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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
02 January 2020 (02.01.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/005244 A1

(51) International Patent Classification:
F01L 1/24 (2006.01) *F01L 1/46* (2006.01)
F01L 1/18 (2006.01)

(21) International Application Number:
PCT/US2018/039915

(22) International Filing Date:
28 June 2018 (28.06.2018)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant: **CUMMINS INC.** [US/US]; 500 Jackson Street, Columbus, IN 47201 (US).

(72) Inventors: **MACKEY, Jason W.**; 1967 Remington Drive, Columbus, IN 47201 (US). **TING, Darren Yaoshun**; 1900 McKinley Avenue, Columbus, IN 47203 (US).

(74) Agent: **SHUSTER, Elizabeth A.** et al.; Taft Stettinius & Hollister LLP, One Indiana Square, Suite 3500, Indianapolis, IN 46204-2023 (US).

(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,

(54) **Title:** RETENTION OF HYDRAULIC LASH ADJUSTER IN ROCKER LEVER ASSEMBLY

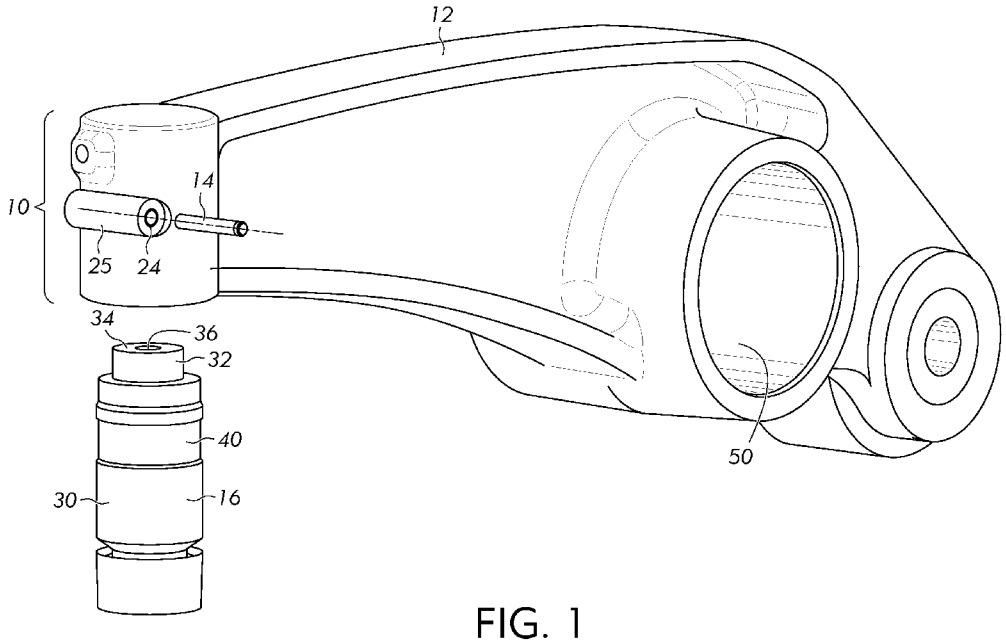

FIG. 1

(57) **Abstract:** A rocker lever sub-assembly for use with a hydraulic lash adjuster including a rocker lever arm having a bore wall that surrounds a first bore configured to receive at least part of the hydraulic lash adjuster therein, the bore wall having a second bore that intersects the first bore, and a retention device for insertion into the first and second bores to retain the hydraulic lash adjuster assembled with the first bore. The bore wall defines a retention bore at the intersection of the first and second bores. The second bore is positioned along the bore wall to position the retention device in the annular groove of the hydraulic lash adjuster such that the hydraulic lash adjuster can actuate about the retention device. The retention device can be removed from the second bore to disassemble the hydraulic lash adjuster from the first bore.

WO 2020/005244 A1

[Continued on next page]

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))*

RETENTION OF HYDRAULIC LASH ADJUSTER IN ROCKER LEVER ASSEMBLY

TECHNICAL FIELD

[0001] The present disclosure relates generally to a rocker lever arm assembly, and more particularly but not exclusively to retention of a hydraulic lash adjuster with a rocker lever arm.

BACKGROUND

[0002] An internal combustion engine can include a hydraulic lash adjuster assembled with a rocker lever arm. Hydraulic lash adjusters are very small items in size compared to the rocker lever arm with which they are assembled and even smaller in size when compared to the engine. Typically engines are built in a mass production and assembly line format wherein a worker manipulates and handles the hydraulic lash adjuster to assemble it with the rocker lever arm. Assembly of these parts is time consuming and often difficult given the relative difference in size of parts.

[0003] There are various types of clips for mounting the hydraulic lash adjuster with the rocker lever arm. One type of clip includes two-part retention device that includes a ring disposed in a groove of the lash adjuster and a connecting member. The hydraulic lash adjuster is assembled with ring and the connecting member is assembled with the rocker lever arm. The hydraulic lash adjuster with the ring thereon is inserted into the connecting member. This two-part retention device can be difficult to assemble the lash adjuster with the rocker lever arm quickly. A second type of clip is a load biasing clip that includes legs to resiliently engage opposite sides of a wall of a rockable actuator member. The legs frictionally grip the lash adjuster that is engaged with the actuator member. In this technique, the legs may become distorted during use and decrease the grip on the lash adjuster decreasing performance of the device.

[0004] During the life span of the engine, engines often require service and may require the removal and replacement of the hydraulic lash adjuster. For example, the hydraulic lash adjuster can be damaged or reach the end of its service life. Due to the small size of the hydraulic lash adjuster compared to the engine, if the service person replacing the hydraulic lash adjuster drops the hydraulic lash adjuster over the engine it

will be difficult to locate the misplaced lash adjuster as portions of the engine may need to be disassembled and reassembled to find the missing part. It is also costly to disassemble and reassemble portions of the engine.

[0005] Thus, there is a continuing demand for further contributions in this area of technology.

SUMMARY

[0006] The subject matter of the present application has been developed in response to the present state of the art, and in particular, in response to the problems and needs in the rocker lever arm art that have not yet been fully solved by currently available rocker lever arm designs.

[0007] The present application incorporates a retention device with a hydraulic lash adjuster (HLA) in a rocker lever arm to form a rocker lever arm assembly for the primary benefit of retaining the HLA with the rocker lever arm. Also beneficial is the HLA can be easily and quickly disassembled or removed from the rocker lever arm since the retention device is easily accessible on the exterior of the rocker lever arm. The retention device is also easily dis-assembled and can be quickly re-assembled in the event the HLA needs to be replaced.

[0008] The ease of assembly and dis-assembly of the HLA with the rocker arm is beneficial for many reasons. The engine is often manufactured in a mass production and assembly line manner. Since the HLA can be assembled with the rocker lever arm and retained with the retention device, this arrangement will be easier for a worker that assembles the rocker lever assembly with the engine since the worker can pick up the rocker lever assembly and insert it into the engine with ease. There are less parts that require manipulation by the worker since the rocker lever assembly already includes the HLA and is ready for insertion into the engine. The assembly of the retention device, HLA, and rocker lever arm reduces manufacturing costs.

[0009] Also beneficial is the retention device helps contain and retain the HLA within the rocker lever arm during engine operation. Moreover the engagement of the annular groove of the HLA with the retention device retains the HLA in the rocker lever arm during engine operation. The engagement of the retention device with the annular groove does not impede movement of the HLA during operation of the HLA.

[00010] During a service event of the engine, wherein the HLA, retention device, and rocker lever arm are assembled together such that when the rocker lever arm assembly is removed from the engine, the HLA is removed with it. There is no chance that the HLA will be lost in some part of the engine wherein the HLA cannot be easily and quickly retrieved. The HLA remains securely assembled with the rocker lever arm until the retention device is removed. The complete rocker lever assembly including the retention device, HLA, and rocker lever arm reduces servicing costs.

[00011] This summary is provided to introduce a selection of concepts that are further described below in the illustrative embodiments. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in limiting the scope of the claimed subject matter. Further embodiments, forms, objects, features, advantages, aspects, and benefits shall become apparent from the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[00012] In order that the advantages of the subject matter may be more readily understood, a more particular description of the subject matter briefly described above will be rendered by reference to certain embodiments that are illustrated in the appended drawings.

[00013] Understanding that these drawings depict only typical embodiments of the subject matter and are not therefore to be considered to be limiting of its scope, the subject matter will be described and explained with additional specificity and detail through the use of the drawings, in which:

[00014] FIG. 1 is a perspective view of a rocker lever arm, a retention device, and hydraulic lash adjuster in a dis-assembled configuration of the present disclosure;

[00015] FIG. 2 is a bottom view of the rocker lever arm shown in FIG. 1;

[00016] FIG. 3 is a partial view of the rocker lever arm shown in FIG. 2;

[00017] FIG. 4 is a perspective view of the rocker lever arm, retention device, and hydraulic lash adjuster shown in FIG. 1 in a pre-assembly state;

[00018] FIG. 5 is a perspective view of the rocker lever arm, retention device, and hydraulic lash adjuster shown in FIG. 1 in an assembled state;

[00019] FIG. 6 is a side view of the rocker lever arm, retention device, and hydraulic lash adjuster shown in FIG. 5;

[00020] FIG. 7A is a side view of A-A cross section of the rocker lever arm, retention device, and hydraulic lash adjuster shown in FIG. 6 wherein the hydraulic lash adjuster is fully collapsed; and

[00021] FIG. 7B is a side view of A-A cross section of the rocker lever arm, retention device, and hydraulic lash adjuster shown in FIG. 6 wherein the hydraulic lash adjuster is fully extended.

DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[00022] For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, any alterations and further modifications in the illustrated embodiments, and any further applications of the principles of the invention as illustrated therein as would normally occur to one skilled in the art to which the invention relates are contemplated herein.

[00023] Generally, the present invention is premised on a combination of a retention device for a hydraulic lash adjuster (HLA) assembled with a rocker lever arm. The retention device is easily accessible relative to the HLA and the rocker lever arm. The retention device can quickly assemble the HLA with the rocker lever arm to thereby retain the HLA in the rocker lever arm. The retention device can also be quickly removed from the HLA and the rocker lever arm to thereby dis-assemble the HLA from the rocker lever arm.

[00024] In one embodiment of the present invention, FIG. 1 depicts a rocker lever sub-assembly 10 that includes a rocker lever arm 12 and a retention device 14. The rocker lever sub-assembly 10 can also include an HLA 16.

[00025] FIGS. 1-3 depict the rocker lever arm 12 having a bore wall 20 that surrounds a first bore 22 that is configured to receive at least part of the HLA 16 therein. The bore wall 20 has a second bore 24 configured to intersect the first bore 22. The bore wall 20 defines a retention bore 26 at the location of the intersection of the first bore 22 and the second bore 24. In one form, the second bore 24 is perpendicular to the first bore 22. However, in other forms, the second bore 24 is not perpendicular to the first bore 22.

[00026] The first bore 22 is sized to receive the HLA 16 and has a diameter that corresponds to a diameter of the HLA 16. The first bore 22 has a length sufficient to receive a portion or all of the HLA 16 therein.

[00027] The second bore 24 is sized and configured to receive the retention device 14 therein. In the illustrated form, the second bore 24 is cylindrical. In other forms, the second bore 24 can have a different cross-sectional shape such as square, rectangular, or oval to name a few. The bore wall 20 includes an outer wall 25 configured to house the

second bore 24 therein. The outer wall 25 has a length and thickness sufficient to receive the second bore 24. The second bore 24 is positioned along the bore wall 20 such that when the HLA 16 is assembled with the first bore 22, the second bore 24 is adjacent to an annular groove of the HLA 16 as illustrated in FIGS. 7A and 7B.

[00028] The retention bore 26 is sized to receive and retain a portion of the retention device 14 therein. The retention bore 26 spans from the intersection of the second bore 24 to the first bore 22. The retention bore 26 is positioned along the bore wall 20 such that when the HLA 16 is assembled with the first bore 22, the retention bore 26 is adjacent to the annular groove of the HLA 16 as illustrated in FIGS. 7A and 7B.

[00029] The retention device 14 is configured for insertion into the second bore 24 and the first bore 22 to retain the HLA 16 assembled with the first bore 22. The retention device 14 is configured to assemble with the retention bore 26. In the illustrated form, the retention device 14 is a pin, roll pin, or a dowel pin. In other forms, the retention device 14 is a clip fastening mechanism that is configured to interact with the second bore 24, the retention bore 26, and the HLA 16 to secure the HLA 16 with the first bore 22. The retention device 14 is configured for removal from the second bore 24 and the first bore 22 to disassemble the HLA 16 from the first bore 22.

[00030] The HLA 16 includes a cylindrical body 30 from which projects the lash adjusting cylindrical plunger 32 having a semi-spherical end 34 including a central oil hole 36. The body 30 includes an annular groove 40 on an outer surface through which oil is received into the HLA 16 for actuating the lash adjusting functions and supplying oil through the hole 36 of the plunger 32. The annular groove 40 is sized to receive a portion of the retention device 14 when the retention device 14 is inserted in the annular groove 40. The retention device 14 is configured to engage the annular groove 40 to retain the HLA 16 in the first bore 22.

[00031] The rocker lever arm 12 is pivoted on an axle 50 in a cylinder head, not shown.

[00032] FIG. 1 depicts the rocker lever arm 12, retention device 14, and HLA 16 in a dis-assembled configuration. The rocker lever arm 12, retention device 14, and HLA 16 are shown in FIG. 4 in a pre-assembly state wherein the HLA 16 is inserted into the first bore 22 however the HLA 16 is not retained in the first bore 22 by the retention device 14.

In FIG. 5 the rocker lever arm 12, the retention device 14, and HLA 16 are shown in an assembled state, wherein the HLA 16 is inserted in the first bore 22 and the retention device 14 is inserted in the second bore 24 and the retention bore 26 to retain the HLA 16 in the first bore 22.

[00033] FIGS. 6, 7A, and 7B, illustrate actuation of the HLA 16 from a fully collapsed position illustrated in FIG. 7A to a fully extended position illustrated in FIG. 7B. The HLA 16 moves in the first bore 22 relative to the retention device 14 retained in the retention bore 26. As such, the annular groove 40 of the HLA 16 engages the retention device 14 when the lash adjusting cylindrical plunger 32 actuates. The retention device 14 ca be removed from the second bore 24 and the retention bore 26 to dis-assemble the HLA 16 from the rocker lever arm 12.

[00034] Various aspects of the present disclosure are contemplated as described in the claims. According to one aspect, a rocker lever sub-assembly for use with a hydraulic lash adjuster, the rocker lever sub-assembly includes a rocker lever arm having a bore wall that surrounds a first bore configured to receive at least part of the hydraulic lash adjuster therein, the bore wall having a second bore that intersects the first bore; and a retention device configured for insertion into the second bore and the first bore to retain the hydraulic lash adjuster assembled with the first bore.

[00035] In one embodiment of the rocker lever sub-assembly further includes a hydraulic lash adjuster having an annular groove; and wherein the retention device is inserted in the annular groove. In one further refinement the rocker lever sub-assembly includes the second bore is positioned along the bore wall adjacent the annular groove of the hydraulic lash adjuster. In a refinement of this embodiment, the retention device is a clip. In yet a further refinement of this embodiment, the retention device is a pin. In yet a further refinement, the bore wall includes an outer wall configured to house the second bore therein. In another refinement, the bore wall defines a retention bore at the location of intersection of the first bore and the second bore. In yet a further refinement, the retention device is configured to assemble with the retention bore. In another refinement, the retention device is configured for removal from the second bore and the first bore to disassemble the hydraulic lash adjuster from the first bore.

[00036] According to another aspect, a rocker lever sub-assembly for use with a hydraulic lash adjuster, the rocker lever sub-assembly includes a rocker lever arm having a first bore that intersects a second bore at an retention bore, the first bore configured to receive at least part of the hydraulic lash adjuster, the second bore configured to receive a retention device; and a retention device configured to retain the hydraulic lash adjuster with the first bore when the retention device is assembled with the second bore and the retention bore. In another embodiment, a hydraulic lash adjuster has an annular groove, and the retention device is configured to engage the annular groove to retain the hydraulic lash adjuster in the first bore. In a further refinement, the second bore is adjacent to the annular groove of the hydraulic lash adjuster when the hydraulic lash adjuster is assembled with the first bore. In yet another refinement, the retention device is a clip. In yet another refinement, the retention device is a pin. In yet another embodiment, the bore wall includes an outer wall configured to house the second bore therein. In yet another embodiment, the retention device is configured for removal from the second bore and the first bore to disassemble the hydraulic lash adjuster from the first bore.

[00037] According to another aspect, a method includes inserting a hydraulic lash adjuster in a first bore of a rocker lever arm, the rocker lever arm defining a second bore that intersects the first bore at a retention bore; and inserting a retention device in the second bore and the retention bore to retain the hydraulic lash adjuster with the rocker lever arm. In one further embodiment, the hydraulic lash adjuster has an annular groove; and the method includes inserting the retention device in the annular groove. In another further embodiment, the method includes actuating the hydraulic lash adjuster relative to the retention device within the first bore. In another embodiment, the method further includes after the inserting the retention device, removing the retention device from the second bore and the retention bore to dis-assemble the hydraulic lash adjuster from the rocker lever arm.

[00038] In the above description, certain relative terms may be used such as "up," "down," "upper," "lower," "horizontal," "vertical," "left," "right," and the like. These terms are used, where applicable, to provide some clarity of description when dealing with relative relationships. But, these terms are not intended to imply absolute relationships, positions, and/or orientations. For example, with respect to an object, an "upper" surface

can become a "lower" surface simply by turning the object over. Nevertheless, it is still the same object.

[00039] Reference throughout this specification to "one embodiment," "an embodiment," or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present disclosure. Appearances of the phrases "in one embodiment," "in an embodiment," and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment. Similarly, the use of the term "implementation" means an implementation having a particular feature, structure, or characteristic described in connection with one or more embodiments of the present disclosure, however, absent an express correlation to indicate otherwise, an implementation may be associated with one or more embodiments.

[00040] The described features, structures, advantages, and/or characteristics of the subject matter of the present disclosure may be combined in any suitable manner in one or more embodiments and/or implementations. In the following description, numerous specific details are provided to impart a thorough understanding of embodiments of the subject matter of the present disclosure. One skilled in the relevant art will recognize that the subject matter of the present disclosure may be practiced without one or more of the specific features, details, components, materials, and/or methods of a particular embodiment or implementation. In some instances, the benefit of simplicity may provide operational and economic benefits and exclusion of certain elements described herein is contemplated as within the scope of the invention herein by the inventors to achieve such benefits. In other instances, additional features and advantages may be recognized in certain embodiments and/or implementations that may not be present in all embodiments or implementations. Further, in some instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the subject matter of the present disclosure. The features and advantages of the subject matter of the present disclosure will become more fully apparent from the following description and appended claims, or may be learned by the practice of the subject matter as set forth hereinafter.

[00041] In reading the claims, it is intended that when words such as "a," "an," "at least one," or "at least one portion" are used there is no intention to limit the claim to only one item unless specifically stated to the contrary in the claim. When the language "at least a portion" and/or "a portion" is used the item can include a portion and/or the entire item unless specifically stated to the contrary.

[00042] The present subject matter may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

WHAT IS CLAIMED IS:

1. A rocker lever sub-assembly for use with a hydraulic lash adjuster, the rocker lever sub-assembly comprising:

a rocker lever arm having a bore wall that surrounds a first bore configured to receive at least part of the hydraulic lash adjuster therein, the bore wall having a second bore that intersects the first bore; and

a retention device configured for insertion into the second bore and the first bore to retain the hydraulic lash adjuster assembled with the first bore.

2. The rocker lever sub-assembly of claim 1, further comprising:

a hydraulic lash adjuster having an annular groove; and

wherein the retention device is inserted in the annular groove.

3. The rocker lever sub-assembly of claim 2, wherein the second bore is positioned along the bore wall adjacent the annular groove of the hydraulic lash adjuster.

4. The rocker lever sub-assembly of claim 1, wherein the retention device is a clip.

5. The rocker lever sub-assembly of claim 1, wherein the retention device is a pin.

6. The rocker lever sub-assembly of claim 1, wherein the bore wall includes an outer wall configured to house the second bore therein.

7. The rocker lever sub-assembly of claim 1, wherein the bore wall defines a retention bore at the location of intersection of the first bore and the second bore.

8. The rocker lever sub-assembly of claim 1, wherein the retention device is configured to assemble with the retention bore.

9. The rocker lever sub-assembly of claim 1, wherein the retention device is configured for removal from the second bore and the first bore to disassemble the hydraulic lash adjuster from the first bore.

10. A rocker lever sub-assembly for use with a hydraulic lash adjuster, the rocker lever sub-assembly comprising:

a rocker lever arm having a first bore that intersects a second bore at an retention bore, the first bore configured to receive at least part of the hydraulic lash adjuster, the second bore configured to receive a retention device; and

a retention device configured to retain the hydraulic lash adjuster with the first bore when the retention device is assembled with the second bore and the retention bore.

11. The rocker lever sub-assembly of claim 10, further comprising:

a hydraulic lash adjuster having an annular groove, and the retention device is configured to engage the annular groove to retain the hydraulic lash adjuster in the first bore.

12. The rocker lever sub-assembly of claim 10, wherein the second bore is adjacent to the annular groove of the hydraulic lash adjuster when the hydraulic lash adjuster is assembled with the first bore.

13. The rocker lever sub-assembly of claim 10, wherein the retention device is a clip.

14. The rocker lever sub-assembly of claim 10, wherein the retention device is a pin.

15. The rocker lever sub-assembly of claim 10, wherein the bore wall includes an outer wall configured to house the second bore therein.

16. The rocker lever sub-assembly of claim 10, wherein the retention device is configured for removal from the second bore and the first bore to disassemble the hydraulic lash adjuster from the first bore.

17. A method, comprising:

inserting a hydraulic lash adjuster in a first bore of a rocker lever arm, the rocker lever arm defining a second bore that intersects the first bore at a retention bore; and

inserting a retention device in the second bore and the retention bore to retain the hydraulic lash adjuster with the rocker lever arm.

18. The method of claim 17, further comprising:

wherein the hydraulic lash adjuster has an annular groove; and

inserting the retention device in the annular groove.

19. The method of claim 18, further comprising:

actuating the hydraulic lash adjuster relative to the retention device within the first bore.

20. The method of claim 17, further comprising:

after the inserting the retention device, removing the retention device from the second bore and the retention bore to dis-assemble the hydraulic lash adjuster from the rocker lever arm.

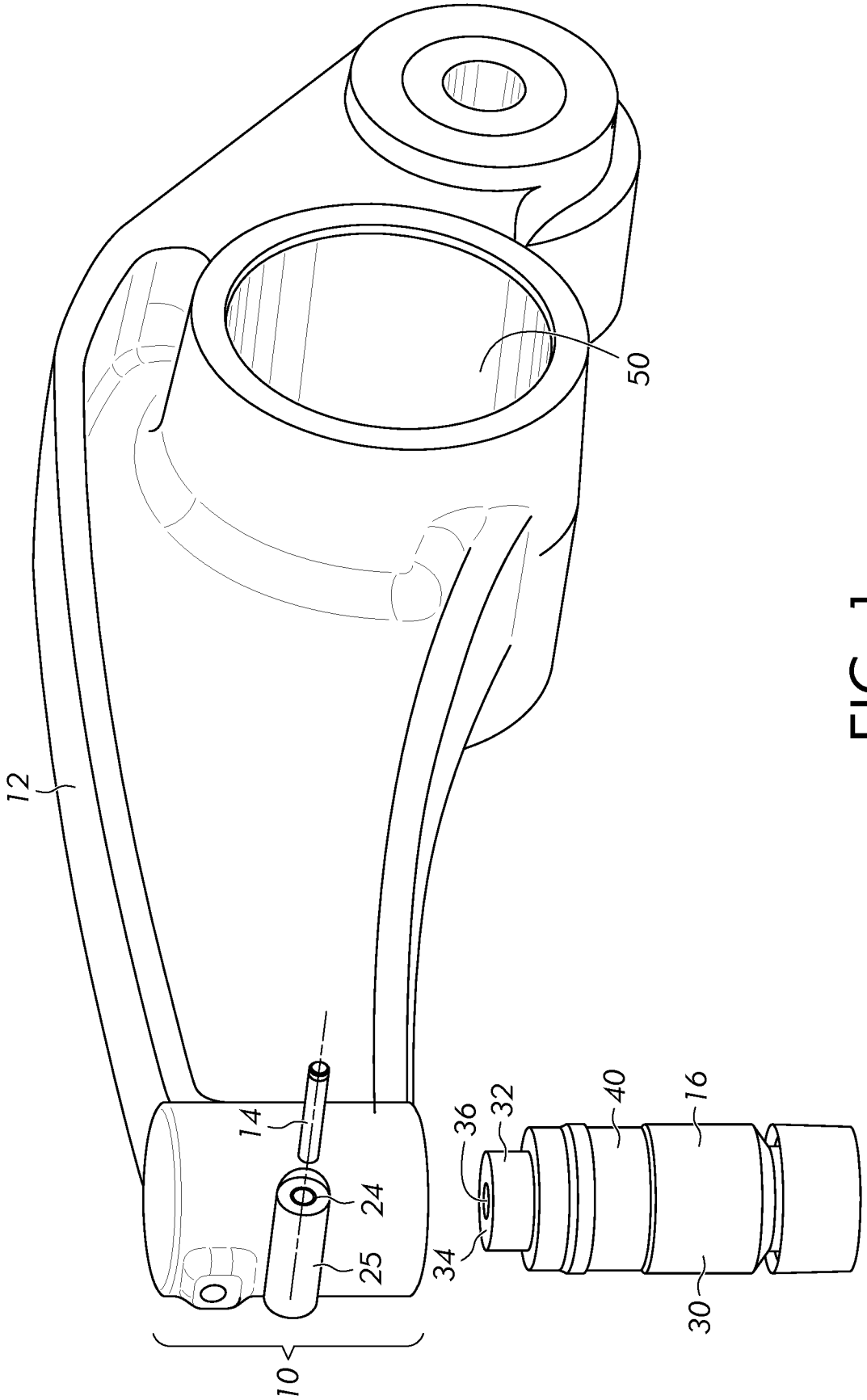

FIG. 1

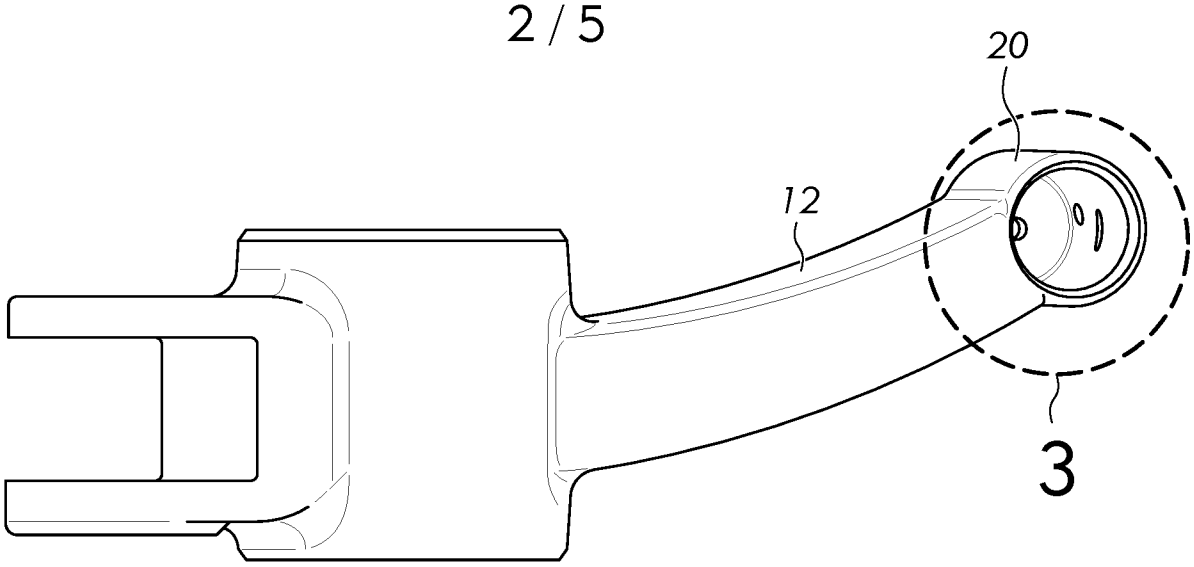

FIG. 2

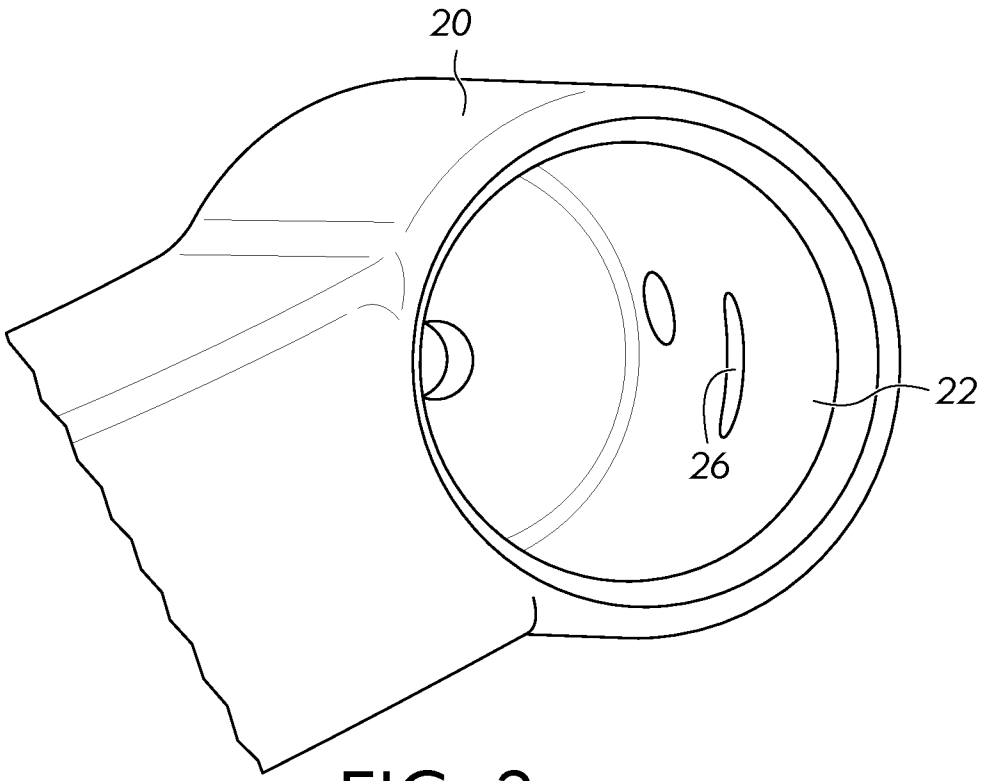

FIG. 3

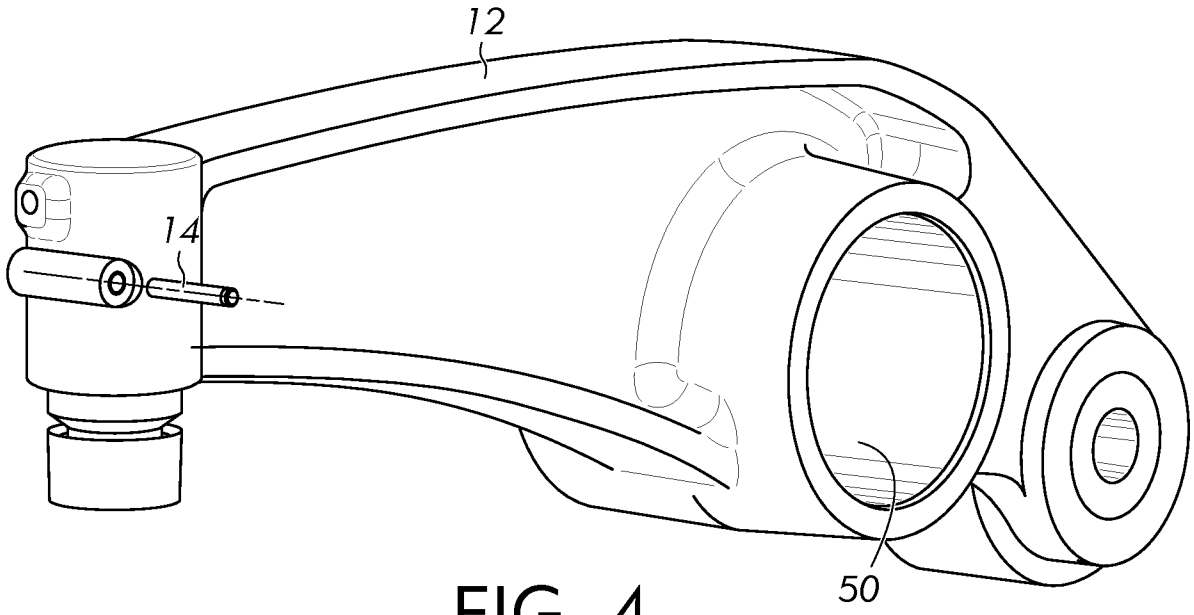

FIG. 4

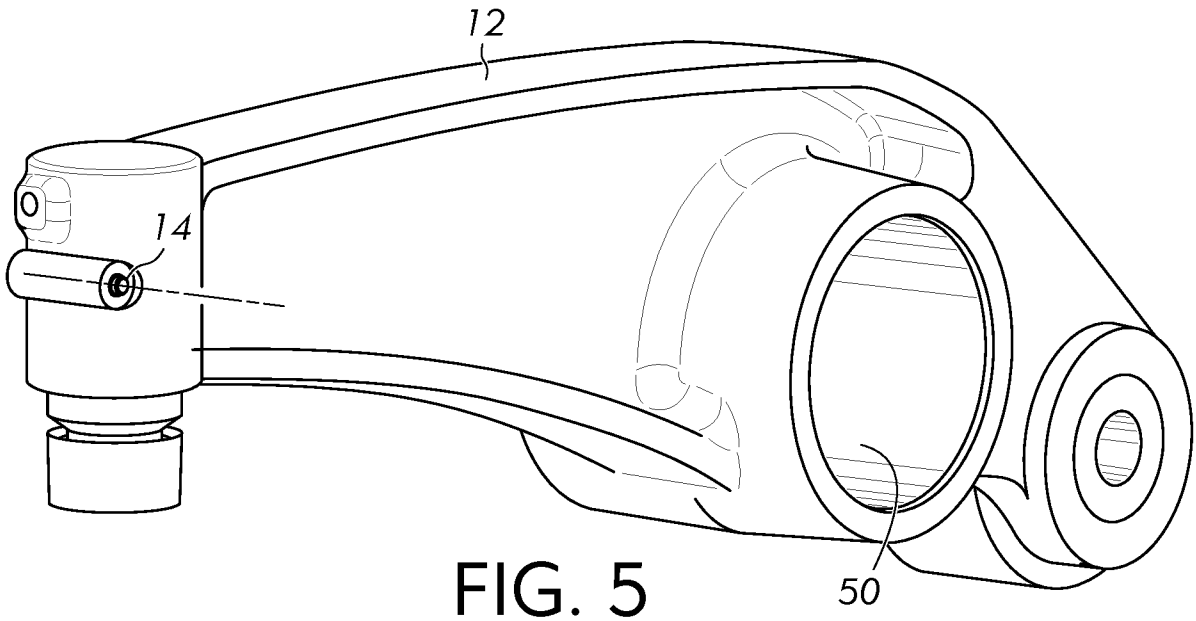

FIG. 5

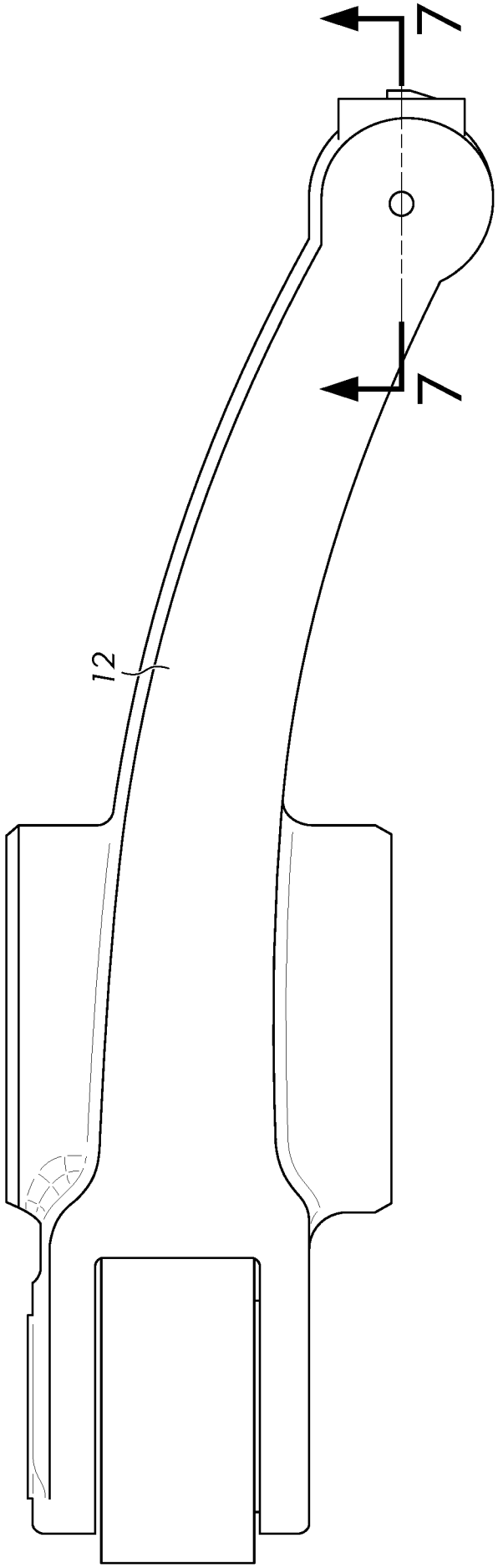

FIG. 6

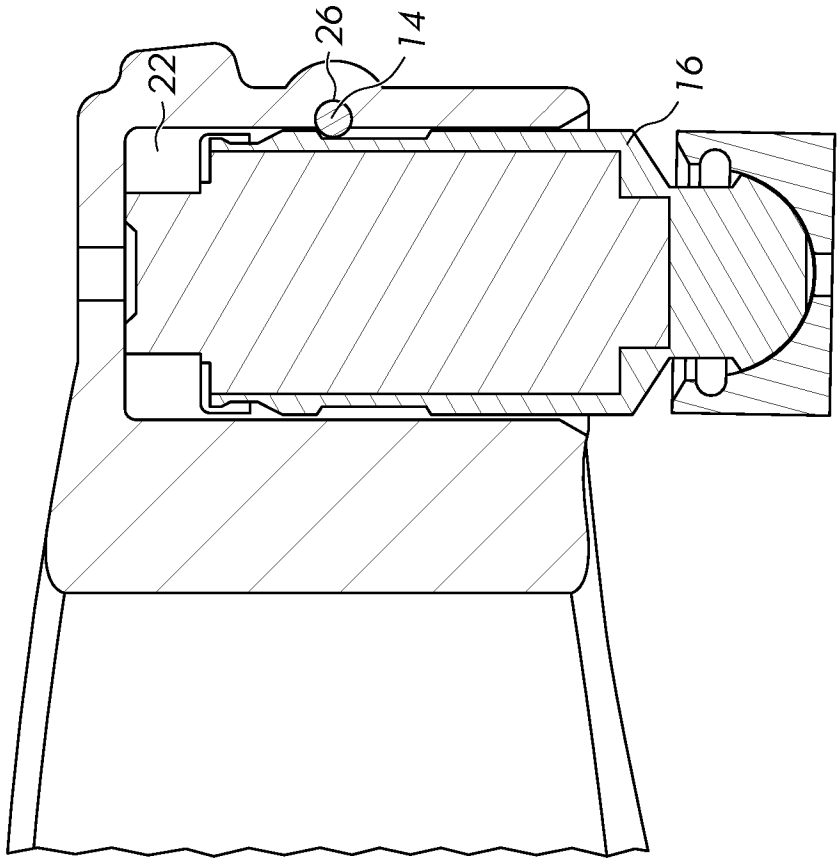

FIG. 7B

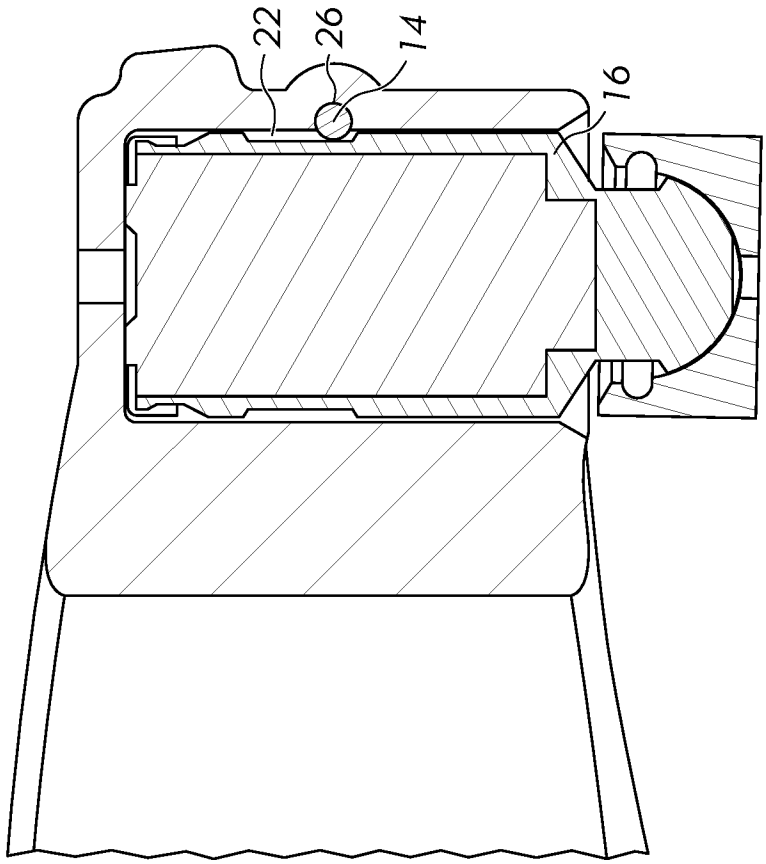

FIG. 7A

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 18/39915

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - F01L 1/24, F01L 1/18, F01L 1/46 (2018.01)
CPC - F01L 2001/187, F01L 1/2416, F01L 1/24, F01L 1/2411, F01L 1/18, F01L 1/46, F01L 1/2405

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)
See Search History Document

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- A	US 2009/0145388 A1 (Hiramatsu) 11 June 2009 (11.03.2009) Entire document especially para [0020]-[0025] and figs. 1, 2 and 5	1-4, 6 ----- 5, 7-20
A	US 2008/0041326 A1 (Engelhardt et al.) 21 February 2008 (21.02.2008) Entire document especially para [0021]-[0023], [0026] and figs. 1 and 3	10-20
A	US 2008/0245327 A1 (Christgen et al.) 9 October 2008 (09.10.2008) Entire document especially para [0012], [0021], [0024] and fig. 1	10-20
A	US 2011/0000451 A1 (Kraus) 6 January 2011 (06.01.2011) Entire document	1-20
A	US 2011/0041791 A1 (Miyoshi et al.) 24 February 2011 (24.02.2011) Entire document	1-20
A	US 2011/0017160 A1 (Kishi et al.) 27 January 2011 (27.01.2011) Entire document	1-20
A	US 2015/0308300 A1 (Schaeffler Technologies AG & Co. KG) 29 October 2015 (29.10.2015) Entire document	1-20
A	US 2016/0265394 A1 (GT Technologies) 15 September 2016 (15.09.2016) Entire document	1-20
A	US 2013/0306015 A1 (Otics Corporation) 21 November 2013 (21.11.2013) Entire document	1-20

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"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)
"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
"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
"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
"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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 August 2018	20 SEP 2018
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774