(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 February 2016 (11.02.2016)

WIPO | PCT

(10) International Publication Number
WO 2016/022127 A1

(51) International Patent Classification:
B60G 9/00 (2006.01) *B60G 7/00* (2006.01)

(21) International Application Number:
PCT/US2014/050144

(22) International Filing Date:
7 August 2014 (07.08.2014)

(25) Filing Language: English

(26) Publication Language: English

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(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, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, 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, 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).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

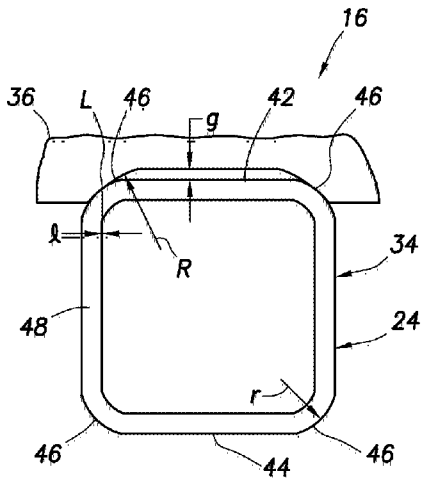
— *of inventorship (Rule 4.17(iv))*

Published:

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

(54) Title: SUSPENSION SYSTEM WITH AXLE CLAMP THAT ACCOMODATES AXLE VARIATIONS

FIG. 7



(57) Abstract: A vehicle suspension system can include an axle having generally planar upper and lower side surfaces, and a clamp that secures the axle in the suspension system. The clamp may secure the axle without contacting the axle upper and lower side surfaces. Another vehicle suspension system can include an axle having a generally hollow rectangular cross- section with curved corners, and a clamp that secures the axle in the suspension system. The clamp may apply a clamping force only to the curved corners of the axle. Another vehicle suspension system can include an axle, and a clamp that secures the axle in the suspension system. A radius on the clamp may contact the axle, and the radius may decrease in a direction away from a location of contact between the clamp and the axle.

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SUSPENSION SYSTEM WITH AXLE CLAMP THAT ACCOMMODATES AXLE VARIATIONS

TECHNICAL FIELD

This disclosure relates generally to vehicle suspension systems and, in one example described below, more particularly provides a suspension system with an axle clamp that accommodates dimensional variations of an axle.

BACKGROUND

A clamp can be used to secure an axle to other components of a suspension system. For example, a clamp can secure an axle to a spring beam or a trailing arm of a suspension system.

Typically, where a clamp is used to secure an axle, the clamp is configured for particular dimensions (including manufacturing tolerances) of that specific axle. Unfortunately, this practice “locks in” the clamp for use with only that particular axle, thereby preventing axles with other dimensions or manufacturing tolerances from being used in the suspension system, or requiring the clamp to be re-designed to match a different axle.

Therefore, it will be appreciated that improvements are needed in the art of suspension system design and construction. Such improvements may allow a clamp to be used with a variety of differently dimensioned axles, or may allow an axle with a relatively wide range of manufacturing tolerances to be secured using the clamp.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a representative partially cross-sectional view of a vehicle that can embody principles of this disclosure.

FIG. 2 is a representative perspective view of one lateral side of a suspension system that can be used with the vehicle of FIG. 1, and which can embody the principles of this disclosure.

FIG. 3 is a representative elevational view of the suspension system.

FIG. 4 is a representative rear view of the suspension system.

FIG. 5 is a representative cross-sectional view of the suspension system, taken along line 5-5 of FIG. 4.

FIGS. 6-8 are representative cross-sectional views of an axle and an upper clamp member of the suspension system.

FIGS. 9 & 10 are representative enlarged scale views of two examples of contacting portions of the axle and upper clamp member.

DETAILED DESCRIPTION

Representatively illustrated in FIG. 1 is a vehicle 10 which can embody principles of this disclosure. However, it should be clearly understood that the vehicle 10 is merely one example of an application of the principles of this disclosure in practice, and a wide variety of other examples are possible. Therefore, the scope of this disclosure is not limited at all to the details of the vehicle 10 described herein and/or depicted in the drawings.

The vehicle 10 is depicted as including a tractor 12 and a trailer 14. It is contemplated that the principles of this disclosure can be incorporated into a trailer of any type (as well as other types of vehicles), and so the term "vehicle" is used herein to refer to trailers of various types, as well as to refer to self-propelled vehicles.

The trailer 14 of FIG. 1 includes multiple suspension systems 16 which suspend a frame 18 of the trailer above a road surface. Wheels 20 and tires 22 are rotatably mounted at each end of each suspension system 16. None, any or all of the suspension systems 16 may be liftable (so that the wheels 20 can be raised out of contact with a road surface).

Referring additionally now to FIGS. 2-4, an example of one of the suspension systems 16 is representatively illustrated. Only one lateral side of the suspension system 16 is depicted in FIGS. 2-4, it being understood that an opposite side of the suspension system is substantially a mirror-image of the portion depicted in FIGS. 2-4.

In this example, the suspension system 16 includes a laterally extending axle 24. The wheels 20 and tires 22 (not visible in FIGS. 2-4, see FIG. 1) are rotatably mounted at

opposite ends of the axle 24, for example, with conventional hubs (not shown), spindles 26, bearings (not shown), king pins (if the suspension system 16 is steerable), etc.

A hanger bracket 28 is used to attach the suspension system 16 to the frame 18 of the vehicle 10. The hanger bracket 28 in this example also pivotably mounts a spring beam 30 at its forward end. An air spring 32 resiliently spaces a rearward end of the spring beam 30 away from the vehicle frame 18.

In other examples, the hanger bracket 28 may not be used or a different type of bracket may be used, the spring beam 30 could be replaced by a trailing arm or other type of pivoting suspension beam or arm, the air spring 32 could be a coiled spring. etc. Thus, it should be clearly understood that the scope of this disclosure is not limited to any particular details of the suspension system 16 described herein or depicted in the drawings.

In the FIGS. 2-4 example, the axle 24 is secured to the spring beam 30 between the hanger bracket 28 and the air spring 32. In other examples, the axle 24 could be secured at another position, or these components of the suspension system 16 could be otherwise arranged (e.g., the air spring 32 could be mounted directly above the axle,, the axle could be secured above the spring beam 30, etc.).

A clamp 34 is used to secure the axle 24 to the spring beam 30. The clamp 34 includes members 36, 38 positioned respectively above and below the axle 24. When fasteners 40 are tightened, a clamping force is applied via the members 36, 38 to the axle 24.

In the FIGS. 2-4 example, a single upper member 36 and separate lower members 38 are used, and the fasteners 40 are U-bolts. However, in other examples multiple upper members

and/or a single lower member could be used, and the fasteners could be individual bolts or other types of fasteners, etc. Thus, the scope of this disclosure is not limited to any particular details of the clamp 34 as described herein or depicted in the drawings.

It is desired in this example for the clamping force used to secure the axle 24 to the spring beam 30 to be applied only at relatively rigid rounded corners 46 of the axle, rather than at generally planar upper and lower side surfaces 42, 44 of the axle. In this manner, buckling of the axle 24 due to the compressive clamping force applied thereto can be avoided.

It is also desired in this example for the clamp 34 to be configured such that a relatively wide variation in dimensions of the axle 24 can be accommodated by the clamp. In this manner, the same clamp 34 can be used with axles 24 manufactured using different processes, with different manufacturing tolerances, different wall thicknesses, etc.

Referring additionally now to FIG. 5, a cross-sectional view of the suspension system 16 (specifically, the clamp 34) is representatively illustrated. In this view, the manner in which the clamp 34 secures the axle 24 to the spring beam 30 can be more clearly seen.

Note that the axle 24 has a generally rectangular hollow cross-section, and that the upper and lower clamp members 36, 38 are spaced apart from the upper and lower side surfaces 42, 44 of the axle. Thus, the upper and lower clamp members 36, 38 only contact the curved corners 46 of the axle 24.

Referring additionally now to FIGS. 6-8, various examples of dimensional variations in the axle 24 are representatively illustrated with the upper clamp member 36,

in order to show how such dimensional variations can be accommodated in this example. Only a portion of the upper clamp member 36 that contacts the axle 24 is depicted in FIGS. 6-8 for illustrative clarity. In addition, it should be noted that a portion of the lower clamp member 38 that contacts the axle 24 is similarly configured to the portion of the upper clamp member 36, and so only the upper clamp member portion is illustrated in FIGS. 6-8.

A radius *r* of the axle corners 46 is smaller in FIG. 7 as compared to in FIG. 6. A thickness of a wall 48 of the axle 24 is greater in FIG. 8 as compared to in FIGS. 6 & 7. There are also variations in width and height of the axle 24 in the FIGS. 6-8 configurations. Thus, it will be appreciated that the clamp 34 can accommodate a variety of different forms of dimensional variation.

Note that the upper side surface 42 of the axle 24 remains spaced apart from the clamp member 36, with a gap *g* between the axle surface and the clamp member in each of the FIGS. 6-8 configurations. In this way, the clamping force is not applied from the clamp 34 to either of the upper and lower side surfaces 42, 44 of the axle 24.

Note, also, that the clamp member 36 is internally radiused (see radius *R*) near or at a location *L* where the clamp member contacts the curved corners 46 of the axle 24. Preferably, the clamp radius *R* is consistently larger than the axle radius *r*, although the clamp radius *R* can vary, as described more fully below.

In each of the FIGS. 6-8 configurations, the location *L* of contact between the clamp member 36 and the axle 24 is laterally offset inwardly relative to an inner surface of the wall 48 of the axle. This lateral offset *l* is greatest

in the FIG. 6 configuration, and is least in the FIG. 7 configuration.

However, it is generally preferred for the location *L* to not be laterally offset from the walls 48, but to instead be between inner and outer surfaces of the wall, in order to enhance a resistance to buckling of the axle due to the compressive clamping force applied by the clamp 34. In this regard, the walls 48 being referred to are the vertical walls of the axle 24, and the inner and outer surfaces are the vertical surfaces of the walls. In some examples, however, the walls 48 may not be exactly vertical (e.g., the walls could be inclined somewhat, etc.). In any event, the walls 48 being referred to are the walls being clamped between the clamp members 36, 38.

Referring additionally now to FIGS. 9 & 10, enlarged scale cross-sectional views of examples of the clamp 34 configuration are representatively illustrated. In these views, some relative dimensions of the clamp member 36 and axle 24 have been somewhat exaggerated, so that certain features are more easily seen.

In the FIG. 9 configuration, the axle corner 46 contacts the clamp member 36 at a generally planar surface 50 formed in the clamp member. The planar surface 50 can extend a distance *D* sufficient to accommodate an expected range of dimensional variations in the axle 24.

The radius *R* is formed on opposite sides of the planar surface 50. In the FIG. 9 configuration, the radius *R* is constant, but in other examples the radius could vary (with, for example, an elliptical or parabolic form).

For example, the radius *R* can decrease in a direction away from the planar surface 50 (and away from the location *L* of contact between the clamp member 36 and the corner 46).

However, preferably at all points the radius *R* is greater than the radius *r* of the corner 46 (although in some examples the radius *R* could be equal to the radius *r*).

In the FIG. 9 configuration, the location *L* of contact between the clamp member 36 and the corner 46 is not laterally offset from an inner surface of the wall 48. Thus, the lateral offset *l* is zero in this example. However, the location *L* of contact between the clamp member 36 and the corner 46 could be laterally offset inward from the inner surface of the wall 48, or could be between the inner and outer surfaces of the wall, if desired.

In the FIG. 10 configuration, the planar surface 50 is not formed in the clamp member 36. Instead, the clamp member 36 contacts the corner 46 at the radius *R*, which extends in opposite directions from the location *L* of contact.

In this example, the radius *R* can decrease in opposite directions away from the location *L* of contact. For example, the radius *R* could have an elliptical or parabolic form, or could otherwise continuously vary in opposite directions away from the location *L*.

It is not necessary for the radius *R* to vary, or for the radius *R* to vary in a same manner, on both opposite sides of the location *L*. In the FIG. 10 example, different sections of the radius *R* (indicated as *R1* and *R2* in FIG. 10) vary in different manners (the radius *R1* decreases in a direction away from the location *L*, and the radius *R2* does not vary).

Of course, as dimensions of the axle 24 vary, the location *L* of contact can also vary, and so it is contemplated that the radius *R* can continuously decrease in at least one direction away from the location of contact. However, it should be understood that it is not necessary

for the radius *R* to continuously decrease in any direction, since in some examples the radius *R* could decrease non-continuously or in steps, or the radius may not decrease at all. Indeed, it is not necessary for the radius *R* to be provided in the clamp member 36 at all (e.g., planar surfaces could be used instead).

In the FIG. 10 configuration, the location *L* of contact between the clamp member 36 and the corner 46 is not laterally offset inwardly from the wall 48 of the axle 24, but is instead between the inner and outer surfaces of the wall. The lateral offset *l* is negative in this example. However, the lateral offset *l* could be zero or positive in the FIG. 10 configuration, if desired.

It may now be fully appreciated that the above disclosure provides significant advancements to the art of suspension system design and construction. In examples described above, various types of axle dimensional variations can be accommodated by the clamp 34, while still allowing the axle 24 to be secured to the spring beam 30, and without a clamping force of the clamp causing buckling of the axle.

More specifically, the above disclosure provides to the art a vehicle suspension system 10 including an axle 24 having generally planar upper and lower side surfaces 42, 44, and a clamp 34 that secures the axle 24 in the suspension system 10. The clamp 34 secures the axle 24 without contacting the axle upper and lower side surfaces 42, 44.

The clamp 34 applies a clamping force to the axle 24, but the axle upper and lower side surfaces 42, 44 can be free of any of the clamping force. The clamping force may be applied only to corners 46 of the axle 24.

In some examples, a non-constant radius *R* of the clamp 34 contacts the axle 24. The radius *R* may be continuously varied. The radius *R* can decrease in a direction away from a location *L* of contact between the clamp 34 and the axle 24.

The clamp 34 may contact the axle 24 only at curved corners 46 of the axle. A radius *R* of the clamp 34 may apply a clamping force to a radius *r* of the axle 24, with the clamp radius *R* being greater than the axle radius *r*.

In some examples, a generally planar surface 50 of the clamp 34 applies a clamping force to a curved corner 46 of the axle 24. In some examples, the clamping force is applied only at a location *L* laterally between inner and outer surfaces of a wall 48 of the axle 24.

Also provided to the art by the above disclosure is a vehicle suspension system 10 which, in one example, includes an axle 24 having a generally hollow rectangular cross-section with curved corners 46, and a clamp 34 that secures the axle 24 in the suspension system 10. The clamp 34 applies a clamping force only to the curved corners 46 of the axle 24.

In some examples, radii *R* of the clamp 34 apply the clamping force to radii *r* of the axle 24. The clamp radii *R* can each be greater than or equal to the axle radii *r*.

The above disclosure also describes a vehicle suspension system 10 that includes an axle 24, and a clamp 34 that secures the axle in the suspension system 10. In this example, a radius *R* on the clamp 34 contacts the axle 24, and the radius *R* decreases in a direction away from a location *L* of contact between the clamp 34 and the axle 24.

Although various examples have been described above, with each example having certain features, it should be

understood that it is not necessary for a particular feature of one example to be used exclusively with that example. Instead, any of the features described above and/or depicted in the drawings can be combined with any of the examples, in addition to or in substitution for any of the other features of those examples. One example's features are not mutually exclusive to another example's features. Instead, the scope of this disclosure encompasses any combination of any of the features.

Although each example described above includes a certain combination of features, it should be understood that it is not necessary for all features of an example to be used. Instead, any of the features described above can be used, without any other particular feature or features also being used.

It should be understood that the various embodiments described herein may be utilized in various orientations, such as inclined, inverted, horizontal, vertical, etc., and in various configurations, without departing from the principles of this disclosure. The embodiments are described merely as examples of useful applications of the principles of the disclosure, which is not limited to any specific details of these embodiments.

In the above description of the representative examples, directional terms (such as "above," "below," "upper," "lower," etc.) are used for convenience in referring to the accompanying drawings. However, it should be clearly understood that the scope of this disclosure is not limited to any particular directions described herein.

The terms "including," "includes," "comprising," "comprises," and similar terms are used in a non-limiting sense in this specification. For example, if a system,

method, apparatus, device, etc., is described as "including" a certain feature or element, the system, method, apparatus, device, etc., can include that feature or element, and can also include other features or elements. Similarly, the term "comprises" is considered to mean "comprises, but is not limited to."

Of course, a person skilled in the art would, upon a careful consideration of the above description of representative embodiments of the disclosure, readily appreciate that many modifications, additions, substitutions, deletions, and other changes may be made to the specific embodiments, and such changes are contemplated by the principles of this disclosure. For example, structures disclosed as being separately formed can, in other examples, be integrally formed and *vice versa*. Accordingly, the foregoing detailed description is to be clearly understood as being given by way of illustration and example only, the spirit and scope of the invention being limited solely by the appended claims and their equivalents.

WHAT IS CLAIMED IS:

1. A vehicle suspension system, comprising:

an axle having generally planar upper and lower side surfaces; and

a clamp that secures the axle in the suspension system, wherein the clamp secures the axle without contacting the axle upper and lower side surfaces.

2. The suspension system of claim 1, wherein the clamp applies a clamping force to the axle, and wherein the axle upper and lower side surfaces are free of any of the clamping force.

3. The suspension system of claim 2, wherein the clamping force is applied only to corners of the axle.

4. The suspension system of claim 1, wherein a non-constant radius of the clamp contacts the axle.

5. The suspension system of claim 4, wherein the radius is continuously varied.

6. The suspension system of claim 4, wherein the radius decreases in a direction away from a location of contact between the clamp and the axle.

7. The suspension system of claim 1, wherein the clamp contacts the axle only at curved corners of the axle.

8. The suspension system of claim 1, wherein a radius of the clamp applies a clamping force to a radius of the axle, and wherein the clamp radius is greater than the axle radius.

9. The suspension system of claim 1, wherein a generally planar surface of the clamp applies a clamping force to a curved corner of the axle.

10. The suspension system of claim 1, wherein the clamp applies a clamping force to a curved corner of the axle, the clamping force being applied only at a location laterally between inner and outer surfaces of a wall of the axle.

11. A vehicle suspension system, comprising:

an axle having a generally hollow rectangular cross-section with curved corners; and

a clamp that secures the axle in the suspension system, wherein the clamp applies a clamping force only to the curved corners of the axle.

12. The suspension system of claim 11, wherein a non-constant radius of the clamp contacts the axle.

13. The suspension system of claim 12, wherein the radius is continuously varied.

14. The suspension system of claim 12, wherein the radius decreases in a direction away from a location of contact between the clamp and the axle.

15. The suspension system of claim 11, wherein the axle has generally planar upper and lower side surfaces, and wherein the clamp secures the axle without contacting the axle upper and lower side surfaces.

16. The suspension system of claim 15, wherein the axle upper and lower side surfaces are free of any of the clamping force.

17. The suspension system of claim 11, wherein the clamp contacts the axle only at the curved corners of the axle.

18. The suspension system of claim 11, wherein radii of the clamp apply the clamping force to radii of the axle, and wherein the clamp radii are each greater than the axle radii.

19. The suspension system of claim 11, wherein generally planar surfaces of the clamp apply the clamping force to the curved corners of the axle.

20. The suspension system of claim 11, wherein the clamping force is applied only at locations laterally between inner and outer surfaces of walls of the axle.

21. A vehicle suspension system, comprising:

an axle; and

a clamp that secures the axle in the suspension system, wherein a radius on the clamp contacts the axle, and wherein the radius decreases in a direction away from a location of contact between the clamp and the axle.

22. The suspension system of claim 21, wherein the axle has generally planar upper and lower side surfaces, and wherein the clamp secures the axle without contacting the axle upper and lower side surfaces.

23. The suspension system of claim 21, wherein the clamp applies a clamping force to the axle, and wherein the axle upper and lower side surfaces are free of any of the clamping force.

24. The suspension system of claim 23, wherein the clamping force is applied only to corners of the axle.

25. The suspension system of claim 21, wherein the radius is continuously varied.

26. The suspension system of claim 21, wherein the clamp contacts the axle only at curved corners of the axle.

27. The suspension system of claim 21, wherein the radius of the clamp applies a clamping force to a radius of the axle, and wherein the clamp radius is greater than the

axle radius at the location of contact between the clamp and the axle.

28. The suspension system of claim 21, wherein a generally planar surface of the clamp applies a clamping force to a curved corner of the axle.

29. The suspension system of claim 21, wherein the location of contact between the clamp and the axle is laterally between inner and outer surfaces of a wall of the axle.

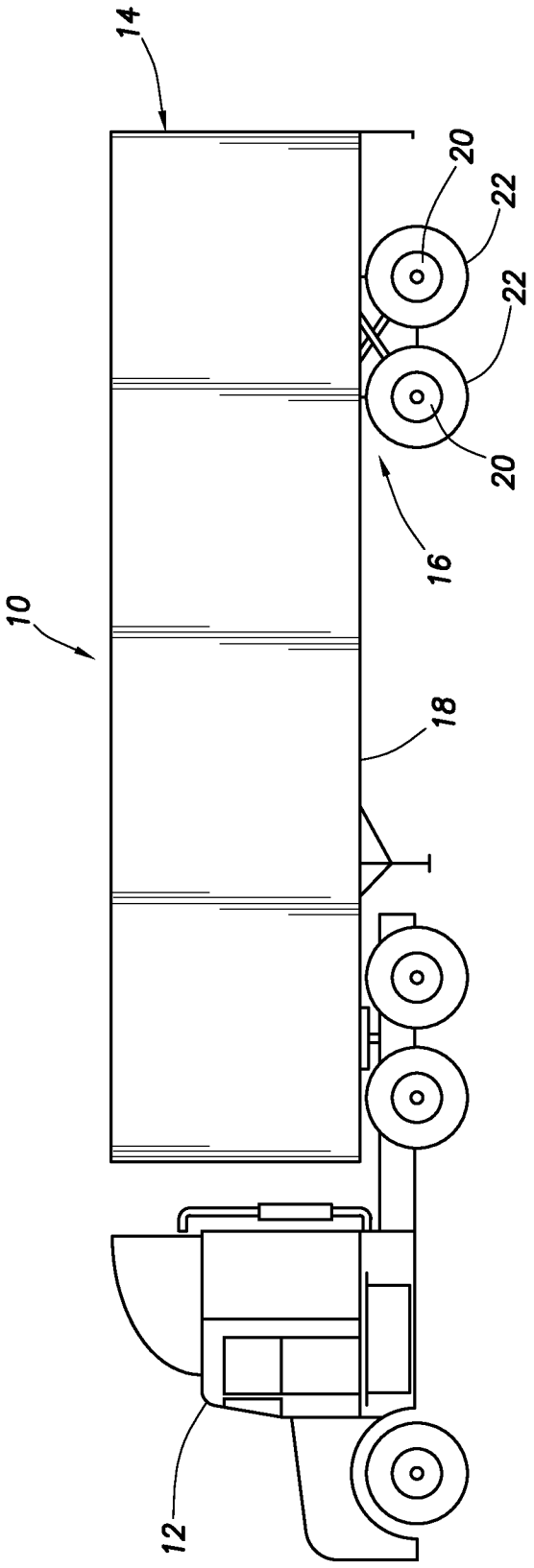

FIG.1

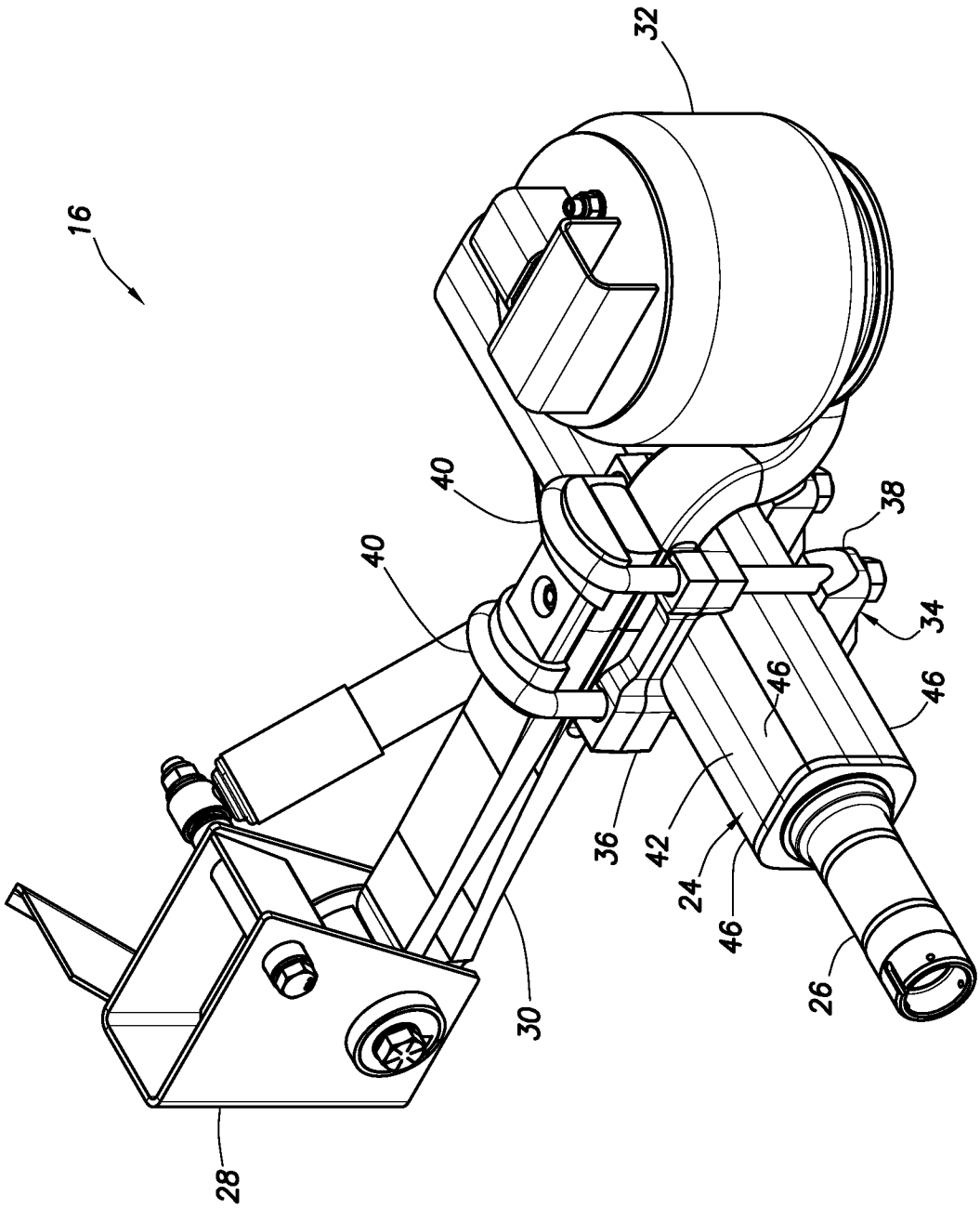

FIG.2

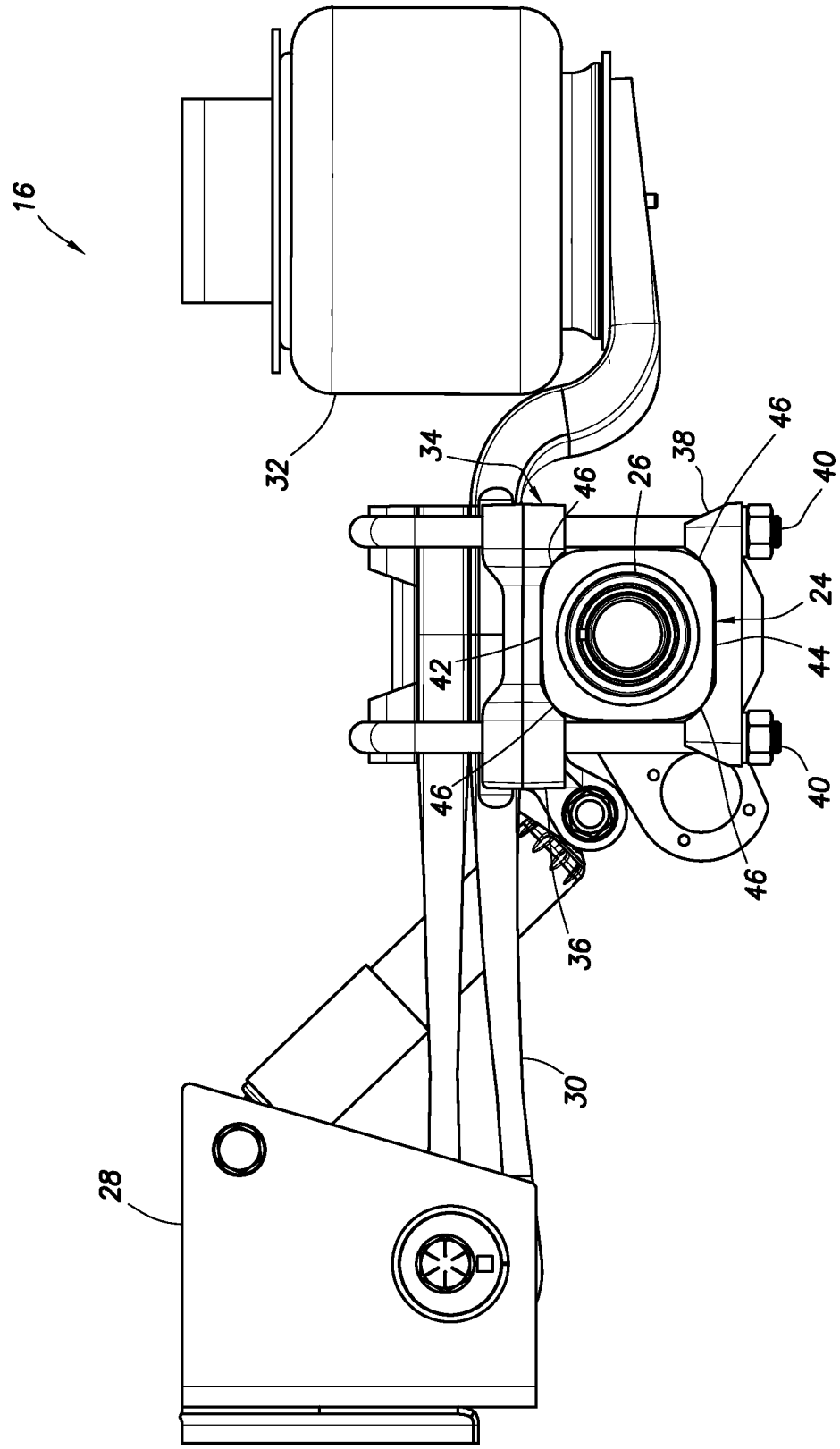

FIG.3

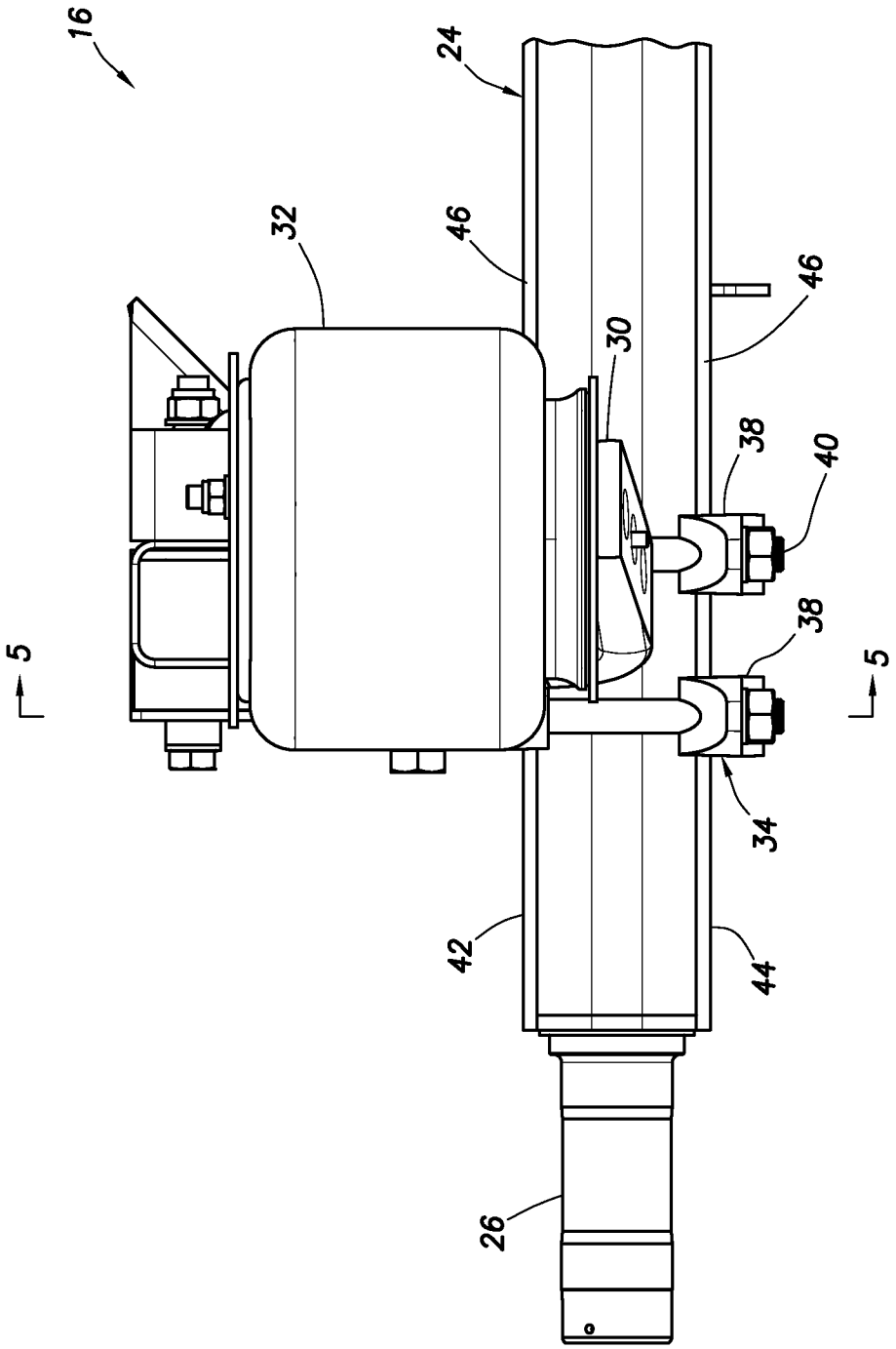

FIG.4

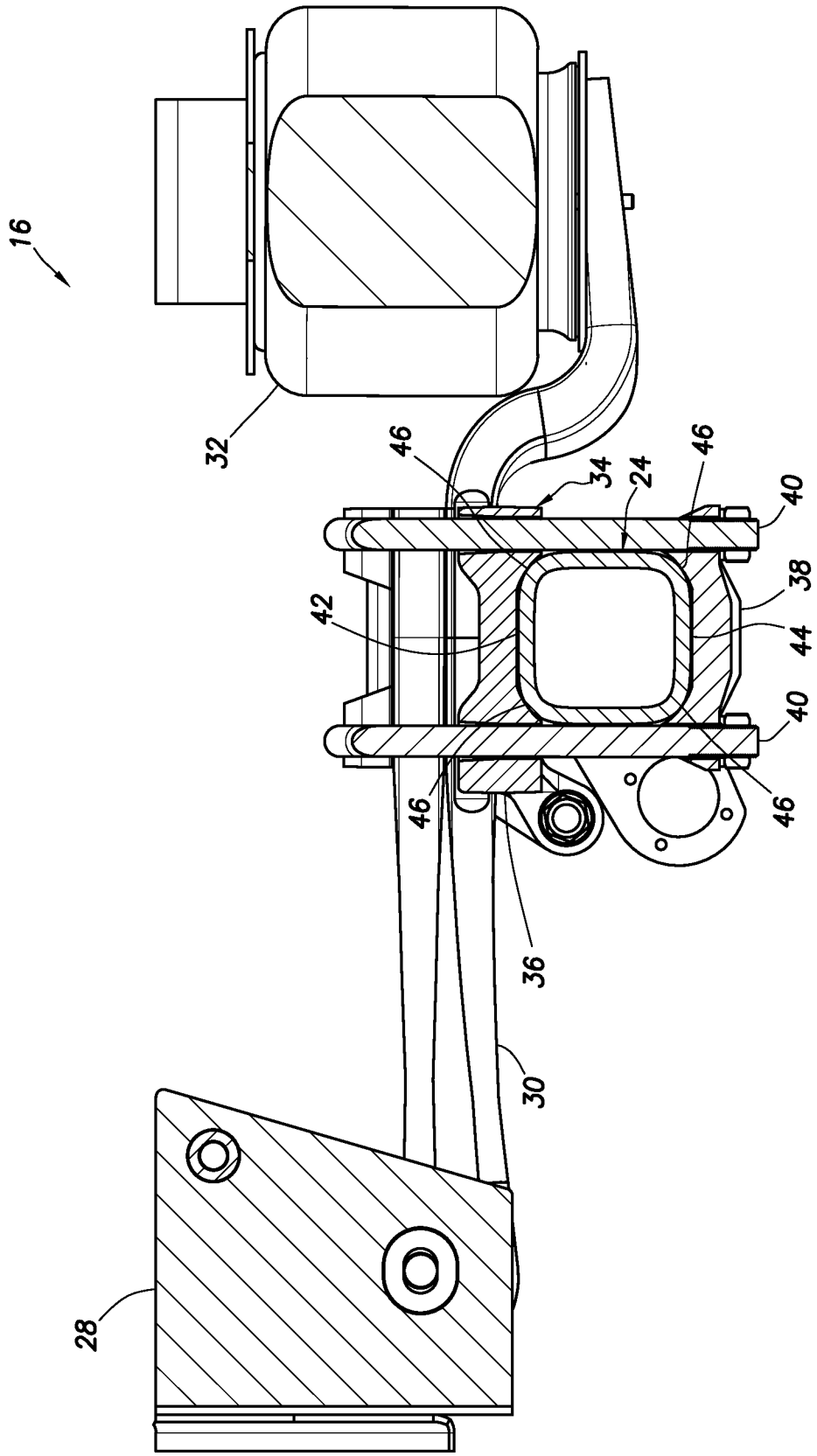

FIG.5

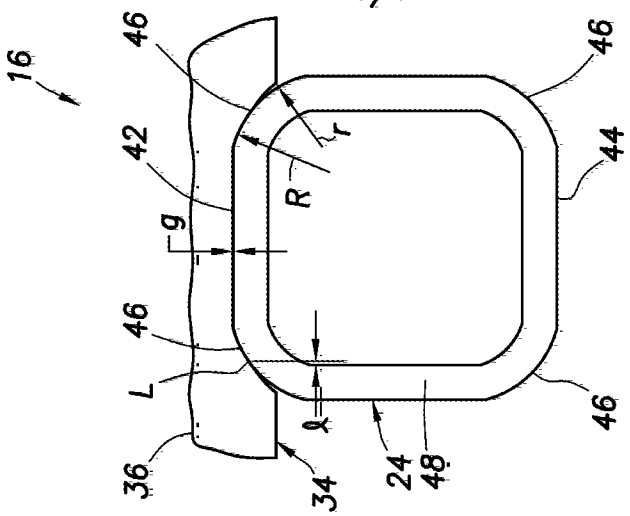

FIG.8

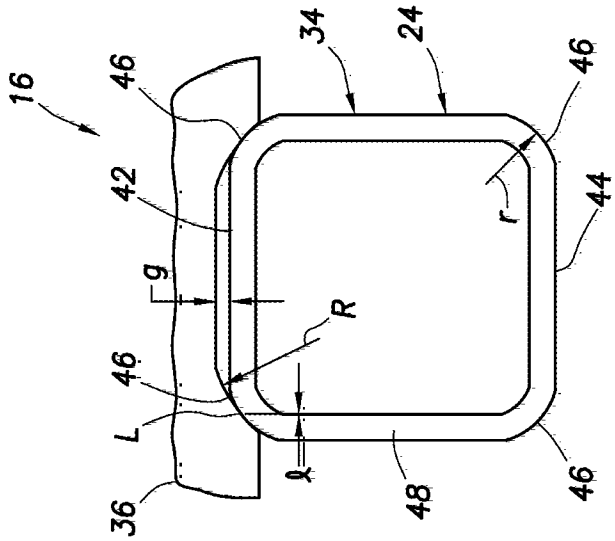

FIG.7

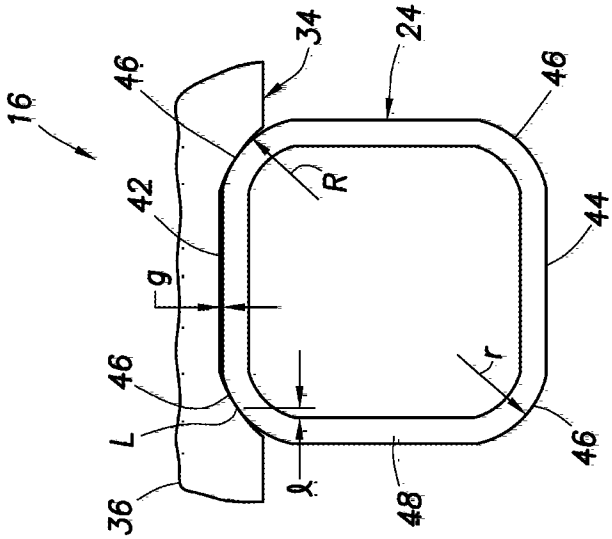

FIG.6

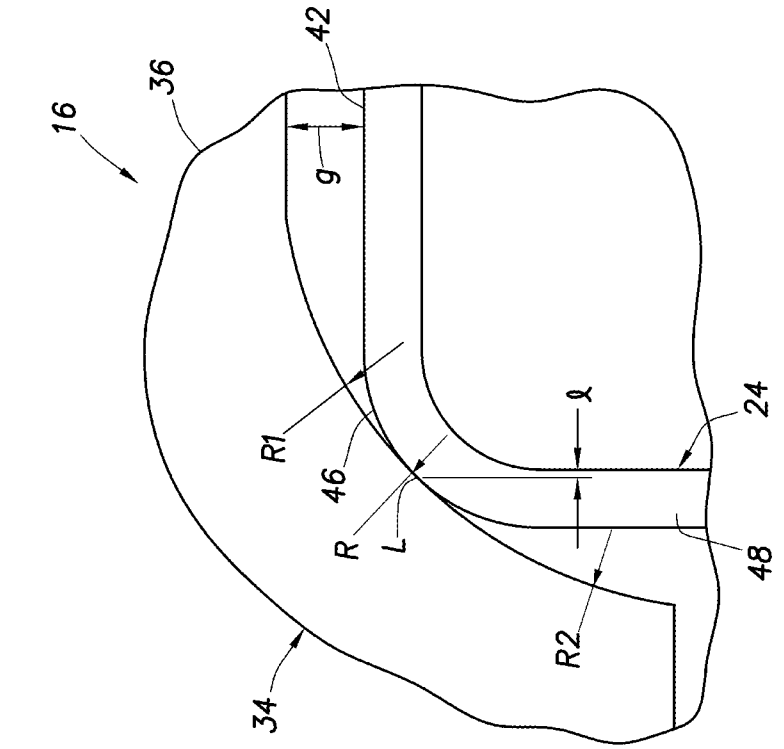

FIG.10

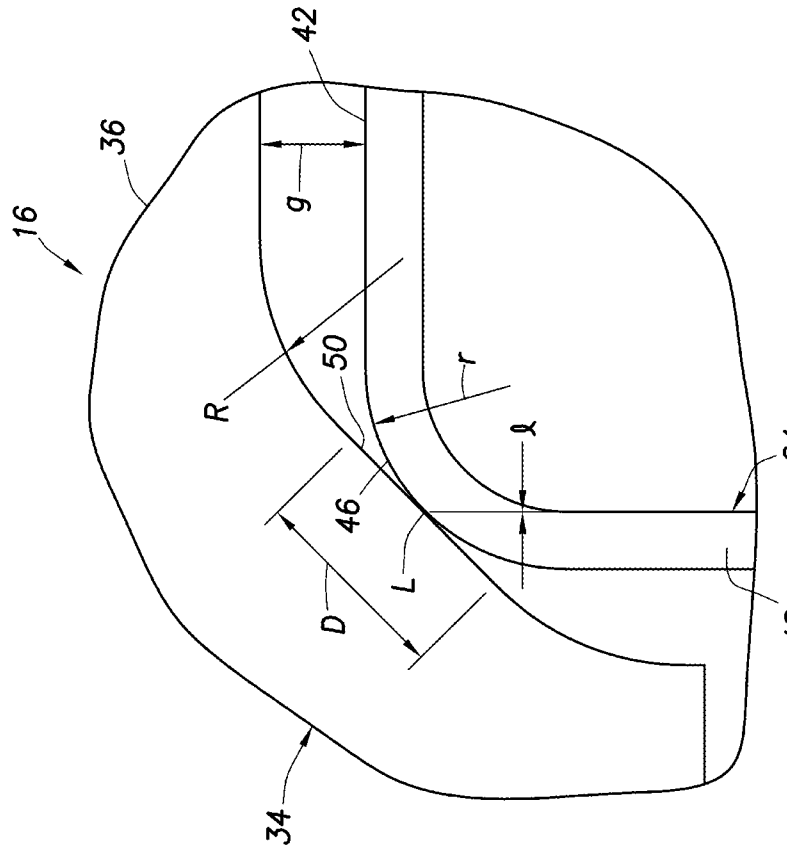

FIG.9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/050144

A. CLASSIFICATION OF SUBJECT MATTER

B60G 9/00(2006.01)i, B60G 7/00(2006.01)i

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 9/00; B60G 5/00; B60G 7/00; B60G 9/02; B60G 001/00; B60G 11/46

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: suspension, clamp, corner, gap, radius, axle and clamping force

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005-0146107 A1 (MELTON et al.) 07 July 2005 See abstract, paragraphs [0011]-[0013] and figures 1, 2.	1-29
A	WO 2010-066232 A1 (BPW BERGISCHE ACHSEN KG) 17 June 2010 See abstract, page 4, line 13 - page 9, line 12 and figures 1-8.	1-29
A	US 2005-0253351 A1 (PAN et al.) 17 November 2005 See abstract, paragraphs [0020]-[0036] and figures 2B-5.	1-29
A	US 6264231 B1 (SCULLY, ROBERT M.) 24 July 2001 See abstract, column 4, line 8 - column 5, line 14 and figures 6-12.	1-29
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☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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06 May 2015 (06.05.2015)	**07 May 2015 (07.05.2015)**

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