bolster is accommodated within the space so provided between the wheel-sets.

4. A railway vehicle according to Claim 3, wherein the bolster is provided with side flanges which are supported via a secondary spring mounting within the height of side frames for the vehicle, and the arrangement is such that the line of action of the secondary spring mounting is substantially the same as that for a primary spring mounting between the side frames and respective axle boxes of the wheel-sets.

5. A railway vehicle according to Claim 4, wherein the secondary spring mounting is in the form of flexicoiling springs.

6. A railway vehicle according to any one of the preceding Claims and having side frames which are connected to respective axle boxes via a primary spring mounting for restraining the axle boxes in pitch, wherein the plan-view stiffness of each said primary spring mounting is designed to the less than the lateral stiffness of said elastic connection.

7. A railway vehicle according to Claim 6, wherein each primary spring mounting may comprise rubber pads which provide a required vertical/plane-view stiffness ratio.

8. A railway vehicle according to Claim 7, wherein the rubber pads are in the form of a laminated unit incorporating steel plates.

9. A railway vehicle according to Claim 7 or Claim 8, wherein the rubber pads or pad/plate units are inclined at a predetermined angle to the horizontal to produce a desired longitudinal/lateral stiffness relationship for the primary spring mounting.

10. A railway vehicle according to any one of claims 1 to 9, and having side frames connected to respective axle boxes via a primary spring mounting, wherein each said side frame is of fabricated construction comprising a bridge member of I-section from which a sub-frame depends, said bridge member and sub-frame defining a space therebetween into which respective side flanges of a bolster project, each said flange being supported by the respective sub-frame via a secondary spring mounting.

11. A railway vehicle according to Claim 10, wherein the space defined by said bridge member and sub-frame houses a combined vertical and lateral damping arrangement for the bolster comprising a pair of friction blocks which are loaded by a required amount by spring biasing means into contact

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bolster and the bridge members 27 of the side-frames. As shown in Figure 3, the central part 35 of the upper face of the bolster is strengthened and provided with a cast annular recess 36 for rotatably supporting the underframe 37 of the vehicle body via a mating annular ring 38.

Referring to Figure 5, a bolster 18 of fabricated construction is shown as an alternative to the case bolster of Figure 3. It will be noted that the construction includes an upper steel plate 40, onto the upper surface of which an annular ring 41 is located centrally and welded thereto to provide the annular recess 36. The steel plate is strengthened and made stiff by a dished lower plate 42 which is welded to the underside of the plate 40 which, in this embodiment, but not necessarily, leaves a projecting outer edge of the plate 40 which constitutes the side flange 26.

With the design of the side frames 19 as described above and because of the rectangular spaces 28 defined therein an alternative form of vertical damper arrangement to that described above with reference to Figure 3 has been proposed. Thus, referring to Figure 6, the damper arrangement comprises two vertical friction liners 43 extending transversely between and rigidly fixed to the sub-frame 24 of the two side frames 19, each liner being arranged to receive in frictional engagement therewith a friction block 44. The friction blocks 44 are urged into engagement with their respective liners by spring biasing means, 45, which may provide a predetermined loading to control the frictional effect, and hence the damping rate, of the arrangement. It will be seen from Figure 6 that the alternative damper arrangement can be made as an extremely compact unit and located in that part of the space 28 above the flexicoiling spring mounting 22.

WHAT WE CLAIM IS:-

1. A railway vehicle of the kind having at least two wheel-sets, each with a live axle mounted in a respective pair of axle bearings, at least one axle bearing of one wheel-set being elastically interconnected with at least one axle bearing of the other wheel-set through bracing means providing bracing between the wheel-sets, wherein said bracing means comprise a frame structure for each wheel-set which extends transversely of the vehicle and is rigidly connected between axle boxes housing said axle bearings of its respective wheel-set, said frame structures being shaped and arranged so as to be connected together by said elastic connection at a level, which is below the axle height of the vehicle.

2. A railway vehicle according to Claim 1, wherein each frame structure comprises a transversely arranged horizontally extending frame member of generally shallow V-form in plan rigidly connected at its ends to

upwardly extending frame members which are in turn, rigidly connected to their respective axle boxes, the transverse frame members being connected via said elastic connection at their apices.

3. A railway vehicle according to Claim 1 or Claim 2, wherein the frame structures are connected via said elastic connection at a level well below said axle height, and wherein a bolster is accommodated within the space so provided between the wheel-sets.

4. A railway vehicle according to Claim 3, wherein the bolster is provided with side flanges which are supported via a secondary spring mounting within the height of side frames for the vehicle, and the arrangement is such that the line of action of the secondary spring mounting is substantially the same as that for a primary spring mounting between the side frames and respective axle boxes of the wheel-sets.

5. A railway vehicle according to Claim 4, wherein the secondary spring mounting is in the form of flexicoiling springs.

6. A railway vehicle according to any one of the preceding Claims and having side frames which are connected to respective axle boxes via a primary spring mounting for restraining the axle boxes in pitch, wherein the plan-view stiffness of each said primary spring mounting is designed to be less than the lateral stiffness of said elastic connection.

7. A railway vehicle according to Claim 6, wherein each primary spring mounting may comprise rubber pads which provide a required vertical/plane-view stiffness ratio.

8. A railway vehicle according to Claim 7, wherein the rubber pads are in the form of a laminated unit incorporating steel plates.

9. A railway vehicle according to Claim 7 or Claim 8, wherein the rubber pads or pad/plate units are inclined at a predetermined angle to the horizontal to produce a desired longitudinal/lateral stiffness relationship for the primary spring mounting.

10. A railway vehicle according to any one of claims 1 to 9, and having side frames connected to respective axle boxes via a primary spring mounting, wherein each said side frame is of fabricated construction comprising a bridge member of I-section from which a sub-frame depends, said bridge member and sub-frame defining a space therebetween into which respective side flanges of a bolster project, each said flange being supported by the respective sub-frame via a secondary spring mounting.

11. A railway vehicle according to Claim 10, wherein the space defined by said bridge member and sub-frame houses a combined vertical and lateral damping arrangement for the bolster comprising a pair of friction blocks which are loaded by a required amount by spring biasing means into contact

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with friction liners extending transversely between and fixed to the sub-frames of said side frames.

- 5 12. A railway vehicle according to any one of claims 1 to 11, wherein each said axle box is fabricated to provide a bearing support surface which is semi-circular or less, for supporting a cartridge bearing, and the cartridge bearing is rigidly fixed in position by a
10 part-circular strap appropriately fixed on the axle box and tightened down onto said cartridge bearing.

13. A railway vehicle constructed, arranged and adapted for use substantially as hereinbefore described with reference to the
15 accompanying drawings.

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