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Patankar et al.

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(54) **LIFTER ASSEMBLY**

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F01L 13/00 (2006.01)
F01L 1/46 (2006.01)

(52) **U.S. Cl.**
CPC ***F01L 1/14*** (2013.01); ***F01L 13/0036*** (2013.01); *F01L 2001/467* (2013.01); *F01L 2305/00* (2020.05); *F01L 2810/02* (2013.01)

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CPC F01L 2305/00; F01L 2001/467; F01L 2810/02; F01L 1/14; F01L 1/08;
(Continued)

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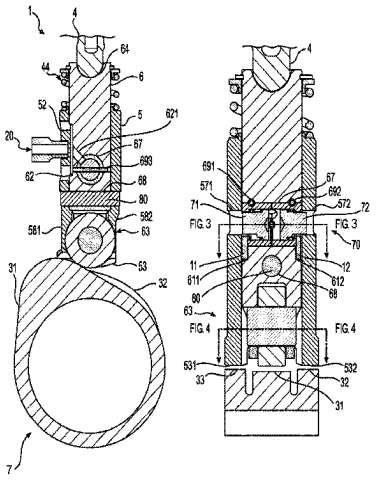
(57) **ABSTRACT**

A lifter assembly can comprise an outer body comprising an oil port and opposed latch ports. An inner body can comprise a roller assembly or tappet configured to lift and lower to follow a cam. The inner body comprises a pin passage comprising an inner diameter. A pin assembly is mounted in the pin passage. The pin assembly comprises a bushing abutting the inner diameter. The bushing comprises a pin port. A pin comprises a rim and a narrow end configured for sliding in the pin port.

14 Claims, 8 Drawing Sheets



(58) **Field of Classification Search**
CPC F01L 1/46; F01L 13/00; F01L 13/0036; F01L 13/0005
USPC 123/90.48
See application file for complete search history.

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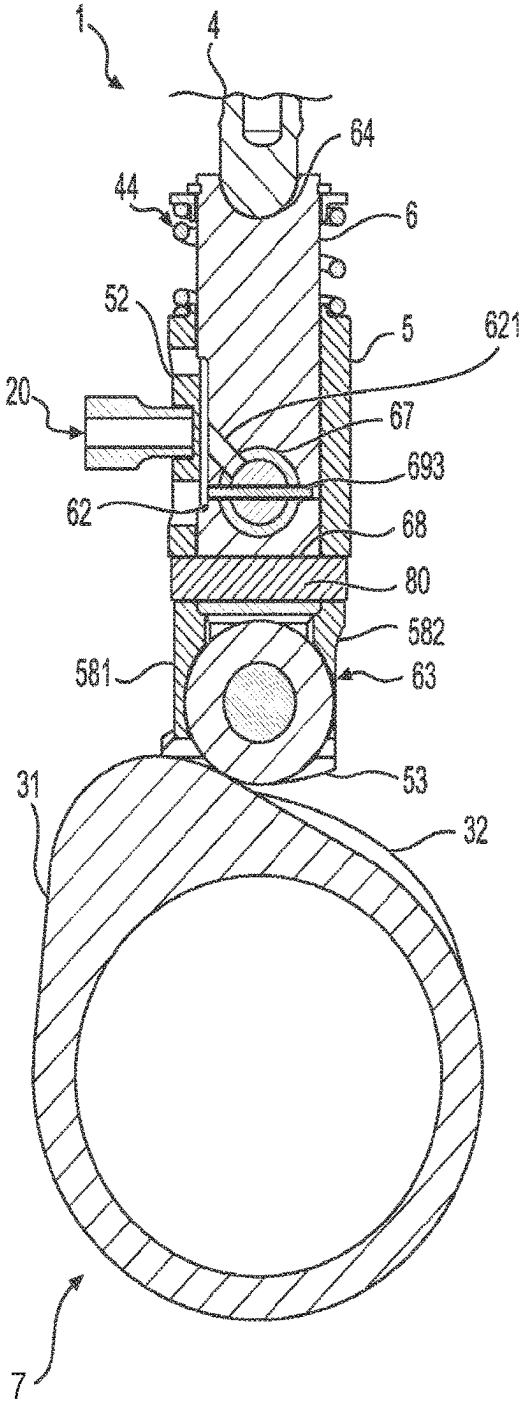
1
4
64
44
6
52
5
621
20
67
693
62
68
80
582
581
63
53
31
32
7

FIG. 1A

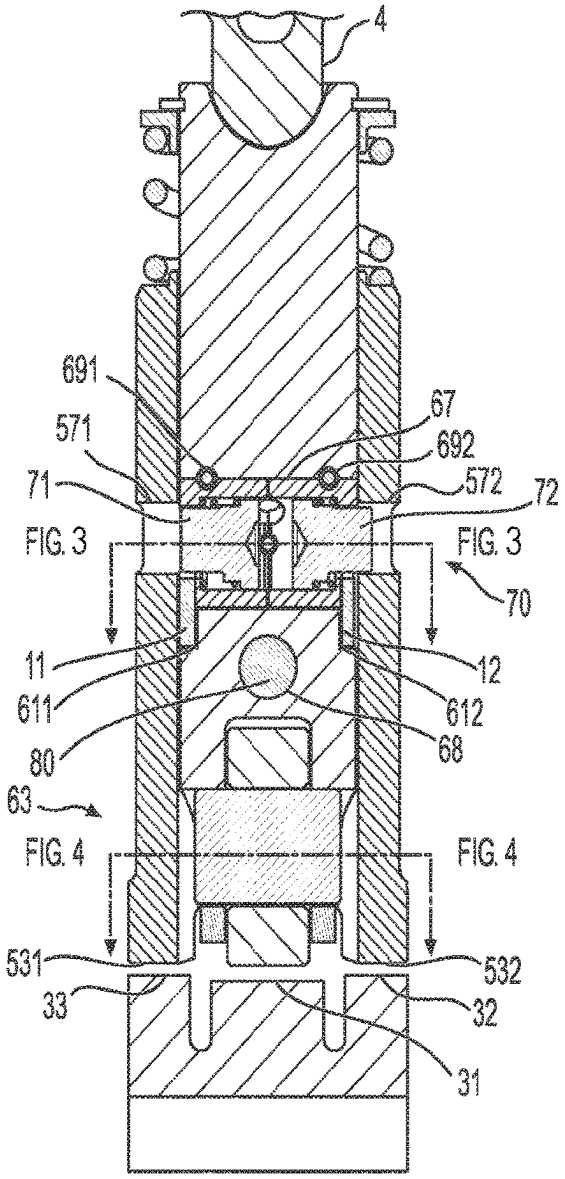
4
691
67
571
692
71
572
72
FIG. 3
FIG. 3
70
11
12
611
612
80
68
63
FIG. 4
FIG. 4
531
532
33
32
31

FIG. 1B

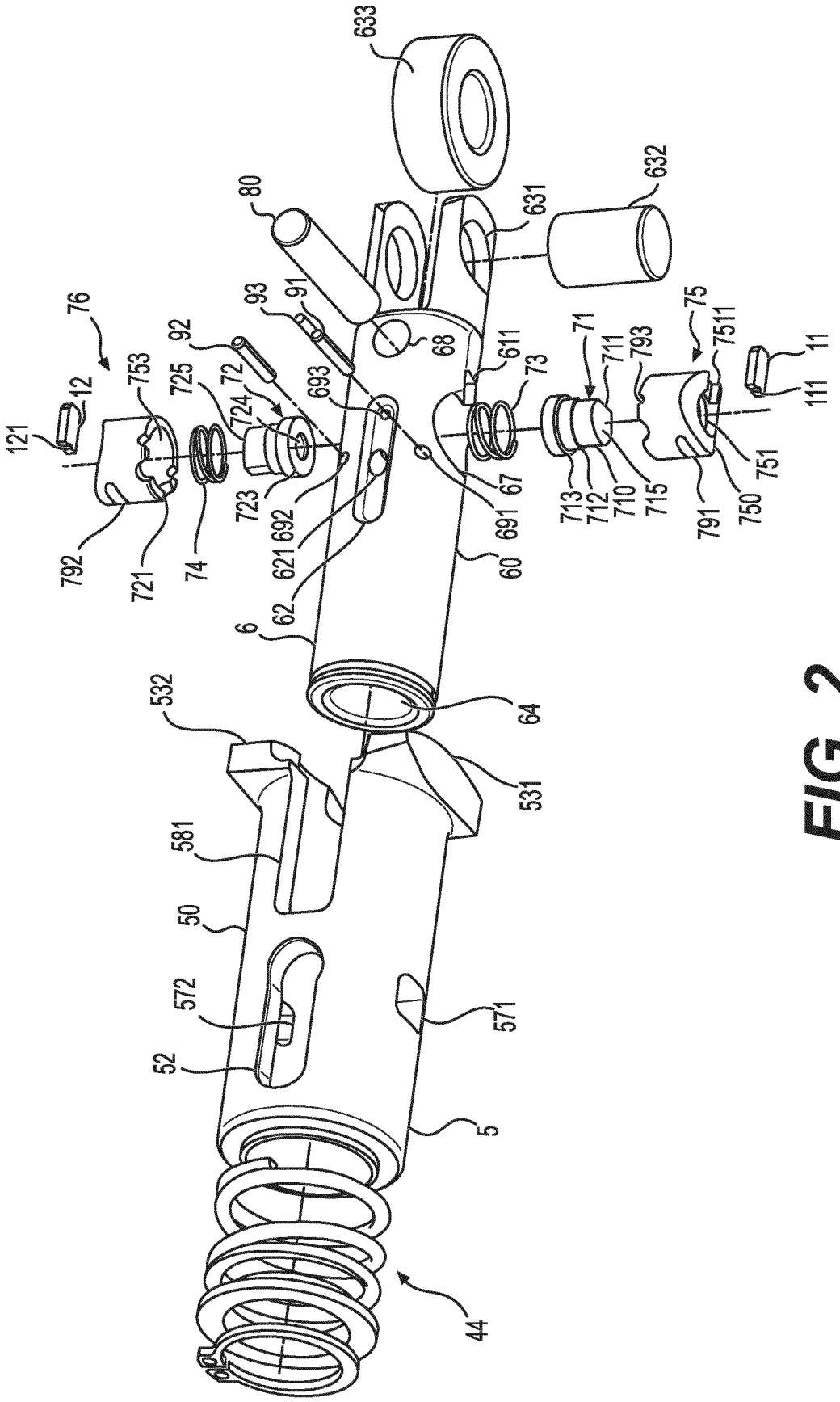
633
632
631
80
93
91
92
68
611
73
71
711
793
75
7511
11
111
76
753
725
72
724
693
12
121
723
692
621
62
6
792
721
74
691
67
713
712
710
715
791
750
751
60
532
64
531
581
50
572
52
571
5
44

FIG. 2

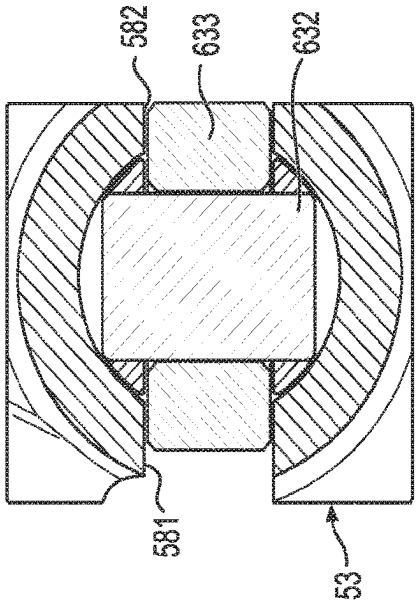
582
633
632
581
53

FIG. 4

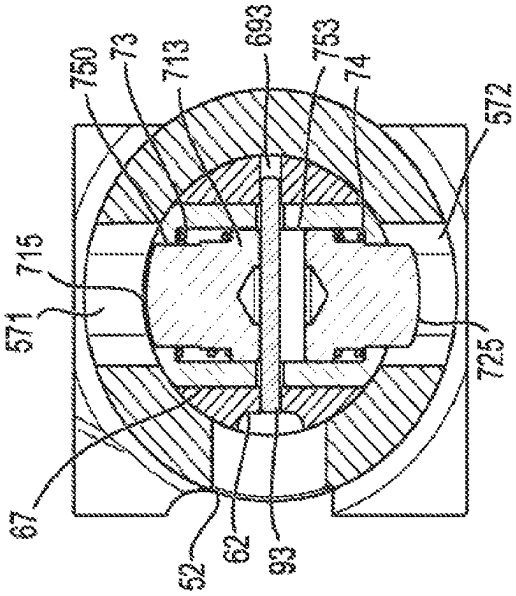
693
753
760
73
713
74
572
715
571
725
67
52
62
93

FIG. 3

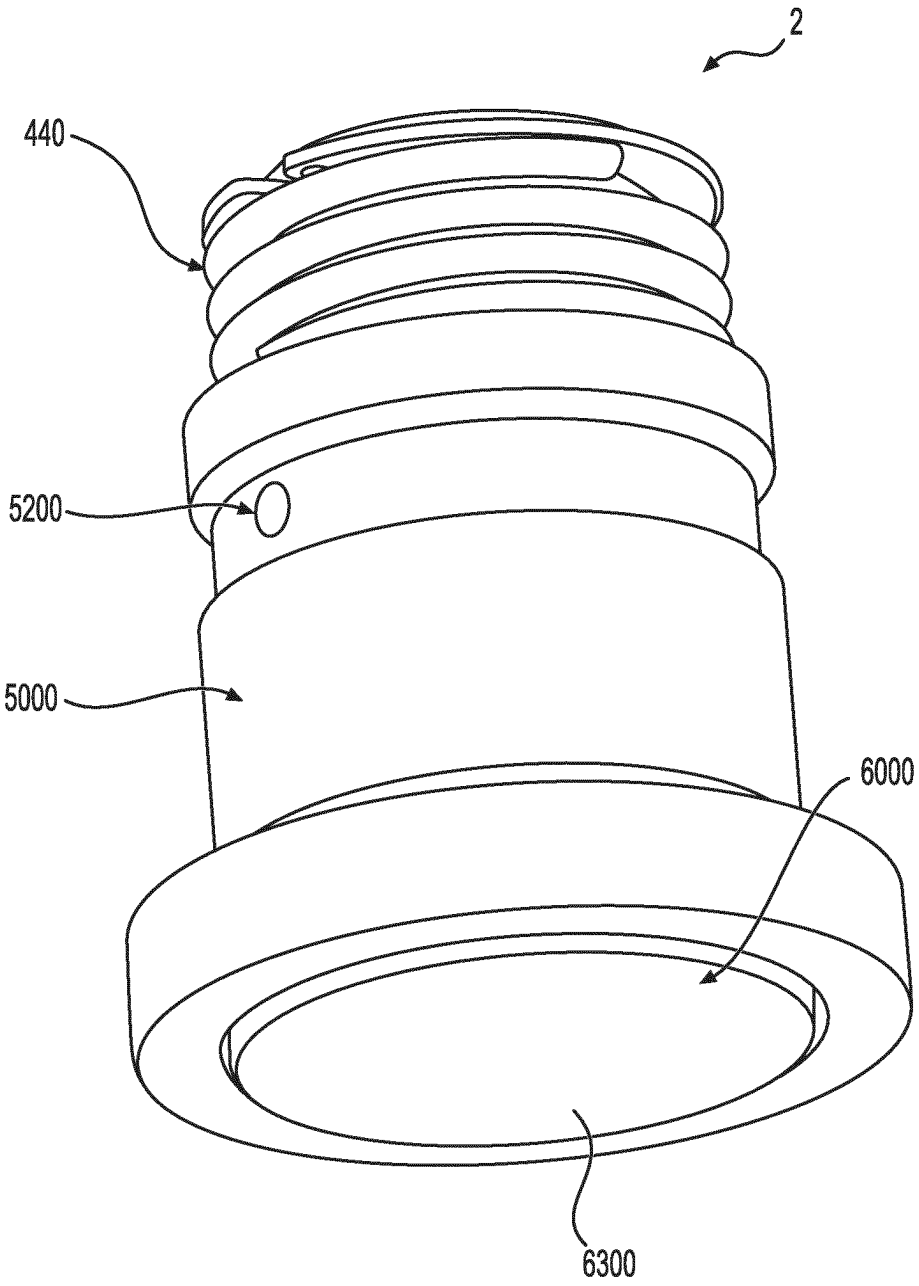

FIG. 5

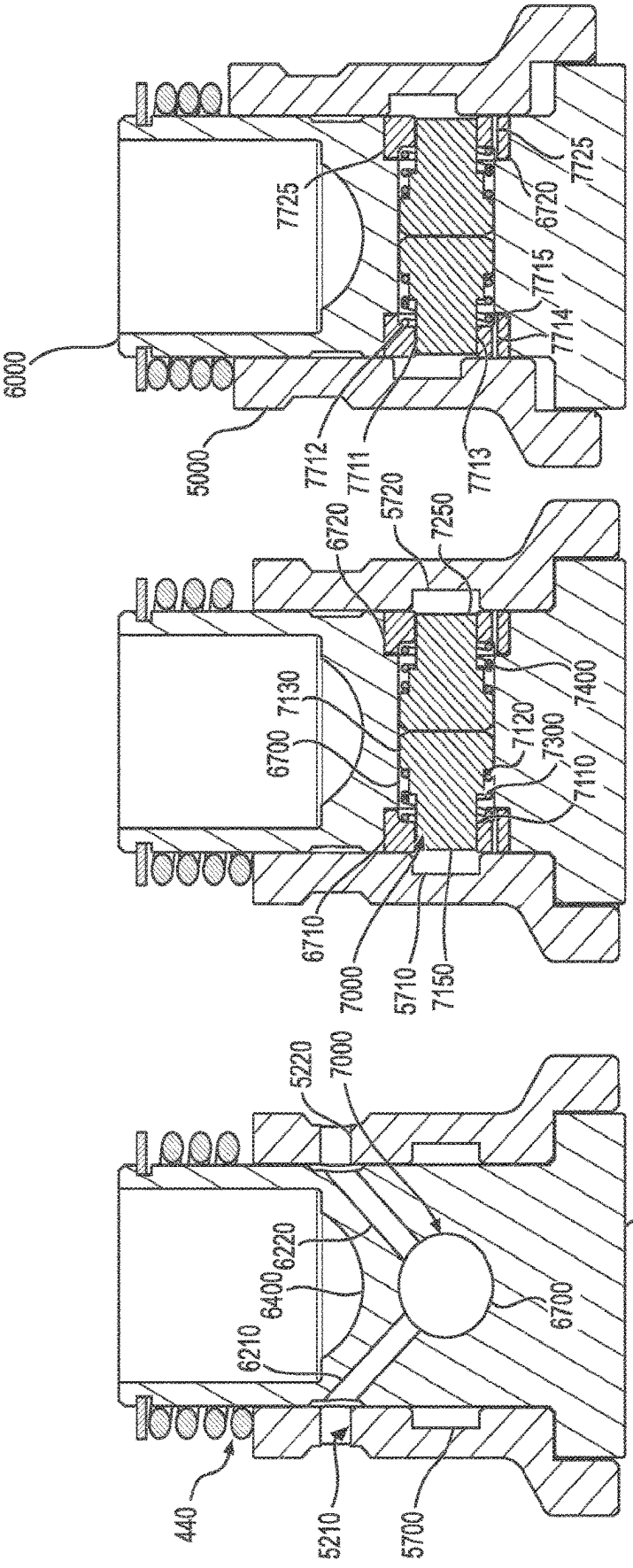

FIG. 6C

FIG. 6B

FIG. 6A

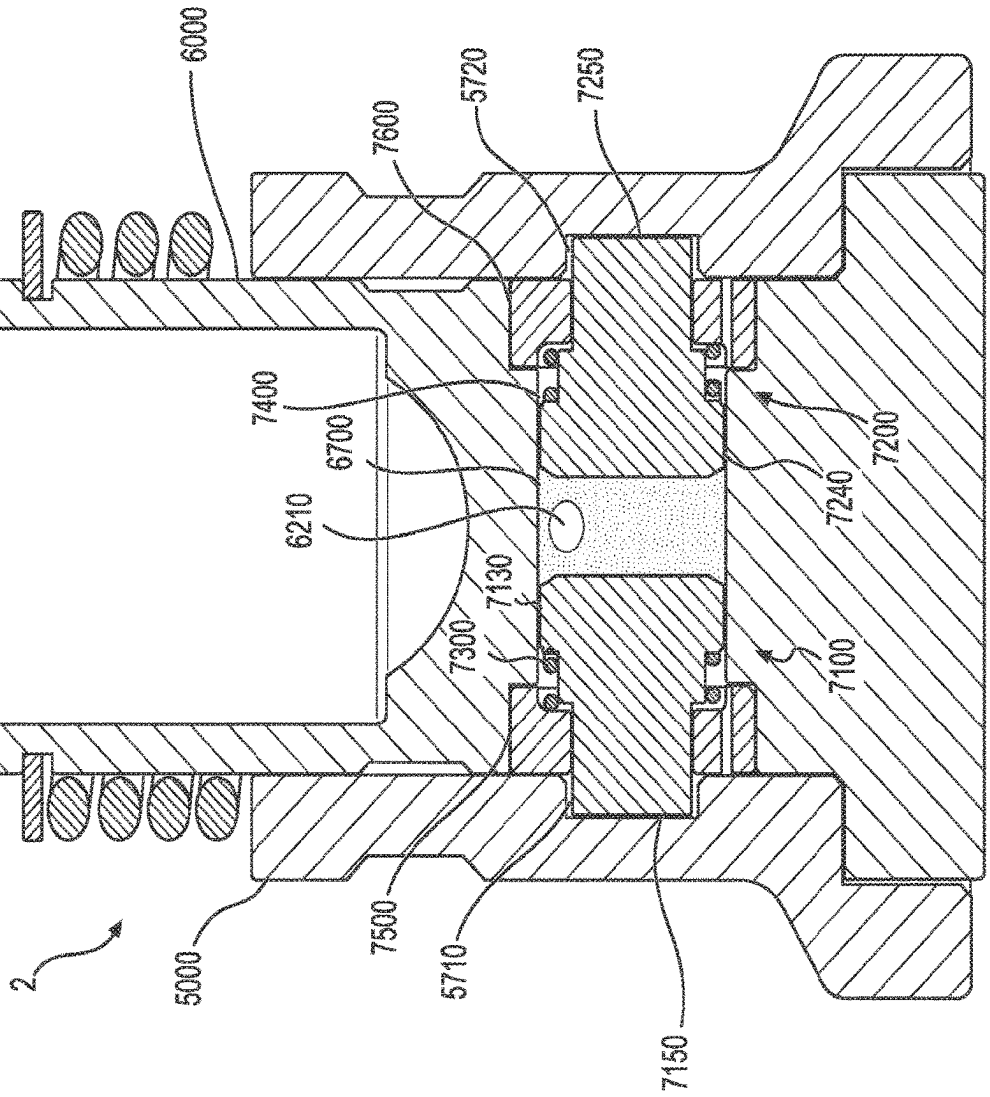
6000
7600
5720
7250
7400
6700
6210
7130
7300
7200
7240
7100
2
5000
7500
5710
7150

FIG. 7

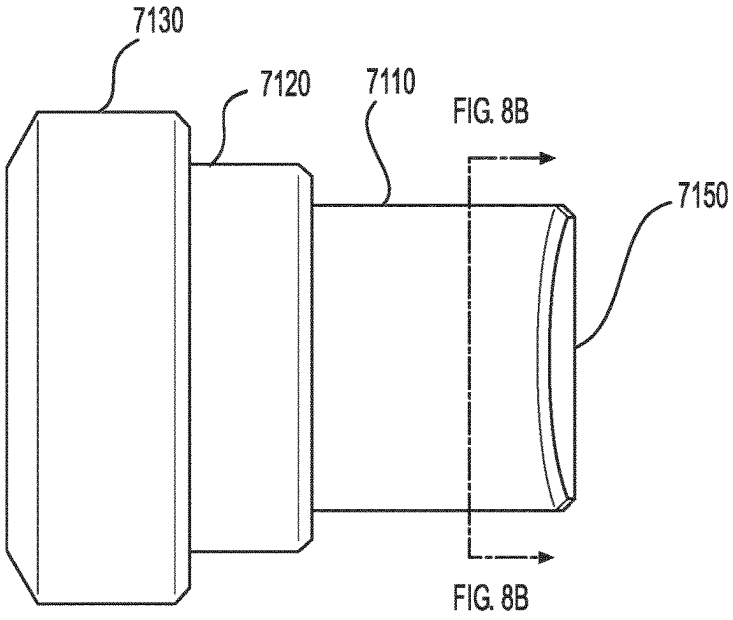

FIG. 8A

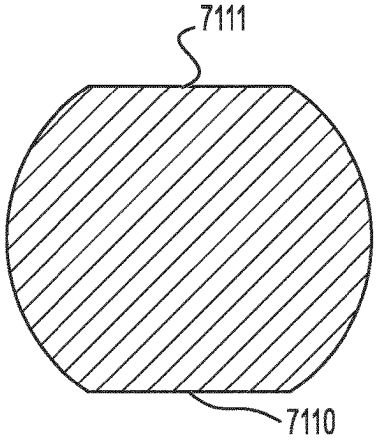

FIG. 8B

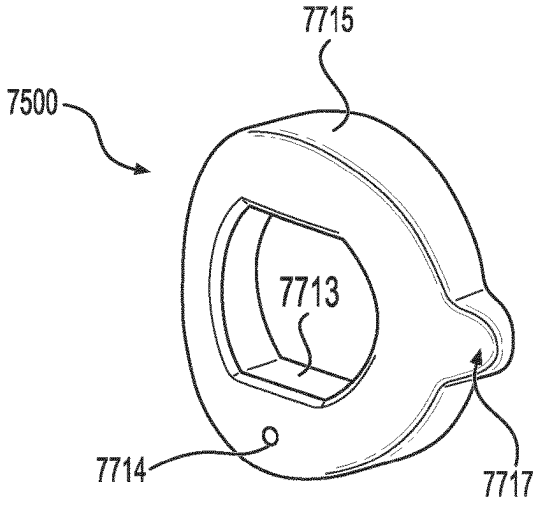

FIG. 9A

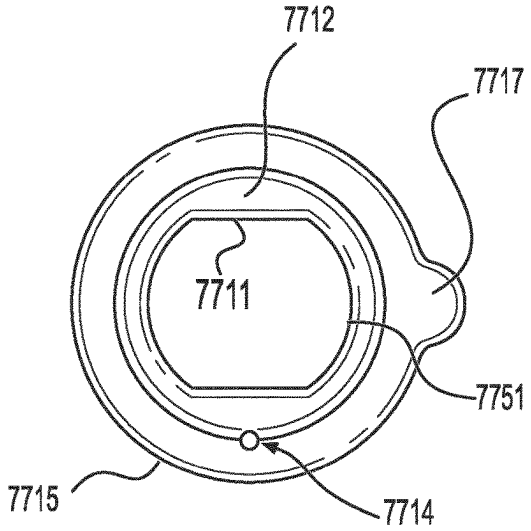

FIG. 9B

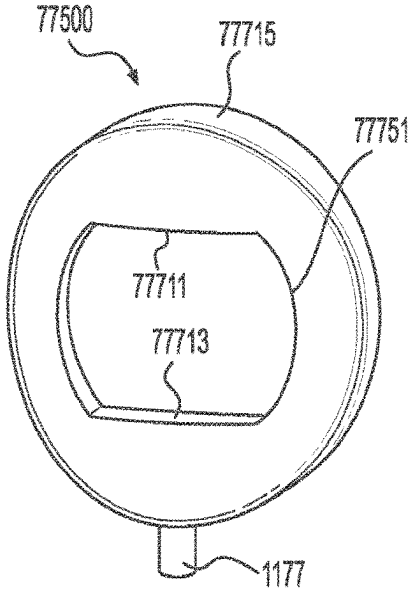

FIG. 10A

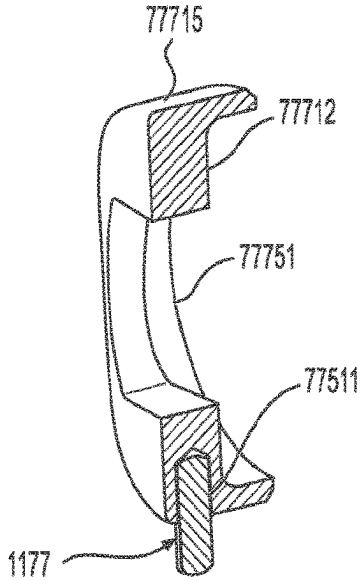

FIG. 10B

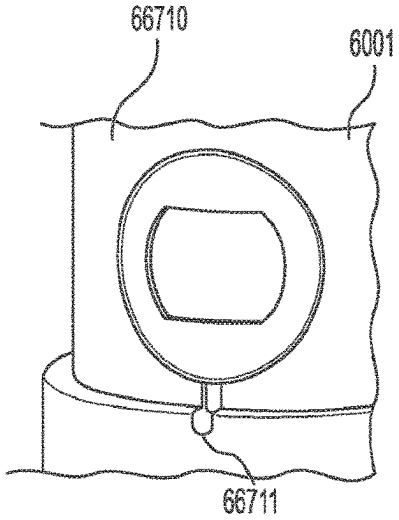

FIG. 11A

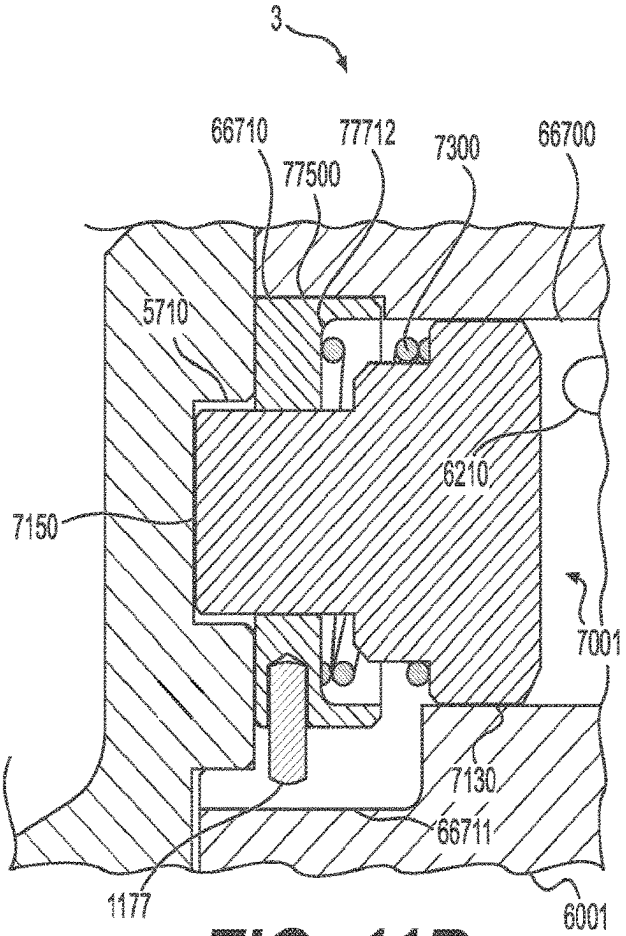

FIG. 11B

LIFTER ASSEMBLY

This is a United States § 371 National Stage Application of PCT/EP2020/025471 filed Oct. 22, 2020 and claims the benefit of Indian provisional application 20/1911042844 filed Oct. 22, 2019, all of which are incorporated herein by reference.

FIELD

This application provides a lifter assembly and pin assembly.

BACKGROUND

Engines can be designed to lift and lower valves in a valvetrain by installing a lifter assembly in the engine block and by rotating a cam formed with one or more lift profiles. Challenges exist for fast actuation and oil control.

SUMMARY

The methods and devices disclosed herein improve the art by way of a lifter assembly comprising an outer body comprising an oil port and opposed latch ports. An inner body can comprise a roller assembly or tappet configured to lift and lower to follow a cam. The inner body comprises a pin passage comprising an inner diameter. A pin assembly is mounted in the pin passage. The pin assembly comprises a bushing abutting the inner diameter. The bushing comprises a pin port. A pin comprises a rim and a narrow end configured for sliding in the pin port.

A pin assembly can be configured for mounting in a pin passage. The pin assembly comprises a bushing for abutting an inner diameter of the pin passage. The bushing comprises a pin port. A pin comprises a rim and a narrow end configured for sliding in the pin port.

The bushing can be pressed to a stepped inner diameter of the inner body. Then, the rim can slide against the inner diameter.

In another alternative, the inner body can comprise a slot, and the bushing can comprise a recess. A stake can span a portion of the slot and into the recess. The slot can form a fluid leak-down path. Or, the bushing can further comprise a fluid leak-down path. Or, the stake can comprise a fluid leak-down path.

The bushing can alternatively comprise a step and a bore in a tubular structure configured so that the rim is guided within the bore and is limited by the step. The bushing can comprise an end wall comprising the pin port. The end wall can comprise a spring seating area. The pin assembly comprises a spring biased against the spring seating area and the rim. The pin assembly can be biased so that the pin is retracted away from the latch ports. The lifter assembly and pin assembly can be configured so that the inner body further comprises a stop pin bore intersecting the pin passage. A stop pin can be installed in the stop pin bore with the stop pin configured to limit the travel of the pin. The bushing can also be configured with an oil slot to fluidly communicate with the oil passage.

The pin port and the narrow end can be keyed in an anti-rotation configuration. An anti-rotation groove can alternatively be formed in an external diameter of the bushing and a rod bore can be formed through the inner body and can intersect the pin passage. Then, an anti-rotation rod can be seated in the anti-rotation groove and in the rod bore.

In another alternative, the inner body can further comprise a follower anti-rotation bore. The outer body can further comprise a follower anti-rotation slot. A follower anti-rotation rod can be seated to extend out of the follower anti-rotation bore into the follower anti-rotation slot. The follower anti-rotation bore can pass through the inner body. And, the anti-rotation rod can pass through the inner body completely and extends out into a second follower anti-rotation slot.

Additional objects and advantages will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the disclosure. The objects and advantages will also be realized and attained by means of the elements and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**A & **1**B show a lifter assembly and a pin assembly.

FIG. **2** is an exploded view of a lifter assembly and a pin assembly.

FIG. **3** is a view of a stop pin and pin travel. The pin assembly is shown with one pin latched and one pin unlatched in FIGS. **1**B & **3**.

FIG. **4** is a view of a bearing assembly configured to oppose twist relative to the outer body.

FIGS. **5-7** are views of an alternative lifter assembly and alternative pin assembly.

FIGS. **8**A & **8**B are views of a pin.

FIGS. **9**A & **9**B are views of an alternative bushing.

FIGS. **10**A & **10**B are views of another alternative bushing.

FIGS. **11**A & **11**B are views of an alternative lifter assembly with an alternative pin assembly.

DETAILED DESCRIPTION

Reference will now be made in detail to the examples which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts. Directional references such as "left" and "right" are for ease of reference to the figures.

A lifter assembly **1**, **2**, **3** can be used in an engine between a cam rail and a valvetrain to lift and lower one or more valves of combustion cylinders according to the patterns formed on the cams **7** of the cam rail. A cam **7** is shown generally in FIGS. **1**A & **1**B. Lobes **31-33** impart lift profiles to the lifter assembly **1-3**. If the lifter assembly, is latched (FIGS. **7** & **11**; Right-hand of FIG. **1**B; & bottom of FIG. **3**), a first lift profile is imparted to one or more valves via the connection of push rod **4** to the valvetrain. If the lifter assembly is unlatched (FIGS. **6**B & **6**C; Left-hand of FIG. **1**B and top of FIG. **3**), a different lift profile is imparted to the one or more valves. Such variable valvetrain (VVA) techniques as engine braking (EB), cylinder deactivation (CDA), Late or Early valve closing or opening (LIVC, EIVC, LIVO, LEVO, EIVC, EIVO, EIVO, EEVO), and lost motions can be accomplished. In this disclosure, the latch pin assembly **70**, **7000**, **7001** is shown biased to the unlatched position, but the latch pin assembly can be biased to the latched position as by adjusting the springs and oil control.

A lifter assembly **1**, **2**, **3** can comprise an outer body **5**, **5000** comprising an oil port **52**, **5200** and opposed latch ports **571**, **572**, **5710**, **5720**. In lifter assembly **1**, the opposed

latch ports **571**, **572** can be formed by tooling or cross-drilling, as examples. It would not be desired to have the inner body **6** rotate inside the outer body **5**. In lifter assembly **2**, **3**, the opposed latch ports **5710**, **5720** can be formed by a recess **5700** carved or tooled or cast in an inner diameter of the outer body **5000**. In the lifter assembly **2**, the inner body **6000** can rotate within the outer body **5000** because the latch ports in the recess **5700** can accommodate the rotation.

An inner body **6**, **6000** can comprise a roller assembly **63** or tappet **6300** configured to lift and lower to follow the lobes **31-33** of cam **7**. The inner body **6**, **6000** comprises a pin passage **67**, **6700**, **66700** comprising an inner diameter. A pin assembly **70**, **7000**, **7001** is mounted in the pin passage **67**, **6700**, **66700**. The pin assembly **70**, **7000**, **7001** comprises a bushing **75**, **76**, **7500**, **7600**, **77500** abutting the inner diameter. In lifter assembly **1**, the inner diameter is largely cylindrical and the bushing **75**, **76** is tubular and the bushing can be pressed or slipped inside the inner diameter. In lifter assembly **2**, **3**, the inner diameter is also largely cylindrical, but the inner diameter is stepped with steps **6710**, **6720**, **66710** at a junction of the external surface of the inner body. An outer surface **7715**, **7725**, **77715** of the bushing **7500**, **7600**, **77500** can be pressed to the steps **6710**, **6720**, **66710** of stepped inner diameter of inner body **6000**, **6001**. The inner body **6000** of lifter assembly **2** can comprise an additional anti-rotation step in addition to the step **66710** so that the bushing **7500** can comprise an anti-rotation notch **7717** to press to the stepped inner body.

The bushing **75**, **76**, **7500**, **7600**, **77500** is configured not to rotate and the pins **71**, **72**, **7100**, **7200** can be configured not to rotate. This can improve the lifter assembly by reducing fluid pressure needed for actuation. And, the bushing can be used to support and align the pin. During use, the pins receive load, and the support and alignment provided by the bushing can improve load-bearing, prevent pin bending, and improve actuation response. Further, the bias springs **73**, **74**, **7300**, **7400** can have reduced spring length and spring stress due to the support offered by the bushing. For switching the lifter assembly **1**, **2**, **3** between latched and unlatched, a fluid is supplied via oil supply **20** or gallery to outer body oil port **52**, **5210**, **5220** and inner body oil passages **621**, **6210**, **6220** to move the pins **71**, **72**, **7100**, **7200**. The bushing **75**, **76**, **7500**, **7600**, **77500** comprises a pin port **751**, **7751**, **77751**. The pin **71**, **72**, **7100** comprises a rim **713**, **723**, **7130**, **7240** and in some configurations a cup **724** to receive the supplied fluid. With appropriate fluid pressure, the pin can be moved. A narrow end **710**, **7100** of the pin can be configured for sliding in the pin port **751**, **7751**, **77751**. An optional spring-guiding lip **712**, **7120** can also function as a travel stop to limit how far the pin can slide through the pin port. The pin port **751** can be formed in an end wall **750** of the bushing **75**, **76** or the pin port **7751**, **77751** can be stamped or molded or formed through the body of the bushing **7500**, **77500**.

The pin port **751**, **7751**, **77751** and the narrow end **710**, **7100** are keyed in an anti-rotation configuration. This can mean that the narrow end **710** is cylindrical but for a flat **711** that slides against a corresponding flat in end wall **750**. Or, two flats **7111**, **7110** can be formed in the otherwise cylindrical narrow end **7100**. These two flats **7111**, **7110** on the pins can slide against corresponding flats **7711**, **7713**, **77711**, **77713** in the pin port **7751**, **77751** of the bushing **7500**, **77500**. Additional curves or other shapes can be formed on the end faces **715**, **725**, **7150**, **7250** such as chamfers or rounding that prevents stiction, over-travel, or adhesion to the latch ports **5710**, **5720**, **571**, **572**.

In the pin assembly **70**, the bushing **75**, **76** comprises a step and a bore **753** in a tubular structure configured so that the rim **713** is guided within the bore **753** and is limited by the step. The step can be a part of the end wall **750** and the step can be comprised of the end wall **750** or a formation on the end wall. The bushing **75**, **76** can be configured to seat a bias spring **73**, **74** against the end wall **750** or the bushing **7500**, **77500** can be configured to seat a bias spring **7300**, **7400** against a spring rim **7712**, **77712** in the body of the bushing. The bias springs **73**, **74**, **7300**, **7400** can be seated against the end wall **750** or spring rim **7712**, **77712**, as appropriate, and can surround optional spring-guiding lip **712**, **7120** with an abutment to rim **713**, **723**, **7130**, **7240**. It can be said that the bushing **75**, **76**, **7500**, **77500** comprises an end wall comprising the pin port, wherein the end wall comprises a spring seating area such as the spring rim **7712**, **77712** or a portion or formation on the end wall **750**, and wherein the pin assembly further comprises a spring biased against the spring seating area and the rim **713**, **723**, **7130**, **7240**.

This configures the pins **71**, **72**, **7100** as normally-biased unlatched. The pin assembly **70**, **7000**, **7001** is biased so that the pins **71**, **72**, **7100** are retracted away from the latch ports **571**, **572**, **5710**, **5720**. It can be possible, as shown in the lifter assembly **1**, to form the inner body **6** with a stop pin bore **693** intersecting the pin passage **67**. A stop pin **93** can be placed in the stop pin bore **693** to limit the travel of the pins **71**, **72**. When pressurized fluid is supplied to the oil port **52** of the outer body **5**, it is configured to fluidly communicate with an oil passage **621** in the inner body **6**. The bushing can be configured with an oil slot **721** to fluidly communicate with the oil passage **621** to receive the pressurized fluid. Then, the pin **72** can be pushed to overcome the bias spring **74** to latch in the latch port **572**. But without pressurized fluid, the bias spring **73** pushes the pin **71** out of the latch port **571** and into the inner body **6** so that the inner body can reciprocate within the outer body **5** according to the cam lobe profiles. To prevent the bias spring **73** from overcoming the bias spring **74**, or vice versa, the stop pin **93** can be inserted. Then the rims **713**, **723** abut the stop pin when biased to the unlatched or retracted pin assembly position. Overtravel of the pins **71**, **72** is prevented. Stop pin slots **793** can be formed in the bushings **75**, **76** to accommodate the stop pin **93**. This can provide an anti-rotation feature to the bushings **75**, **76**.

An additional anti-rotation feature can be provided to the bushings **75**, **76**. An anti-rotation groove **791**, **792** can be formed in an external diameter of the bushing **75**, **76**. Corresponding rod bores **691**, **692** can be formed through the inner body **6** to intersect the pin passage **67**. Anti-rotation rods **91**, **92** can be seated in the anti-rotation grooves **791**, **792** and the rod bores **691**, **692** to prevent the bushings from rotating and altering the position of the flats **711** on the pins **71**, **72**. Force transfer to the flats **711** can be assured.

In additional aspects, pin support and anti-rotation of the pins **7100**, **7200** can be shown. In FIGS. **6**A-**7** & **11**B the rim **7130**, **7240** slides against the inner body **6700**. Pressurized fluid can be supplied to oil passage **6210** to push the pins **7100**, **7200** apart as in FIGS. **7** & **11**B. To return from the latched position to the unlatched position of FIGS. **6**B & **6**C, it can be beneficial to include an oil drain slot **66711** as a fluid leak-down path in addition to the step **66710**. Bushing **77500** can comprise an anti-rotation stake **1177** pressed in the slot **77511** of the bushing and pressed into the drain slot **66711**. Fluid pressure can be relieved while securing an anti-rotation function. The bias springs **7300**, **7400** can assist

with pushing the pressurized fluid out of the drain slot **66711** to return to the unlatched position.

Alternatively, the bushing **7500**, **7600** can comprise an oil drain **7714**, **7725** as a fluid leak-down path to alleviate the fluid pressure and return from a latched position to an unlatched position.

In yet another alternative, in the lifter assembly **1**, the inner body **6** comprises a slot **611**, **612**. The bushing **75**, **76** can comprise a recess **7511**. The pin assembly **70** can then further comprise a corresponding stake **11**, **12** spanning a portion of the slot **611**, **612** and into the recess **7511**. The stake **11**, **12** can hold the pin port steady relative to the inner body **6**. The stake **11**, **12** can provide a flat against which the pin flat **711** slides. And, the stake **11**, **12** can alternatively include a slot **111**, **121** to provide a fluid leak-down path.

In another anti-rotation aspect, the lifter assembly **1** can comprise a follower anti-rotation bore **68** in the inner body **6**. The outer body can comprise a follower anti-rotation slot **581**. A follower anti-rotation rod **80** can be seated to extend out of the follower anti-rotation bore **68** into the follower anti-rotation slot **581**. The follower anti-rotation bore can pass through the inner body **6** and the outer body **5** can comprise a second follower anti-rotation slot **582**. The anti-rotation rod **80** can pass through the inner body **6** completely and extend out into both the follower anti-rotation slot **581** and the second follower anti-rotation slot **582**. The anti-rotation rod **80** can assist with preventing the twisting of the bearing assembly **63** relative to the cam **7**. The anti-rotation rod **80** can also provide a travel limit for restricting the motion of the inner body **6** relative to the outer body **5** as the anti-rotation rod **80** engages with the follower anti-rotation slot **581** and the second follower anti-rotation slot **582**.

In an additional aspect, the bearing assembly **63** can be configured to prevent its twisting against the cam **7** by way of the bearing **633** bracing against the follower anti-rotation slot **581** and the second follower anti-rotation slot **582**. Bearing **633** can rotate on an axle **632** supported in ports **631** of axle arms associated with the inner body **6**. It is possible to form guide grooves on inner surfaces of tappet arms **531**, **532** of the outer body **5**. The axle **632** and bearing **633** can be guided against twisting relative to the outer body **5** thereby. Tappet arms **531**, **532** can terminate in tappet surfaces **53** that slide on lobes **32**, **33** of cam **7**.

The latched or unlatched position of the latch assembly **70**, **7000**, **7001** can control what cam lobe profile is transferred through the inner body **6**, **6000** to push rod seat **64**, **6400** to push rod **4** and onward to an affiliated valvetrain. A bias assembly **44**, **440** can comprise features such as springs, snap rings, spring seats, and the like to assist in the lifter assembly **1**-**3** following the cam **7**.

While the disclosure has shown a lifter assembly, other hydro-mechanical latching mechanisms can benefit from the latch pin assemblies **70**, **7000**, **7001** herein. While the disclosure has omitted hydraulic lash adjusters (HLAs) from the lifter assemblies **1**-**3**, it is possible to include HLAs with the anti-rotation and leak-down paths herein.

Other implementations will be apparent to those skilled in the art from consideration of the specification and practice of the examples disclosed herein.

What is claimed is:

1. A lifter assembly, comprising:

an outer body comprising an oil port and latch ports;

an inner body comprising a roller assembly or tappet configured to lift and lower to follow a cam, the inner body further comprising an oil passage fluidly communicating with a pin passage comprising an inner diameter; and

a pin assembly mounted in the pin passage, the pin assembly comprising:

a bushing abutting the inner diameter, the bushing comprising a pin port having at least one flat portion; and

a pin comprising a rim and a narrow end, the narrow end configured for sliding in the pin port and having at least one corresponding flat portion;

wherein the pin port and the narrow end are keyed in an anti-rotation configuration via the at least one flat portion of the pin port and the at least one corresponding flat portion of the narrow end, and wherein the bushing and the pin passage are keyed in an anti-rotation configuration.

2. The lifter assembly of claim **1**, wherein the inner diameter is stepped and the bushing is pressed to the stepped inner diameter.

3. The lifter assembly of claim **2**, wherein the rim slides against the inner diameter.

4. The lifter assembly of claim **1**, wherein the inner body comprises a slot, and wherein the bushing comprises a recess, and wherein the pin assembly further comprises a stake spanning a portion of the slot and into the recess.

5. The lifter assembly of claim **4**, wherein the stake comprises a fluid leak-down path.

6. The lifter assembly of claim **1**, wherein the bushing further comprises a fluid leak-down path.

7. The lifter assembly of claim **1**, wherein the bushing comprises a step and a bore in a tubular structure configured so that the rim is guided within the bore and is limited by the step.

8. The lifter assembly of claim **7**, wherein the bushing comprises an end wall comprising the pin port, wherein the end wall comprises a spring seating area, and wherein the pin assembly further comprises a spring biased against the spring seating area and the rim.

9. The lifter assembly of claim **7**, further comprising an anti-rotation groove in an external diameter of the bushing; a rod bore through the inner body and intersecting the pin passage; and an anti-rotation rod seated in the anti-rotation groove and in the rod bore.

10. The lifter assembly of claim **1**, wherein the inner body further comprises a stop pin bore intersecting the pin passage, and wherein the lifter assembly further comprises a stop pin in the stop pin bore, the stop pin configured to limit a travel of the pin.

11. The lifter assembly of claim **1**, wherein the inner body further comprises a follower anti-rotation bore, wherein the outer body further comprises a follower anti-rotation slot, and wherein the lifter assembly further comprises a follower anti-rotation rod seated to extend out of the follower anti-rotation bore into the follower anti-rotation slot.

12. The lifter assembly of claim **11**, wherein the follower anti-rotation bore passes through the inner body, wherein the outer body comprises a second follower anti-rotation slot, and wherein the anti-rotation rod passes through the inner body completely and extends out into the second follower anti-rotation slot.

13. The lifter assembly of claim **1**, wherein the bushing is configured with an oil slot to fluidly communicate with the oil passage.

14. The lifter assembly of claim 1, wherein the pin assembly is biased so that the pin is retracted away from the latch ports.

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