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(54) Title: STEERING AXLE ASSEMBLY

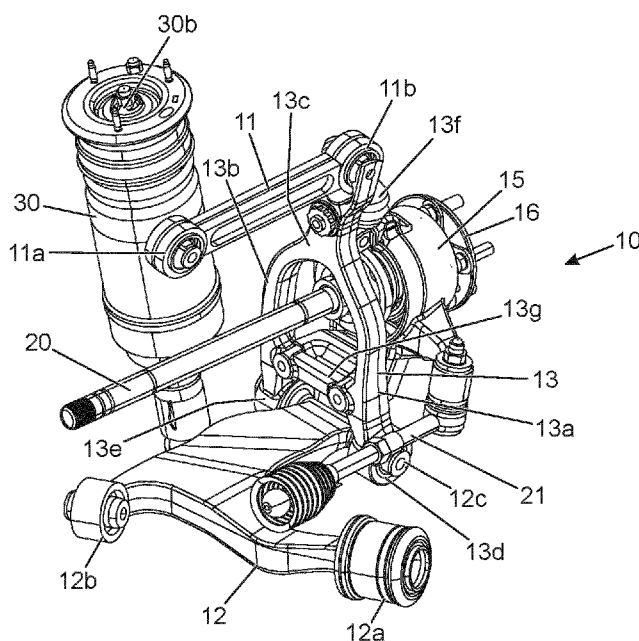


Fig. 1

(57) Abstract: Aspects of the present invention relate to a steering axle assembly for a vehicle, and a vehicle having a steering axle assembly. The steering axle assembly comprises an upper control arm and a lower control arm, each of the upper arm and lower arm having at least one body connection for pivotable attachment to a vehicle body, a wheel knuckle supporting a wheel hub for connection to a vehicle wheel, wherein a connection yoke extends between the upper control arm and the lower control arm, the connecting yoke being pivotally connected to the upper arm and the lower arm, and wherein the wheel knuckle is pivotally mounted on the connecting yoke and is pivotally moveable.



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STEERING AXLE ASSEMBLY

TECHNICAL FIELD

5 The present disclosure relates to a vehicle suspension. Aspects of the invention relate to a to a steering axle assembly for a vehicle and to a vehicle having a steering axle assembly.

BACKGROUND

Conventionally vehicles have a suspension which separates a vehicle into unsprung mass, generally the wheels and axles, and a sprung mass, the vehicle body and occupants. The
10 suspension acts to both define the handling of the vehicle that is how the vehicle responds to acceleration and steering, and also to reduce or damp the transmission of vibrations from the unsprung mass to the sprung mass. Damping the transmission of vibrations is desirable to minimise noise within a cabin of the vehicle and provide occupant comfort. In some
15 circumstances, for example where the suspension assembly is supported on a subframe that is itself mounted to the vehicle structure with vibration-isolating or damping components, further damping of road noise and external vibrations is provided.

In many vehicles, the volume available to accommodate the suspension assembly is constrained, for example to minimise intrusions into the cabin volume and to maximise the
20 load bed width and volume. It can however be difficult to provide a suspension assembly that has both the desired noise and vibration isolation, but also minimises “wheel wobble”, that is undesirable movement of the wheel away from its normal vertical movement path. For example, Macpherson struts permit a relatively simple suspension assembly, but allow wheel wobble and also provide a direct transmission route for vibration through the Macpherson strut
25 to the vehicle top mount.

It is an aim of the present invention to address one or more of the disadvantages associated with the prior art.

30 SUMMARY OF THE INVENTION

Aspects and embodiments of the invention provide a steering axle assembly and a vehicle having a steering axle assembly as claimed in the appended claims

According to an aspect of the present invention there is provided a steering axle assembly
35 and a vehicle having a steering axle assembly.

According to an aspect of the invention, there is provided a steering axle assembly for a vehicle, the steering axle assembly comprising an upper control arm and a lower control arm, each of the upper arm and lower arm having at least one body connection for pivotable attachment to a vehicle body, a wheel knuckle supporting a wheel hub for connection to a vehicle wheel, wherein a connecting yoke extends between the upper control arm and the lower control arm, the connecting yoke being pivotably connected to the upper arm and the lower arm, and wherein the wheel knuckle is pivotally mounted on the connecting yoke and is pivotally moveable.

The connecting yoke may comprise a pair of legs. The legs may have at their lower ends respective forwards and rearward connection parts for connection to the lower control arm. The forwards and rearward connection parts may form a continuation of the respective legs. The connecting yoke may comprise first and second legs. The first leg may have a forward connection part; and the second leg may have a rearward connection part.

A swivel support member may extend between the legs. The swivel support member may extend transversely between the legs. The swivel support member may be fixedly mounted to the legs, for example by welds or mechanical fasteners. In a variant, the swivel support member may be formed integrally with the connecting yoke. The swivel support member may be located upwards of the forwards and rearward connection parts. The swivel support member may support a lower swivel mount for pivotally supporting the wheel knuckle. The connecting comprises an upper portion where the legs are connected to each other. The legs extend downwardly from the upper portion. At least in certain embodiments, the legs may be spaced apart from each other along their length. The legs may extend downwardly substantially parallel to each other.

The connecting yoke is disposed in a generally upright configuration. The connecting yoke may comprise or consist of a wishbone shape or an A-frame shape.

The steering axle assembly may comprise a spring assembly connected to the lower arm, and having a spring assembly upper connector for connection to a top mount of a vehicle body.

The steering axle assembly may comprise a damper assembly connected to the lower arm, and having a damper assembly upper connector for connection to a top mount of a vehicle body.

Optionally the spring assembly and the damper assembly comprise a common spring and damper assembly.

5 The steering axle assembly may comprise drive shaft for driveably connecting a wheel hub supported in the wheel knuckle to a drive train of a vehicle.

10 A suspension kinematic axis may be defined by the pivotable connection of the connecting yoke to the upper control arm and the lower control arm, and a steering axis may be defined by the pivotal mounting of the wheel knuckle on the connecting yoke, the suspension kinematic axis and the steering axis being not parallel.

The steering axis may be inclined at a greater angle to the vertical than the suspension kinematic axis.

15 The connection yoke may comprise a pair of legs connected by an upper part, the ends of the legs extending to either side of a lower control arm yoke connection part of the of the lower control arm.

20 The wheel knuckle may be moveable through a steering angle of at least about $\pm 25^\circ$ and preferably through a steering angle of up to about $\pm 30^\circ$.

25 The wheel knuckle may comprise a lower swivel mount receiving aperture. At least a portion of the lower swivel mount may be disposed in the lower swivel mount receiving aperture. The lower swivel mount may comprise a protuberance, such as a boss. The protuberance may extend into the lower swivel mount receiving aperture.

According to a further aspect of the present invention there is provided a wheel knuckle for a vehicle comprising:

30 a wheel hub for connection to a vehicle wheel;
an upper wheel knuckle connection for engaging with an upper swivel mount; and
a lower wheel knuckle connection for engaging with a lower swivel mount;
wherein a lower swivel mount receiving aperture is formed in the wheel knuckle
for receiving at least a portion of the lower swivel mount. The wheel knuckle according to this
35 aspect of the present invention may be incorporated into the steering axle assembly described herein.

The lower swivel mount receiving aperture may extend through the wheel knuckle. The lower swivel mount receiving aperture may comprise or consist of a through aperture. The lower swivel mount receiving aperture may be sized to accommodate pivoting movement of the wheel knuckle relative to the swivel support member. For example, the lower swivel mount receiving aperture may be sized to accommodate pivoting movement about the steering axis.

The wheel knuckle may comprise a lower wheel knuckle connection which is at least partially disposed in the lower swivel mount receiving aperture. The lower wheel knuckle connection may extend into the lower swivel mount receiving aperture. The lower wheel knuckle connection may engage with and may be pivotal relative to the lower swivel mount. The lower wheel knuckle connection may comprise or consist of a pivot pin. The pivot pin may define a pivot axis. The pivot axis may be at least substantially aligned with the steering axis. Alternatively, the lower wheel knuckle connection may comprise a ball joint. The lower wheel knuckle connection may locate in the lower swivel mount. The lower wheel knuckle connection may locate in a collar, a bush or a bearing provided in the lower swivel mount.

The lower swivel mount receiving aperture may form a platform for supporting the lower wheel knuckle connection. The platform may be formed below the lower swivel mount receiving aperture. A bore may be formed through the platform for receiving a mounting portion of the lower wheel knuckle connection. The mounting portion of the lower wheel knuckle connection may comprise a shaft which locates in the bore. A mechanical fastener may fasten the lower wheel knuckle connection in position. The mechanical fastener may, for example, comprise a threaded fastener. The platform may be supported by forwards and rearward supports. The forwards and rearward supports may, for example, comprise upright walls formed on opposing sides of the lower swivel mount receiving aperture.

According to a further aspect of the invention there is provided a vehicle having a steering axle assembly according to the previous aspect of the invention.

Within the scope of this application it is expressly intended that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination, unless such features are incompatible. The applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to amend any originally filed claim to

depend from and/or incorporate any feature of any other claim although not originally claimed in that manner.

BRIEF DESCRIPTION OF THE DRAWINGS

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One or more embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

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Figure 1 shows a perspective view of a steering axle assembly in accordance with an embodiment of the invention;

Figure 2 shows a further perspective view of the steering axle assembly of figure 1;

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Figure 3 shows a further perspective view of the steering axle assembly of figure 1;

Figure 4 shows a further perspective view of the steering axle assembly of figure 1;

Figure 5 is a side view of the steering axle assembly of figure 1;

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Figure 6 is a plan view of the steering axle assembly of figure 1 in a first steering angle;

Figure 7 is a plan view of the steering axle assembly of figure 1 in a second steering angle;

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Figure 8 is a plan view of the steering axle assembly of figure 1 in a third steering angle; and

Figure 9 shows a figurative sectional view through a vehicle having steering axle assemblies in accordance with an embodiment of the invention.

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DETAILED DESCRIPTION

A steering axle assembly in accordance with an embodiment of the present invention is described herein with reference to the accompanying figures.

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A steering axle assembly is shown at 10 in figures 1 to 4. The steering axle assembly 10 comprises an upper control arm 11 and a lower control arm 12. A connection yoke 13 is

pivotally connected to the distal ends of each of the upper control arm 11 and lower control arm 12 and extends between the upper control arm 11 and lower control arm 12.

The upper control arm 11 is substantially elongate, and has a upper control arm body connection part 11a for pivotal connection to a vehicle body, as shown diagrammatically at 50 in figure 9, and an upper control arm yoke connection part 11b for pivotal connection to the connection yoke 13. The lower control arm 12 is substantially L-shaped, and has a forward body connection part 12a and a rearward body connection part 12b for connection to a vehicle. The lower control arm 12 further has a lower control arm yoke connection part 12c for pivotal connection to the connection yoke 13. The lower control arm 12 preferably has a length to width ratio in excess of 1, that is the forwards-rearwards length of the lower control arm 12 is greater than the length of the portion extending to the lower control arm yoke connection part. The forward connection part 12a and rearward connection part 12b may be connected the vehicle body through low stiffness compliance bushes, resulting in better isolation of vibrations between the lower control arm 12 and the vehicle body

As shown in figures 1 to 4, the connection yoke 13 is stirrup-shaped, with a pair of legs 13a, 13b and an upper portion 13c connecting the legs 13a, 13b. The ends of the legs 13a, 13b extend to either side of the lower control arm yoke connection part 12c of the lower arm 12. Leg 13a has at its lower end a forwards connection part 13d for connection to the lower control arm 12 and leg 13b similarly has at its lower end a rearward connection part 13e for connection to the lower control arm 12. The upper portion 13c is connected to the upper control arm yoke connection part 11b of the upper arm 11. The configuration of the connection yoke 13 thus resists torsional forces along its length.

The upper portion 13c further comprises an upper swivel mount 13f for pivotally engaging a wheel knuckle 15 as discussed below

Extending between the legs 13a, 13b of the connection yoke 13 is a swivel support member 13g, located upwards of the forwards connection part 13d and rearward connection part 13e. The swivel support member 13g supports a lower swivel mount 13h for pivotally supporting a wheel knuckle 15 as discussed below.

The steering axle assembly 10 further comprises a wheel knuckle 15. The wheel knuckle 15 supports wheel hub 16, which comprises bolts 16a to engage a wheel in conventional manner. The wheel knuckle 15 has an upper wheel knuckle connection 18a which engages with and is

pivotal relative to upper swivel mount 13f, and a lower wheel knuckle connection 18b, which engages with and is pivotal relative to lower swivel mount 13h.

As shown in Figures 3 and 4, an aperture 19 is formed in the wheel knuckle 15 for receiving at least a portion of the lower swivel mount 13h. The lower swivel mount receiving aperture 19 is in form of a through aperture which extends through the wheel knuckle below the wheel hub 16. The lower swivel mount 13h is in the form of a protuberance (such as a boss) which locates in the lower swivel mount receiving aperture 19. The lower swivel mount receiving aperture 19 is spaced apart from the bottom of the wheel knuckle 15 so as to form a platform 23 for supporting the lower wheel knuckle connection 18b. As shown in Figure 4, the platform 23 is supported by upright walls 24a, 24b formed on opposing sides of the lower swivel mount receiving aperture 19. The lower wheel knuckle connection 18b comprises a pivot pin in the present embodiment. The lower wheel knuckle connection 18b has a mounting portion, such as a shaft or a shank, which locates in a bore extending through the platform 23. A head portion of the lower wheel knuckle connection 18b engages an underside of the wheel knuckle 15.

To provide drive to the wheel hub 16, a drive shaft 20 is drivingly connected to the wheel hub 16 in conventional manner, and has a splined end 20a for connection to a drive train of the vehicle. The drive train of the vehicle may be electrical, for example a motor-generator connected directly or indirectly to drive shaft 20 or a mechanical transmission driven by an internal combustion engine.

It will be apparent that the steering axle assembly 10 may be used with steered but undriven wheels, and thus drive shaft 20 may be omitted.

To provide steering, a steering rod 21 is pivotally connected to arm 22 extending from the knuckle 15. As will be described in more detail below, longitudinal movement of the steering rod will cause the wheel knuckle 15 to rotate about a steering axis defined by the upper wheel knuckle connection 18a and lower wheel knuckle connection 18b. Although a steering rod 21 is shown her, any other steering actuator or steering mechanism may be provided to cause the wheel knuckle 15 to rotate.

A combined spring, spring aid and damper assembly is shown at 30. The spring, spring aid and damper assembly 30 is connected at its lower end 30a to a pin 12d on the lower arm 12. At its upper end the spring and damper assembly is provided with a top mount connector 30b to engage and support a body 50 of the vehicle. It will be apparent that the spring and damping

assembly may be replaced by separate components, but providing a combined assembly is advantageous for meeting packaging limitations

As illustrated in figure 5, the steering axle assembly 10 thus defines two axes, a suspension kinematic axis A and a steering axis B. The suspension kinematic axis A is defined by the plane containing the pivotal connections between the upper and lower arms 11, 12 and the connection yoke 13 and defines the path through which the suspension moves when displaced upwardly or downwardly under load or in response to vehicle movement or the ground surface. The steering axis B passes through the upper wheel knuckle connection 18a and lower wheel knuckle connection 18b and is the axis about which the wheel knuckle 15, and hence a wheel supported on the wheel knuckle, rotates when the steering rod 20 is moved.

As will be apparent from figure 5, the suspension kinematic axis A and steering axis B are not parallel. Steering axis B is inclined relative to the vertical at a greater angle than suspension kinematic axis A.

Rotation of the wheel knuckle 15 in response to movement of the steering rod 21 is illustrated in figures 6 to 8. In figure 6, the steering rod 21 is in a central position and the wheel knuckle is in a fore-aft position, so that the vehicle is travelling straight ahead. In figure 7, the steering rod 21 has been moved in an inboard direction, causing the wheel knuckle 15 to rotate in a clockwise direction C about the steering axis B. In figure 8, the steering rod 21 has been moved in an outboard direction, causing the wheel knuckle to rotate in an anti-clockwise direction D about the steering axis B.

Figure 9 diagrammatically shows a vehicle body 50 with steering axle assemblies 10 located either side of the vehicle body 50. Each steering axle assembly 10 supports a wheel and tyre, shown diagrammatically at 51. The respective upper control arm body connection part 11a, forward body connection part 12a and rearward body connection part 12b, and top mount connector 30b are connected to the vehicle body 50 in appropriate manner (not shown). The steering axle assemblies 10 in this example are directly opposed and symmetrically arranged. As illustrated in figure 9, the compact steering axle assemblies 10 disposed in a relatively small volume, and in particular do not intrude above a floor 52, thus minimising intrusion into a load space or vehicle cabin.

The steering axle assembly as shown herein is thus advantageous in that it provides the handling refinement of a dual-wishbone suspension in a compact package. The use of low stiffness bushes to support the lower control arm 12 permits a low wheel fore-aft stiffness,

which is generally desirable, but is associated with the problems of degraded ride and bump steer and handling. By providing the wheel knuckle 15 on the connection yoke 13, the wheel centre moves with the lower control arm 12 but the wheel knuckle 15 does not rotate as it would on a conventional dual-wishbone assembly, thus reducing the ride and bump steer problems. Additionally, by locating the steering axis B in a position outboard of the suspension kinematic axis A, and by selecting the shape of the upper and lower control arms, a large steering angle of up to about $\pm 25^\circ$ and even a steering angle of up to about $\pm 30^\circ$.

The geometry of the upper and lower control arms 11, 12, connection yoke 13 and wheel knuckle 15 can be selected to provide the desired parameters of roll centre height, anti-lift and camber gain, as would be appreciated by one skilled in the art of vehicle suspension design.

It will be appreciated that various changes and modifications can be made to the present invention without departing from the scope of the present application.

CLAIMS

1. A steering axle assembly for a vehicle, the steering axle assembly comprising;
an upper control arm and a lower control arm, each of the upper arm and lower
5 arm having at least one body connection for pivotable attachment to a vehicle body, and
a wheel knuckle supporting a wheel hub for connection to a vehicle wheel,
wherein a connecting yoke extends between the upper control arm and the
lower control arm, the connecting yoke being pivotably connected to the upper arm and the
lower arm,
10 and wherein the wheel knuckle is pivotally mounted on the connecting yoke and
is pivotally moveable about a steering axis,
the connecting yoke comprising a pair of legs having at their lower ends
respective forwards and rearward connection parts for connection to the lower control arm,
wherein a swivel support member extends between the legs, the swivel support
15 member being located upwards of the forwards and rearward connection parts and supporting
a lower swivel mount for pivotally supporting the wheel knuckle.
2. The steering axle assembly of claim 1 comprising a spring assembly connected
to the lower arm, and having a spring assembly upper connector for connection to a top mount
20 of a vehicle body.
3. The steering axle assembly of claim 1 or claim 2 comprising a damper assembly
connected to the lower arm, and having a damper assembly upper connector for connection
to a top mount of a vehicle body.
25
4. The steering axle assembly of claim 3 where dependent on claim 2 wherein the
spring assembly and the damper assembly comprise a common spring and damper assembly.
5. The steering axle assembly of any one of the preceding claims comprising a
30 drive shaft for driveably connecting the wheel knuckle to a drive train of a vehicle.
- 6 The steering axle assembly of any one of the preceding claims wherein a
suspension kinematic axis is defined by the pivotable connection of the connecting yoke to
the upper control arm and the lower control arm, and wherein the steering axis is defined by
35 the pivotal mounting of the wheel knuckle on the connecting yoke, the suspension kinematic
axis and the steering axis being not parallel.

7. The steering axle assembly of claim 6 wherein the steering axis is inclined at a greater angle to the vertical than the suspension kinematic axis.
8. The steering axle assembly of any one of the preceding claims wherein the wheel knuckle is moveable through a steering angle of at least about $\pm 25^\circ$ and preferably through a steering angle of up to about $\pm 30^\circ$.
9. The steering axle assembly of any one of the preceding claims, wherein the wheel knuckle comprises a lower swivel mount receiving aperture; at least a portion of the lower swivel mount being disposed in the lower swivel mount receiving aperture.
10. The steering axle assembly as claimed in claim 9, wherein the wheel knuckle comprises a lower wheel knuckle connection which may be disposed at least partially in the lower swivel mount receiving aperture.
11. A vehicle comprising the steering axle assembly of any one of the preceding claims.

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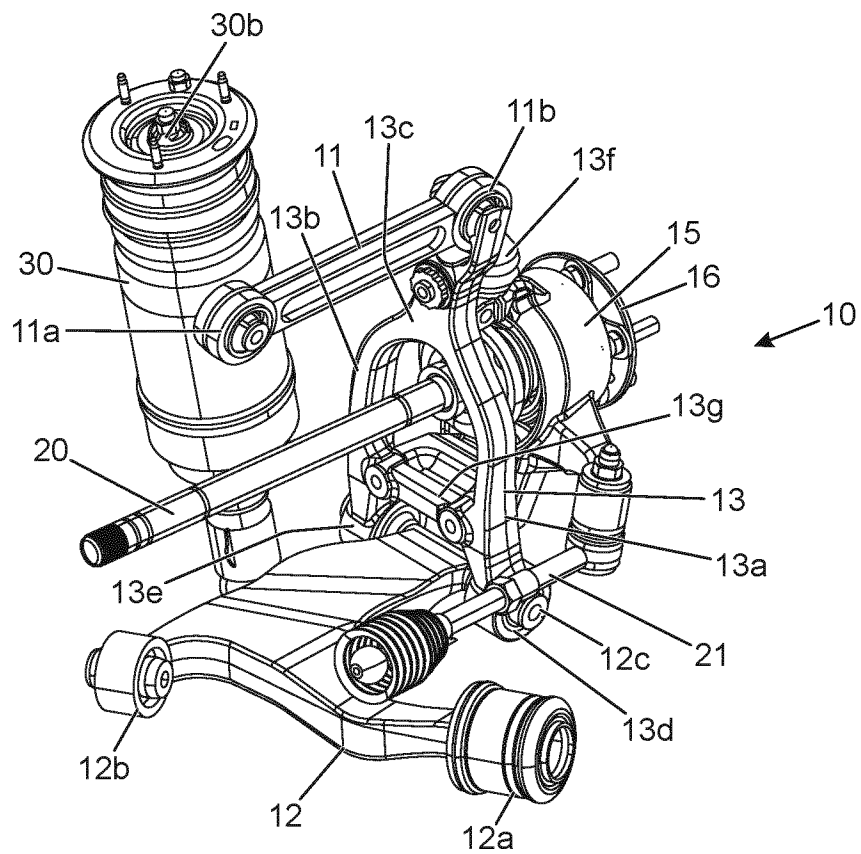


Fig. 1

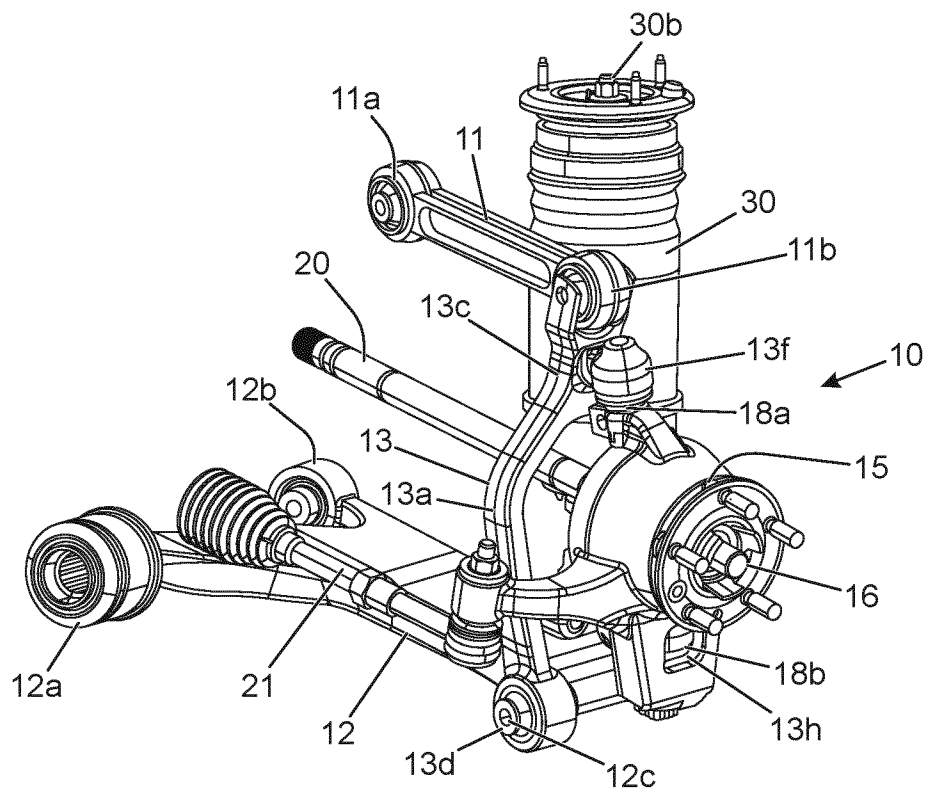


Fig. 2

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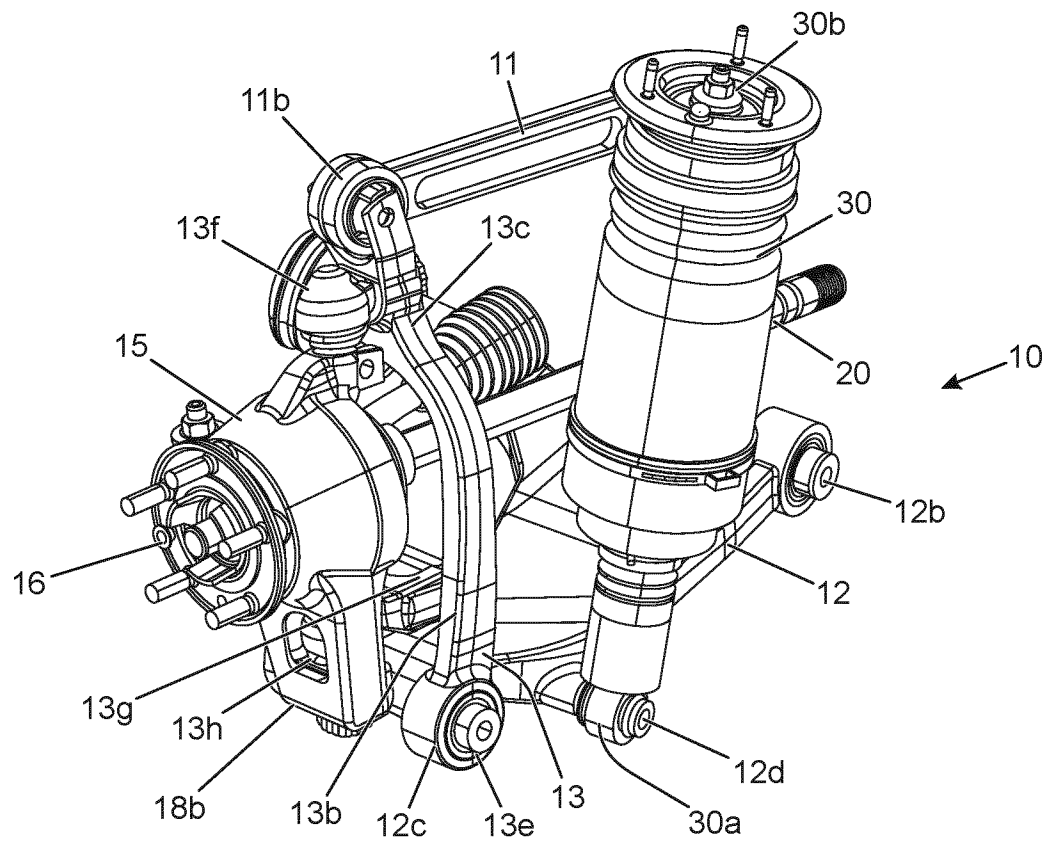


Fig. 3

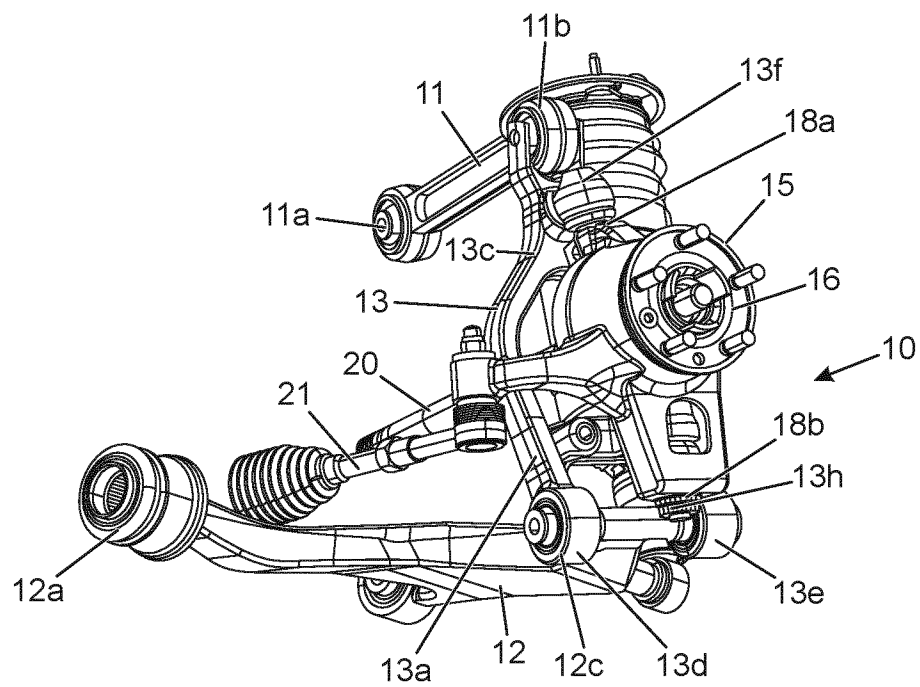


Fig. 4

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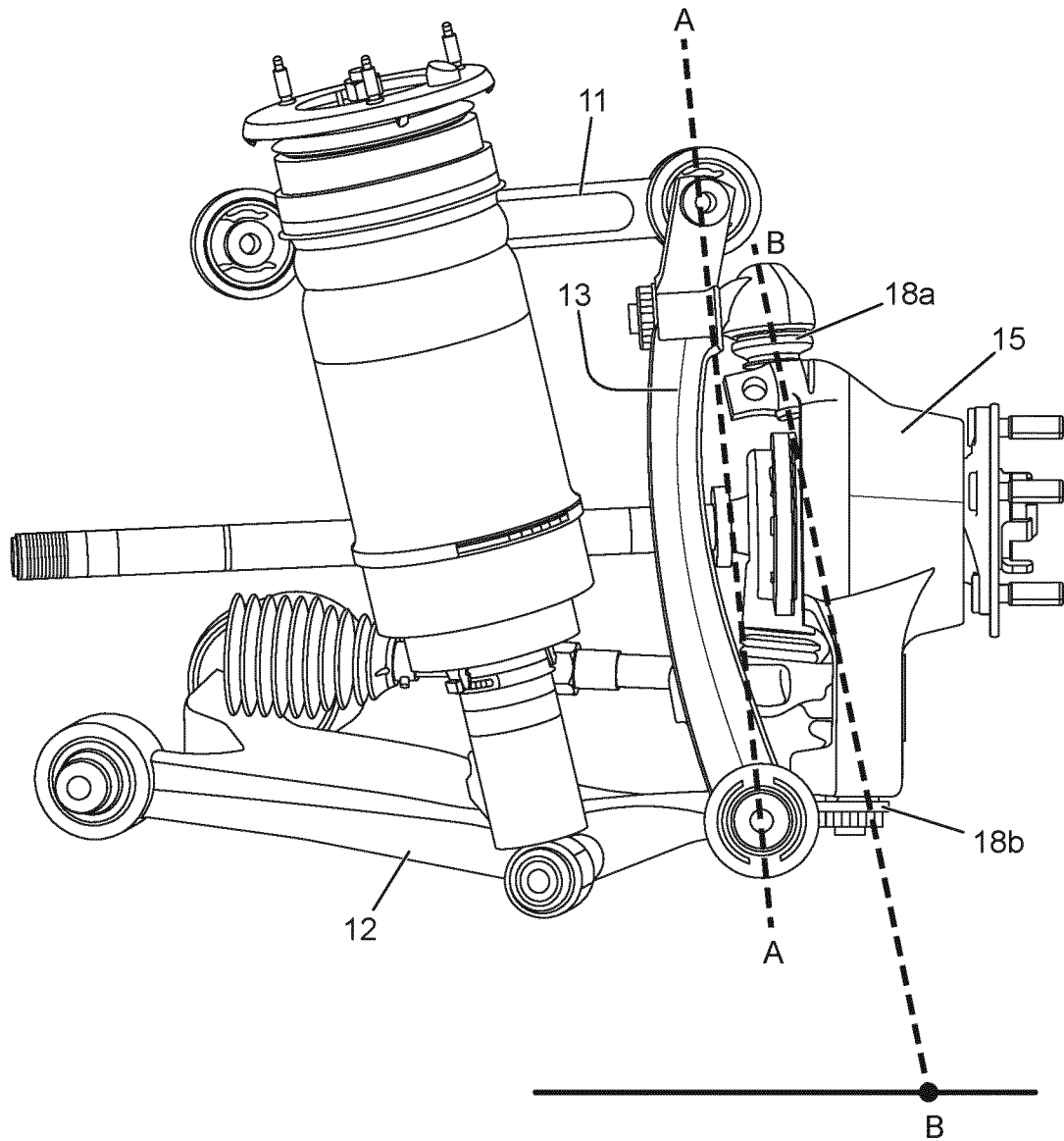


Fig. 5

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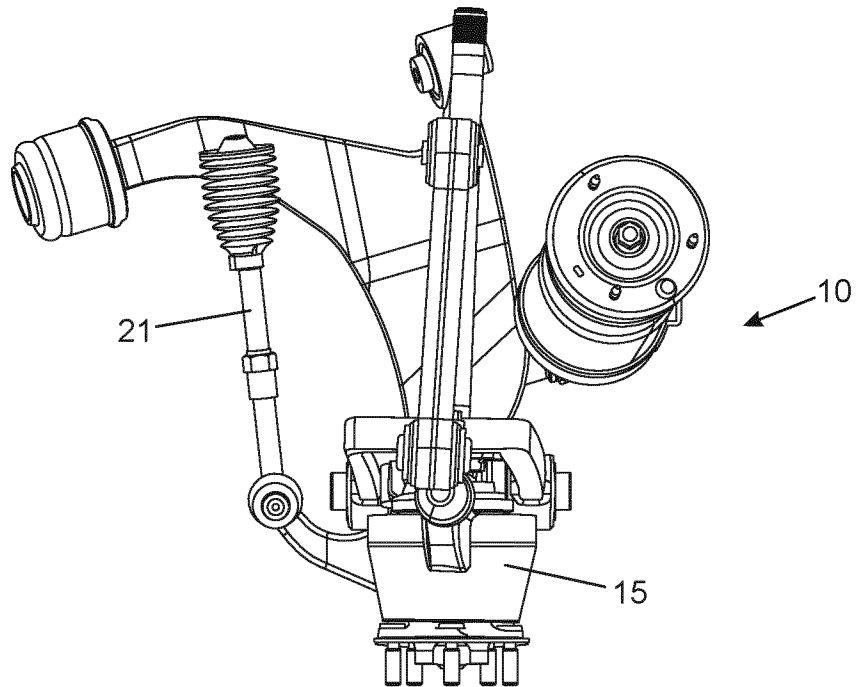


Fig. 6

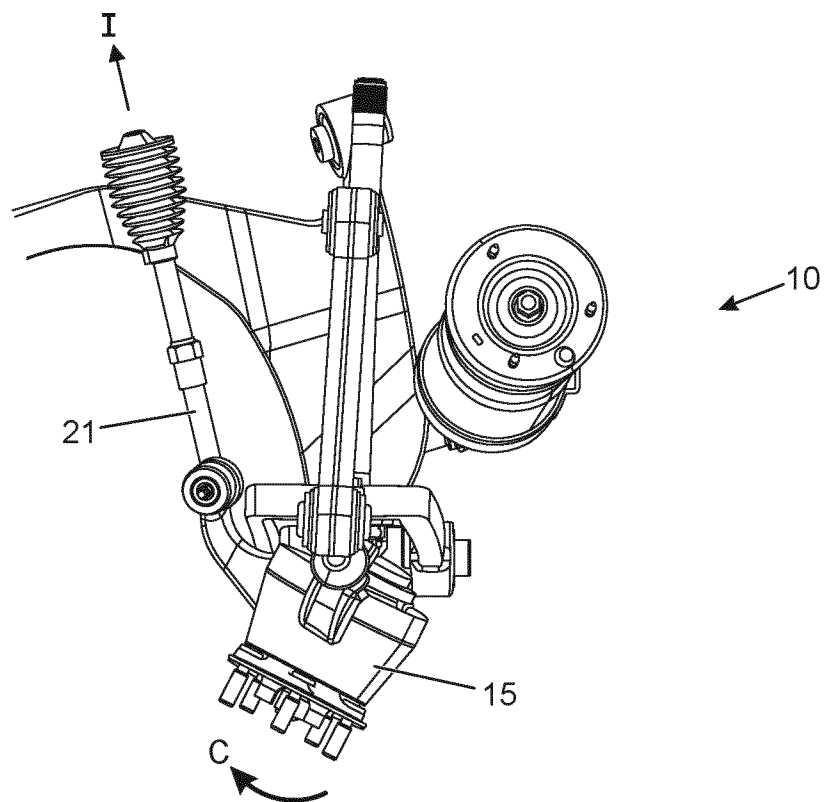


Fig. 7

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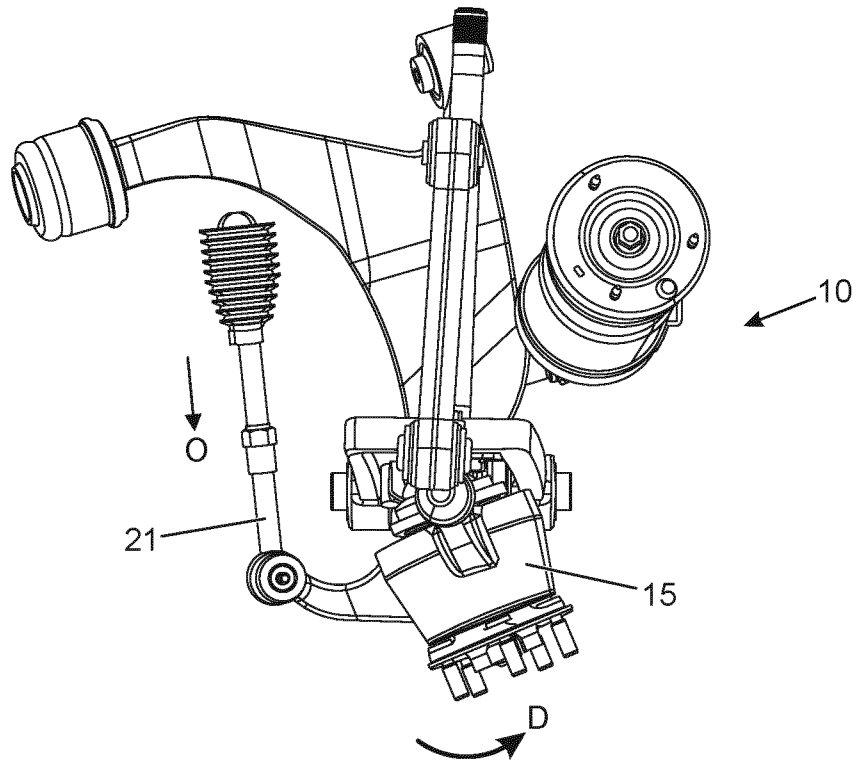


Fig. 8

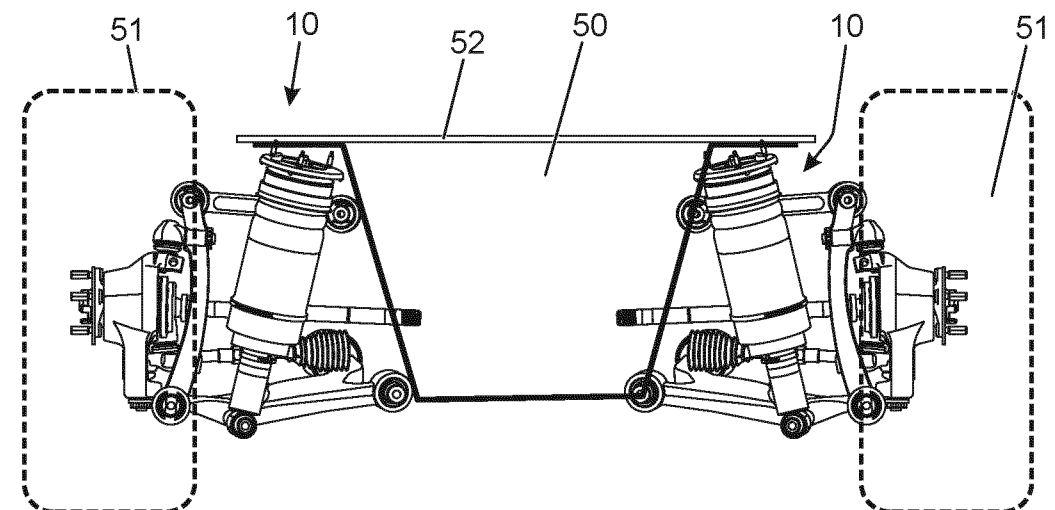


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/057220

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60G3/20 B60G7/00 B62D7/18
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 B62D

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2 402 562 A (LEWIS ROBERT P) 25 June 1946 (1946-06-25) the whole document	1,5-11
X	FR 2 827 813 A1 (PEUGEOT CITROEN AUTOMOBILES SA [FR]) 31 January 2003 (2003-01-31) the whole document	1,4-11
Y	page 4, lines 17-27 page 5, lines 4-5 page 5, lines 22-33 page 5, lines 11-17 page 6, lines 15-26 claim 5	1-11
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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

10 June 2020

Date of mailing of the international search report

18/06/2020

Name and mailing address of the ISA/

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Authorized officer

Sluimer, Paul

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/057220

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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