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[54] **STABILIZING HIGH SPEED RAILWAY TRUCKS**
5 Claims, 5 Drawing Figs.

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[51] Int. Cl. **B61f 3/08,** B61f 5/20, B61f 5/24
[50] Field of Search .... 105/164, 168, 197, 199, 167, 185, 189, 190 R, 190 A, 191, 193, 197 R, 199 R, 200, 171, 197 A, 197 B, 201, 224.1, 213

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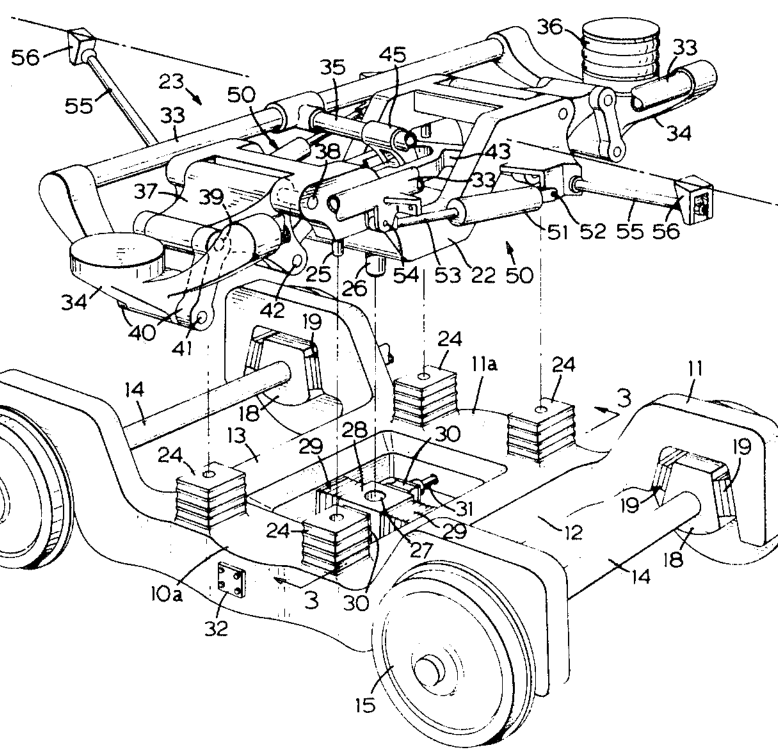
ABSTRACT: In a railway truck a pivot between the truck frame and the cooperating bolster is permitted to have lateral displacement to improve the riding qualities of the truck. The pivot is maintained automatically centered by motor means which oppose centrifugal forces that would displace the pivot, e.g., while the truck traverses a curve, thereby ensuring that lateral displacement is still possible under such conditions. A special design of such a truck is provided with a bolster comprising two parts, designated upper and lower parts, the lower bolster part being pivotally mounted on the truck transom, while the upper bolster part mounts the vehicle body for vertical springing movement; the two bolster parts are connected together by an articulated linkage for lateral arcuate movement about a longitudinal tilting axis under the action of motor means.



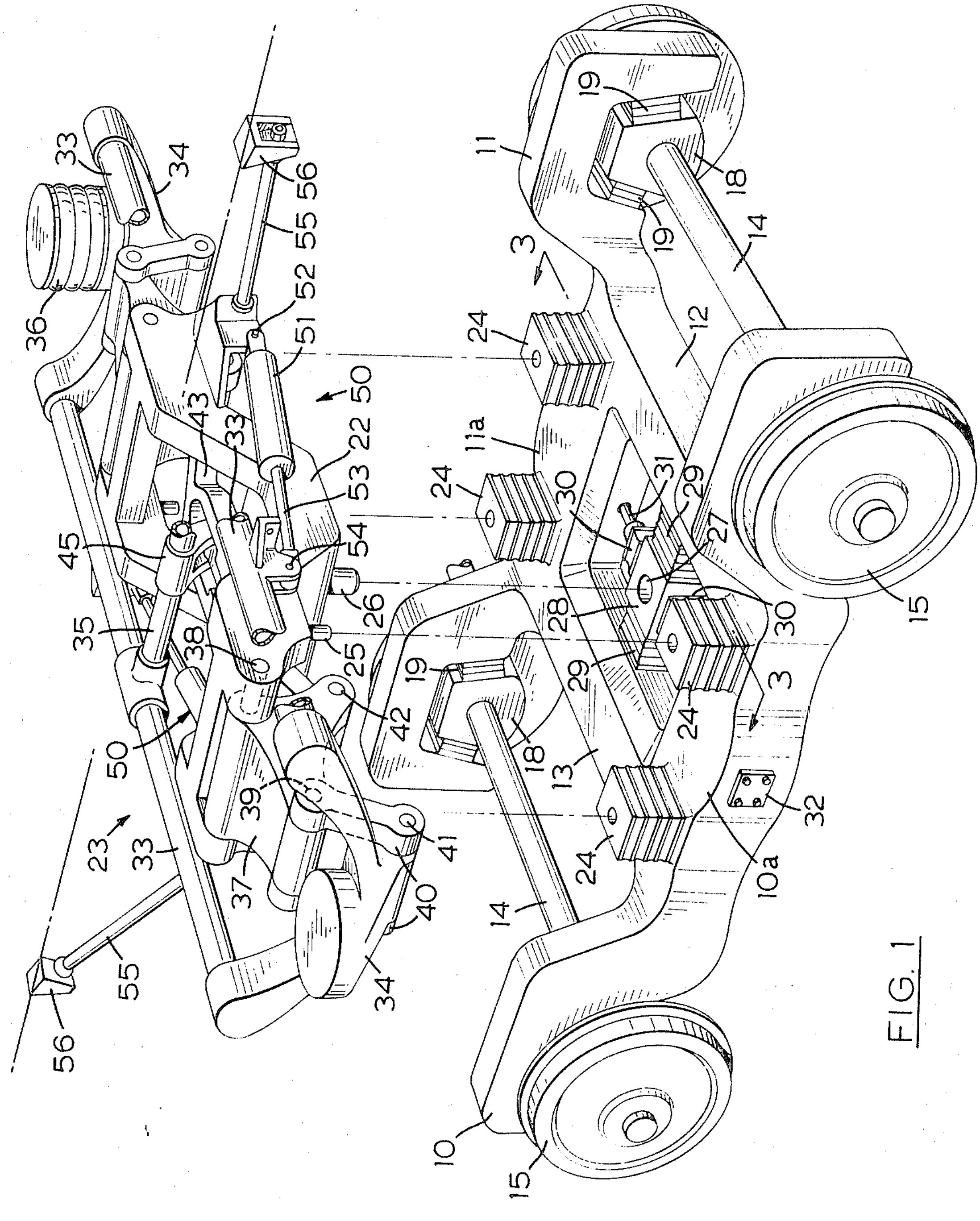


FIG. 1

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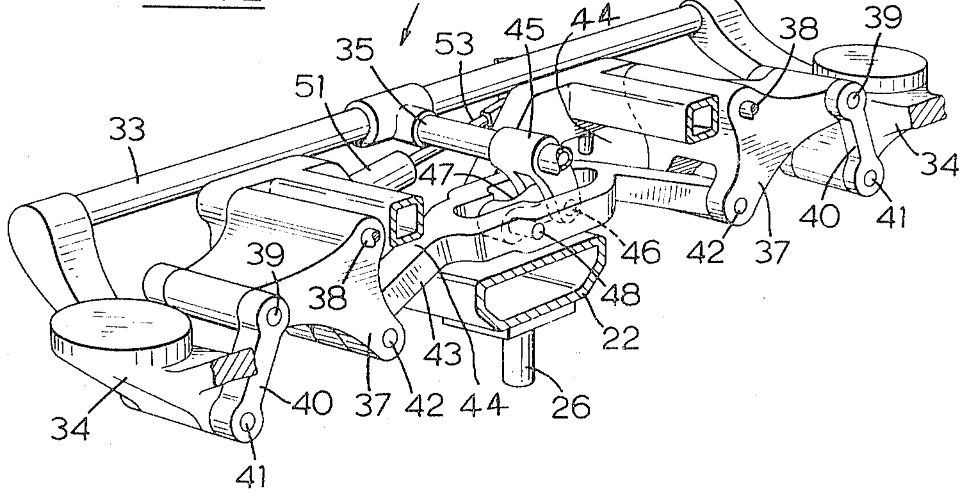
FIG. 2



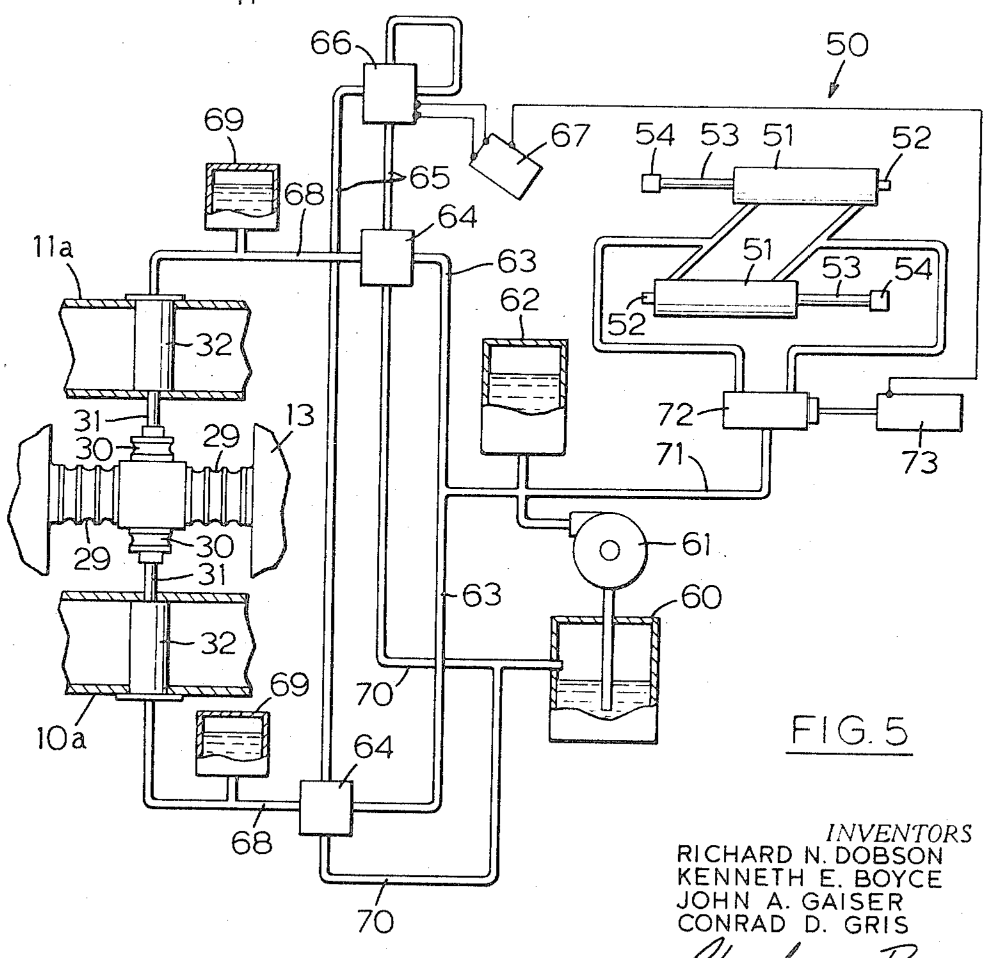


FIG. 5

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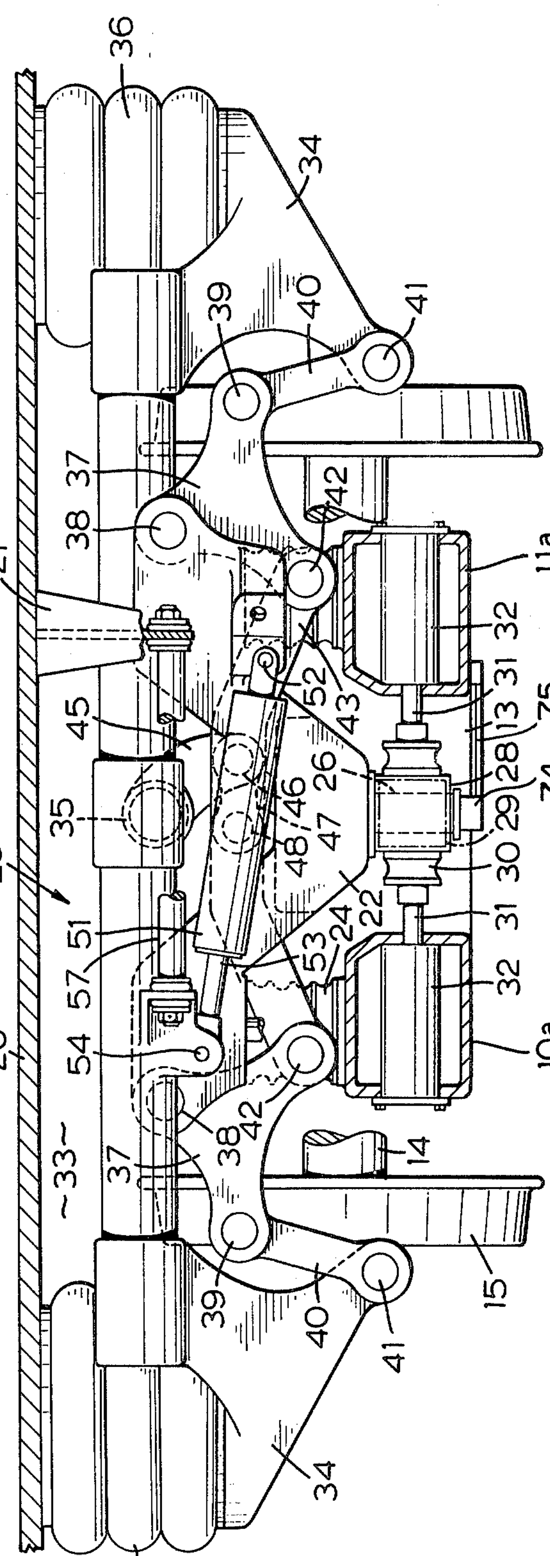

FIG. 3

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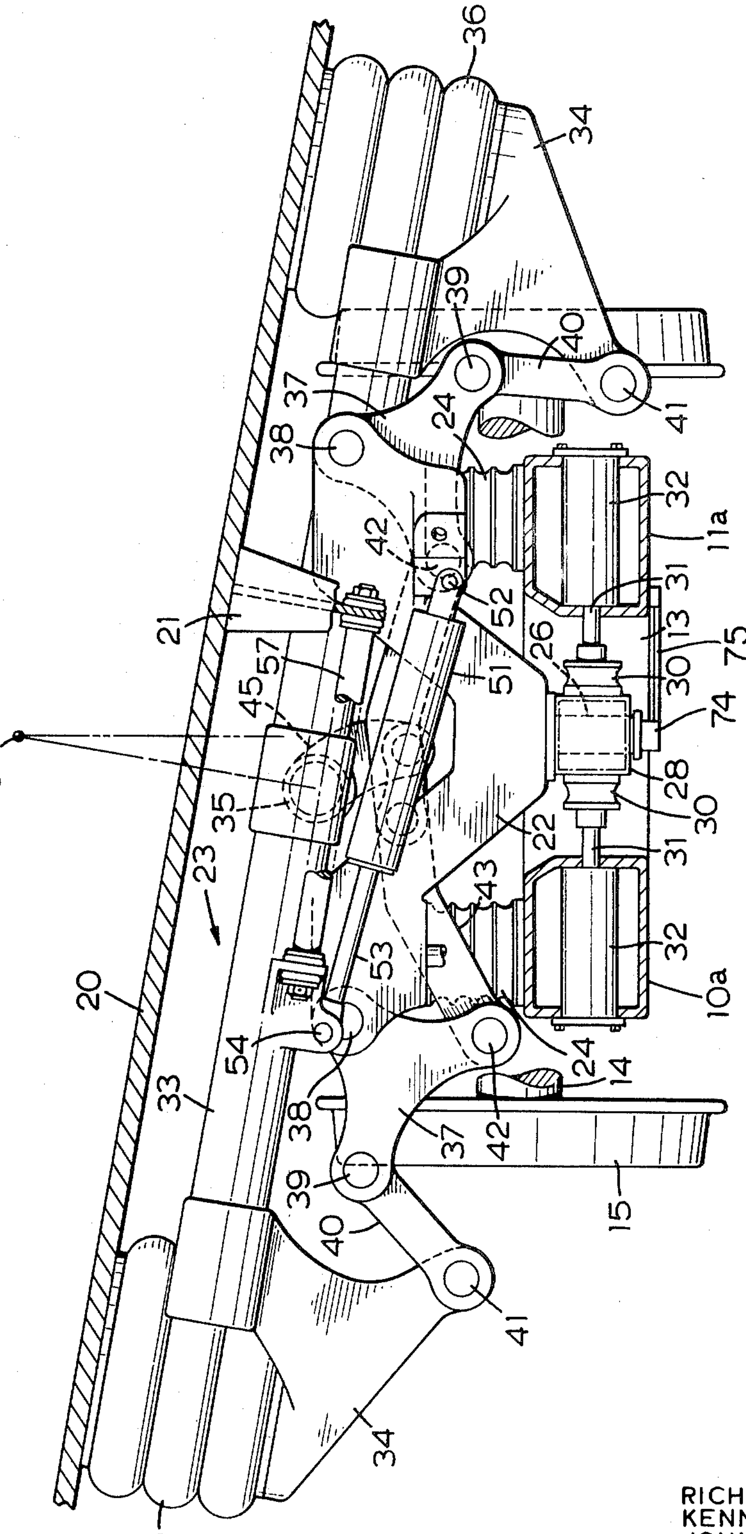

FIG. 4

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STABILIZING HIGH SPEED RAILWAY TRUCKS

FIELD OF THE INVENTION

This invention is concerned with improvements in or relating to railway trucks, and especially but not exclusively to such trucks intended for use in high speed passenger cars.

REVIEW OF THE PRIOR ART

It is a continuing requirement for railway vehicles, particularly passenger cars, to achieve higher speeds combined with a safe, comfortable ride, and it is now considered a normal requirement for such cars to travel at speeds as high as 120 m.p.h., speeds in excess of this figure usually requiring a specially built track structure. It is of course apparent that faster scheduled train times can be achieved if the average speed can be maintained as near as possible to the maximum, even around curves, but attempts to take present normal passenger cars around curves at these speeds, even when the track is given the maximum possible banking elevation, results in uncomfortably high lateral forces (i.e., greater than 0.05 g.) being applied to the passengers. Accordingly, a number of proposals have been made hitherto to tilt the cars about a longitudinal axis, and thereby reduce the lateral force applied to passengers.

It is found that careful location of the tilting or roll axis is required relative to the center of gravity if the maximum effective banking angles are to be compatible with passenger safety. From considerations of speed, comfort and safety the center of gravity is designed to be as low as possible, and desirably the roll axis should be just below the center of gravity, so that relatively high tilt angles can be employed in curves, while the resultant of the centrifugal and gravity forces is still within the middle one third of the track gauge, which is the generally accepted safety limit.

It is desirable also to provide as far as possible that the structure and components used in the trucks are, as much as possible, the same or very closely similar to those of existing vehicles, so that the servicing and maintenance thereof can readily be accomplished with existing railway equipment, shop skills and personnel.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a new railway truck having a laterally displaceable pivot between the truck and a cooperating bolster, and wherein means are provided for maintaining the pivot centered against the action of centrifugal forces tending to displace it laterally, for example as the truck traverses a curve.

In accordance with the invention there is provided a railway truck comprising a truck frame constituted by transversely spaced side frames and transom means extending between the said frames; at least two wheel and axle assemblies mounted by the frame and on which the truck runs; a bolster frame; a truck frame pivot member mounted by the truck frame and engageable with a cooperating bolster frame pivot member mounted by the bolster frame, the pivot members cooperating with one another to constrain the bolster frame for pivoting movement about a generally vertical axis, one of the said pivot members being mounted by its mounting for lateral movement relative to its frame, motor means operatively connected between one of the pivot members and its respective frame and operative to move the pivot member laterally, detector means operative with the truck upon the presence of a condition applying a force on the said pivot members urging lateral movement of the pivot axis from a center position, and means operative in response to said detector means for actuating the motor means to at least oppose the said force and urge the said pivot axis toward the said center position.

DESCRIPTION OF THE DRAWINGS

A particular preferred embodiment will now be described, by way of example, with reference to the accompanying diagrammatic drawings, wherein

FIG. 1 is a perspective view with the bolster displaced vertically from the truck frame for clarity of illustration,

FIG. 2 is a similar view of the bolster with parts thereof broken away for greater clarity of illustration,

FIG. 3 is a section taken on the line 3—3 of FIG. 1,

FIG. 4 is a view similar to that of FIG. 3, but showing the car body supported by the truck frame in an inclined attitude, as when traversing a curve, and

FIG. 5 is a schematic diagram of the control circuit for the automatically operated bolster centering devices of the embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The particular preferred embodiment illustrated herein and modifications thereto are also described and claimed in our copending application Ser. No. 2796, filed Jan. 14, 1970. The embodiment comprises a four-wheel, high-speed passenger truck, having a frame which is a unitary steel casting to provide maximum rigidity. The frame comprises two parallel side frame members **10** and **11**, which have their center portions (**10***a* and **11***a* respectively) depressed to the greatest possible extent, these members being connected to one another intermediate their ends by two longitudinally spaced transoms **12** and **13**. The truck runs on two similar wheel and axle assemblies, each constituted by a respective axle **14** and pair of wheels **15**. The truck is of course provided with conventional brakes, but the specific details of the construction and arrangement thereof will be apparent to those skilled in the art, and are not further described herein since they form no part of the present invention. A truck in accordance with the present invention may also be a motorized unit, in which case each axle will, for example, be driven by a respective electric motor and gear unit (not illustrated) mounted on the frame and operatively connected to the respective axle.

Each axle **14** is rotatably mounted in the frame by a respective pair of journals **18**, each of which in this particular embodiment is mounted and guided for the necessary generally vertical movement by two resilient suspension units **19**. These suspension units are of the kind comprising a plurality of flat layers of a suitable rubber, or a suitable rubber like material, interleaved with flat metal plates, and provided with metal end plates by which the unit is connected respectively to the journal and the adjacent side frames. Such units operate in compression and have a longitudinal compression axis generally perpendicular to the plane of the said flat plates; they inherently have the characteristic of a highly damped spring and are able to accommodate a substantial amount of movement along their longitudinal axis, while permitting relatively high shear displacement of their end plates, the shear characteristic being controllable by control of the compression along the said axis. The compression axes of the two units **19** supporting each journal **18** are inclined towards each other to intersect at or close to the normal loaded position of the rolling axis of the axle.

The car body that is to be mounted on the truck is indicated diagrammatically herein in FIGS. **3** and **4** as a flat floor member **20**, having two downwardly extending bracket members **21** fastened to the underside thereof on either side adjacent each truck. Bolster frame means for mounting the body on the truck frame comprise lower and upper bolster members **22** and **23** respectively, the lower bolster member **22** being supported by the side frames and pivotally connected to the frame between the transoms **12** and **13**, while the upper bolster member **23** is supported by the lower bolster member and in turn supports the vehicle body **20**.

The means supporting the lower bolster member **22** on the truck frame comprise four resilient suspension units **24**, disposed at the four corners of a rectangle with their longitudinal compression axes generally vertical, spigots such as **25** on the lower bolster fitting into the top plate of the respective unit **24**. Each suspension unit **24** is mounted between the depressed portion of the respective side frame and an upwardly curved portion of the bolster member, the arrangement permitting the use of relatively long units, while maintaining the lower bolster as low as possible in the truck in order to maintain the center of gravity of the whole truck as low as possible. The center portion of the lower bolster is depressed as much as possible, and is provided with a downwardly extending spigot **26** that is freely rotatable without play in an aperture **27** in a pivot member **28**.

The pivot member **28** is mounted between the two transoms **12** and **13** by two opposed longitudinally spaced resilient suspension units **29**, and also by motor means constituted by two opposed motor units to be described in detail below, the motor units being connected to the member **28** via respective suspension members **30**. Each unit **29** is disposed between a flat surface of the respective transom and a corresponding flat surface of the pivot member **28**, with the longitudinal compression axes thereof coincident and extending longitudinally of the truck, while each unit **30** extends between a flat surface of the pivot member and the adjacent end of a piston **31** of a respective motor unit **32** mounted inside the respective depressed central frame portion.

The upper bolster member **23** has the general form of an open frame, and in this embodiment comprises two parallel transverse members **33** connected rigidly together by two end members **34** and a central member **35**. The two end members **34** carry respective massive laterally spaced air springs **36**, mounted with their compression axes vertical, by which the car body **20** is mounted on the bolster, the springs being supplied in conventional manner with operating air under pressure from the train air pressure line. The end portions of the lower bolster member **22** extend upwards into the respective openings in the upper bolster member, so as to reduce the overall height of the composite bolster as much as possible.

Each end of the upper member **23** is connected to the respective end member **34** of the lower member **22** by an articulated linkage comprising a generally Y-shaped link member **37**, which is operative as a bellcrank lever and is pivoted to the member **22** about its crank pivot axis by a pivot rod **38**. The end of one crank arm of the link member **37** is connected by a pivot rod **39** to the adjacent ends of two spaced parallel links **40**, the other ends of the links **40** being connected by a pivot rod **41** to the member **34**. The ends of the other crank arms of the Y link members **37** are connected by pivot rods **42** to the respective ends of a connecting link **43**, which extends through apertures **44** provided in the member **22**, the link **43** being bowed upwards to clear the depressed central portion of the member **22** over its full range of movement.

The articulated linkage is completed by means of a depending link **45** fixed rigidly at its upper end to the central member **35** and pivoted at its lower end by a rod **46** to one end of a short transverse link **47** that is disposed generally parallel to the connecting link **43** and is accommodated in a recess therein. The other end of the transverse link **47** is connected to the link **43** by a pivot rod **48**.

The required rolling or tilting motion of the two bolster parts relative to one another is produced under the control of mechanism to be described in detail below, this mechanism controlling the operation of motor means comprising two double-acting hydraulic units **50**, which are disposed one on each side of the bolster. Each unit **50** comprises a cylinder member **51** pivotally connected at **52** to the lower bolster member **22** and a piston member **53** pivotally connected at **54** to the upper member **23**. It will be apparent that of course the connection of the units **50** can be reversed. Diagonally extending links **55** (FIG. **1**) are connected by spherical rubber bushings to the lower bolster **22** and to brackets **56** fastened to the car floor approximately in the center thereof, so that they will not foul the truck side frames as the car body tilts relative thereto. Laterally extending links **57** (FIGS. **3** and **4**) are connected by similar bushings to the upper bolster member and the brackets **21** of the car floor. These links **55** and **57** ensure that there can be no substantial transverse and/or longitudinal motion between the bolster and the car body, and the springs **36** are required to accommodate only vertical displacement and to provide only vertical springing.

The action of the connecting linkage can be seen by a comparison of FIGS. **3** and **4**, which show the upper bolster member respectively in its horizontal position and in one of its extreme tilted positions. It is important to note that one action of the linkage is to keep the roll center **58** approximately stationary in the position illustrated during the bolster tilting, avoiding the large lateral motions that would be encountered for example with a suspension comprising two spaced single links. The tilting action illustrated in FIG. **4** is produced by an increase in length of the motor units **50**, forcing the upper bolster member **23** to the left (as seen in the Figure) relative to the lower member **22**. This movement of the upper member **23** causes a corresponding clockwise movement of the links **37** about the rods **38** via the connection constituted by the end members **34** and the links **40**. This lateral movement of bolster member **23** causes a corresponding lateral movement of connecting link **43**, via the links **45** and **47**, that applies an additional clockwise rotation to the bellcrank links **37**. In the absence of the links **43**, **45** and **47**, and their described action on the links **37**, the lateral displacement of the upper bolster member would cause it to tilt about a laterally moving effective axis disposed approximately midway between the rods **38**, and at the same level as the axes of these rods (i.e., below the level of the floor **20**). The effect of these additional links is therefore to raise the height of the tilt axis **58**, and by careful choice of the lengths of the individual links of the articulated linkage it can be located in the desired position.

In this particular embodiment the immediately adjacent ends of the two bolster members have the lower bolster member end above the respective upper bolster member end, so that the upper bolster member is suspended by the articulated linkage from the lower bolster member. It is also contemplated that the two bolster members may be suspended from one another by some other means, the connecting linkage ensuring that the required relative movement takes place between them upon operation of the motor units **50**.

In a passenger vehicle the preferred height of the axis **58** above the car floor is such that it is located approximately at the level of an elbow of the average seated passenger. The actual determination of the lengths of the links to achieve this result for a particular truck construction can be effected by one of the methods known to those skilled in the art; such as a graphical method.

Referring especially to FIG. **5**, each of the motor units **32** is supplied with an operating liquid under pressure, usually a suitable oil. This liquid is drawn from a reservoir **60** by a pump **61** and supplied thereby to a pressure reservoir **62**, the pump being controlled in a known manner by means which are now shown to maintain the liquid in the reservoir **62** between predetermined pressure limits. Liquid from the reservoir is fed via pipes **63** to two servo valves **64**, which are controlled via pipes **65** from a hydraulic slave pilot transducer **66**. The transducer **66** is in turn controlled electrically by a master transducer device, indicated herein as box **67**, and to be described in more detail below. The servo valves **64** feed liquid via respective pipes **68** and air-containing reservoirs **69** to their respective motor units **32**. While the truck is running straight the servovalves **64** maintain substantially equal high pressures in their motor units **32**, centering the member **27**, the excess oil returning to the reservoir **60** via pipes **70**. The usual random track forces applied to the member **27** are absorbed by the reservoirs **69**, the air in these reservoirs causing them to act as air springs.

As the vehicle traverses a curve corresponding large lateral centrifugal forces are applied to the lower bolster member, and thence to the pivot pin **26** and pivot member **27**, so that the latter is urged to move off center. The device **67** feeds a corresponding control signal to the slave transducer **66** that in turn operates one or both of the servovalves **64** to effectively increase the pressure applied to one motor unit and decrease the pressure applied to the other motor unit, so that a corresponding force is applied to the member **27** by the units opposing the said centrifugal forces and urging the member **27** to return to its central position.

Such a control can be arranged to maintain the member **27** substantially central at all times, with the result that the shear forces applied to the suspension units **24** and **29** are very considerably reduced, so that more resilient units can be used than if these units sustained the effect of these lateral forces. Such more resilient units of course result in a softer and quieter suspension. In an alternative arrangement the centering of the member **27** is controlled by a movement detector member **74** mounted on the pivot member **27** and connected by a link **75** to one of the side frames. The detector member can operate as described above for the transducer **67**, or may be mechanically connected to a servovalve such as the valve **64**, that is operative under control of the detector member to supply additional oil under pressure to the appropriate motor unit cylinder **32** until the pivot block has been moved back to its center position. Such a centering system operates completely automatically under control of the detector member and independently of the tilting control system. In this embodiment the oil supplied from the pump **61** and reservoir **62** is also fed to the tilting motor means **50** via connecting pipes **71** and a servovalve **72**.

Since the links **55** and **57** between the upper bolster member **23** and the car body **20** prevent relative lateral and rotational motions thereof only relative vertical motion need be accommodated by the main secondary suspension air springs **36**. Such springs do not therefore have to resist and/or accommodate the relatively large lateral translation motions that would otherwise be applied to them by a fast moving train. The connection between the upper and lower bolster members, namely the articulated linkage and the operator units **50**, only permit relative lateral motion thereof under the control of the units **50**, which is in effect a rotational motion about the center **58**. The weight of the car body and of the bolster is supported from the truck frame by the units **24** which are designed principally to accommodate the pivoting of the vehicle body on the truck as it traverses a curve. The wheel primary suspension units **19** permit vertical translation of the axle **15** and a limited lateral translation of the wheels relative to the frame, such as to accommodate the usual irregularities in the track.

It will be seen therefore that the various required springing and mounting functions are separated out into three distinct groups, thereby assisting in permitting conventional components to be used. The first group comprises the upper bolster member **23** and the associated air springs **36** which provide vertical secondary springing with no lateral motion. The second group comprises the mounting of the upper bolster member to the lower bolster member, whereby the two members function as a single unit between the frame and the car body for mounting the latter, but are moved relative to one another to provide the lateral tilting of the car body. The third group comprises the special pivot suspension which freely permits the pivoting motion of the bolster relative to the truck frame, accommodates lateral displacements of the bolster relative to the truck frame and permits the bolster structure to remain centered despite high lateral centrifugal forces generated by deficiencies in the track superelevation.

It will therefore be apparent to those skilled in the art that all of the parts of the suspension are of relatively conventional construction and can readily be manufactured and services using conventional existing equipment, shop skills and personnel.

What we claim is:

1. A railway truck comprising a truck frame constituted by transversely spaced side frames and transom means extending between the said side frames; at least two wheel and axle assemblies mounted by the frame and on which the truck runs; a bolster frame supported on the truck frame; a truck frame pivot member mounted by the truck frame and engageable with a cooperating bolster frame pivot member mounted by the bolster frame, the pivot members cooperating with one another to constrain the bolster frame for pivoting movement about a generally vertical axis, one of the said pivot members being mounted by its mounting for lateral movement relative to its frame; motor means operatively connected between one of the pivot members and its respective frame and operative to move the pivot member laterally with respect to its respective member, detector means operative with the truck upon the presence of a centrifugal force on the pivot members urging lateral movement of the pivot axis from a center position, and means operative in response to said detector means for actuating the motor means to at least oppose the said force and urge the said pivot axis toward the said center position.

2. A truck as claimed in claim **1**, wherein the said motor means comprise oppositely operating hydraulic units in operative engagement between the truck frame and the truck frame pivot member, means for supplying operating liquid under pressure to the said hydraulic units, and a reservoir containing operating liquid and gas connected between each hydraulic unit and the said liquid supplying means, whereby the gas in the said reservoirs provides the effect of springs accommodating minor movements of the truck frame pivot member.

3. A truck as claimed in claim **1**, wherein the said motor means comprise opposed hydraulic units comprising respective cylinder members each mounted in a respective truck side frame and having their respective piston members in operative engagement with the truck frame pivot member.

4. A truck as claimed in claim **3**, wherein the said detector means comprises a movement detector member mounted on the truck frame operatively connected between the truck frame pivot member and a truck side frame and providing a corresponding signal upon movement of the truck frame pivot member from the center position, and the means responsive to the detector means comprise servo means receiving the said signal and feeding operating liquid to the said hydraulic units in response thereto.

5. A truck as claimed in claim **3**, wherein the truck frame pivot member is mounted on the transom means for lateral movement relative to the truck frame by opposed longitudinally extending resilient suspension units having their compression axes coincident and disposed longitudinally of the truck.

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