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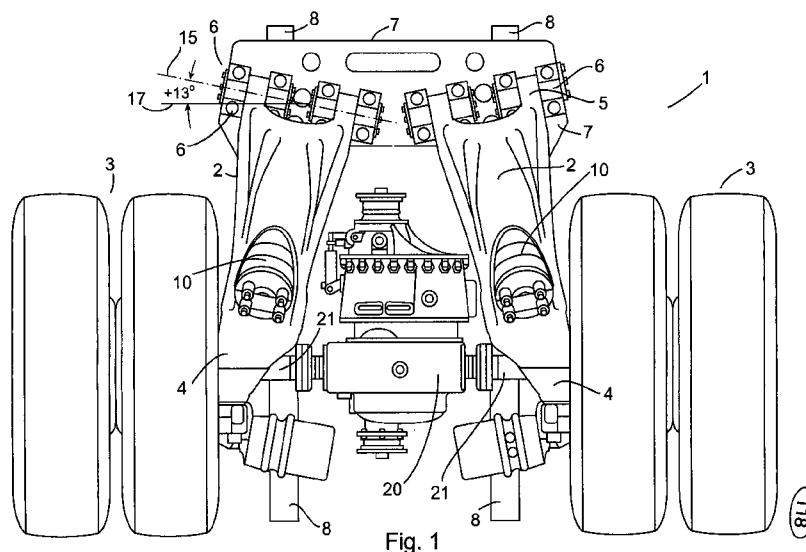


Fig. 1

(57) Abstract: An independent suspension system (1) for mounting driven twin road wheels (3) on a vehicle 8. The suspension system (1) includes a trailing arm (2) on which the twin road wheels (3) are mounted. The road wheels (3) are mounted at a lower end (4) of the arm (2). A pivot assembly (6) for pivotally mounting the arm (2) on the vehicle chassis (8) is provided at an upper end (5) of the arm (2).

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“A Suspension System”**INTRODUCTION**

5 This invention relates to a suspension system.

The invention particularly relates to a truck rear driven suspension system suitable for twin road wheels, and primarily to vehicles having a rear axle weight of 15,000 lbs (6,800 kg) upwards, typically class 6, 7 and 8 trucks, tour and intercity buses
10 and large recreational vehicles. Conventional truck rear suspensions typically comprise a beam axle and twin road wheels and tyres. Such beam axle suspension systems are generally chosen because of the space constraints which arise from the legislated maximum width of such trucks of approximately 2,500 mm. Chassis rail spacing is also relatively standardised at approximately 850 mm. As a result of
15 the overall width constraint the distance between the inside of the twin tyres and the outside of the chassis rail is in the order of only 200 mm. This provides a very small space in which to accommodate the necessary mechanisms of a suspension system.

20 The present invention is directed towards providing an improved suspension system which gives improved performance while at the same time is able to operate in such a confined mounting space.

Statements of Invention

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According to the invention there is provided a suspension system for mounting twin road wheels on a vehicle chassis characterised in that the suspension system is an independent suspension system comprising a trailing arm, or a semi-trailing arm on which the twin road wheels are mounted, said road wheels being mounted at a
30 lower end of the arm, and a pivot assembly for pivotally mounting the arm on the vehicle chassis being provided at an upper end of the arm.

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In another embodiment a pivot axis of the pivot assembly of the arm is angled positively or negatively relative to a transverse axis of the chassis in a horizontal plane.

- 5 In a further embodiment the pivot axis of the pivot assembly of the arm is angled positively or negatively relative to the horizontal in a vertical plane.

- In another embodiment the pivot assembly of the arm is mounted flexibly on the chassis allowing the pivot axis of the pivot assembly to angulate in the horizontal
10 and vertical planes as a function of the load imposed on the wheels.

In another embodiment the trailing arm is torsionally flexible allowing it to deform angularly under load inducing camber change in the wheels.

- 15 In a preferred embodiment the trailing arm is of U-section. Conveniently a spring and associated damper unit is nested within the arm.

- In another embodiment the trailing arm is of two part construction, namely an upper part for mounting on the chassis and a lower part on which the wheels are
20 mounted, the lower part being attached to the upper part by a swivel connector allowing the lower part to swivel relative to the chassis mounted upper part to allow the wheel equalise tyre loads thus maintaining a generally vertical orientation to the ground throughout the suspension stroke.

- 25 In another embodiment means is provided for restraining the relative swivelling movement of the two parts of the trailing arm - for example bonded rubber compounds or rubber parts in compression.

- In another embodiment the road wheels have a drive system comprising a hub
30 reduction gear system, universally jointed propshafts and a differential gearbox mounted to chassis rails of the vehicle.

In another embodiment the system includes a drive comprising an electric motor mounted either in the hub or on the chassis.

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In another embodiment the hub is a non reduction direct drive type.

Detailed Description of the Invention

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The invention will be more clearly understood by the following description of some embodiments thereof, given by way of example only with reference to the accompanying drawings, in which:

10 Fig. 1 is an underneath plan view of a vehicle suspension system according to the invention;

 Fig. 2 is an elevational view of the suspension system of Fig.1;

15 Fig. 3 is an underneath plan view of another suspension system;

 Fig. 4 is a plan view of the suspension system of Fig.3; and

 Fig. 5 is an elevational view of the suspension system of Fig.3.

20

Referring to the drawings, and in initially to Figs. 1 and 2 thereof, there is illustrated a vehicle suspension system according to the invention indicated generally by the reference numeral 1. The suspension system 1 includes a pair of trailing arms 2 each having twin driven road wheels 3 mounted at an outer end 4 thereof. An upper
25 inner end 5 of each trailing arm 2 is rotatably mounted by a pivot assembly 6 to a mounting bracket 7. This mounting bracket 7 is in use mounted to an underside of chassis rails 8 of a vehicle. The pivot assembly 6 allows the trailing arm 2 to swing in a generally vertical plane.

30 In the suspension system 1 illustrated, the suspension trailing arm 2 is an open generally U-section member which envelops a spring 10 and associated damper unit 11 which are nested within the arm 2, as can be best seen in Fig. 2. It will be noted that the invention is not limited to this specific trailing arm 2 configuration, however, an open section as illustrated has advantages for the purposes of the invention as it

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permits a designer to design an arm strong in resisting loading in the vertical plane, yet suitable for providing the required amount of torsional flexibility to achieve the desired control of camber change characteristics which is an object of the invention.

5 It will be noted that a hub assembly 12 mounted at the outer end 4 of each trailing arm 2 is offset from the centre line of the trailing arm 2 in the horizontal plane as best seen in Fig. 1. It will be apparent that as the load on the tyres 3 is increased an increasing torsional moment is imposed on the trailing arm 2 such as to cause an increasing negative camber of the wheels 3 relative to the chassis 8.

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The pivot assembly 6 for each arm 2 comprises a set of bearings 16 supporting pivot pins which engage upper forked ends of the arm 2 for pivoting about a pivot axis 15.

Referring in particular to Fig. 1 it will be noted that the pivot axis 15 of bearings 16 of
15 the pivot assembly 6 is angled in the horizontal plane relative to a transverse axis 17 of the chassis 8. In this case the angle is $+13^\circ$, but for the purposes of this invention it may be at any chosen angle positively or negatively in relation to the chassis axis depending on the precise geometrical suspension characteristics the designer wishes to achieve in any particular application. In the case illustrated, the angulation of the
20 bearing axis relative to the chassis axis in this case $+13^\circ$, is such as to create increasing negative camber of the wheel relative to the chassis as the wheel moves from rebound to bump. If a negative bearing axis angle relative to the chassis is chosen, the wheel develops a positive camber relative to the chassis as the wheel moves from rebound to full bump.

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Referring now in particular to Fig. 2, it will be noted that in this example the trailing arm 2 bearing axis 15 is positioned horizontally in the elevational view. By orienting this bearing axis at a positive or negative angle to the horizontal plane, the camber change from rebound to bump can be arranged to be positive or negative to varying
30 degrees depending on the amount of angulation.

By using differing combinations and values of the variables described above – wheel/arm offset; arm torsional rigidity; arm bearing axis angulation in both horizontal and vertical planes – this invention enables a designer to optimise the

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camber change of the twin tyred road wheel independent suspension to most closely match the design and performance specifications of the vehicle.

In another embodiment of the invention, the trailing arm bearings 16 may be fitted on flexible mountings, the stiffness of which is so designed as to permit the bearing axis 15 to adopt varying angles in both the vertical and horizontal planes as a function of increasing load to further optimise the camber angle change with the increasing wheel load, thus permitting different relatively camber change to be achieved in the roll and the bounce modes.

Referring in particular to Fig.1 there is shown a differential gearbox 20 mounted to the chassis rails 8 with universally jointed propshafts 21 connected to a hub reduction gear system.

Referring now to Fig.'s 3 to 5, there is shown another suspension system according to a second embodiment of the invention, indicated generally by the reference numeral 30. Parts similar to those described previously are assigned the same reference numerals. In this case a two part trailing arm 32 is provided comprising an upper or inner part 33 pivotally mounted on the chassis 8 to swing the trailing arm 32 in a generally vertical plane and an outer part 34 connected to the inner part 33 by a rotatable joint 35 whose axis is parallel to the centre line of the arm axis and passing through the wheel hub 12 axis centrally between the tyre/wheel assemblies. By means of this rotatable joint 35 the wheel 3 is permitted to angulate in camber mode and remain perpendicular to the ground throughout the suspension movement as a function of the balancing of the equal vertical forces on the two tyres. This rotation may be free using a suitable bearing or restricted as for example by using a bonded rubber or other such synthetic compound in sheer or compression between the two rotating surfaces.

It will be appreciated that with a conventional beam axle system there is zero camber angle change (the inclination of the wheel plane to the vertical) of the wheels relative to the road as the suspension moves from rebound to full bump – apart from such minor changes that may result from flexing of the axle beam. With independent suspension systems one can go from one extreme to the other- a

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swing axle system has a camber change relative to the chassis equivalent to the angulation of the propshaft whereas a trailing arm suspension has a zero camber change relative to the chassis. Thus in bounce mode the trailing arm exhibits zero camber change relative to the road whilst in pure roll mode the camber change
5 relative to the road corresponds to the roll angle. On the other hand the swing axle displays considerable camber change in bounce but in pure roll the camber change is zero. Other suspension types exhibit varying degrees of camber change in roll and bounce depending on the suspension geometries.

10 Because of the space constraints abovementioned it is unsatisfactory to mount a double wishbone suspension as the necessarily short arms would require very severe angulation of the wishbone arms to achieve a suitable amount of wheel travel.

15 With a twin road wheel configuration an ideal suspension would be one in which the twin tyres on each side of the vehicle were in equal contact with the ground so that the loading on each set of twins was equally distributed providing maximum traction and minimum wear. This would require zero or minimum camber change of the wheels relative to the road in both bump and roll mode and combinations of these
20 two modes.

The present invention resolves the compromises necessary between packaging constraints and relative camber changes in bump and roll modes.

25 The suspension of the invention comprises a trailing arm in which the rotational axis of the arm may be at right angles to the chassis or in some cases at either a positive or negative angle to the chassis in the horizontal plane. The ninety degree geometry is designated a trailing arm whilst the other positive or negative angled arms are designated semi trailing arms.

30 Advantageously the present invention provides a rear driven twin wheel suspension system which is able to package the differential, propshafts, universal joints, brakes and twin wheels within the width constraint whilst still controlling camber change within acceptable limits for a high speed on highway commercial truck or bus.

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It is widely accepted in the truck industry that independent suspension provides superior performance. It is also widely accepted that an independent rear suspension would confer more benefit than an independent front suspension.

- 5 Whilst independent front suspensions are now commonly used, especially in buses, there is as yet no twin wheel, driven independent rear suspensions on the market for these types of heavy vehicle, despite the known benefits. It is evident from this fact alone that there are inherent difficulties associated with the application and installation of twin wheel, driven, independent rear suspension to highway trucks
10 and buses. These technical difficulties have now been overcome by the present invention.

The invention is not limited to the embodiments hereinbefore described which may be varied in both construction and detail within the scope of the appended claims.

CLAIMS

1. A suspension system for mounting driven twin road wheels on a vehicle chassis characterised in that the suspension system is an independent
5 suspension system comprising a trailing arm or a semi-trailing arm on which the twin road wheels are mounted, said road wheels being mounted at a lower end of the arm, and a pivot assembly for pivotally mounting the arm on the vehicle chassis being provided at an upper end of the arm.
- 10 2. A suspension system as claimed in claim 1 wherein a pivot axis of the pivot assembly of the arm is angled positively or negatively relative to a transverse axis of the chassis in a horizontal plane.
- 15 3. A suspension system as claimed in claim 1 or claim 2 wherein the pivot axis of the pivot assembly of the arm is angled positively or negatively relative to the horizontal in a vertical plane.
- 20 4. A suspension system as claimed in any preceding claim wherein the pivot assembly of the arm is mounted flexibly on the chassis allowing the pivot axis of the pivot assembly to angulate in the horizontal and vertical planes as a function of the load imposed on the wheels.
- 25 5. A suspension system as claimed in any preceding claim wherein the trailing arm is torsionally flexible allowing it to deform angularly under load inducing camber change in the wheels.
6. A suspension system as claimed in any preceding claim wherein the trailing arm is of U-section.
- 30 7. A suspension system as claimed in claim 6 wherein a spring and associated damper unit are nested within the arm.
8. A suspension system as claimed in any preceding claim wherein the trailing arm is of two part construction, namely an upper part for mounting on the

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chassis and a lower part on which the wheels are mounted, the lower part being attached to the upper part by a swivel connector allowing the lower part to swivel relative to the chassis mounted upper part to allow the wheel equalise tyre loads thus maintaining a generally vertical orientation to the ground throughout the suspension stroke.

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9. A suspension system as claimed in claim 8 wherein means is provided for restraining the relative swivelling movement of the two parts of the trailing arm.

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10. A suspension system as claimed in any preceding claim wherein the road wheels have a drive system comprising a hub reduction gear system, universally jointed propshafts and a differential gearbox mounted to chassis rails of the vehicle.

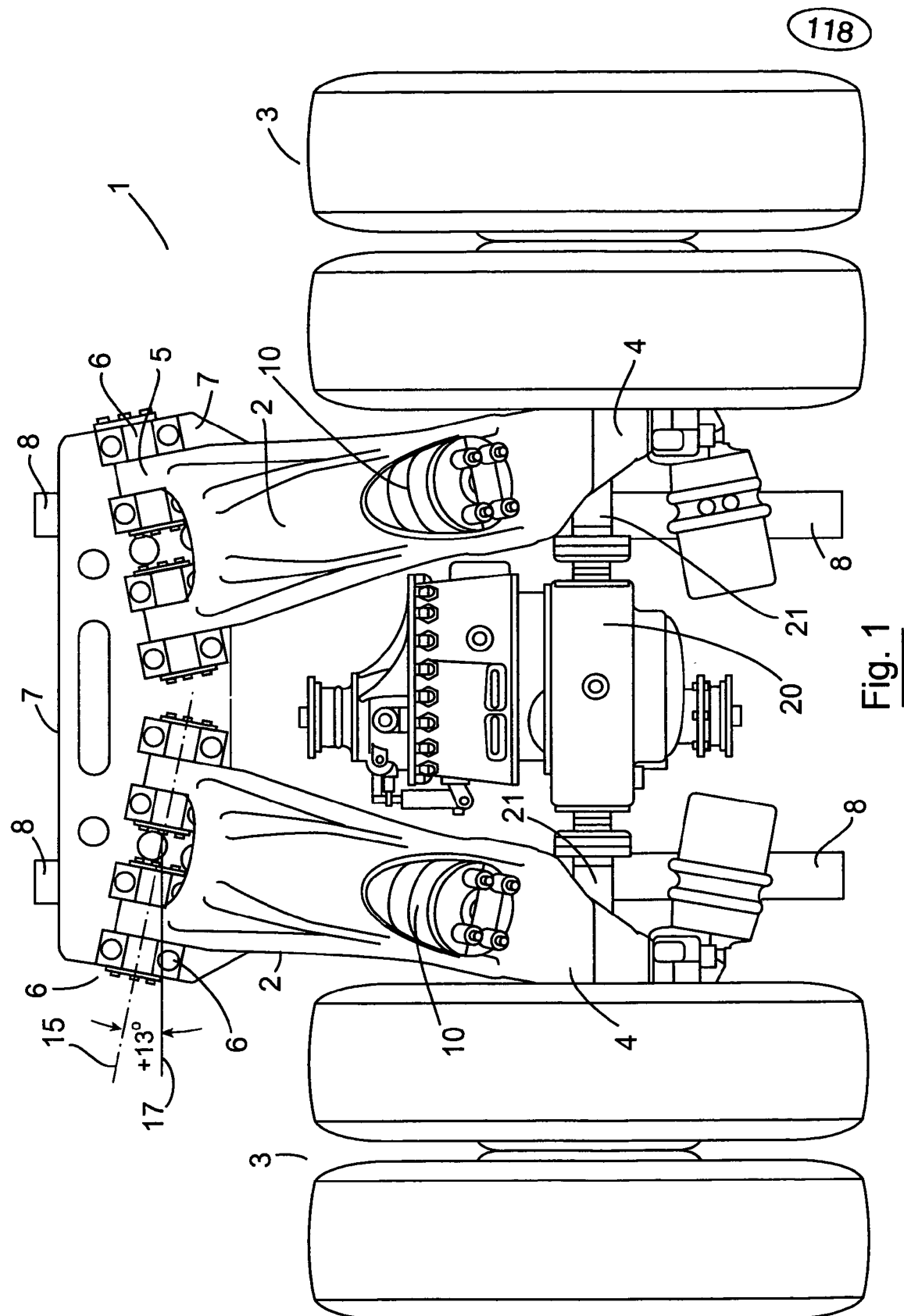
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11. A suspension system as claimed in claim 10 wherein the system includes a drive comprising an electric motor mounted either in the hub or on the chassis.

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12. A suspension system as claimed in claim 10 or claim 11 wherein the hub is a non reduction direct drive type.

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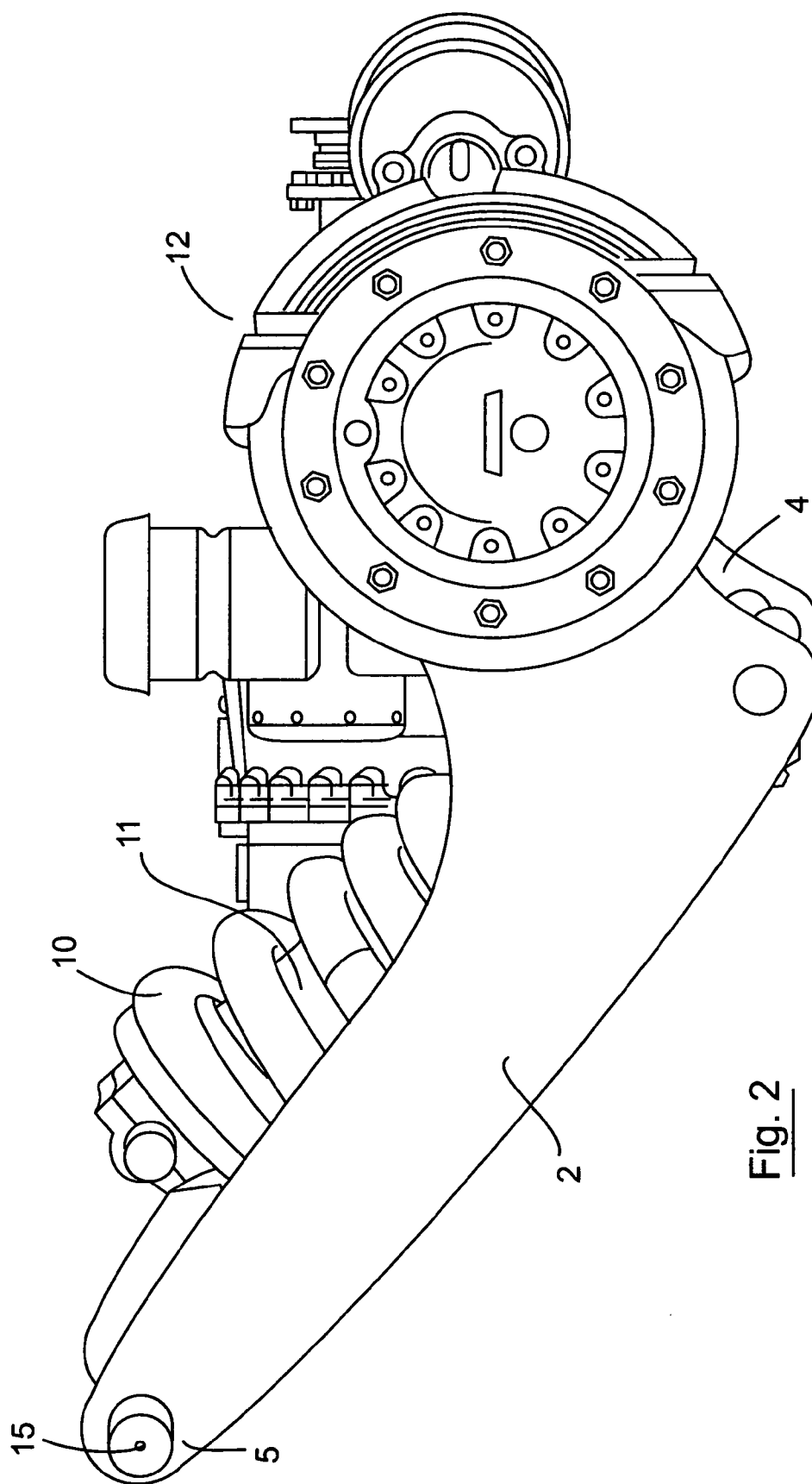


Fig. 2

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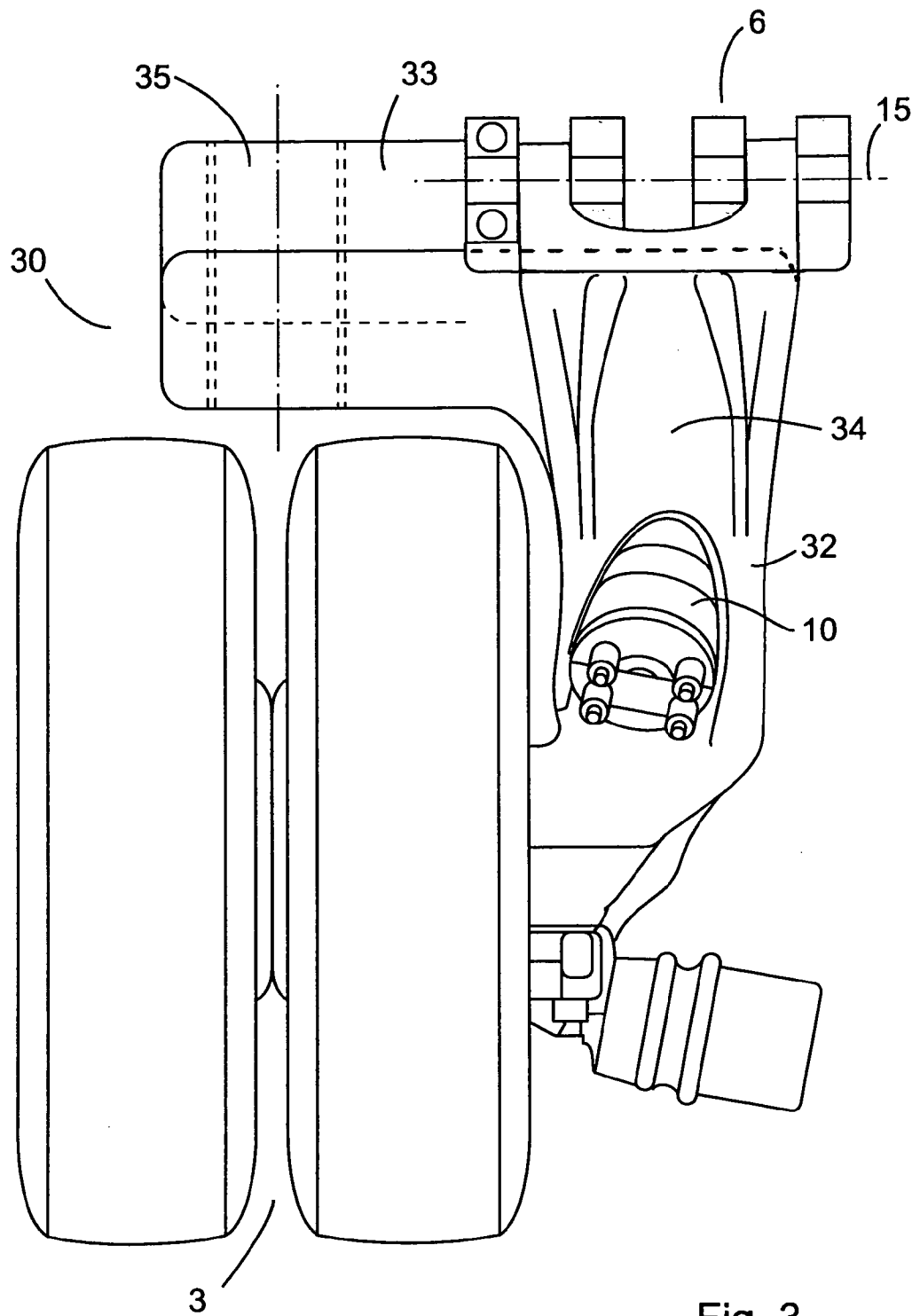


Fig. 3

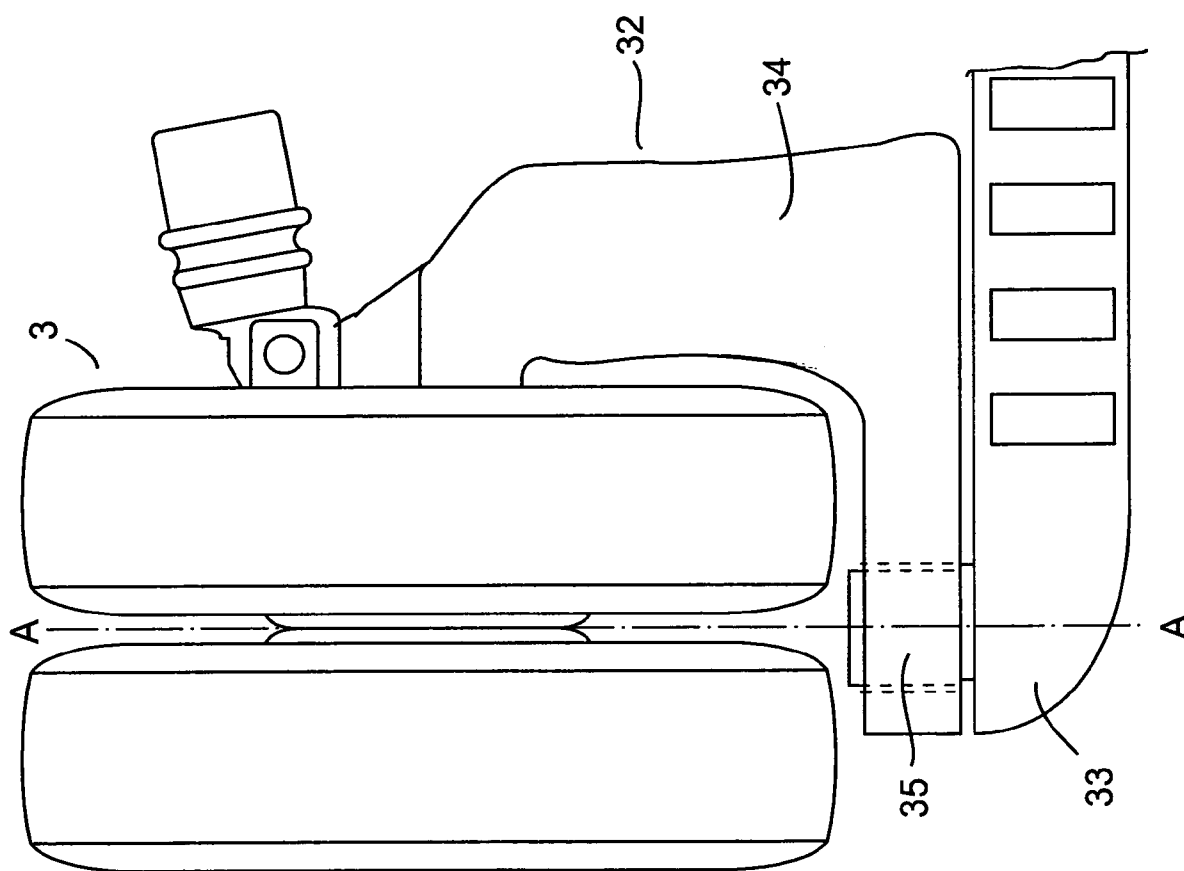
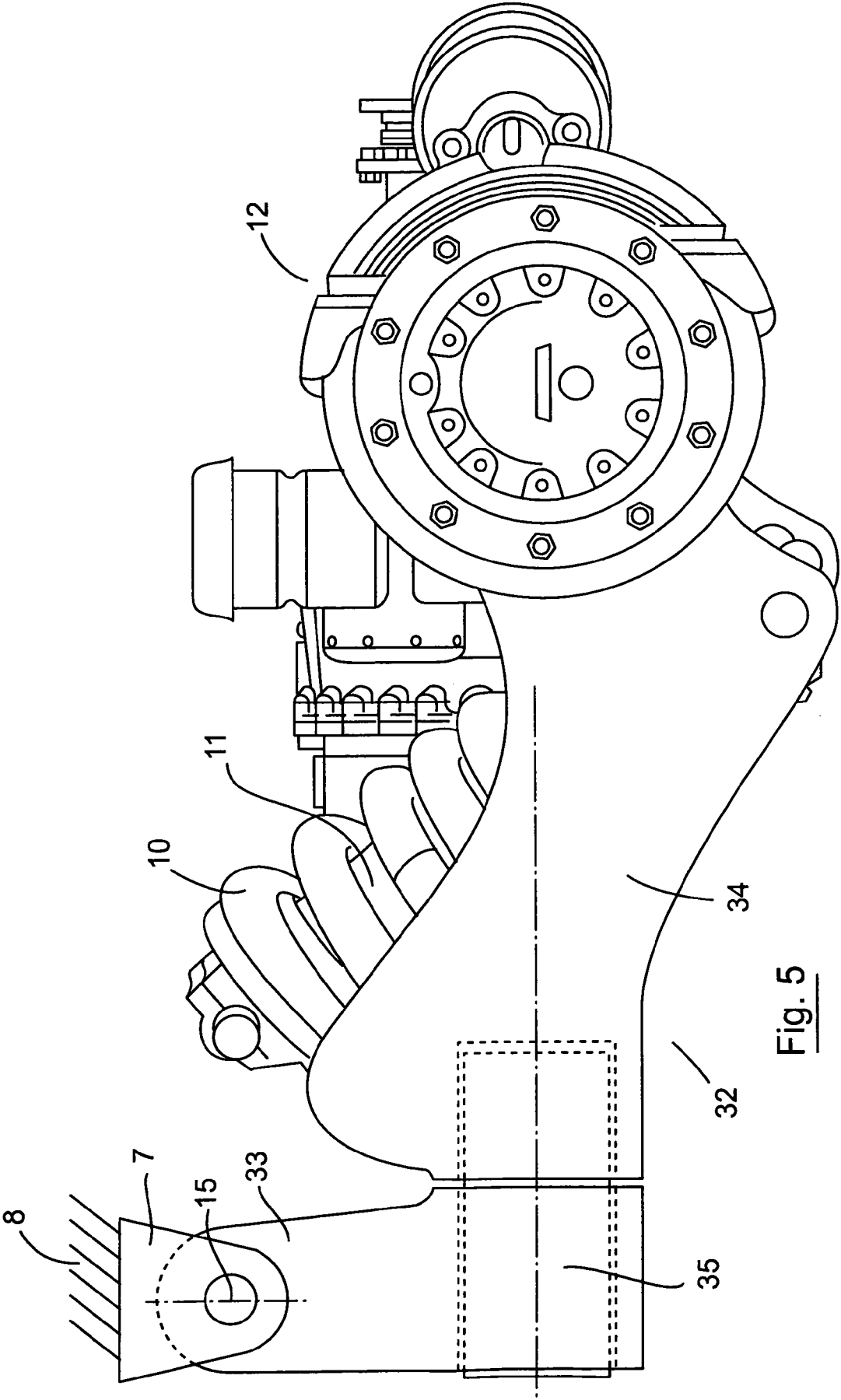


Fig. 4



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/064188

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60G3/14
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 086 076 A (PREM HANS [AU] ET AL) 11 July 2000 (2000-07-11) figures	1, 3-9
X	US 3 773 348 A (DAVIS L) 20 November 1973 (1973-11-20) page 1, lines 2-3; figures	1, 3-9
Y	US 2005/253352 A1 (ZIECH JAMES F [US]) 17 November 2005 (2005-11-17) paragraphs [0004], [0006], [0017], [0024], [0031]; figures	2, 10-12
Y	EP 1 348 587 A2 (ARVINMERITOR TECHNOLOGY LLC [US]) 1 October 2003 (2003-10-01) paragraphs [0002], [0014] - [0019]; figures 1,2	2
Y		10-12

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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