

"BRACED RAIL TRUCKS"

The present invention relates to trucks for rail vehicles and in particular to apparatus for improving the stability of such trucks.

5 It is of course well known to provide a rail vehicle with a pair of trucks located at opposite ends of the vehicle to support the body of the vehicle. Conventionally these trucks are provided with a pair of axles and are pivoted to the body of the vehicle to permit the trucks to negotiate a curve.

10 A commonly used truck assembly includes a pair of longitudinal side frames with a pair of axle assemblies extending between the side frames at opposite ends. The axle assemblies are supported so they may rotate about a horizontal axis to allow the truck to roll

15 along rails. The side frames are interconnected by a bolster that is mounted to the side frame through a set of springs to accommodate vertical, and to a certain extent, lateral loads. The bolster is

20 pivotally connected to the vehicle to provide the connection between the vehicle and the truck. The bolster may be displaced vertically relative to the frames in slides so that there is freedom to move vertically but not longitudinally. This permits

25 the transmission of longitudinal forces between the bolster and the side frames. The connection of the bolster to the side frames permits each side frame to pivot relative to the bolster about a horizontal axis and as such allows the wheels to

30 move vertically with respect to one another. This allows the truck to travel over track which is uneven

and maintains a good load distribution between the four wheels of the truck.

5 This arrangement of truck provides a very stiff constraint against any out of phase yaw displacements of the wheelsets (that is, it maintains the wheelsets parallel to one another). However, the arrangement offers very little restraint to inphase yaw displacement in which the wheel sets remain parallel to one another but not perpendicular to the side frames. This inphase yaw displacement is commonly known as lozenging and results in two undesirable characteristics. Firstly, an unstable condition known as hunting can occur in which the yaw displacements occur in a continuous oscillatory manner excited by the action of the wheels against the rails. Such a motion promotes high wheel and rail wear, causes high shock levels to be transmitted to the rails and the vehicle body and can, in extreme cases, lead to derailment of the vehicle.

20 The second action occurs on curves. When the vehicle travels on curves of sufficiently small radius to cause the leading wheelset to come into flange contact with the outer rail the wheelset experiences a yaw torque which turns it toward the outer rail. This creates a very high angle of attack of the leading axle with the rail and it is well known that such high angles of attack result in high levels of wear and noise as well as creating high force levels and the possibility of derailment.

30 One solution to such lozenging has been to use trucks having a rigid H frame. In this type of construction the bolster and side frames are integrally formed so that relative longitudinal displacement between the side frames cannot occur. Such frames tend to be extremely rigid so that their ability to

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accommodate vertical movement between the axles is not very good, and surprisingly they have a relatively low critical velocity, that is the velocity at which instability occurs.

5 It has also been suggested to use braces extending diagonally between the side frames and rivetted to them at spaced locations. This construction is also inherently rigid and therefore has the disadvantages of low stability associated with the H frame truck.

10 Proposals have also been made to use diagonal braces between the journal boxes of the wheel sets. However, this arrangement becomes complicated by the movement of the journal boxes relative to the side frames and increases the unsprung weight of the vehicle. Further, the arrangement can conveniently be used only on trucks in which the frames
15 are located in-board of the wheels when the side frames are in the conventional outboard position. This complicates the structure used to brace their axles and further increases the unsprung weight.

20 According to one aspect of the present invention there is provided a truck comprising a truck frame having a longitudinal axis and including a pair of laterally spaced side frame members, means for connecting the truck frame to a vehicle body, a pair of wheelsets extending between the side frame members at opposite ends thereof and supported
25 for rotation about a horizontal transverse axis, first resilient means interposed between the wheelsets and respective ones of the side frame members to accommodate movement of the wheelsets from a mutually parallel position, and bracing means extending between the side
30 frame members, the bracing means being independent of the connecting means and comprising a pair of struts connected at opposite ends to the side frame members and inclined to the longitudinal axis of the truck frame, the struts having associated second resilient means to accommodate relative

longitudinal movement between the side frame members, the first resilient means and the bracing means thereby providing the truck frame with controlled flexibility in shear.

- 5 According to a second aspect of the present invention there is provided a truck comprising a frame having a pair of laterally spaced side members, a bolster extending between the side frame members, a pair of wheelsets extending between the side frame members at opposite ends
- 10 thereof to support the members, first resilient means interposed between the wheelsets and the respective members, strut means extending between the side frame members to brace the frame, and second resilient means connected between the side frame members and the strut
- 15 means, the first and second resilient means providing a yaw stiffness and a lateral stiffness for the truck, the stiffnesses being selected such that an increase in at least one of the stiffnesses lowers the critical velocity of the truck.

According to a third aspect of the present invention there is provided a method of increasing the stability of a truck having a frame comprising a pair of laterally spaced side members with a pair of wheelsets at opposite ends thereof, the method comprising selecting values of yaw stiffness and lateral stiffness lying on a characteristic curve for maximum critical velocity on a plot of yaw stiffness versus lateral stiffness, locating first resilient means between the wheelsets and the side frame members to attain the selected value of yaw stiffness of the truck, and resiliently bracing the side frame members to provide the selected value of lateral stiffness for the frame.

According to a fourth aspect of the present invention there is provided a method of increasing the stability of an existing truck having a pair of laterally spaced side frames with a pair of axle assemblies at opposite ends thereof and a bolster extending laterally between the side frames, the method comprising determining the existing values of yaw stiffness and lateral stiffness, selecting an increased value of at least the lateral stiffness of the truck, locating first resilient means between the axle assemblies and the side frames to determine the yaw stiffness of the truck, bracing the side frames, and locating second resilient means between the bracing means and the side frames to provide the required value of lateral stiffness.

According to a fifth aspect of the present invention there is provided a truck comprising a pair of longitudinally spaced transversely extending wheelsets each

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having a pair of wheels with an axle extending there-
between, a truck frame including a pair of laterally
spaced side members each of which has an axle receiving
member at opposite ends thereof, and a bolster
5 extending between the side frame members intermediate
the axle receiving members, each of the receiving
members being located on a respective one of the
axles to maintain the wheelsets in spaced parallel
relationship, first elastomeric means interposed
10 between each receiving member and the axle to
accommodate controlled movement of the axles from
a mutually parallel position and thereby determine
the yaw stiffness of the truck, brace means independent
of the bolster extending between the side frame
15 members to increase the lateral stiffness of the
truck, and resilient coupling means connecting the
brace means to the side frame members, the brace
means thereby providing a controlled flexibility
in shear.

20 According to a sixth aspect of the invention
there is provided a method of improving the stability
of a truck having a frame including a pair of long-
itudinal side members supported at opposite ends on
a pair of transverse wheelsets and means for connecting
25 the frame to a vehicle body, the method comprising
inserting resilient means between the wheelsets and
respective ones of the side frame members to reduce
the resistance to out of phase yaw displacement
between the wheelsets, and locating brace means
30 with associated resilient means between the side
frame members independently of the connecting means
to increase the resistance to a force tending to
displace laterally one of the wheelsets relative to
the other.

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An embodiment of the invention will now be described by way of example only, with reference to the accompanying drawings, in which:-

- 5 Figure 1 is a side view of a truck,
 Figure 2 is an underview of the truck shown in Figure 1,
 Figure 3 is a detail of a portion of the truck shown in Figure 2,
10 Figure 4 is a series of curves showing the relationship between yaw stiffness and lateral stiffness for a given truck.

Referring now to the drawings, a truck 20 includes a pair of longitudinal side frames 22 - 24 supporting a pair of wheelsets 26 - 28. Each wheelset includes a pair of flanged wheels 30 secured to an axle 32, the ends of which are supported in journal boxes 34. The journal boxes 34 are secured in yokes 36 formed at each end of the side frames 22 - 24 so that the axles may rotate about a generally horizontal axis relative to the side frames 22 - 24. An elastomeric pad 37 is positioned between each journal box 34 and yoke 36 to provide a primary suspension for the axle assembly and to permit limited controlled movement of the wheelsets out of parallel.

A bolster 38 extends between the side frames 22 - 24 and passes through an aperture 40 formed in the central portion of each side frame. The ends of the bolster 38 are supported on a spring assembly 42 to permit vertical movement between the bolster 38 and the side frames 22 - 24 and bear against slides 44 connected to the vertical edges of the apertures 40 so that the bolster may move vertically but not longitudinally relative to the side frames.

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A pair of webs 48 are welded to the side frames 22 - 24 between the yokes 36. The webs 48 are equally spaced from the centre line of the truck and are inclined relative to the longitudinal axis of the truck. A pair of struts 50 extend between diagonally opposite webs 48 so that the struts intersect on the centre line of the truck. The struts are received in the webs 48 in the manner best shown in Figure 3. Each strut 50 has a reduced portion 52 at each end that terminates in a thread 54. A hole 56 is formed in the web 48 of a diameter greater than the diameter of the reduced portion 52. A pair of elastomeric inserts 58 is located between the reduced portion 52 and the wall of the hole 56 and each has a radially directed shoulder 60 that bears against the face of the web 48. Washers 62 are mounted on the reduced portion 52 to engage the outer faces of the elastomeric inserts 58 and a nut 64 attached to the thread 54 to compress the shoulders 60 of the inserts between the washers 62 and the outer faces of the web 48. The inserts 58 therefore provide an elastic connection between the struts 50 and the web 48 and provide a controlled flexibility between the side frames of the truck. The struts 50 are attached to one another at their point of intersection by means of a shackle 66 to inhibit vertical vibration of the struts 50.

In operation, the struts 50 are effective to oppose lozenging of the side frames, that is relative longitudinal movement between the side frames but by virtue of the elastic connection and their flexibility in bending do not introduce undue rigidity which would inhibit vertical displacement between the wheelsets 26. The elastomeric inserts 58 are chosen to provide the desired degree of shear

flexibility in the truck for a dynamically stable configuration. The inserts 37 assist in providing the optimum value of such flexibility but the primary contribution is from the inserts 58.

5 Figure 4 shows a typical family of curves for
a given truck that illustrates the relationship between
the truck stiffness and the critical velocity which
is the velocity at which a truck experiences insta-
10 bility. The parameter K_B is defined as the resis-
tance to out of phase yaw displacement between the
axles, that is the resistance offered to a couple
tending to move the wheelsets out of a parallel
condition. The Stiffness K_S is the stiffness offered
15 to a force tending to laterally displace one of the
wheelsets 26 relative to the other. The relationship
between K_B and K_S is determined by the dimensions of
the truck, the disposition of the struts 50 and the
resilience of the elastomeric inserts 58. The curves
20 indicated V1, V2, V3 etc., represent characteristic
critical velocities at which a truck having a yaw
stiffness $K_{B(n)}$ and a lateral stiffness $K_{S(n)}$ that
lie on the characteristic curve V_n will have a
critical velocity V_n . Beyond that velocity the truck
becomes inherently unstable. It will be observed
25 that there is a curve $V_{C \text{ MAX}}$ that interconnects the
saddle points of the characteristic curves and
represents the maximum velocity of the truck before
instability occurs. Therefore, by selecting values
of K_S and K_B that lie on the curve $V_{C \text{ MAX}}$, the
30 critical velocity of the truck may be a maximum.
The curves are subtended by a line having a value
 $K_S = 1/a^2 K_B$ where "a" is half the distance between
the axles 26, 28. For all practical considerations
it can be shown that $K_S < 1/a^2 K_B$ for a truck in
35 which the wheelsets are not directly coupled. The

configuration of the struts 50 and the stiffness of the inserts 58 may therefore be chosen to ensure that the maximum critical velocity is obtained.

5 The characteristic curves beyond the curve $V_{C \text{ MAX}}$ each have a critical velocity lower than $V_{C \text{ MAX}}$. Therefore a rigid truck such as that utilising an H frame or employing rivetted cross braces would have a low critical velocity which explains the
10 instability of such trucks. Similarly, a truck having a high degree of flexibility, such as a conventional 3 piece truck assembly, would also have a low critical velocity. However, by introducing the elastic bushes to provide controlled flexibility in shear, a truck with the desired critical velocity may be obtained.

15 In tests performed by the applicant a Barber Type S2 truck was modified by utilising the structure shown in the drawings. The struts 50 were inclined at an angle of 66° to the longitudinal axis of the truck and the inserts 58 prepared from an elastomeric
20 material having a hardness of 70 durometer. The inserts had an outside diameter of 3 inches so that an annulus of material of area approximately 6 square inches and 1 inch thick was positioned between the washers 62 and the web 48. The length of the struts
25 between the washers 62 was 82.5 inches and the struts were made from low carbon steel with an outside diameter 2 inches. The inserts 58 when assembled on the struts 50 and web 48 provided a stiffness of 4×10^7 N/M measured along the axis of the strut.
30 With this arrangement the stiffness of the truck was increased from a value of 2×10^5 N/m for K_s to $2 \cdot 10^6$ N/m. The critical velocity of the truck was calculated to be increased from 31 m.p.h. to 74 m.p.h. (neglecting the effects of friction damping).

35 It will be apparent that the structure disclosed

is particularly adaptable to retrofitting to existing trucks in order to increase their critical velocity and curving behaviour. Such a retrofit may be accomplished with the simple addition of the webs 48 to the truck frame or the utilisation of existing holes in the side frames of the truck if such are available. The stiffness imparted to the truck may be varied by the selection of the elastomeric material and by the dimensions of the inserts 58. The stiffness K_B is not greatly affected by the retrofitting of struts 50 and the existing value of K_B may therefore limit the increase in critical velocity that can be achieved by a simple retrofit below the value $V_C \text{ MAX}$.

It will be seen therefore that the disadvantages associated with the prior art are obviated or mitigated in a simple, convenient manner. Although in the embodiment described the struts 50 pass beneath the bolster 38, they may if practical pass through apertures in the bolster. This allows the struts to be positioned close to the rotational axis of the wheelset and minimise the tendency to twist the side frames about their longitudinal axes. The provision of the elastomeric blocks 37 also contributes to the improved performances of the truck. The effect of these blocks is to lower K_B and it can be seen from Figure 4 that a reduction in this value leads to a reduction of critical velocity. However, a similar plot showing the characteristic curves of angle of attack would show that a reduction in K_B reduces the angle of attack and so improves the curving characteristics of the truck. The provision of the strut 50 then increases the value of K_s without unduly affecting K_B so that an increased critical velocity is obtained whilst retaining the improved curving characteristics.

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CLAIMS

1. A truck comprising a truck frame having a longitudinal axis and including a pair of laterally spaced side frame members, means for connecting the truck frame to a vehicle body, a pair of wheelsets extending between the side frame members at opposite ends thereof and supported for rotation about a horizontal transverse axis, first resilient means interposed between the wheelsets and respective ones of the side frame members to accommodate movement of the wheelsets from a mutually parallel position, and bracing means extending between the side frame members, the bracing means being independent of the connecting means and comprising a pair of struts connected at opposite ends to the side frame members and inclined to the longitudinal axis of the truck frame, the struts having associated second resilient means to accommodate relative longitudinal movement between the side frame members, the first resilient means and the bracing means thereby providing the truck frame with controlled flexibility in shear.
2. A truck according to claim 1 wherein the connecting means comprises a bolster extending transversely between the side frame members and resiliently supported thereon.
3. A truck according to claim 2 wherein the second resilient means is interposed between terminal portions of the struts and respective ones of the side frame members.
4. A truck according to claim 3 wherein the struts pass through apertures in the members and the second resilient means is interposed between the struts and respective members in the region of the apertures.





5. A truck according to claim 3 wherein the second resilient means provide the sole connection between the struts and the truck frame.

5 6. A truck according to any one of the claims 2 to 4 wherein the flexibility in shear of the truck is selected to provide a maximum critical velocity.

10 7. A truck comprising a frame having a pair of laterally spaced side members, a bolster extending between the side frame members, a pair of wheelsets extending between the side frame members at opposite ends thereof to support the members, first resilient means interposed between the wheelsets and the respective members, strut means extending
15 between the side frame members to brace the frame, and second resilient means connected between the side frame members and the strut means, the first and second resilient means providing a yaw stiffness and a lateral stiffness for the truck, the stiffnesses being selected such that an
20 increase in at least one of the stiffnesses lowers the critical velocity of the truck.

25 8. A truck according to claim 7 wherein the strut means includes a pair of struts extending between the side frame members.

9. A truck according to claim 8 wherein the second resilient means provides the sole attachment of the struts to the truck frame.

30 10. A truck according to claim 9 wherein the struts are equally and oppositely inclined to each of the side frame members.



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11. A truck according to claim 10 wherein the second resilient means comprises elastomeric members interposed between the side frame members and the struts.
- 5 12. A truck according to claim 11 wherein the struts are supported by webs depending from the side frame members and the elastomeric members are received between the webs and the struts.
- 10 13. A truck according to claim 12 wherein the webs are positioned normal to the longitudinal axis of the struts.



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5. 14. A method of increasing the stability of a truck having a frame comprising a pair of laterally spaced side members with a pair of wheelsets at opposite ends thereof, the method comprising selecting values of yaw stiffness and lateral stiffness lying on a characteristic curve for maximum critical velocity on a plot of yaw stiffness versus lateral stiffness, locating first resilient means between the wheelsets and the side frame members to attain the selected value of yaw stiffness of the truck, and resiliently bracing the side frame members to provide the selected value of lateral stiffness for the frame.

15. A method of increasing the stability of an existing truck having a pair of laterally spaced side frames with a pair of axle assemblies at opposite ends thereof and a bolster extending laterally between the side frames, the method comprising determining the existing values of yaw stiffness and lateral stiffness, selecting an increased value of at least the lateral stiffness of the truck, locating first resilient means between the axle assemblies and the side frames to determine the yaw stiffness of the truck, bracing the side frames, and locating second resilient means between the bracing means and the side frames to provide the said required value of lateral stiffness.

16. A method according to claim 15 wherein the required value is selected to lie adjacent a line expressing the limit $K_s = 1 / a^2 K_B$ on a plot of K_s versus K_B where K_s is the resistance offered to a force tending to laterally



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displace the axles relative to one another, K_B is the resistance to out of phase yaw displacement between the axles and "a" is one half the distance between the axles.

5 17. A method according to claim 15 or 16 wherein the bracing means includes elastomeric members at opposite ends of a strut fitted between the side frames.

10 18. A truck comprising a pair of longitudinally spaced transversely extending wheelsets each having a pair of wheels with an axle extending therebetween, a truck frame including a pair of laterally spaced side members each of which has an axle receiving member at opposite ends thereof, and a bolster extending between the side frame
15 members intermediate the axle receiving members, each of the receiving members being located on a respective one of the axles to maintain the wheelsets in spaced parallel relationship, first elastomeric means interposed between
20 each receiving member and the axle to accommodate controlled movement of the axles from a mutually parallel position and thereby determine the yaw stiffness of the truck, brace means independent of the bolster extending
between the side frame members to increase the lateral stiffness of the truck, and resilient coupling means connecting
25 the brace means to the side frame members, the brace means thereby providing a controlled flexibility in shear.

19. A truck according to claim 18 wherein the brace means includes a pair of struts extending between the side frame
30 members each oppositely inclined to the axis of rotation of the wheelsets.

20. A truck according to claim 19 wherein the coupling means comprise elastomeric bushings interposed between the



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struts and the side frame members.

21. A truck according to claim 20 wherein the coupling
means provides the sole connection between the brace means
5 and the truck frame.

22. A truck according to claim 21 wherein the struts are
equally and oppositely inclined to the axis of rotation of
the wheelsets.
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23. A truck according to claim 22 wherein the struts
intersect on the longitudinal axis of the truck.

24. A truck according to claim 21 wherein the struts are
15 interconnected at their point of intersection.

25. A truck according to claim 24 wherein the struts are
received in webs located on the side frame members and
extending normal to the longitudinal axis of the struts.
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26. A truck according to claim 25 wherein bosses are
provided on each of the struts adjacent each of the webs
and an elastomeric bush is located between respective ones
of the boss and the web.
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27. A truck according to claim 26 wherein each of the
struts extends through its respective web and a plate is
located on the strut on the opposite side of the web to the
boss, an elastomeric bush being located between the plate
30 and the web.

28. A method of improving the stability of a truck having
a frame including a pair of longitudinal side members
supported at opposite ends on a pair of transverse



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wheelsets and means for connecting the frame to a vehicle body, the method comprising inserting resilient means between the wheelsets and respective ones of the side frame members to reduce the resistance to out of phase yaw displacement between the wheelsets, and locating brace means with associated resilient means between the side frame members independently of the connecting means to increase the resistance to a force tending to displace laterally one of the wheelsets relative to the other.

29. A method according to claim 28 wherein the resistances are selected such that an increase in one of the said resistances provides a reduction in the maximum critical velocity of the truck.

30. A rail truck substantially as herein described with reference to the accompanying drawings.

