



(51) International Patent Classification:
B60G 3/20 (2006.01)

(21) International Application Number:
PCT/IB2017/057425

(22) International Filing Date:
27 November 2017 (27.11.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
201621040495 28 November 2016 (28.11.2016) IN

(71) Applicants: **TATA MOTORS EUROPEAN TECHNICAL CENTRE PLC** [GB/GB]; 18 Grosvenor Place, London Greater London SW1X 7HS (GB). **TATA MOTORS LIMITED** [IN/IN]; Bombay House, 2 Homi Mody Street, Mumbai 400001 (IN).

(72) Inventor: **WRIGHT, Christopher**; c/o Jaguar Land Rover, Patents Department W/1/073, Abbey Road, Whitley, Coventry Warwickshire CV3 4LF (GB).

(74) Agent: **JAGUARLANDROVERLIMITED**; Patents Department W/1/073, Abbey Road, Whitley, Coventry Warwickshire CV3 4LF (GB).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) Title: SUSPENSION AND STEERING SYSTEM FOR A VEHICLE

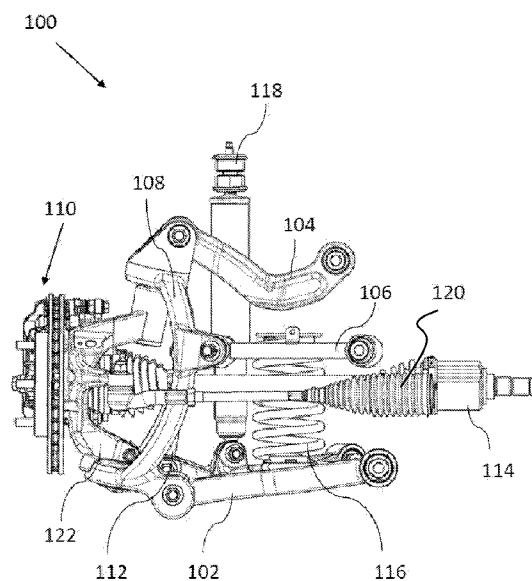


Figure 1

(57) Abstract: A suspension and steering system for a vehicle, a suspension assembly for the system, and a vehicle comprising the system are disclosed. The suspension and steering system comprises a wheel hub knuckle (122; 222), a steering assembly (120; 220) coupled to the wheel hub knuckle (122; 222) and a suspension assembly. The suspension assembly has at least one control member (102, 104, 106; 202, 204, 206), and an intermediate bracket means (108; 208). The at least one control member (102, 104, 106; 202, 204, 206) is coupled to the intermediate bracket means (108; 208), the coupling point of the at least one control member on the intermediate bracket means (108; 208) being spaced longitudinally from a steering axis of the system.



SUSPENSION AND STEERING SYSTEM FOR A VEHICLE

TECHNICAL FIELD

5 The present disclosure relates to a suspension and steering system for a vehicle and particularly, but not exclusively, to a dual knuckle system comprising a suspension assembly and a steering assembly. Aspects of the invention relate to a system which can be employed as a front wheel independent suspension system, to a rear wheel independent suspension system and to a vehicle comprising the system.

10

BACKGROUND

Suspension systems perform a number of functions within a vehicle. Primarily they should reduce the noise, vibration and harshness (NVH) of the vehicle, isolating the passengers from road shocks. Suspension systems also regulate the stability of the vehicle by enabling contact between wheels and the road and maintain proper wheel geometry. However, these must also be balanced with vehicle requirements such as sufficient handling.

20 There are two main categories of suspension systems; dependent and independent. Dependent, or 'rigid axle' systems have the two front or back wheels connected on the same axle. This system is mechanically straightforward, and therefore generally robust. However, as the wheels react to road shocks in conjunction, the efficacy of the handling is reduced, particularly when compared to independent suspension systems.

25 Independent systems, as the name suggests, are configured so that the individual wheels can move independently from one another, reacting individually to road disturbances. Consequently, the configuration of independent suspension systems can be rather complex, but does allow for better vehicle handling, and can enhance the stability of the vehicle.

30

As independent suspension systems afford characteristics that are advantageous for modern on-road cars, it is these that are typically used. By using an independent system, the individual wheel geometries can be controlled. The positioning of the wheel includes the steered direction, and the camber, caster and toe angle alignments.

The MacPherson type is a common front suspension system which comprises a telescopic damper with the coil pivoted at the top end to the vehicle body, which is employed as the upper steering pivot. Consequently, the MacPherson type is both a light and compact suspension system, which is particularly useful for front suspensions
5 where packaging volume is an issue. However, specific positioning of the telescopic damper is required for suitable caster angle, and often in such systems there is diminished possibility for camber and toe alignment control.

Another suspension system, which offers improved management of wheel position, is
10 the double wishbone suspension system. A double wishbone system comprises two links of a wishbone configuration (an A-shape) which are generally in parallel when in the usual ride position. The links, or arms, are used to link the wheel hubs to the axle or chassis, and act to control the position of the wheel. For example, in a double wishbone suspension system it is common to have the upper link, or arm, shorter in
15 length than the lower control arm so that negative camber is generated, counteracting the positive camber often induced whilst a vehicle corners.

Furthermore, a system which improves on some of the advantages presented by the double wishbone suspension system is the multilink suspension system. This is
20 derived from the double wishbone system but is comprised of at least three substantially horizontal links, or arms, and one or more substantially vertical arms, or links. By providing a system which has an increased number of independent arms, generally provided with ball joints or bushings at the arm joints, the horizontal and vertical forces, and consequently wheel geometries, can be configured and handled
25 more precisely than other suspension systems. Therefore this results in overall improved handling of the vehicle whilst augmenting passenger comfort.

Both the double wishbone and the multilink suspension systems may also comprise of an integral link. In such a suspension system, an 'integral' link may be provided
30 between the lower control arm and the knuckle. It further acts as a mount for the hub, to which the wheel and tyre assembly is attached. However, in other suspension systems the integral link may be provided between a lower and upper arm, or the knuckle and an upper arm. The integral link acts to control the fore-aft compliance of the system. For example, in a wishbone system in which the integral link is attached

between the lower link and the knuckle, the vertical springing characteristics are improved giving enhanced road-wheel control. As an integral link can improve the vertical stiffness of the system, as well as the horizontal compliance there is a better overall compromise between handling and the NVH of the vehicle.

5

Consequently integral link suspension systems present many advantages over other suspension types. However, the integral link can also work to constrain the knuckle, or upper links, preventing the ability to steer through significant steer angles. For this reason, as well as significant packing constraints, integral link suspension systems have typically been designed only as independent rear wheel suspension systems (IRS).

10

It is against this background that the present invention has been devised.

15

At least in certain embodiments, the present invention seeks to overcome or ameliorate at least some of the disadvantages associated with the prior art.

SUMMARY OF THE INVENTION

20

Aspects and embodiments of the invention provide a suspension and steering system for a vehicle, a suspension assembly for the system, and a vehicle comprising the system as claimed in the appended claims.

25

According to an aspect of the invention, there is provided a suspension and steering system for a vehicle, comprising: a wheel hub knuckle; a steering assembly coupled to the wheel hub knuckle; and a suspension assembly, wherein the suspension assembly comprises: at least one control member; and an intermediate bracket means, wherein the at least one control member is coupled to the intermediate bracket means, and wherein the coupling point of the control member on the intermediate bracket means is spaced longitudinally from a steering axis of the system.

30

This provides a system in which suspension and steering may be combined, in a system which nevertheless provides stability away from or longitudinally separated from the steering axis of the system, thereby also incorporating some of the

advantages of previously considered integral link and multilink systems. This is done by effectively separating the steering system from at least part of the suspension assembly, so that the steering is operable in spite of the provision of at least one suspension control member spaced longitudinally from the steering axis. In previous
5 systems, such a control member would have been attached to the wheel hub knuckle, thereby impeding steering – here, the control member is coupled to the intermediate bracket means, allowing the steering to operate separately. In addition, by employing the configuration of the embodiments of the invention, the steering axis may be longitudinally offset, for example by enabling steering via the inner knuckle which can
10 itself be longitudinally offset.

The coupling point of the control member on the intermediate bracket means may be distal from, off-axis, or not aligned with the steering axis of the system. The steering axis may be defined as or taken to be an axis through the steering assembly coupled
15 to the wheel hub knuckle. This axis may be the axis around which a wheel for mounting on the wheel hub knuckle would rotate in use, thereby providing steering.

The intermediate bracket means may be separate from the wheel hub knuckle, for example it may be that the intermediate bracket means is spaced laterally from the
20 wheel hub knuckle. In embodiments, it could be that the intermediate bracket means is closer in use to a wheel of the vehicle than the wheel hub knuckle. However, in embodiments of the invention, the suspension assembly comprises a vehicle mounting, and the intermediate bracket means is disposed between the vehicle mounting of the suspension assembly and the wheel hub knuckle.

25 In embodiments of the invention, coupling points between components may be provided by pivotal, rotational or hinge-like couplings which may have a plurality of degrees of freedom, dependent on the type of coupling component employed. It will be clear to the skilled person that suitable coupling components would be selected
30 dependent on the function of the elements being coupled. Examples of coupling components which may be employed are flexible couplings, bush pin type flange couplings, rag joints, ball joints, bushings and bearings. In other embodiments, coupling may be provided by hinge couplings, which may have fewer degrees of

freedom. This list is not considered to be exhaustive and other suitable coupling components are envisaged to be used in arrangements of the present invention.

5 Optionally, the at least one control member is one of: a toe control arm; a camber control arm; and a lower control arm.

10 In an embodiment of the invention, the intermediate bracket means comprises an inner knuckle. The system of embodiments of the invention may therefore provide a dual knuckle system, comprising the wheel hub knuckle and the inner knuckle. In this embodiment, the steering axis is taken to be the axis about which the wheel hub knuckle rotates relative to the inner knuckle.

15 Optionally, the at least one control member is a lower control arm, the wheel hub knuckle is coupled to the inner knuckle at a first position and to the lower control arm at a second position, the first position is located at a first end of the wheel hub knuckle, and the second position is located at an opposing second end of the wheel hub knuckle, and the wheel hub knuckle is coupled to a wheel hub assembly. In this embodiment the wheel hub knuckle acts as an integral link connected between the inner knuckle and the lower control arm while also acting as a steerable outer / wheel
20 knuckle. This embodiment therefore obviates a separate integral link within the suspension and steering system while maintaining the functionality of an integral link. The number of components within the system is consequently reduced, thereby reducing the manufacturing cost.

25 Alternatively, the wheel hub knuckle may be coupled to the inner knuckle at at least two positions, wherein at least a first position is located at a first end of the wheel hub knuckle, and at least a second position is located at an opposing second end of the wheel hub knuckle, and wherein the wheel hub knuckle is coupled to a wheel hub assembly.

30

Optionally, the wheel hub assembly comprises a wheel bearing, a wheel hub, a brake disc, a caliper and a road wheel mounting face.

Optionally, the steering assembly comprises a steering track rod coupled to the wheel hub knuckle at a first end and coupled to a steering rack at an opposing second end.

5 Optionally, the steering assembly comprises a driveshaft coupled to the wheel hub assembly at a first end and coupled to a final drive unit at an opposing end.

10 In an embodiment of the invention, the suspension assembly comprises at least two suspension arms pivotally coupled to the vehicle mounting at first ends and pivotally coupled to the inner knuckle at opposing second ends, and a damping system coupled to at least one arm at a first end and to the vehicle mounting at an opposing second end.

15 In an embodiment of the invention, the suspension assembly comprises a lower control arm pivotally coupled to the vehicle mounting at a first end and pivotally coupled to the inner knuckle at an opposing second end, an upper camber control arm pivotally coupled to the vehicle mounting at a first end, and pivotally coupled to the inner knuckle at an opposing second end, a toe control arm pivotally coupled to the vehicle mounting at a first end and pivotally coupled to the inner knuckle at an opposing second end, and a damping system coupled to at least one arm at a first end and to the vehicle mounting at an opposing end.

25 In an embodiment of the invention, the suspension assembly comprises an upper arm pivotally coupled to the vehicle mounting at two substantially horizontal positions at inner first ends of the upper arm, and pivotally coupled to the inner knuckle at an opposing second end, a lower control arm pivotally coupled to the vehicle mounting at two substantially horizontal positions at inner first ends of the lower control arm, and pivotally coupled to the inner knuckle at an opposing second end, and a damping system coupled to at least one arm at a first end and to the vehicle mounting at an opposing second end.

30 Optionally, the suspension assembly according to any of the above embodiments comprises an integral link pivotally coupled to the lower control arm at a first end, and pivotally coupled to the inner knuckle at an opposing second end.

According to another aspect of the invention there is provided a suspension and steering system for a vehicle, comprising: a knuckle; a steering assembly coupled to the knuckle; and a suspension assembly. The suspension assembly may comprise: at least one control member; and an intermediate bracket means. The at least one
5 control member may be coupled to the intermediate bracket means. The coupling point of the control member on the intermediate bracket means may be spaced longitudinally from a steering axis of the system. The steering axis is taken to be the axis about which the wheel and steering assembly rotate relative to the knuckle. Furthermore, the longitudinal direction is the lengthwise direction which may be
10 understood to define a length from the wheel towards a central parallel point of the vehicle, between the front and the rear of the vehicle, perpendicular to a lateral direction/orientation which may be defined along a line between left-hand and right-hand sides of the vehicle).

15 According to another aspect of the invention there is provided a vehicle comprising the suspension and steering system as described above.

According to another aspect of the invention there is provided a system for a vehicle, comprising: a wheel hub knuckle; a steering assembly coupled to the wheel hub
20 knuckle; and a suspension assembly, wherein the suspension assembly comprises: at least one control member; and an intermediate bracket means, wherein the at least one control member is coupled to the intermediate bracket means.

According to another aspect of the invention, there is provided a suspension and
25 steering system for a vehicle, comprising: a wheel hub knuckle; a steering assembly coupled to the wheel hub knuckle; and a suspension assembly, wherein the suspension assembly comprises: at least one control member; and an intermediate bracket, wherein the at least one control member is coupled to the intermediate bracket, and wherein the coupling point of the control member on the intermediate
30 bracket is spaced longitudinally from a steering axis of the system.

In embodiments of the invention, the suspension assembly comprises a vehicle mounting, and the intermediate bracket is disposed between the vehicle mounting of the suspension assembly and the wheel hub knuckle.

Optionally, the at least one control member is one of: a toe control arm; a camber control arm; and a lower control arm.

- 5 In an embodiment of the invention, the intermediate bracket comprises an inner knuckle. The system of embodiments of the invention may therefore provide a dual knuckle system, comprising the wheel hub knuckle and the inner knuckle.

Optionally, the wheel hub knuckle may be coupled to the inner knuckle at at least two
10 positions, wherein at least a first position is located at a first end of the wheel hub knuckle, and at least a second position is located at an opposing second end of the wheel hub knuckle, and wherein the wheel hub knuckle is coupled to a wheel hub assembly.

- 15 Optionally, the wheel hub assembly comprises a wheel bearing, a wheel hub, a brake disc, a caliper and a road wheel mounting face.

Optionally, the steering assembly comprises a steering track rod coupled to the hub knuckle at a first end and coupled to a steering rack at an opposing second end.

20

Optionally, the steering assembly comprises a driveshaft coupled to the wheel hub assembly at a first end and coupled to a final drive unit at an opposing end.

- 25 In an embodiment of the invention, the suspension assembly comprises at least two suspension arms pivotally coupled to the vehicle mounting at first ends and pivotally coupled to the inner knuckle at opposing second ends, and a damping system coupled to at least one arm at a first end and to the vehicle mounting at an opposing second end.

- 30 In an embodiment of the invention, the suspension assembly comprises a lower control arm pivotally coupled to the vehicle mounting at a first end and pivotally coupled to the inner knuckle at an opposing second end, an upper camber control arm pivotally coupled to the vehicle mounting at a first end, and pivotally coupled to the inner knuckle at an opposing second end, a toe control arm pivotally coupled to the

vehicle mounting at a first end and pivotally coupled to the inner knuckle at an opposing second end, and a damping system coupled to at least one arm at a first end and to the vehicle mounting at an opposing end.

- 5 In an embodiment of the invention, the suspension assembly comprises an upper arm pivotally coupled to the vehicle mounting at two substantially horizontal positions at inner first ends of the upper arm, and pivotally coupled to the inner knuckle at an opposing second end, a lower control arm pivotally coupled to the vehicle mounting at two substantially horizontal positions at inner first ends of the lower control arm, and
10 pivotally coupled to the inner knuckle at an opposing second end, and a damping system coupled to at least one arm at a first end and to the vehicle mounting at an opposing second end.

Within the scope of this application it is expressly intended that the various aspects,
15 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
20 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

25

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

Figure 1 is a rear elevation view of a front left-hand-side suspension and steering
30 system according to an embodiment of the invention.

Figure 2 is a front elevation view of the front left-hand-side suspension and steering system of Figure 1, omitting the brakes.

Figure 3 is a front isometric view of the system of Figure 1, omitting the driveshaft and brakes.

Figure 4 is a plan view of the system of Figure 1.

5

Figure 5 is a section view of the system of the embodiment of Figure 2 taken along the section line (A-A) illustrated in Figure 4.

Figure 6 is a rear elevation view of a front left-hand-side suspension and steering system according to another embodiment of the invention.

10

Figure 7 is a front elevation view of the front left-hand-side suspension and steering system of Figure 6.

15 Figure 8 is a rear isometric view of the system of Figure 6.

Figure 9 is a plan view of the system of Figure 6.

Figure 10 is a side elevation view of the system of Figure 6 looking outward from the vehicle structure along the axis of the drive-shaft (omitted from the figure for clarity) towards the inner knuckle with the outer knuckle visible there-through.

20

Figure 11 is a side elevation view of the system of Figure 6 looking inward from the vehicle road wheel along the axis of the drive-shaft (both road wheel and drive-shaft omitted from the figure for clarity) towards the outer knuckle with the inner knuckle visible there-beyond.

25

Figure 12 is a schematic view illustrating a system employed as the front wheel suspension system in a vehicle, according to an embodiment of the invention.

30

DETAILED DESCRIPTION

A suspension and steering system as described with reference to the following embodiments of the invention may be referred to as a dual knuckle suspension and

steering system. Embodiments are described in which an outer or wheel hub knuckle and an intermediate bracket means or inner knuckle (for the suspension assembly) are provided. Although it is a common term to a person skilled in the art, herein a knuckle should be understood to be a rigid component which is coupled to, and structurally supports, at least one other vehicle component. For example, a typical steering knuckle, which may also be referred to as a spindle, is a rigid component which carries a wheel hub and is coupled to suspension control arms.

In embodiments of the invention, a control member of the suspension is coupled, instead of to the wheel hub knuckle as in previously considered systems, to a bracket intermediate the wheel hub knuckle and the suspension mounting. This is so that the control member can be attached longitudinally away from the steering axis (i.e. fore or aft of the steering axis), but nevertheless allow steering of the wheel hub around the suspension. In a typical double wishbone system, as the attachment points of the suspension on the wheel hub or knuckle are essentially aligned with the steering axis, there is no impediment to the steering. In previous systems which are not steered, such as multilink or integral link systems, there are control arms linked to the knuckle away from the steering axis, to provide fore/aft or longitudinal stability, but therefore prevent steering.

20

This intermediate bracket may be simply an extension of a double wishbone-type upper or lower control arm, projecting at least some distance longitudinally (i.e. away from the steering axis), with an additional control arm coupled to the bracket at some point away from the steering axis, but otherwise providing the usual function of such an additional control arm, such as toe or camber control. For example, a short or stub arm could be formed in addition to, or attached to, the upper control arm, projecting longitudinally, with the additional control arm coupled to the end of the stub arm, thereby longitudinally separating that coupling point from the steering axis.

In embodiments of the invention, the intermediate bracket comprises a secondary or inner knuckle, separate from the outer or wheel hub knuckle, to which the main and other control arms of the suspension may be attached.

Overall, in an embodiment of the invention the suspension and steering system for a vehicle comprises an outer knuckle or wheel knuckle, an intermediate bracket means or inner knuckle, a steering assembly, a suspension assembly (which may incorporate the bracket/inner knuckle, and/or the control links, arms or members of the suspension) and a wheel hub assembly. The intermediate bracket means or inner knuckle is coupled to the outer / wheel knuckle, and is coupled at at least two positions on the outer knuckle where at least a first position is located at an end of the outer knuckle, and at least a second position is located at an opposing end of the outer knuckle. In an embodiment of the invention the inner knuckle is coupled directly to the outer knuckle via joints, which are typically bearings, but in other embodiments may be any kind of structural linkage providing the appropriate degree of relative mobility. It should be understood that throughout the following description, any reference to joints encompasses the possibility that in other embodiments the joints may be any kind of structural linkage providing the appropriate degree of relative mobility, even if it is not stated explicitly.

Furthermore, the outer knuckle is coupled to a wheel hub assembly, which comprises a wheel bearing, a wheel hub, a brake disc, a caliper and a road wheel mounting face, and where the outer knuckle may be coupled to any of the components of the wheel hub assembly. Additionally, the outer knuckle is also coupled to the steering assembly, where the steering assembly comprises a steering track rod coupled to the outer knuckle at an end and coupled to a steering rack at an opposing end, and a driveshaft coupled to the wheel hub assembly at an end and coupled to a final drive and differential unit at an opposing end.

The inner knuckle is also coupled to (or incorporated as part of) the suspension assembly. The components of the suspension assembly may vary dependent on the type of suspension assembly used. For example, a double wishbone assembly comprises an upper arm, a lower control arm, and/or a toe control arm in the form of a toe control link, and a damping system, whereas a multilink system may comprise a plurality of upper arms, a plurality of lower control arms, a toe control link or toe control arm and a damping system. In other embodiments the suspension system may also comprise an integral link.

The suspension and steering assembly of embodiments of the invention acts to separate the functionality of the steering assembly from the suspension assembly, so that the steering may act independently of the suspension component. This allows the wheel hub assembly to be steered through significant angles, and in addition, for the suspension to precisely control the position of the wheel, particularly in terms of the caster, camber and toe angles. Therefore, the dual knuckle suspension and steering system for a vehicle presents an advantage over previous suspension systems in that it is an independent system which may be used in conjunction with many suspension system types, such as double wishbone and multilink systems including integral links, but can also be easily steered.

Figure 1 is a rear elevation view of a front left-hand-side dual knuckle system 100, according to an embodiment of the invention. The dual knuckle system 100 comprises a lower control arm 102, a camber control arm in the form of an upper camber control link 104, a toe control arm in the form of a toe control link 106, an intermediate bracket means, for example provided by an inner knuckle 108, a wheel hub knuckle in the form of an outer knuckle 122, a wheel hub assembly 110, an integral link 112, a driveshaft 114, a road spring 116 and a damper 118. The dual knuckle system 100 is pivotally connectable to a vehicle frame (not shown) at the inner end, and is also pivotally connectable to a wheel (not shown) at the outer end.

Figure 2 is a front elevation view of the embodiment of the invention of Figure 1, omitting the brakes. The brakes are omitted merely for illustrative purposes, such that some of the components of the dual knuckle system may be seen more clearly.

Figure 3 is a front isometric view of the embodiment of the invention of Figure 1, omitting the driveshaft 114 and brakes. The omission of these components is merely to provide a clearer view of the construction and arrangement of the remaining components.

Figures 4 and 5 provide additional views of the embodiment of the dual knuckle system 100 of Figure 1, such that different aspects of the dual knuckle system 100 can be seen more clearly.

In the embodiment of the invention according to Figure 1 the lower control arm 102 is connected to a vehicle structure at the inner (vehicle) end by two joints. These may be, but are not limited to, bushes with controlled compliance. The lower control arm 102 is connected to the inner knuckle 108 at the outer (wheel) end by a joint. The joint may be, but is not limited to, a bearing. Additionally, the lower control arm 102 carries the spring 116 and the damper 118. In an alternative embodiment, the spring 116 and/or the damper 118 can be otherwise supported, such as by the upper camber control link 104 or the inner knuckle 108. The damper 118 of Figure 1 is a hydraulic telescopic-acting type and is arranged to be directly connected between the vehicle body and the lower control arm 102. Within this damper type it is possible to have single or twin-tube dampers. Moreover, in yet another embodiment, the damper 118 may be a magnetic ride damper.

The upper camber control link 104 is connected to the vehicle structure at the inner end by a joint, where the joint is shown as a bush with controlled compliance, but in alternative embodiments may be any kind of structural linkage providing the appropriate degree of relative mobility, such as a ball or bearing. The upper camber control link 104 is connected to the inner knuckle 108 at the outer end by a joint, which is shown in the embodiment of Figure 1 as a bearing, but which in another embodiment may be an alternative type of joint such as a bush.

The toe control link 106 is connected to the vehicle structure at the inner end by a bearing joint, although other joints, such as a bushing, are possible in other embodiments. The toe control link is also connected to the inner knuckle 108 at the outer end.

The integral link 112 attaches via joints, using bushes with controlled compliance or otherwise, to the lower control arm 102 and to the inner knuckle 108. This allows the geometry of the inner knuckle 108 to be controlled in position, maintaining the camber and toe angle alignments, as the camber angle alignment is substantially controlled by the relative geometry of the lower control arm 102 and the upper control link 104. The integral link 112 can aid the management of the camber angle, enhancing cornering grip and improving straight-line acceleration. Control of the toe angle may improve vehicle stability by compensating for rolling resistance often caused by the camber

angle of the wheels. Depending on the toe angle size chosen this may also help to reduce wear of the tyres. Therefore, the dual knuckle system 100 according to the embodiment of Figure 1 is comparable to a typical integral link suspension system. However, as the suspension components, including the integral link 112, are connected to the inner knuckle 108 and the steering components are connected only to the outer knuckle 122 or wheel hub assembly 110, the dual knuckle system 100 can also be steered through significant steer angles, as the steering components are no longer constrained in movement by the suspension components. Consequently, it provides significant advantages over many suspension systems, such as a double wishbone or integral link suspension system. Furthermore, in the embodiment of Figure 1, the wheel fore-and-aft compliance can be controlled by the specific stiffness of the bush controlled compliance joints of the integral link 112 and those inboard the lower control arm 102.

The inner knuckle 108 is attached to the outer knuckle 122 by two joints, which are typically, but not limited to, bearings, and which define the road wheel steering axis. From the above, it can be seen that the position and orientation of the inner knuckle 108 is controlled by the lower control arm 102, the upper camber control link 104, the toe control link 106 and the integral link 112.

The outer knuckle 122 is connected to the wheel hub assembly 110. In an embodiment of the invention, the wheel hub assembly 110 comprises a wheel bearing, a hub, a brake disc, a caliper and a road wheel mounting face. The driveshaft 114 is connected to the wheel hub assembly 110, and further is connected to the final drive and differential assembly, which is not shown in Figure 1, and is not considered to be part of the dual knuckle system. The final drive is the set of components which produces and transfers the torque to the driveshaft.

Moreover, the embodiment of the dual knuckle system 100 as shown in Figure 1 comprises a steering track rod 120, which is attachable to a steering rack at the inner end, and to the outer knuckle 122 at the outer end. This arrangement allows the outer knuckle 122, and thus the wheel hub assembly 110, to be steered by the steering rack rod 120 independently of the inner knuckle 108. Additionally, the relative geometry of the lower control arm 102, the upper camber control link 104 and the steering track rod

120 controls the bump steer of the system. Bump steer should be understood as a change in the steer angle caused by geometric and compliance effects as the wheel moves vertically, relative to the vehicle body.

5 The dual knuckle system 100 of Figure 1 provides an alternative embodiment of a typical integral link suspension system, but whose arrangement may be employed as a front wheel suspension system. Generally in an integral link suspension system, the knuckle or upper arm of a suspension is bound by the integral link such that when also constrained by packaging and the driveshaft, it cannot be practically used as a driven
10 wheel suspension system. However, the invention described herein provides a suspension system 100 in which the suspension assembly (comprising the lower control arm 102, the upper camber control arm 104, the toe control link 106, a road spring 116 and damper 118) is independent from the steering assembly (comprising the steering track rod 120 and the driveshaft 114). These components are separated in
15 that the suspension assembly is coupled to the inner knuckle 108, whereas the steering assembly is coupled to the outer knuckle 122. The integral link 112 is connected between the inner knuckle 108 and the lower control arm 102, and thus only acts on the suspension system, which permits the steering to act independently of the main suspension links. Consequently, by using this arrangement the wheel
20 position can be precisely controlled, as in a typically wishbone or multilink system with an integral link, but the wheels can also be steered through significant angles. Therefore the dual knuckle system 100 according to the above described embodiments may be used as a driven wheel suspension system.

25 The embodiment of Figure 1 may be adapted such that an integral link is not used. Additionally, the embodiment of Figure 1 may be adapted to include any multi-link suspension system, such suspension assembly comprises at least three lateral arms, and at least one longitudinal arm, and where the suspension assembly is connected only to the inner knuckle, and the steering assembly is connected only to the outer
30 knuckle or wheel hub assembly. Moreover, an integral link may be used to connect components of the suspension assembly, such as a lower control arm to the inner knuckle, without compromising the steering.

In another embodiment of the system, the suspension system is a double wishbone suspension system. This embodiment comprises an upper arm, which can be seen as an 'A' shape, or similar, and is connected at the two substantially horizontal points, via joints such as ball bearings or bushings, to the inner vehicle structure. Further, the
5 elbow of the arm is connected to the inner knuckle, also by joints such as a ball bearing or a bushing. This embodiment also comprises a lower control arm, which is vertically below but substantially parallel to the upper arm. The lower control arm, which can be seen as an 'A' shape, or similar, is connected at the two substantially horizontal points, via joints such as ball bearings or bushings, to the inner vehicle
10 structure. Further, the elbow of the arm is connected to the inner knuckle, also by joints such as a ball bearing or a bushing. The steering system, comprising the steering rack and driveshaft, is connected to the outer knuckle or outer wheel hub assembly via joints such as ball bearings or bushings. Therefore, the steering assembly and the suspension assembly can act independently of each other, allowing
15 the wheels to be turned through significant steer angles. Furthermore, this embodiment may also comprise an integral link, where the integral link is connected to the lower wishbone arm and to the inner knuckle.

Referring now to Figure 6, there is shown a rear elevation view of a front left-hand-side
20 dual knuckle system 200 according to a further embodiment of the invention. The dual knuckle system 200 corresponds closely to the dual knuckle system 100 described above and like reference numerals have been used for like components, albeit incremented by 100 for clarity. In this embodiment the dual knuckle system 200 comprises a lower control arm 202, a camber control arm in the form of an upper
25 camber control link 204, a toe control arm in the form of a toe control link 206, an intermediate bracket means provided by an inner knuckle 208, a wheel hub knuckle provided by an outer knuckle 222, a wheel hub assembly 210, a driveshaft 214, a road spring 216 (not shown in the figure) and a damper 218. The dual knuckle system 200 is pivotally connectable to a vehicle frame (not shown) at the inner end, and is also
30 pivotally connectable to a wheel (not shown) at the outer end.

In the embodiment of the invention according to Figure 6 the lower control arm 202 is connected to a vehicle structure at the inner (vehicle) end by two joints. These may be, but are not limited to, bushes with controlled compliance. The lower control arm 202 is

connected to the inner knuckle 208 at the outer (wheel) end by a joint. The joint may be, but is not limited to, a bush or a ball joint. Additionally, the lower control arm 202 carries the spring 216 (not shown) and the damper 218. In an alternative embodiment, the spring 216 and/or the damper 218 can be otherwise supported, such as by the
5 upper camber control link 204 or the inner knuckle 208. The damper 218 of Figure 6 is a hydraulic telescopic-acting type and is arranged to be directly connected between the vehicle body and the lower control arm 202.

The upper camber control link 204 is connected to the vehicle structure at the inner
10 end by a joint, where the joint is shown as a bush with controlled compliance, but in alternative embodiments may be any kind of structural linkage providing the appropriate degree of relative mobility, such as a ball or bearing. The upper camber control link 204 is connected to the inner knuckle 208 at the outer end by a joint, which may be, but is not limited to, a bush or a spherical bearing.

15 The toe control link 206 is connected to the vehicle structure at the inner end by a bearing joint, although other joints, such as a bushing, are possible in other embodiments. The toe control link 206 is also connected to the inner knuckle 208 at the outer end.

20 In contrast to the foregoing embodiment of the invention which utilised a separate integral link 112 attached between the lower control arm 102 and the inner knuckle 108, in the embodiment of Figure 6 the restraining function of the integral link 212 is incorporated into the outer / wheel knuckle 222. However, in order to provide the
25 combined function of the integral link 212 and a steerable knuckle 222, the inner knuckle 208 and the outer / wheel knuckle 222 are no longer coupled together at at least two positions. Rather, in the embodiment of Figure 6 the outer / wheel knuckle 222 is coupled at its upper end by an upper joint to the inner knuckle 208 and at its lower end by a lower joint to the lower control arm 202.

30 In this manner the outer or wheel knuckle 222 acts as the steerable support for the wheel hub assembly 210 and also enables the geometry of the inner knuckle 208 to be controlled in position, maintaining the camber and toe angle alignments, as the camber

angle alignment is substantially controlled by the relative geometry of the lower control arm 202 and the upper control link 204.

5 All of the advantages of the separate integral link 112 of the foregoing embodiment are retained (e.g. management of the camber angle, enhanced cornering grip and improved straight-line acceleration) using fewer components. The cost of the system is therefore reduced, albeit the physical shape of the inner knuckle 208 and the outer / wheel knuckle 222 may be more complex than in the earlier embodiment in order to accommodate movement of the wheel hub assembly and drivetrain components.

10

The couplings to the upper and lower ends of the outer / wheel knuckle 222 are both typically ball joints to accommodate movement of the suspension system.

15 The outer knuckle 222 is connected to the wheel hub assembly 210. In an embodiment of the invention, the wheel hub assembly 210 comprises a wheel bearing, a hub, a brake disc, a caliper and a road wheel mounting face. The driveshaft 214 is connected to the wheel hub assembly 210, and further is connected to the final drive and differential assembly, which is not shown in Figure 6, and is not considered to be part of the dual knuckle system. The final drive is the set of components which produces and transfers the torque to the driveshaft.

20 Moreover, the embodiment of the dual knuckle system 200 as shown in Figure 6 comprises a steering track rod 220, which is attachable to a steering rack at the inner end, and to the outer / wheel knuckle 222 at the outer end. This arrangement allows the outer / wheel knuckle 222, and thus the wheel hub assembly 210, to be steered by the steering rack rod 220 independently of the inner knuckle 208. Additionally, the relative geometry of the lower control arm 202, the upper camber control link 204 and the steering track rod 220 controls the bump steer of the system. Bump steer should be understood as a change in the steer angle caused by geometric and compliance effects as the wheel moves vertically, relative to the vehicle body.

30

The dual knuckle system 200 shown in Figure 6 provides an alternative embodiment of an integral link type suspension system, but whose arrangement may be employed as a front wheel suspension system.

The embodiment of Figure 6 may be adapted to include any multi-link suspension system, such suspension assembly comprises at least three lateral arms.

- 5 Figures 7 to 11 provide additional views of the embodiment of the dual knuckle system 200 of Figure 6, such that the different aspects of the dual knuckle system 200 can be seen more clearly.

10 In particular, Figure 11 clearly illustrates the arrangement of the inner knuckle 208 coupled at its upper extremity to the upper camber control link 204 and at its lower extremity to the lower control arm 202. Also visible in the figure is the combined integral link 212 and outer / wheel knuckle 222 which attaches at its upper end to the inner knuckle 208 and at its lower end to the lower control arm 202.

- 15 The above described embodiments may be used on rear wheels or front wheels, as the separation of the steering and suspension components allows for the wheels to be steered, through significant steer angles, because the steering system is substantially independent from the suspension system. Therefore, the dual knuckle suspension and steering system permits in-vehicle options of both front and rear wheel drive.

20

25 The above described embodiments of the invention allow for the outer knuckle to be arranged such that the steering axis may be placed relative to the wheel, and where the outer knuckle may steer relative to the inner knuckle. In addition, the embodiments as described above also allow for configuration of the outer knuckle such that it may be placed at any reasonable given distance from the wheel centre. In an embodiment of the invention such that the outer knuckle is configured to minimise the hub level offset, the front wheel drive induced torque steer may be reduced. For example, it is conceivable that the steering axis could be arranged through the centre of the wheel, such that the hub level offset is effectively zero. This would provide the advantage that

30 the induced torque steer may be greatly reduced in comparison to vehicles with typical suspension systems, such as a MacPherson Strut. Moreover, in another embodiment of the invention in which a two-piece driveshaft 114, 214 is employed in conjunction with the inner knuckle 108, 208 a front wheel drive with high road wheel lock angles is possible.

Figure 12 is a schematic view of an embodiment of the invention 600, which extends to a vehicle comprising the dual knuckle system, wherein a dual knuckle system according to the aforementioned embodiments is employed in a front wheel drive vehicle 602. The vehicle comprises a right-hand side front wheel 606, coupled to a dual knuckle system 610, as hereinbefore described. The vehicle also comprises a left-hand side front wheel 604, coupled to a dual knuckle system 608, as hereinbefore described.

10 In an alternative embodiment of the invention, a dual knuckle system according to the aforementioned embodiments is employed in a rear wheel drive vehicle.

Many modifications may be made to the above examples without departing from the scope of the present invention as defined in the accompanying claims.

15

CLAIMS

1. A suspension and steering system for a vehicle, comprising:
a wheel hub knuckle;
5 a steering assembly coupled to the wheel hub knuckle; and
a suspension assembly,
wherein the suspension assembly comprises:
at least one control member; and
an intermediate bracket means,
10 wherein the at least one control member is coupled to the intermediate bracket means,
and wherein the coupling point of the at least one control member on the intermediate bracket means is spaced longitudinally from a steering axis of the system.
- 15 2. A system according to Claim 1, wherein the intermediate bracket means is spaced laterally from the wheel hub knuckle.
3. A system according to Claim 1 or Claim 2, wherein the suspension assembly comprises a vehicle mounting, and wherein the intermediate bracket means is
20 disposed between the vehicle mounting of the suspension assembly and the wheel hub knuckle.
4. A system according to any preceding claim, wherein the at least one control member is one of: a toe control arm; a camber control arm; and a lower control arm.
- 25 5. A system according to any preceding claim, wherein the intermediate bracket means comprises an inner knuckle.
6. A system according to Claim 5 when dependent on claim 4, wherein,
30 the at least one control member is a lower control arm;
the wheel hub knuckle is coupled to the inner knuckle at a first position and to the lower control arm at a second position;
the first position is located at a first end of the wheel hub knuckle, and the second position is located at an opposing second end of the wheel hub knuckle, and

the wheel hub knuckle is coupled to a wheel hub assembly.

7. A system according to Claim 5, wherein the wheel hub knuckle is coupled to the inner knuckle at at least two positions, wherein at least a first position is located at
5 a first end of the wheel hub knuckle, and at least a second position is located at an opposing second end of the wheel hub knuckle,

and wherein the wheel hub knuckle is coupled to a wheel hub assembly.

- 10 8. A system according to Claim 6 or Claim 7, wherein the wheel hub assembly comprises a wheel bearing, a wheel hub, a brake disc, a caliper and a road wheel mounting face.

9. A system according to any of Claims 5 to 8, wherein the steering assembly
15 comprises:

a steering track rod coupled to the wheel hub knuckle at a first end and coupled to a steering rack at an opposing second end.

10. A system according to Claim 9, wherein the steering assembly comprises:
20 a driveshaft coupled to the wheel hub assembly at a first end and coupled to a final drive unit at an opposing second end.

11. A system according to any of Claims 5 to 10, wherein the suspension assembly comprises:

25 at least two suspension arms pivotally coupled to the vehicle mounting at first ends and pivotally coupled to the inner knuckle at opposing second ends; and

a damping system coupled to at least one arm at a first end, and to the vehicle mounting at an opposing second end.

- 30 12. A system according to any of Claims 5 to 11, wherein the suspension assembly comprises:

a lower control arm pivotally coupled to the vehicle mounting at a first end, and pivotally coupled to the inner knuckle at an opposing second end;

an upper camber control arm pivotally coupled to the vehicle mounting at a first end, and pivotally coupled to the inner knuckle at an opposing second end;

a toe control arm pivotally coupled to the vehicle mounting at a first end, and pivotally coupled to the inner knuckle at an opposing second end; and

5 a damping system coupled to at least one arm at a first end, and to the vehicle mounting at an opposing second end.

13. A system according to any of Claims 5 to 10, wherein the suspension assembly comprises;

10 an upper arm pivotally coupled to the vehicle mounting at two substantially horizontal positions at inner first ends of the upper arm, and pivotally coupled to the inner knuckle at an opposing second end,

a lower control arm pivotally coupled to the vehicle mounting at two substantially horizontal positions at inner first ends of the lower control arm, and
15 pivotally coupled to the inner knuckle at an opposing second end, and

a damping system coupled to at least one arm at a first end, and to the vehicle mounting at an opposing second end.

14. A system according to Claim 12 or Claim 13, wherein the suspension assembly
20 comprises an integral link pivotally coupled to the lower control arm at a first end, and pivotally coupled to the inner knuckle at an opposing second end.

15. A suspension assembly for the system of any of the preceding claims, the suspension assembly comprising:

25 at least one control member; and

an intermediate bracket means,

wherein the at least one control member is couplable to the intermediate bracket means,

and wherein the coupling point of the control member on the intermediate
30 bracket means is configured to be spaced longitudinally from a steering axis of the system.

16. A vehicle comprising the system of any of the preceding claims.

1 / 12

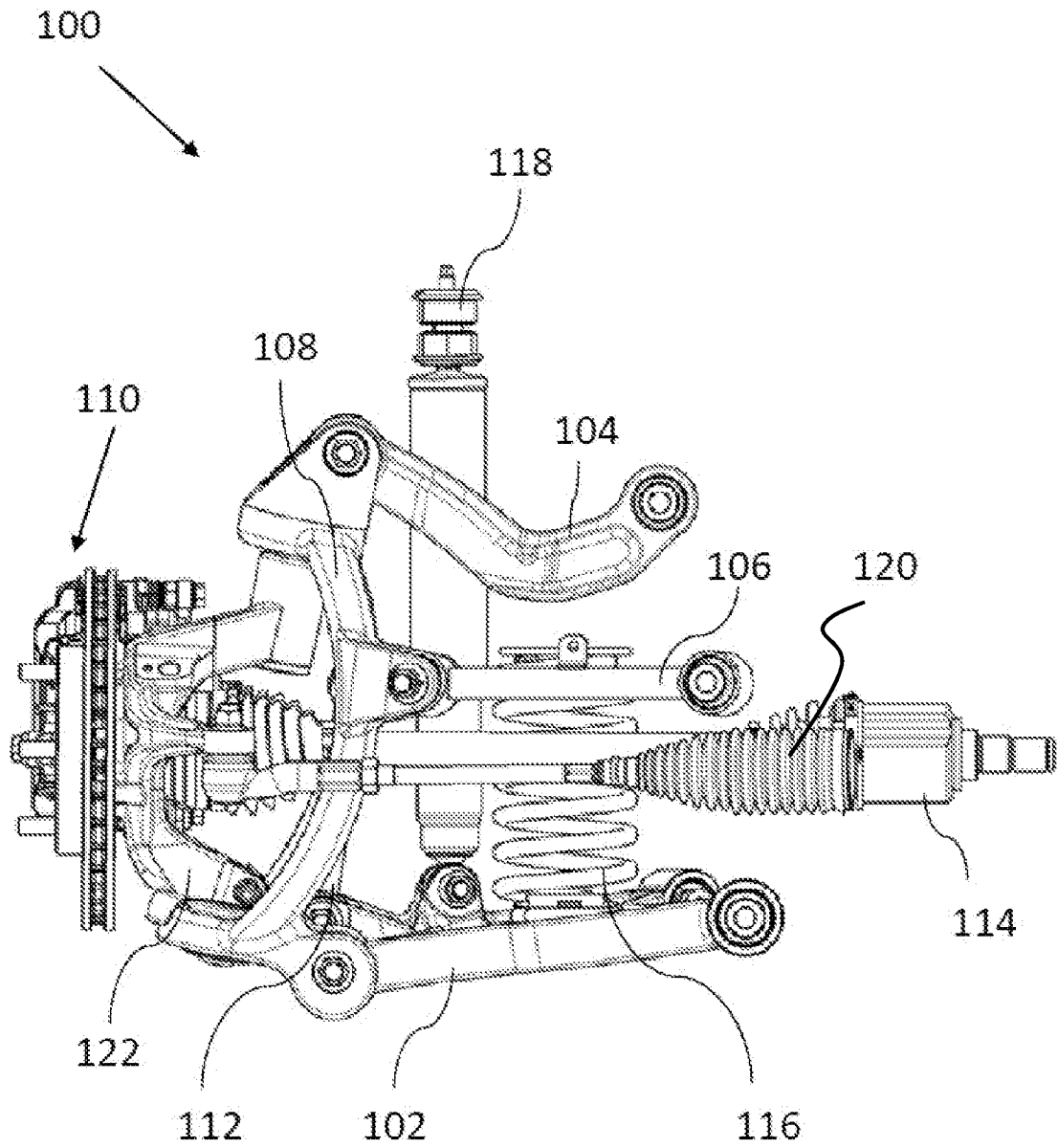


Figure 1

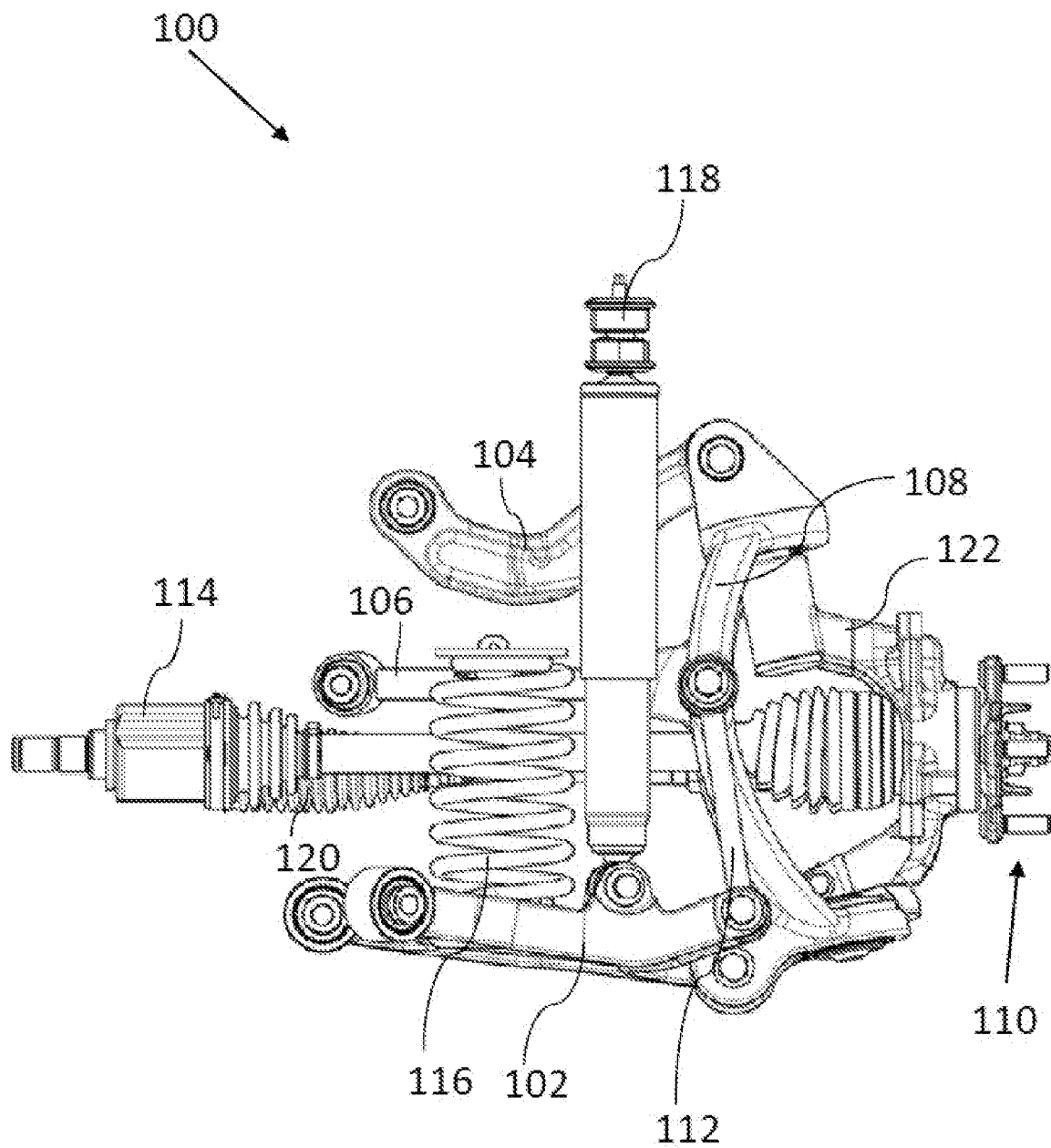


Figure 2

3 / 12

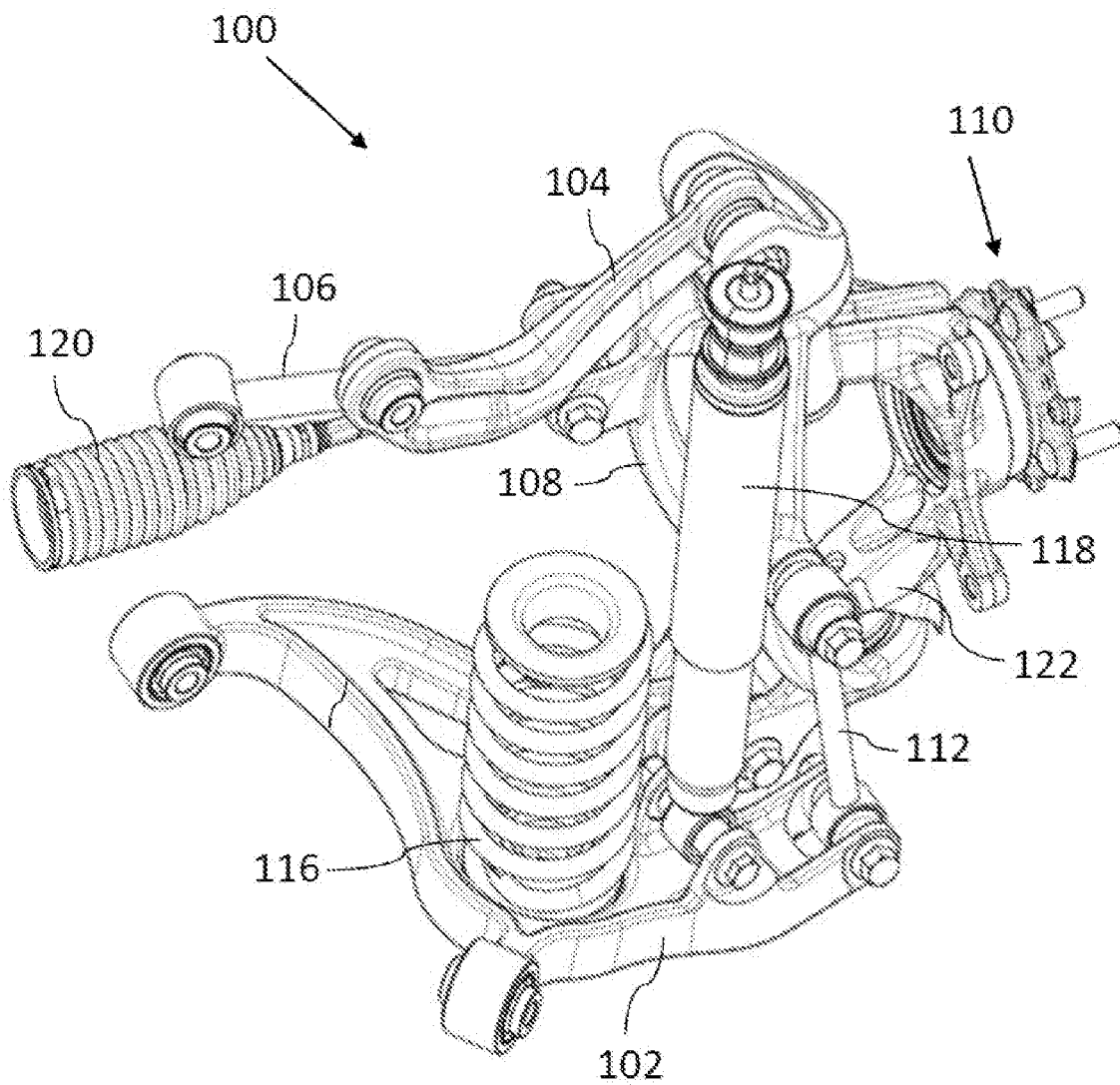


Figure 3

4 / 12

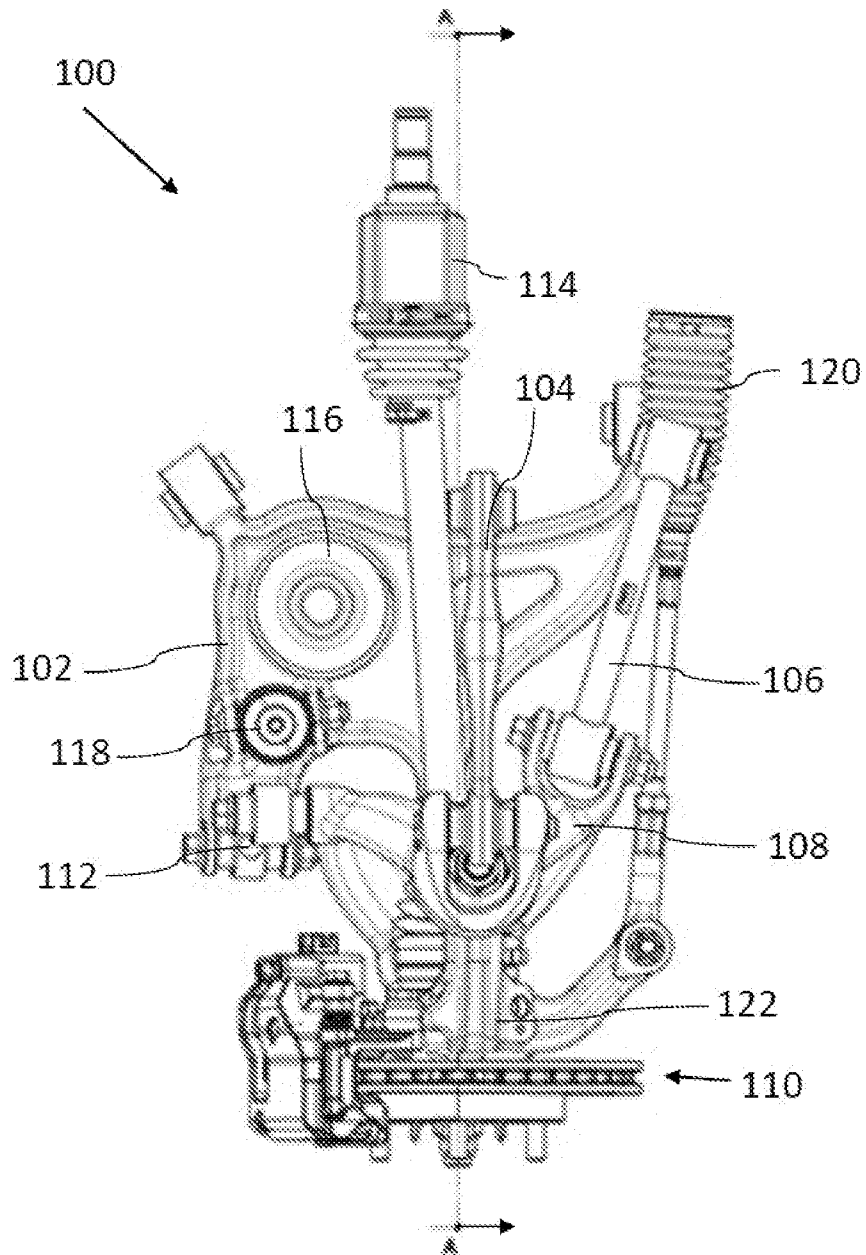


Figure 4

5 / 12

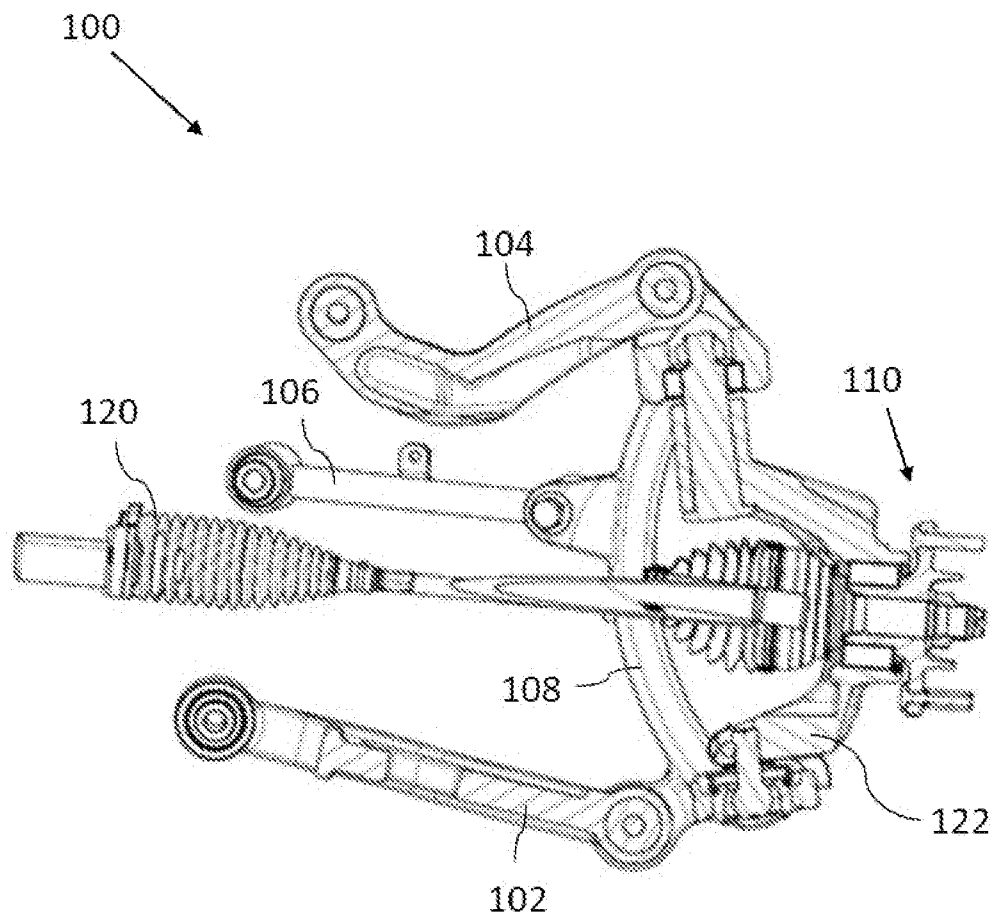


Figure 5

6 / 12

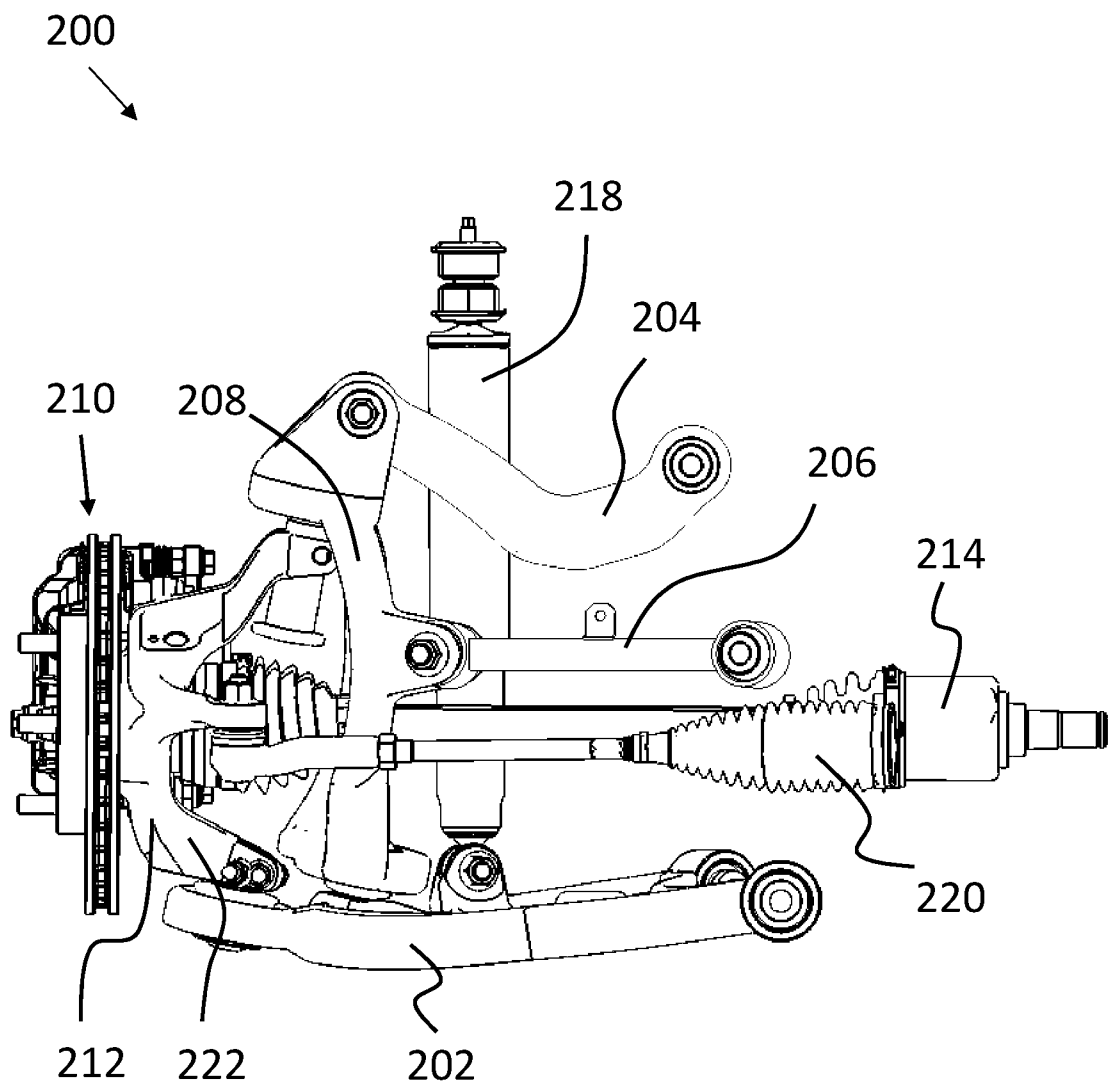


Figure 6

7 / 12

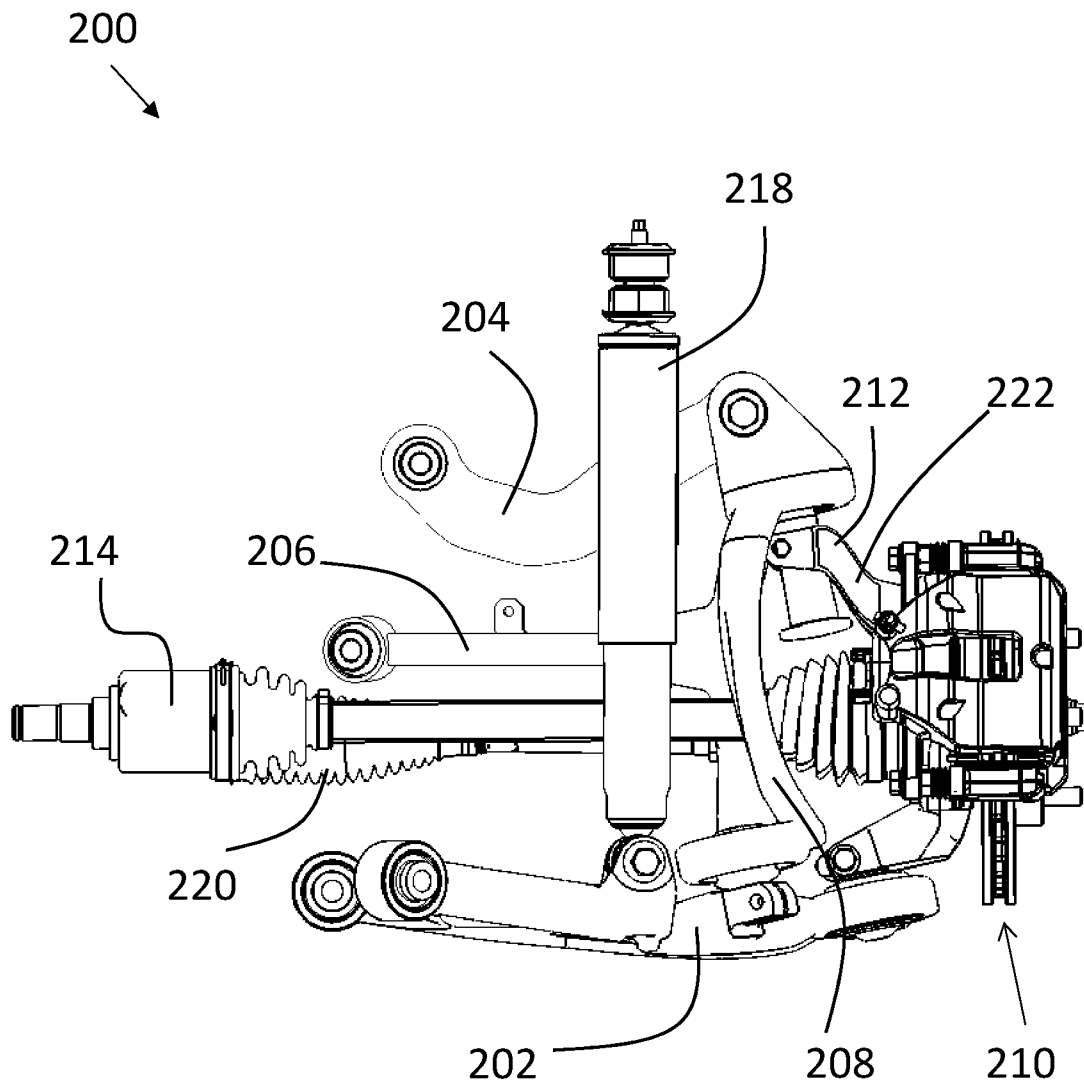


Figure 7

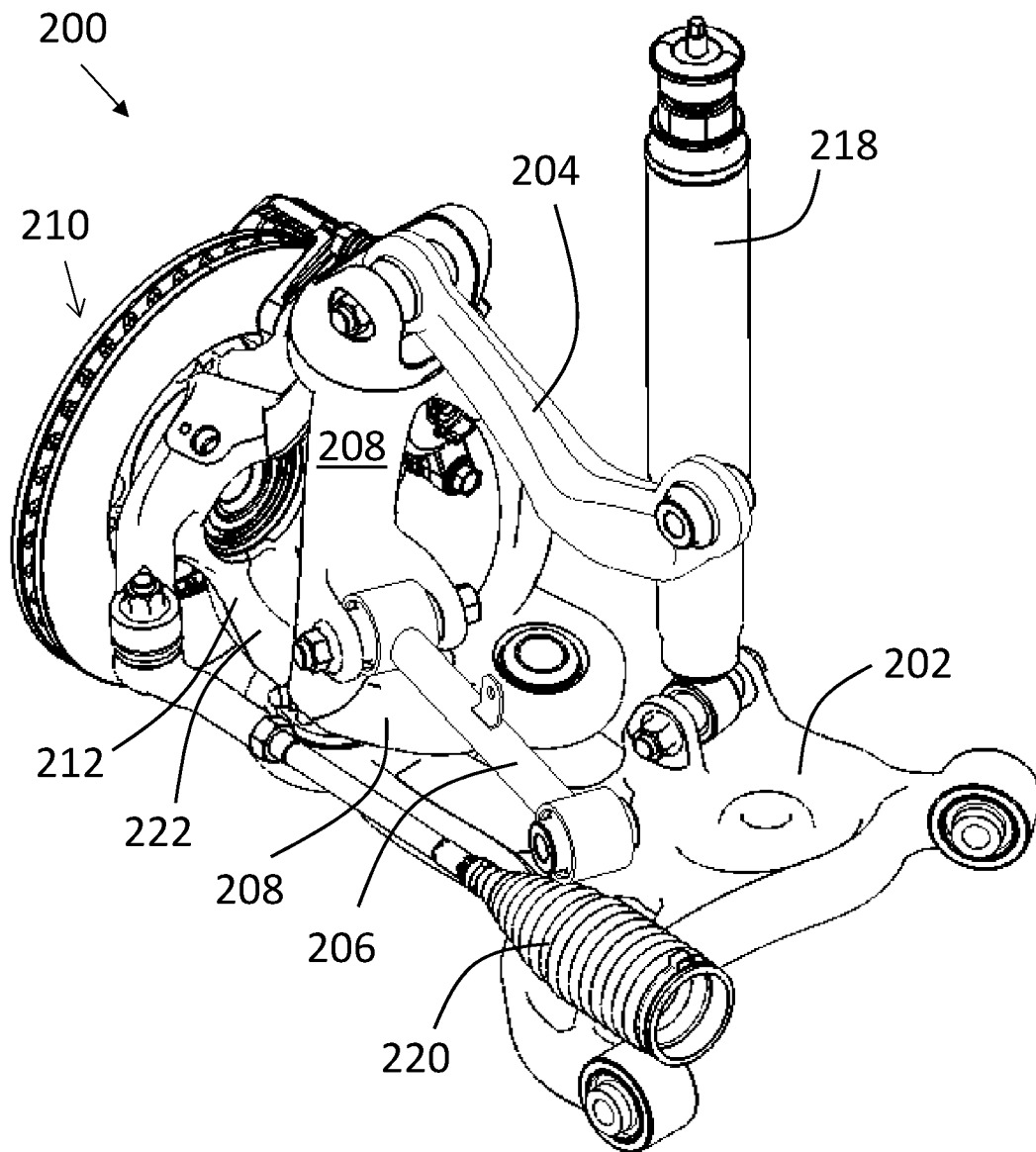


Figure 8

9 / 12

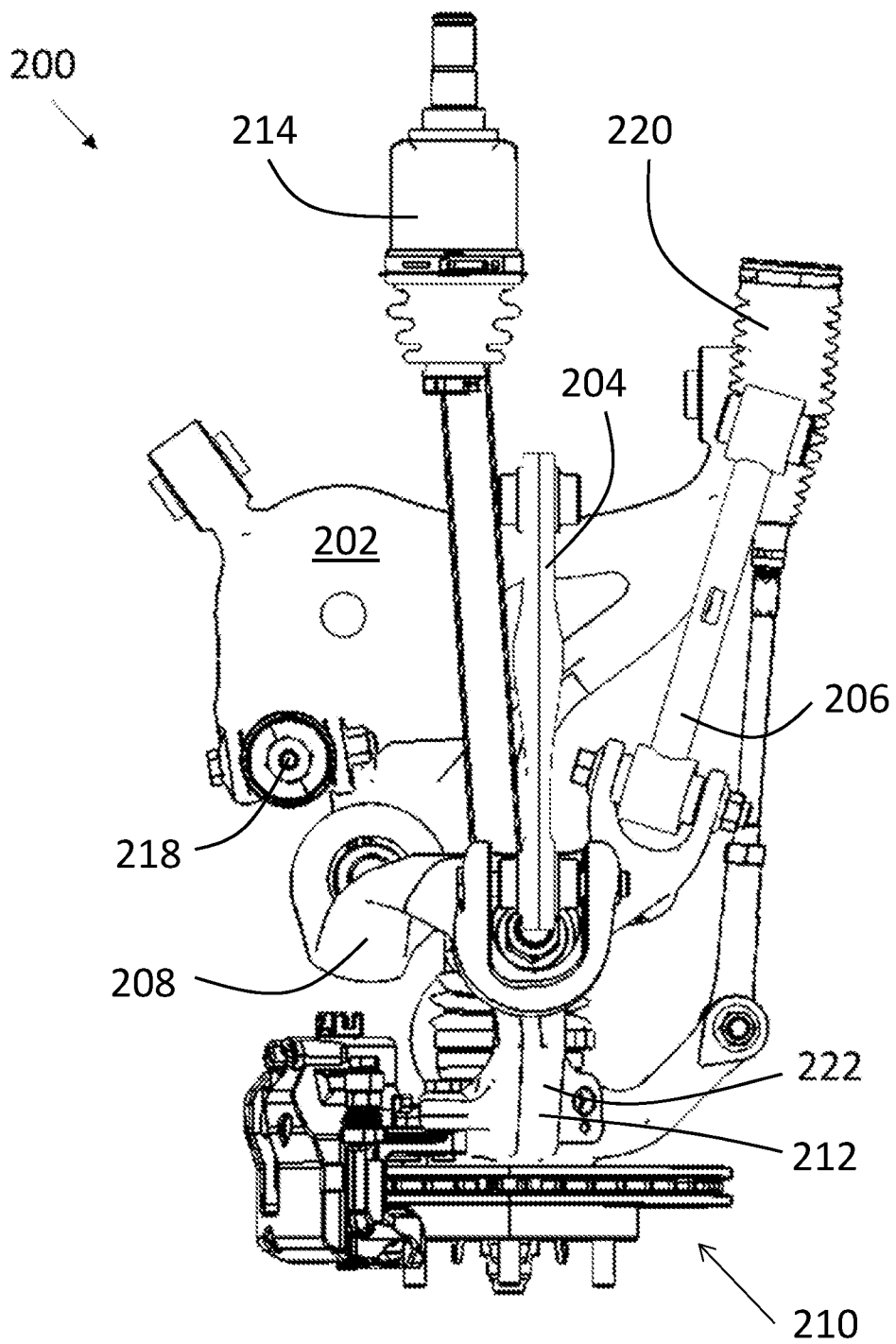


Figure 9

10 / 12

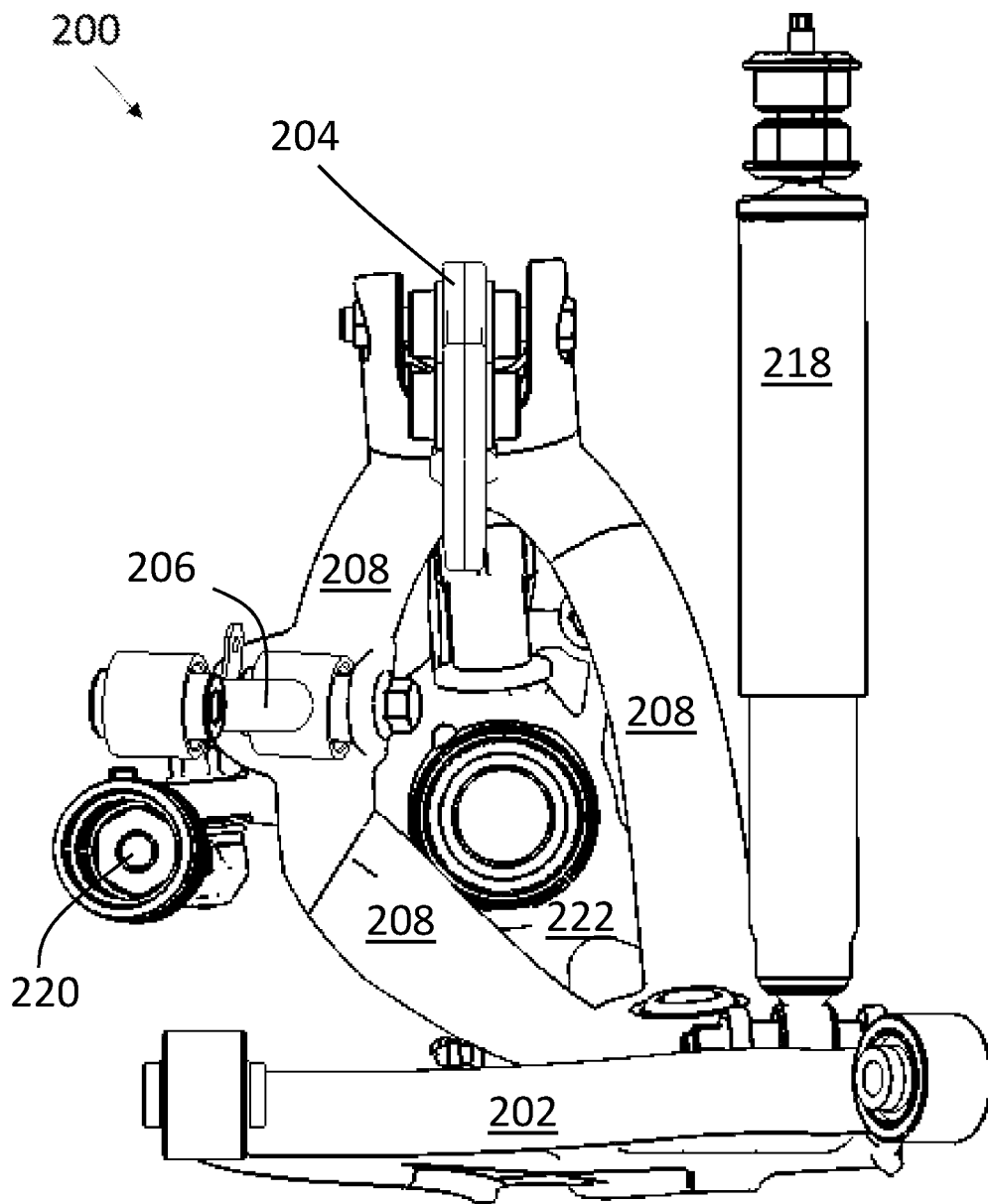


Figure 10

11 / 12

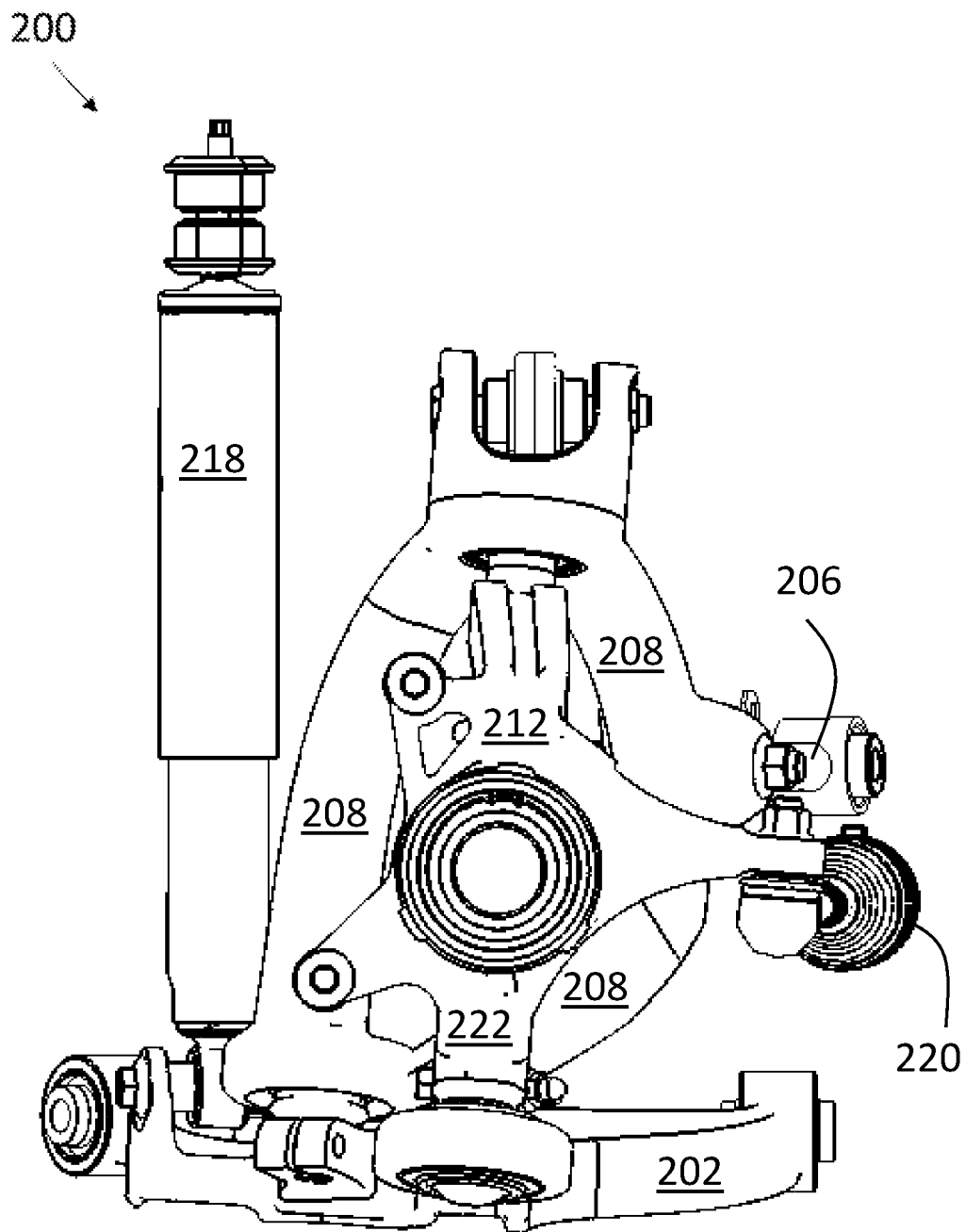


Figure 11

12 / 12

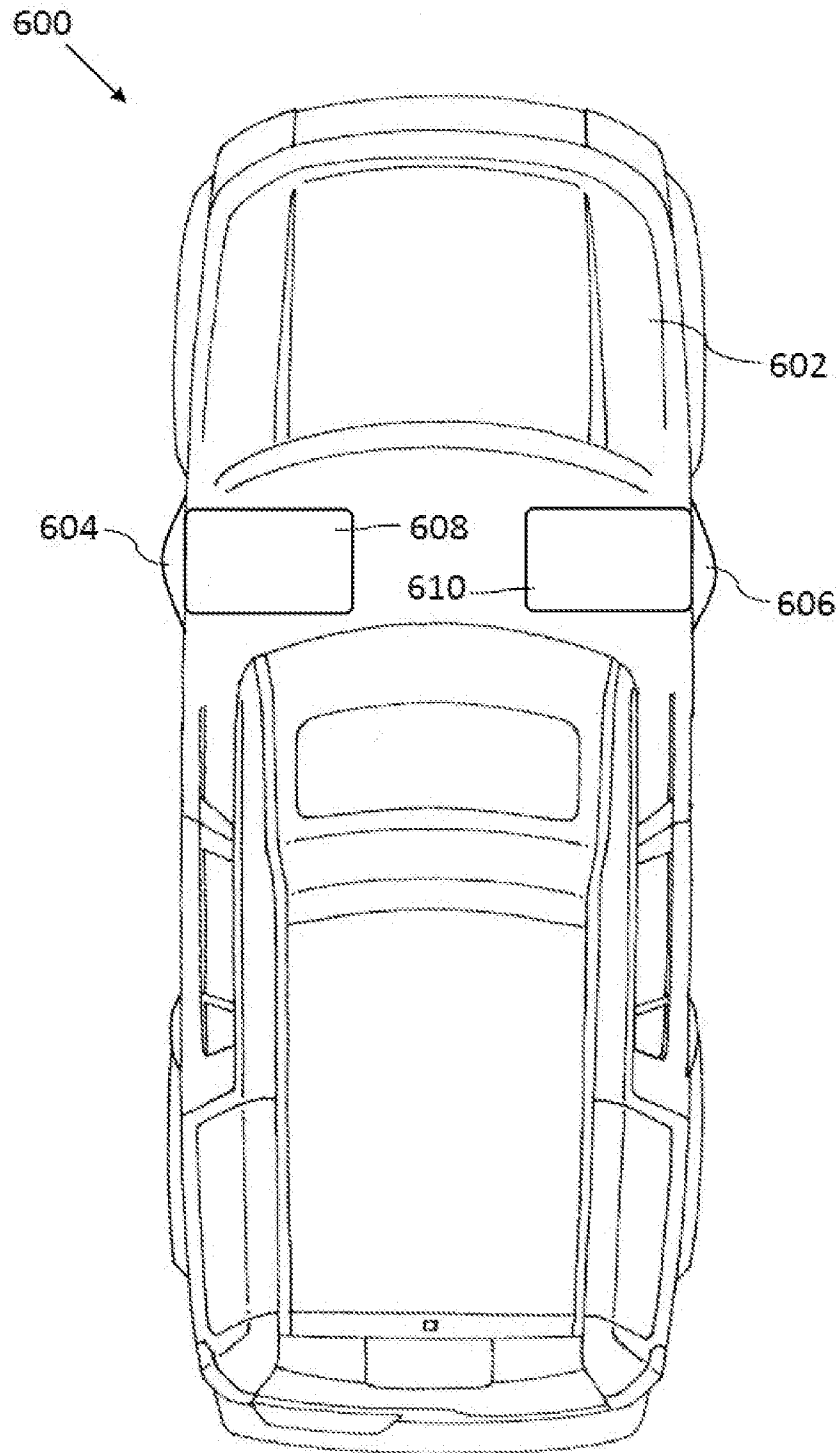


Figure 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2017/057425

A. CLASSIFICATION OF SUBJECT MATTER
B60G3/20 Version=2018.01

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 practicable, search terms used)

Patseer, IPO Internal Database

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US5346241 A (HYUNDAI MOTOR CO LTD) 13 September 1994 (13.09.1994) Column 4; line 1 - 64, Figure 1	1-16
A	US4802688 A (NISSAN MOTOR CO LTD) 07 February 1989 (07.02.1989) Column 3; line 12 - Column 4; line 33	1-16

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

27-02-2018

Date of mailing of the international search report

27-02-2018

Name and mailing address of the ISA/

Indian Patent Office
Plot No.32, Sector 14, Dwarka, New Delhi-110075
Facsimile No.

Authorized officer

Seetha Raman A

Telephone No. +91-1125300200

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB2017/057425

Citation	Pub.Date	Family	Pub.Date
US 5346241 A	13-09-1994	KR 0131301 B1	21-04-1998
US 4802688 A	07-02-1989	JP S6357307 A	12-03-1998