(12) UK Patent Application (19) GB (11) 2 050 273 A

(21) Application No **8013333**
(22) Date of filing **23 Apr 1980**
(30) Priority data
(31) **68110**
(32) **24 May 1979**
(33) **Italy (IT)**
(43) Application published
7 Jan 1981
(51) **INT CL³**
B61F 3/02
(52) Domestic classification
B7L 152 156 159 UG
(56) Documents cited
None
(58) Field of search
B7L
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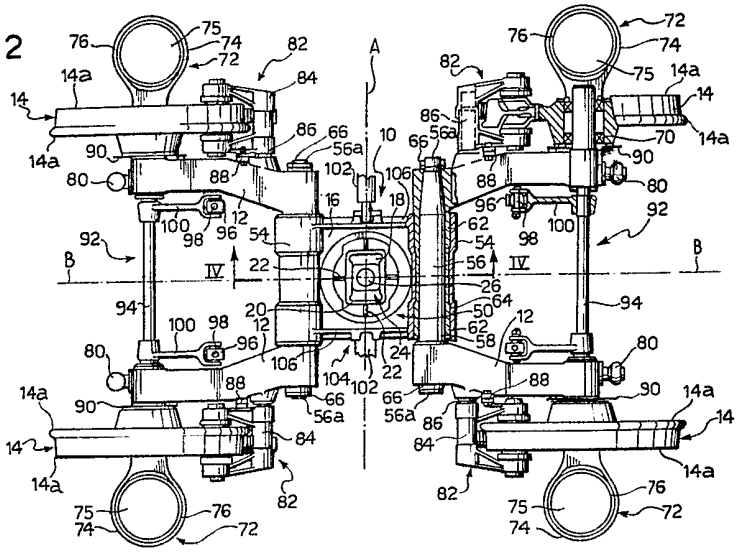
(54) **Bogie for railway vehicles**

(57) The bogie has a support structure (10) in the form of a horizontal rectangular plate (16) provided with transverse tubular supports (54), each of which mounts, via elastomeric bushes 62, a shaft (56) the two ends of which carry respective arms (12). Each arm (12) rotatably mounts a railway wheel (14). The horizontal plate (16) is formed with a rectangular aperture (18) mounting a sliding block (24) for sliding movement transversely of the bogie, though limited play is also provided for longitudinally of the bogie. A bogie pivot pin extends vertically down from the vehicle body through a central hole (26) in the sliding block (24). The pivot pin carries upper and lower plate elements (34, 46) which sandwich upper and lower anular elastomeric elements between themselves and the facing surfaces of the support structure (10).

FIG. 2



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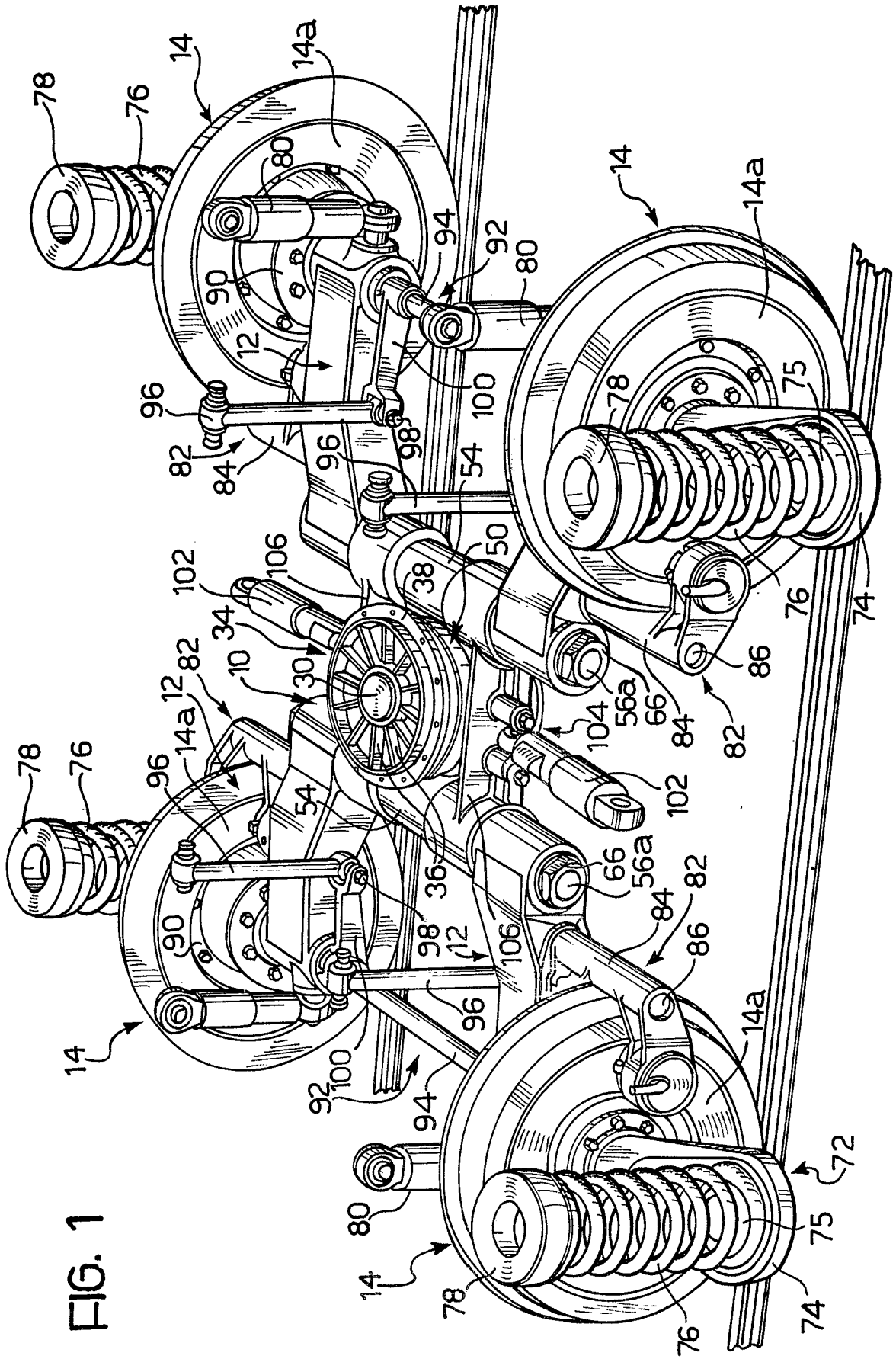
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56a
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74
72
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FIG. 1

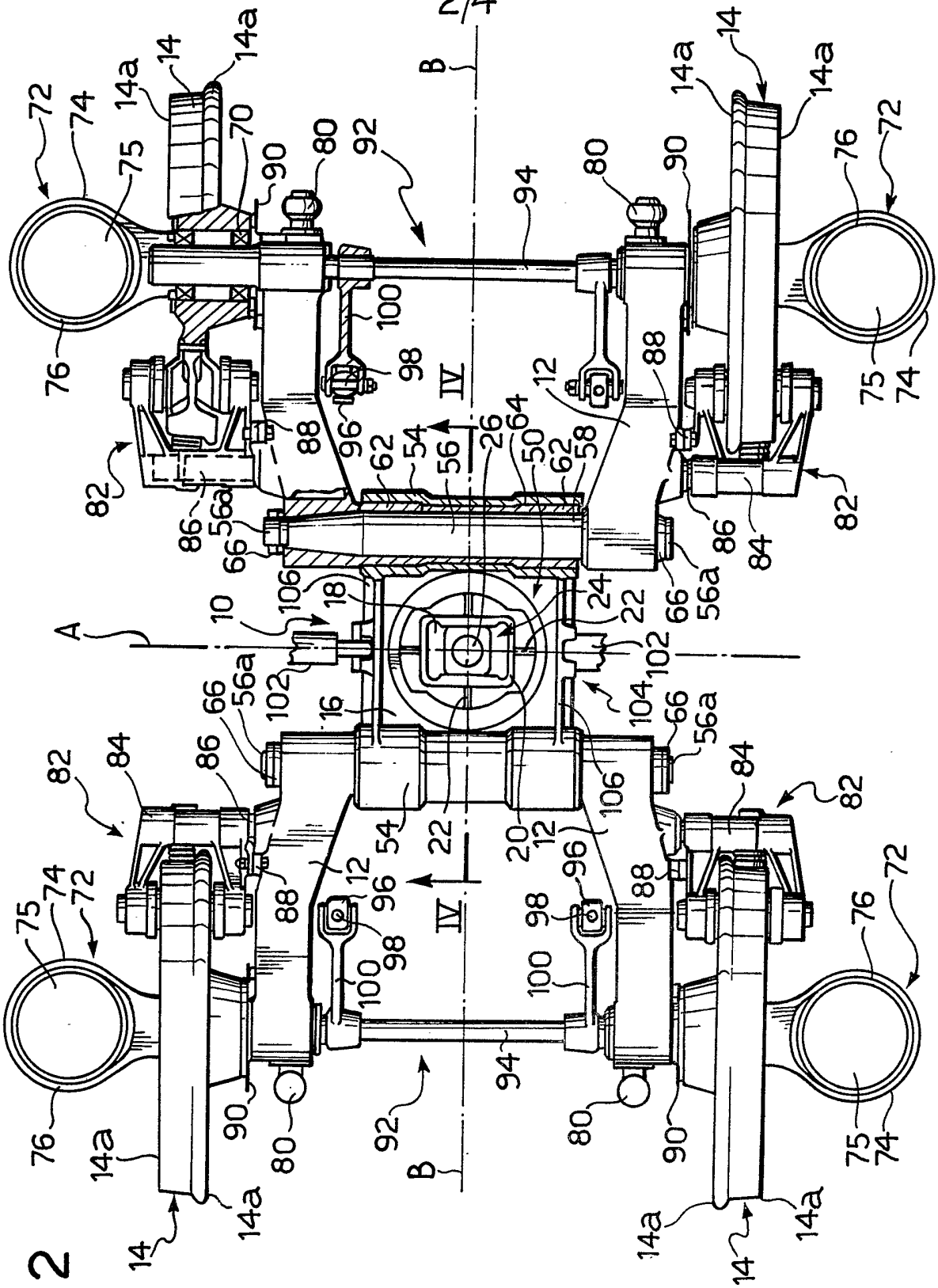
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FIG. 2

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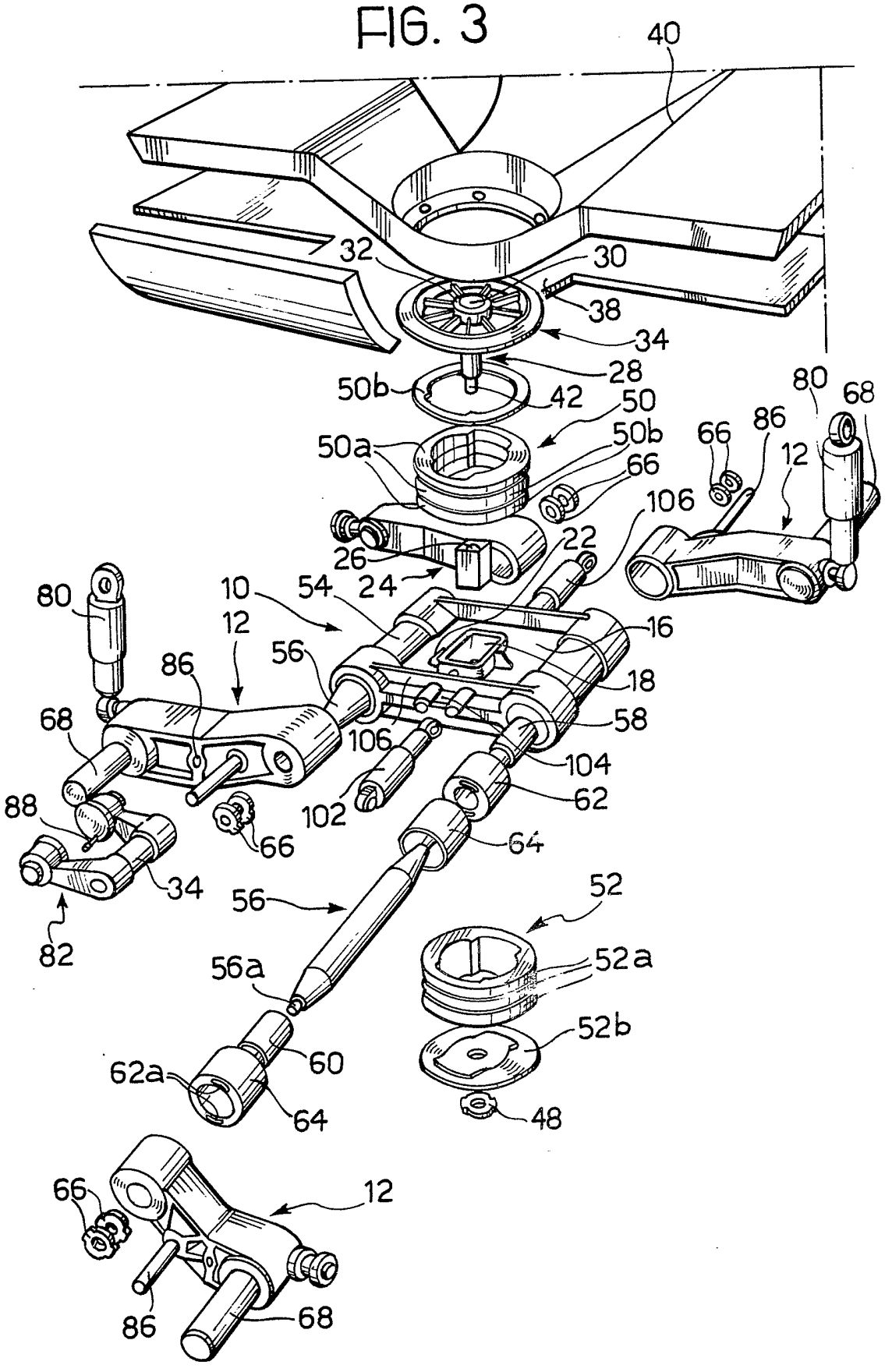
FIG. 3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16
80
12
56
86
18
68
106
58
104
62
102
88
66
64
34
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52
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56a
52a
52b
62a
60
64
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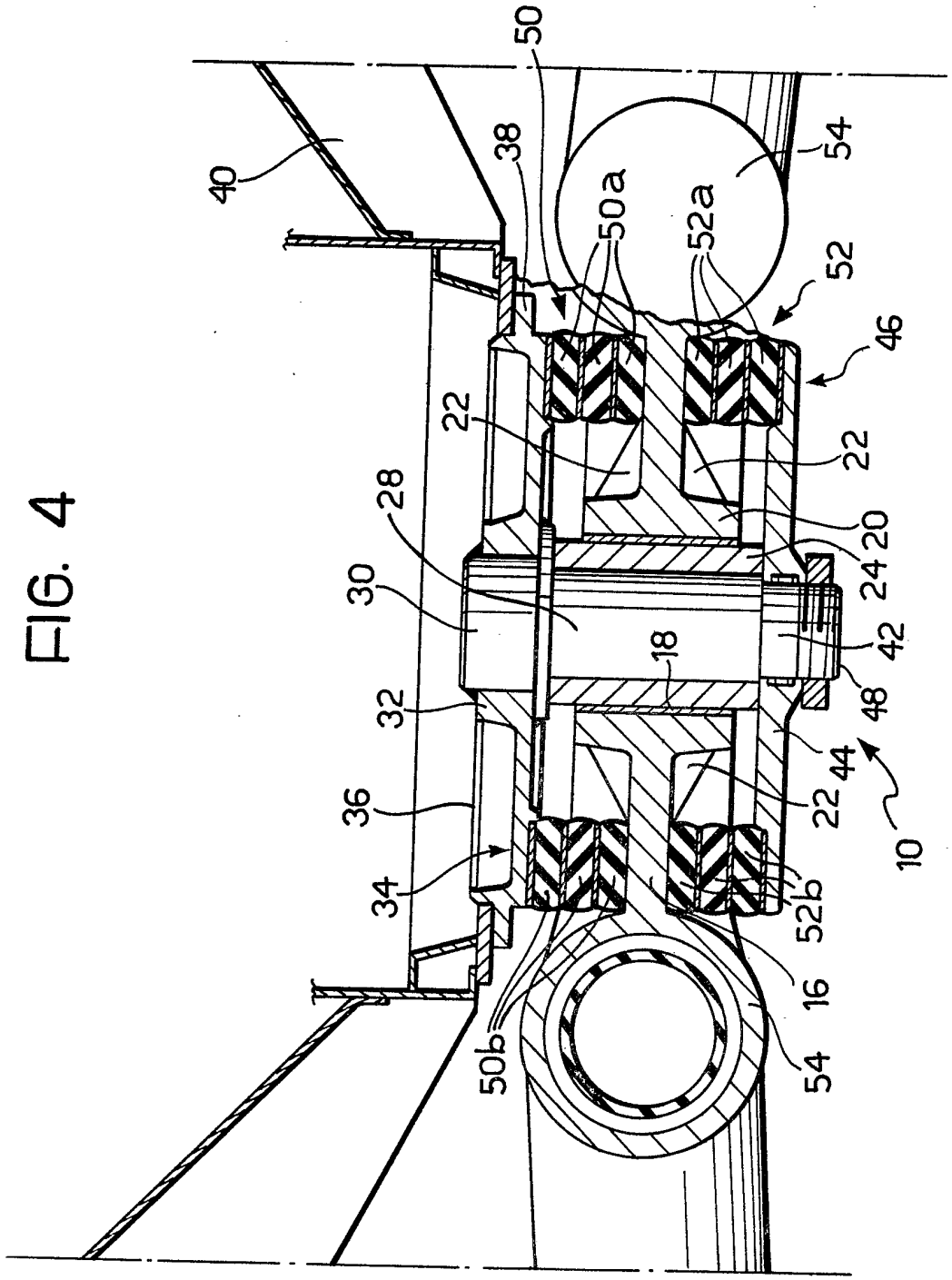
12
86
68

FIG. 4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52b
16
50b
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SPECIFICATION

Bogie for railway vehicles

The present invention relates to railway vehicles and in particular to bogies for such vehicles.

The object of the present invention is to provide a railway vehicle bogie which has a low weight and bulk, is simple and inexpensive to manufacture and maintain, and gives a comfortable ride.

With a view to achieving this object, the present invention provides a railway-vehicle bogie comprising:

- a support structure with a central part in the form of a horizontal plate, wherein there is formed a rectangular aperture the major axis of which is directed transversely of the bogie, the support structure further comprising two tubular transverse supports rigid with the ends of the plate opposite one another in the direction of extent of the longitudinal axis (B) of the bogie,
- two shafts rotatably mounted in the tubular supports with the interposition of bushes of elastomeric material, said bushes serving to permit misalignment between the two shafts and their respective tubular supports, and the said shafts supporting at each end an arm carrying a transversely projecting wheel axle,
- a respective wheel mounted on each axle,
- a helical suspension spring and an hydraulic shock absorber associated with each arm and extending upwards from the region of the free end thereof for connection to a body of the vehicle,
- a rectangular sliding block so mounted in the said rectangular aperture of the support structure as to be capable both of sliding movement along the major axis of the aperture and of limited displacement along the minor axis of the aperture, the sliding block having a central hole the axis of which is vertical,
- an upper plate element arranged for connection to the said vehicle body,
- a bogie pivot pin carried by said upper plate element and projecting downwardly therefrom, the pivot pin extending through the said hole in the sliding block to terminate below the said central plate part of the support structure,
- a lower plate element fixed to the lower end of the said pivot pin,
- a first elastomeric-material annular element clamped between the said upper plate element and the upper surface of the said central plate part, and a second elastomeric-material annular element clamped between the lower surface of the central plate part and the said lower plate element, each of the annular elements of elastomeric material having a rigidity about the longitudinal axis of the bogie which is less than its rigidity about the transverse axis of the bogie.

Preferred embodiments of the bogie posses a number of important advantages, including:

- the possibility of mass production of the parts constituting the bogie;
- a reduction in weight of the bogie, and therefore a reduction in total weight of the railway vehicle of which the bogie forms a part,
- utilisation of a single suspension stage working according to the three main axes of inertia of the vehicle, and consequent elimination of the second suspension stage;
- distribution of the weight of the body of the vehicle on four supports and therefore the possibility of utilising vehicle bodies with a simplified shell structure, (for example, of the type forming subject of Italian Patent Application No. 68110 A/79 filed 24th May 1979 by the same Applicant);
- less degradation of the railway track, due to the increased flexibility of the suspension components in series with the wheels,
- reduction of the stresses on the axles of the wheels,
- reduction of the wear of the rolling cone of each wheel,
- reduction of the static and dynamic stresses on the vehicle body due to the greater number of supports and to the smaller vertical accelerations present;
- the possibility of self steering of the arms carrying the wheels, in such a way as to nullify, when travelling around a curve, misalignment of the wheels with respect to the rails,
- the possibility of each wheel, independently from the others, absorbing possible vertical non-uniformities of the line,
- less degradation of the rails due to a reduction in the unsprung weight, as compared with conventional bogies.

A bogie embodying the invention will now be particularly described, by way of example, with reference to the accompanying diagrammatic drawings, in which:

Figure 1 is a perspective view of the bogie;

Figure 2 is a plan view of the bogie;

Figure 3 is an exploded perspective view of a part of the bogie; and

Figure 4 is a longitudinal section on the line IV-IV of Figure 2 to an enlarged scale.

As shown in Figures 1 and 2, the bogie basically comprises a central support structure 10 to which are pivoted four arms 12 each rotatably mounting a wheel 14.

The support structure 10, which is made as a single piece (for example, as an aluminium casting) has a central part 16 in the form of a horizontal rectangular plate provided with a central rectangular aperture 18 the longer sides of which are directed parallel to the transverse axis A of the bogie. The aperture 18 is formed in a central thickened portion of the plate 16 and is therefore effectively bounded, on both sides of the plate 16, by upstanding walls 20 (see Figure 3), these walls 20 being buttressed by reinforcing ribs 22 projecting from the plate 16.

Axially positioned within the aperture 18 is a sliding block 24 of self lubricating plastics material. The block 24 is of a vertically-elongate parallelepiped form with a square horizontal section and with its longer sides slightly greater in length than the depth of the aperture 18. The sliding block 24 is slidably mounted in the aperture 18 for movement along the transverse axis A of the bogie and is, moreover, free

to perform limited displacements within this aperture 18 in the direction of the longitudinal axis B of the bogie. The permitted travel of the block 24 along the transverse axis A is preferably in the region of 45mm, whilst its permitted movement in the direction of the longitudinal axis B is preferably around 5 mm.

The sliding block 24 is provided centrally with a cylindrical hole 26 which has a vertical axis 26 and is traversed in a rotatable manner by a vertical pivot pin 28. The pin 28 has an upper enlargement 30 (see Figure 4) rigidly fixed to a hub 32 of an upper horizontal disc 34 the upper face of which is provided with spokes 36. In addition, the disc 34 has an annular peripheral flange 38 which is connected by bolts to the bottom of the body 40 of a railway vehicle. This body 40 is preferably of the type illustrated and described in Italian Patent No. 68110 A/79 filed in the name of the same Applicant.

The pivot pin 28 has a lower threaded portion 42 of reduced diameter which traverses a hub 44 of a lower horizontal disc 46. The lower disc 46 is held in position at the lower end of the pivot pin 28 by means of a threaded ring 48 screwed onto the threaded pin portion 42. Clamped between the upper face of the plate 16 and the upper disc 34 is a first annular element 50 of elastomeric material; similarly, between the lower face of the plate 16 and the lower disc 46 is clamped a second annular element 52 of elastomeric material. Both annular elements 50 and 52 have their axes vertical and are identical with one another. In the example illustrated, each element 50 and 52 is constituted by a stack of superimposed rings 50*a*, 52*a* welded by means of vulcanisation to intermediate metal rings 50*b*, 52*b*.

The annular elements 50 and 52 are subjected to an axial pre-compression generated by the tightening up of the threaded ring 48 on the lower end portion 42 of the pivot pin 28. As is illustrated in detail in Figures 2 and 3, each annular element 50, 52 has lateral portions of radially reduced thickness arranged opposite the shorter sides of the aperture 18. As a result, the rigidity of the annular elements 50, 52 in relation to rotation about the transverse axis A of the bogie is greater than their rigidity in relation to rotation about the longitudinal axis B of the bogie. The function of these annular elements 50, 52 of elastomeric material is, as will be more fully described below, that of exercising a resilient restoring force, both in respect of transverse and longitudinal displacements of the sliding block 24 in the aperture 18, and in respect of rotations of the bogie about the pivot pin 28. In addition, the annular elements 50 and 52 have the function of preventing infiltration of water or dust to the central portion of the pin 28 from externally of the support structure 10.

The transverse sides of the plate 16 are integral with respective transverse tubular supports 54 within which are rotatably mounted respective shafts 56. Each end of each shaft 56 projects from the corresponding tubular support 54 and carries by means of a rigid coupling, a respective one of the arms 12. Coaxially interposed between each of the shafts 56 and the corresponding tubular support 54, are a pair of rigid end sleeves 58 separated from one another by a spacer 60, a pair of bushes 62 of elastomeric material surrounding the sleeves 58, and a pair of outer sleeves 64 surrounding the bushes 62 of elastomeric material. The bushes 62 of elastomeric material are preferably of the type commercially known under the mark "Sutuco" and made by the Italian firm SAGA of Milan. These bushes 62 are provided above and below with axially extending slot-like holes 62*a* and therefore have a radial rigidity dependent on the direction of the applied load. The function of the bushes 62 of elastomeric material is to permit misalignment between the shaft 56 and the corresponding tubular support 54 to allow on the one hand, self steering of the arms 12 carrying the wheels 14 when the bogie is traversing a curve, in such a way as to nullify any misalignment of the wheels 14 with respect to the rails, and on the other hand to permit rolling oscillations of these arms 12 in such a way as to allow the wheels 14 to accommodate possible non-uniformities of the railroad track. As a result of this arrangement, each shaft 56 will only be subject to simple flexural stresses, and not to twisting forces.

Each arm 12 is disposed substantially parallel to the longitudinal axis B of the bogie and, as previously mentioned, is connected at one end to the corresponding shaft 56 by means of a rigid coupling, for example a conical coupling. The locking of the arm 12 with respect to the shaft 56 is obtained by means of threaded rings 66 screwed onto a corresponding threaded end part 56*a* of the shaft 56.

Adjacent its distal end each arm 12 mounts an outwardly-projecting axle 68 which rotatably supports a respective wheel 14, with the interposition of counterposed taper roller bearings 70 (see Figure 2). The distal end of the axle 68 carries a projecting support 72 in the form of a horizontal circular base 74 against which reacts, with the interposition of a block 75 of elastomeric material, the lower end of a helical suspension spring 76. The upper end of the helical spring 76 reacts, with the interposition of another block 78 of elastomeric material, against the bottom of the body 40 of the railway vehicle. The four springs 76 associated with the wheel axles 68 constitute a single stage suspension for the body 40 on the bogie. In this way, the structural weight of the body 40 passes directly to the wheels 14 through the springs 76, without stressing intermediate elements. Moreover, the sharing of the weight of the body between eight supports (four on each of two bogies) permits the structures for restraining the body to be of limited weight, and also permits the use of the bodies with a shell structure of the type described in the Italian Patent Application referred to above. The provision of the blocks 75 and 78 against which the ends of the springs 76 react, permits the transverse rigidity of the springs 76 to be reduced. Moreover, lateral or rotational displacements of the bogie with respect to the body are taken up both by the springs 76 and by the blocks 75 and 78.

Associated with the suspension springs 76 are dampers constituted by four vertical hydraulic shock absorbers 80 each of which is interposed between the free end of one of the arms 12 and the body 40 of

the vehicle. Suitable buffers of elastomeric material (not illustrated) are incorporated in a manner known *per se* in the shock absorbers 80, and constitute resilient vertical end-of-travel stops both against compression and extension.

Each wheel 14 is constituted by a unitary cold-rolled steel body. Each face of each wheel 14 carries an annular brake "disc" 14, the two brake "discs" associated with the same wheel being engageable by the brake pads of a brake caliper 82. The brake calipers 82 are actuated in a manner known *per se* by a fluid under pressure. Each caliper 82 is provided with a tubular member 84 which is rotatably mounted on a transverse pivot pin 86 projecting from the corresponding arm 12. Anti-wear bushes, not illustrated, are interposed between the tubular member 84 and the pin 86. The caliper 82 is locked against rotation with respect to the pivot pin 86 by means of a transverse bolt 88 connecting the inner arm of the caliper 82 with the arm 12. Due to this mounting arrangement, the replacement of the brake pads of the caliper 82 can be effected in a simple and rapid manner by rotating the corresponding caliper 82 outwardly from the wheel 14 after removal of the associated bolt 88.

Each wheel 14 is provided with an anti-skid device of type known *per se* comprising a phonic wheel 90 keyed to the inner face of the wheel 14, and an electromagnetic angular velocity sensor, not illustrated carried by the arm 12.

Each pair of arms 12 connected to the same shaft 56 has an associated anti-roll bar indicated in its entirety by 92. The anti-roll bar 92 comprises a transverse shaft 94 connected by articulated joints at its ends to the inner ends of the axles 68 of the wheels 14, and a pair of vertical shafts 96 connected at their upper ends to the body 40 of the railway vehicle and pivoted at their lower ends about transverse pins 98 carried by a pair of longitudinal levers 100 fixed to the ends of the transverse shafts 94. The two transverse shafts 94 of each bogie serve to maintain the spacing between the wheels 14 constant in the event of stresses directed along the axes of these wheels 14.

The bogie further comprises a pair of transverse hydraulic shock absorbers 102 each pivoted at one end to the body and at the other end to a fork member 104 carried by a vertical longitudinal wall 106 of the support structure 10. The use of these transverse shock absorbers 102 may not be necessary since the above described configuration of the bogie permits lateral oscillatory movements associated with the traversal of curves to be nullified.

A brief description will now be given of the stress conditions arising during use of the illustrated bogie as one of a pair of bogies supporting the opposite ends of the body of a railway vehicle.

The mass of the body of the railway vehicle is carried on eight suspension springs 76 (four for each bogie) and these react directly on the wheels 14 of the bogie without any intermediate members whatsoever. Each unit constituted by a pair of arms 12 connected to the same shaft 56 is therefore only subjected to vertical forces due to misalignment between the axis of each suspension spring 76 and the rolling plane of the wheel 14.

As previously mentioned, relative longitudinal and lateral movements between the body and the bogies are resisted by the annular elements 50 and 52 which become elastically deformed by an amount dependent not only on the applied loads but also on the direction of their application (this being so since the elements 50 and 52 have different stiffnesses along the transverse axes A and the longitudinal axes B of the bogies).

When the vehicle is traversing a curve, the centrifugal force acting on the centre of gravity of the body is laterally resisted by the annular elements 50 and 52 of both bogies, and to some degree also by the lateral rigidity of the suspension springs 76.

The elastomeric bushes 62 act in series with the annular elements 50 and 52 in the transmission of lateral forces from the vehicle body via the arms 12 and the wheels 14, to the rails.

For each pair of wheels 14, the turning effect produced in the horizontal plane by the contact force between the wheel on the outside of the curve and the outside rail, is resisted by the bushes 62 which are deformed both radially and conically. The overall result is that the corresponding shaft 56 is turned through a small angle relative to the structure 10 giving a self-steering effect with the wheels 14 and rails being kept in alignment so that contact of the guide flanges of the wheels with the rails is avoided; as a consequence, both wear of the flanges and wear of the rail itself are minimised.

Where the radii of curvature of the track exceeds 250 metres and the vehicle is subjected to non-compensated lateral accelerations of one meter/second^2, the wheels 14 are predisposed to oversteering, with the region of contact of the wheel with the rail lying behind the vertical plane passing through the axis of the wheel.

Due to their limited rigidity, the annular elements 50 and 52 and the bushes 62 provide substantially no vertical reaction to the centrifugal couple experienced by the vehicle while traversing a curve, this reaction being instead provided by the anti-roll bars 92 and by the helical suspension springs 76. Since the vertical forces acting at the ends of the anti-roll bars 92 are equal to one another and are approximately equidistant from the forces acting on the helical suspension springs 76, the units constituted by the arms 12 and their respective shafts 56 are not overloaded. The increase in loading of these units (including their elastomeric parts 50, 52, and 62) is therefore due solely to the horizontal contact forces between the wheels and the rail.

During braking of the railway vehicle, the forces set up elastically deform the annular elements 50 and 52 of elastomeric material until the sliding block 24 of each bogie is brought into abutment one of the longitudinal ends of the aperture 18. Again the bushes 62 of elastomeric material allow the central support structure 10 to be elastically isolated from the arms 12 carrying the wheels 14.

In level haulage conditions of the railway vehicle, the reaction of the annular elastomeric material elements 50 and 52 in shear prevents the occurrence of sliding between the sliding block 24 and the edges

of the aperture 18.

In all the operating conditions mentioned above, the transmission of the forces between the body of the railway vehicle and the wheels 14 takes place through resilient elements. This allows the elimination of unresisted sliding and the play between relatively movable parts of the bogie so that vibrations of the bogie are noticeably reduced.

CLAIMS

1. A bogie for a railway vehicle, said bogie comprising:

a support structure with a central part in the form of a horizontal plate wherein there is formed a rectangular aperture the major axis of which is directed transversely of the bogie, the support structure further comprising two tubular transverse supports rigid with the ends of the plate opposite one another in the direction of extent of the longitudinal axis of the bogie,

two shafts rotatably mounted in the tubular supports with the interposition of bushes of elastomeric material, said bushes serving to permit misalignment between the two shafts and their respective tubular supports, and each said shaft supporting a respective pair of arms each of which is provided with a transversely projecting axle mounting a railway wheel,

a helical suspension spring and an hydraulic shock absorber associated with each arm and extending upwards from the region of the free end thereof for connection to a body of the vehicle,

a rectangular sliding block so mounted in the said rectangular aperture of the support structure as to be capable of sliding movement along the major axis of the aperture and of limited displacement along the minor axis of the aperture, the sliding block having a central hole the axis of which is vertical,

a bogie pivot pin carried by an upper plate element which is arranged for connection to the said vehicle body, the pivot pin extending downwards from said upper plate element, through the said hole in the sliding block, to terminate below the said central plate part of the support structure, a lower plate element being fixed to the lower end of the said pivot pin,

a first annular element of elastomeric material clamped between the said upper plate element and the upper surface of the said central plate part, and a second annular element of elastomeric material clamped between the lower surface of the central plate part and the said lower plate element, each of the annular elements of elastomeric material having a rigidity about the longitudinal axis of the bogie which is less than its rigidity about the transverse axis of the bogie.

2. A bogie according to Claim 1, in which each said annular element is constituted by a stack of rings in which rubber rings alternate with metal rings, the metal rings being rigidly connected to the said rubber rings.

3. A bogie according to Claim 1 or Claim 2, in which the central plate part of the support structure is provided with a thickened central portion in which the said rectangular aperture is formed.

4. A bogie according to Claim 3, in which the thickened central portion extends symmetrically on both sides of the plate, reinforcing ribs being provided between the said thickened central portion and the plate.

5. A bogie according to any one of the preceding claims, in which the radial rigidity of each said bush of elastomeric material differs between the vertical and horizontal planes.

6. A bogie according to any one of the preceding claims, in which each helical suspension spring reacts between a pair of blocks of elastomeric material.

7. A bogie according to any one of the preceding claims, in which each arm supports an hydraulically-operable brake caliper arranged to cooperate with a pair of annular brake discs rigidly connected to the corresponding wheel.

8. A bogie according to Claim 7, in which each brake caliper includes a tubular support which is rotatably mounted on a transverse pivot pin projecting from the corresponding arm, removable rotation-prevention means being provided to normally lock the brake caliper against rotation about the said pivot pin.

9. A bogie according to any one of the preceding claims, in which the support structure is provided on transversely opposite sides thereof with respective mounting forks each of which pivotally mounts a corresponding transverse hydraulic shock absorber.

10. A bogie according to any one of the preceding claims, in which each arm is connected to its corresponding shaft by means of a rigid coupling.

11. A bogie according to any one of the preceding claims, in which a respective anti-roll bar is associated with each said shaft, each anti-roll bar extending between the two arms carried by the associated shaft.

12. A bogie according to Claim 11, in which each anti-roll bar comprises a transverse shaft connected at its two ends by articulated joints to the inner ends of the wheel axles carried by the associated pair of arms, and a pair of vertical shafts pivoted at their lower ends to a pair of levers carried by the transverse shaft, the said vertical shafts being arranged for connection at their upper ends to the body of the railway vehicle.

13. A bogie according to any one of the preceding claims, in which the sliding block is made of self-lubricating plastics material and has a vertically elongate parallelepiped form of square horizontal section.

14. A bogie according to any one of the preceding claims, in which the permitted travel of the sliding block along the major axis of the rectangular aperture formed in the plate of the support structure is between 40 and 50 mm.

15. A bogie according to any one of the preceding claims, in which the permitted the permitted travel of the sliding block along the minor axis of the rectangular aperture formed in the plate of the support structure is between 4.5 and 5.5 mm.

16. A bogie according to any one of the preceding claims, in which the support structure is a single

cast piece of aluminium.

17. A railway vehicle including a pair of bogies each according to any one of the preceding claims.

18. A bogie for a railway vehicle, said bogie being substantially as hereinbefore described with reference to the accompanying drawings.

Printed for Her Majesty's Stationery Office by Croydon Printing Company Limited, Croydon Surrey, 1980.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.