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(54) **LOST MOTION ROCKER BRAKE BIASING AND STROKE LIMITING SYSTEMS**

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F01L 9/10	(2006.01)

(52) **U.S. Cl.**

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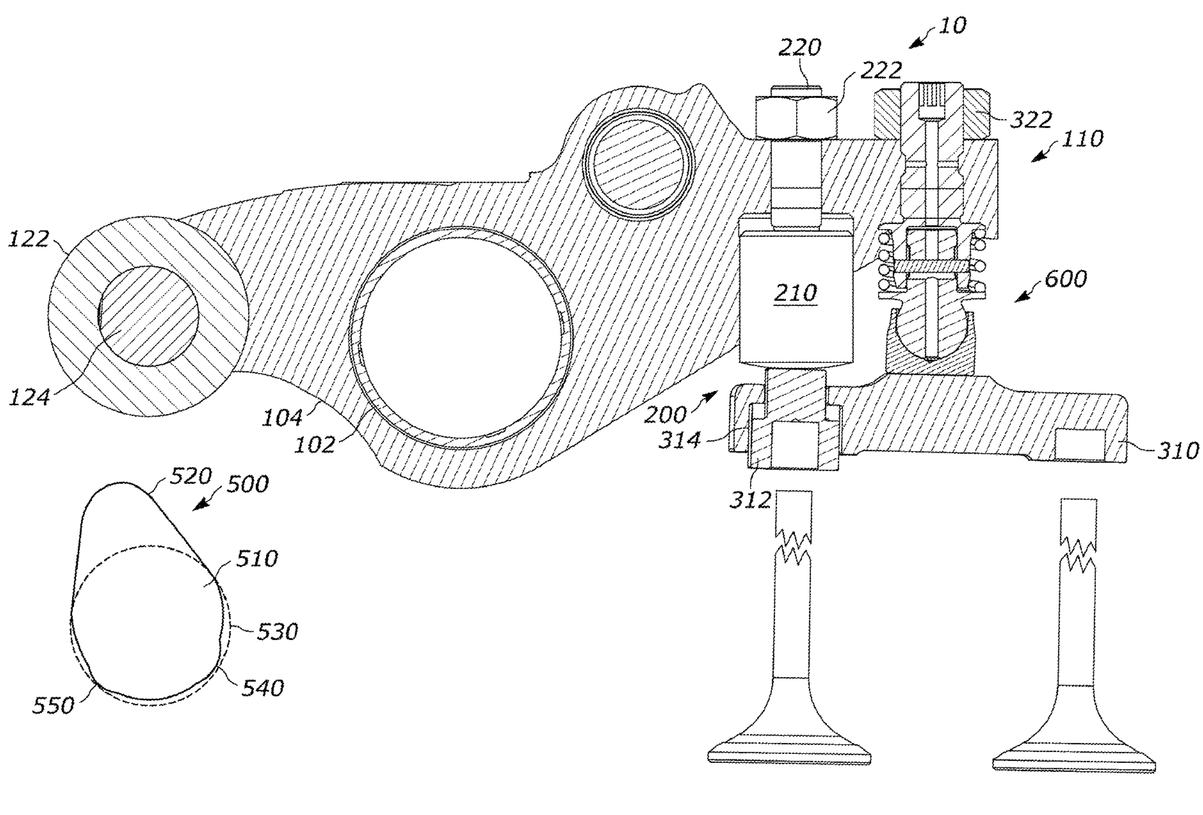
(57) **ABSTRACT**

Systems for valve actuation in internal combustion engines provide for control of rocker arms and other valvetrain components by utilizing biasing and stroke limited components. Such features may be implemented in any valvetrain component, including e-foot assemblies or pushrod assemblies. The biasing component may bias the cam side of a lost motion rocker toward the cam. The components may be extendable to permit a biasing mechanism to keep the valvetrain components in a controlled position at all times. Stroke limiting features may facilitate the formation of small gaps between valvetrain components during the engine cycle for improved lubrication. Stroke limiting features may also retain valvetrain components in an assembled configuration even when not installed in an engine or valve actuation system.



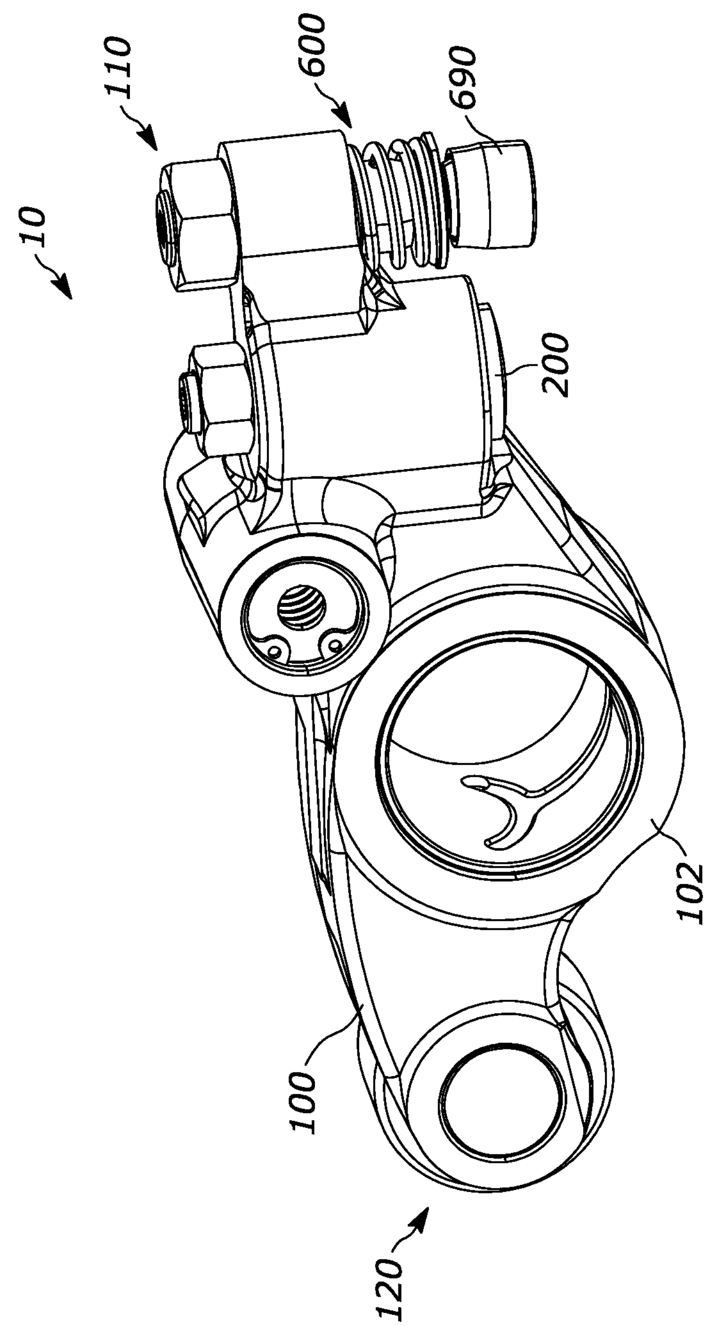


FIG. 1

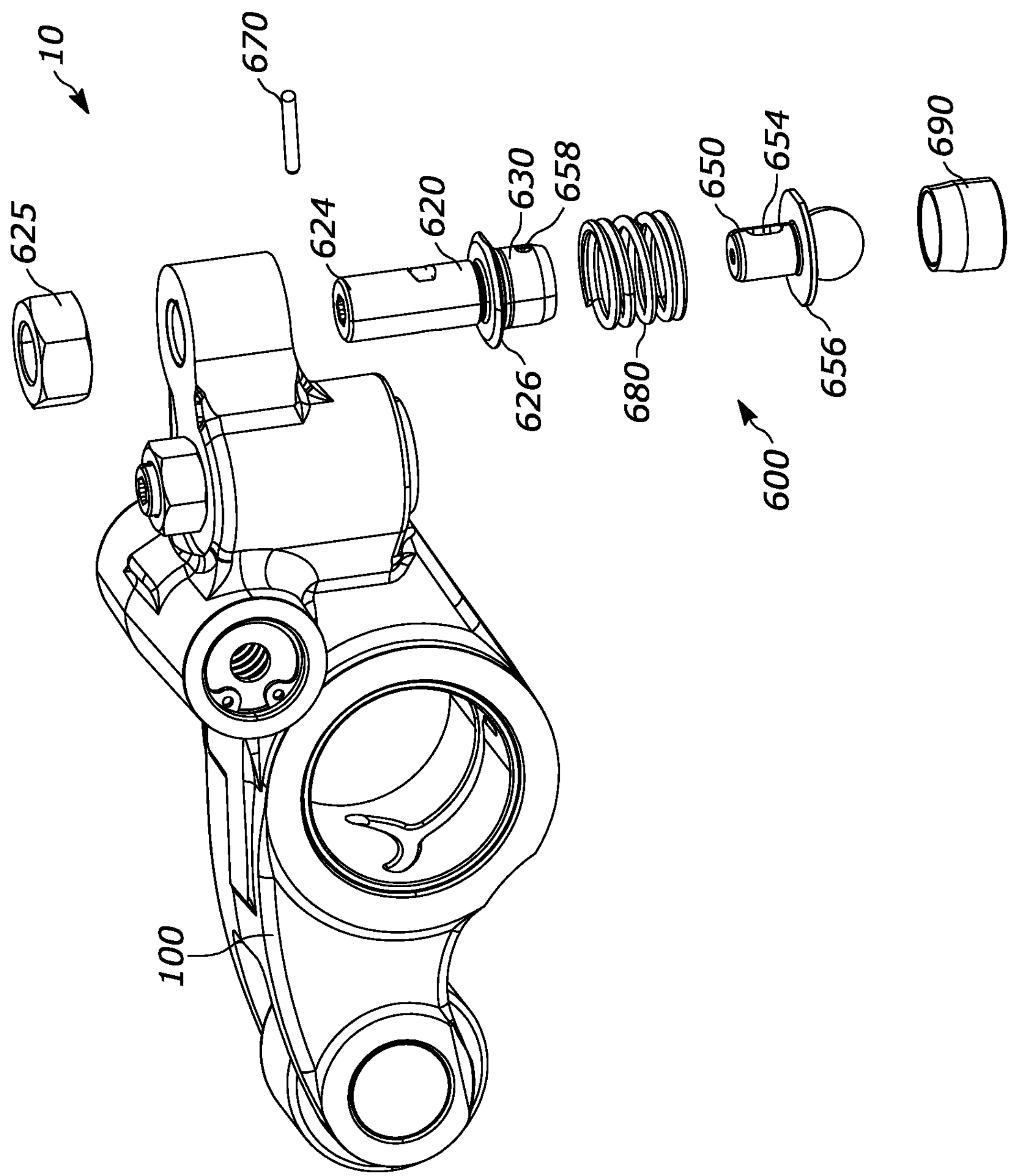


FIG. 2

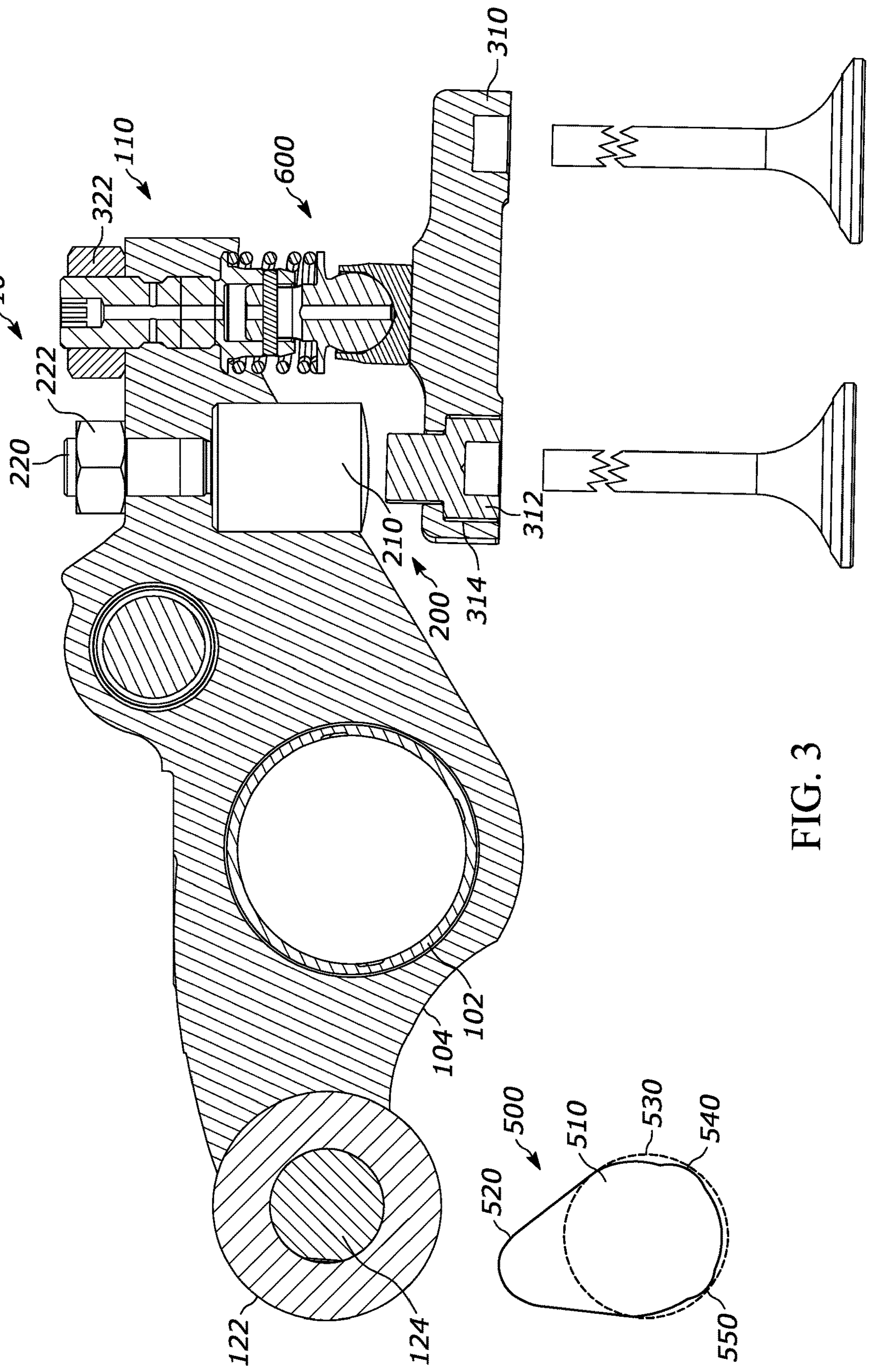

10
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FIG. 3

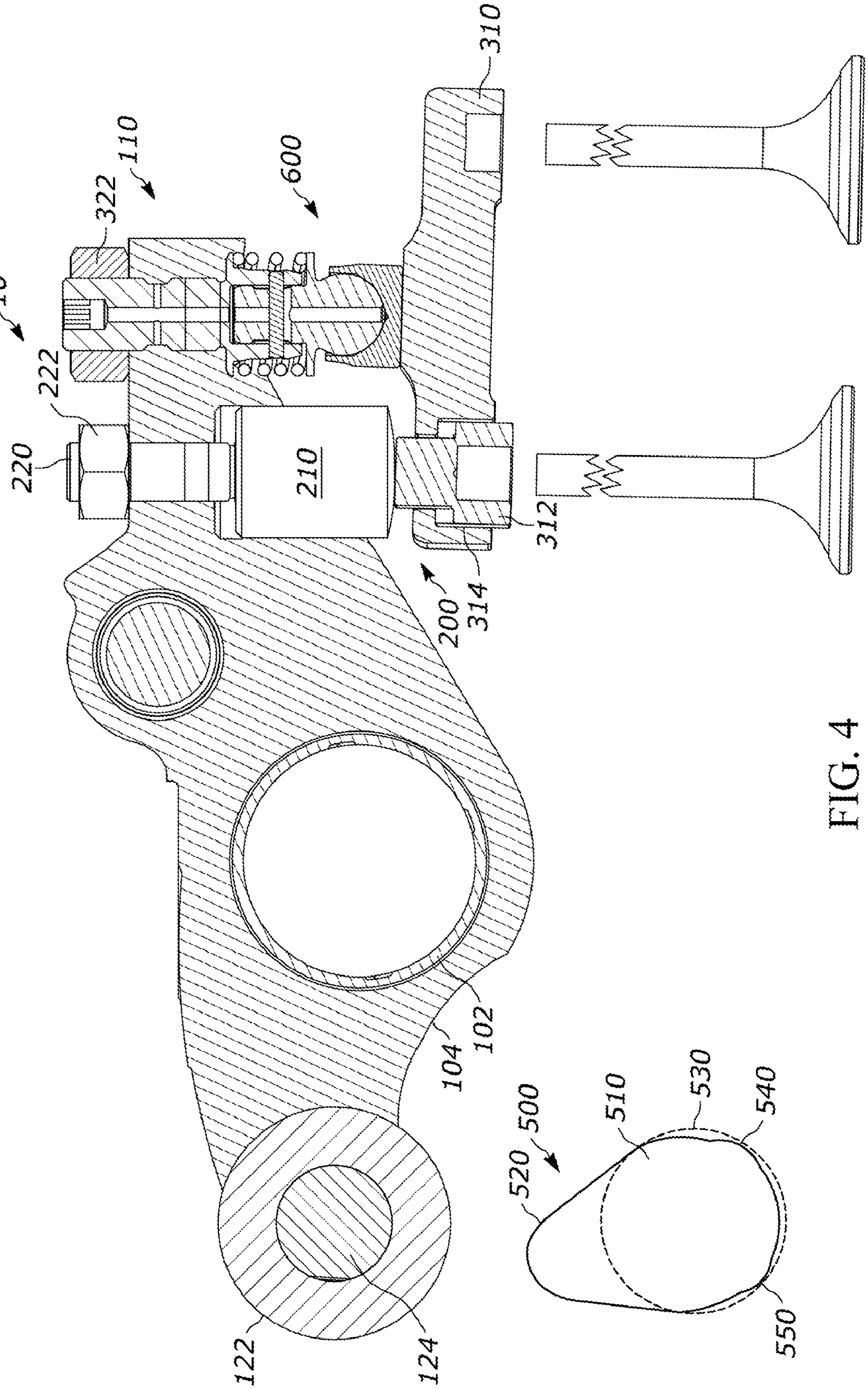
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FIG. 4

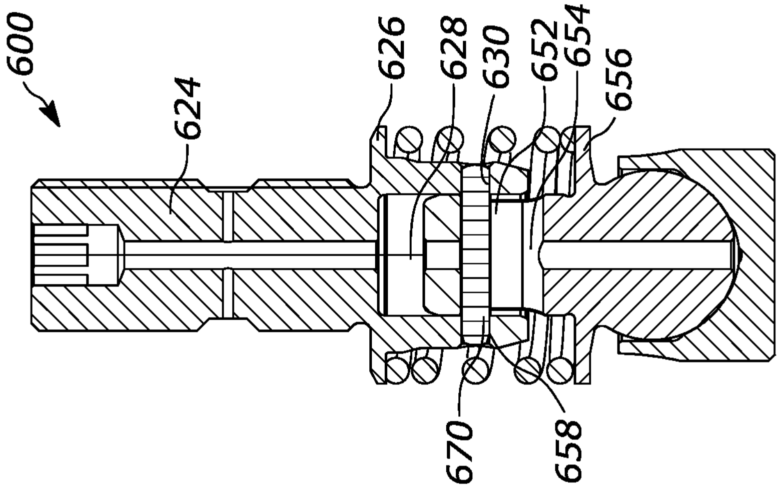
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FIG. 6

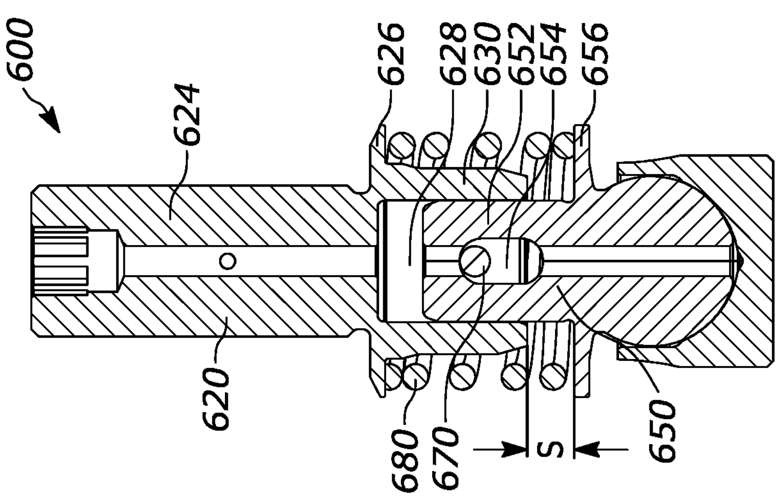
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FIG. 5

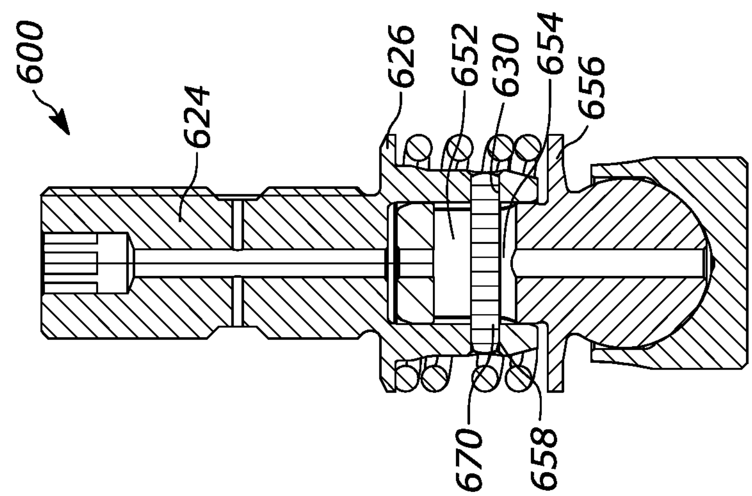
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FIG. 8

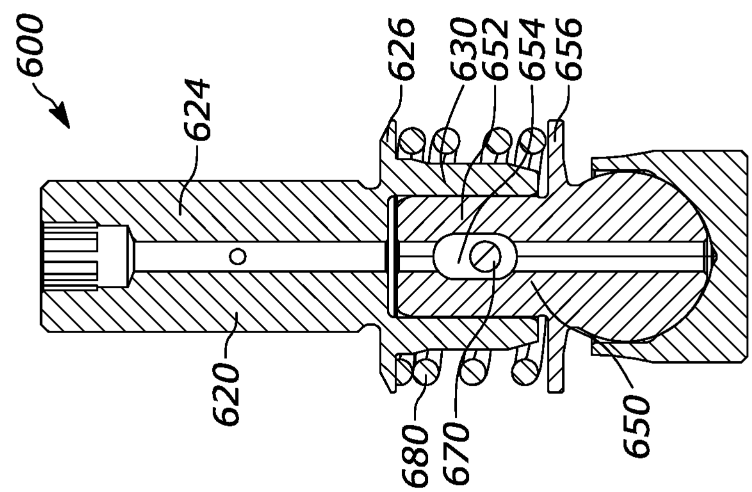
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FIG. 7

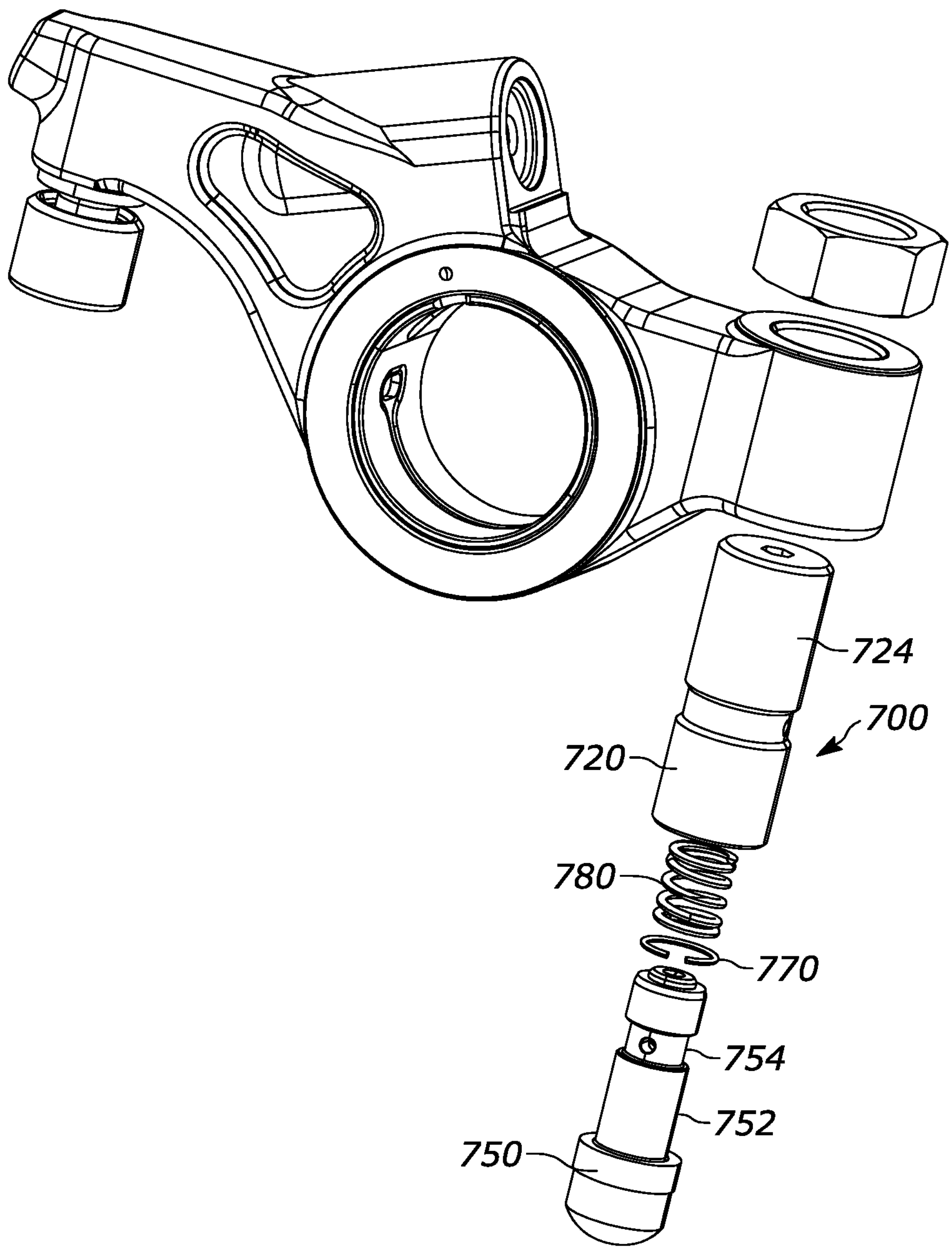

FIG. 9

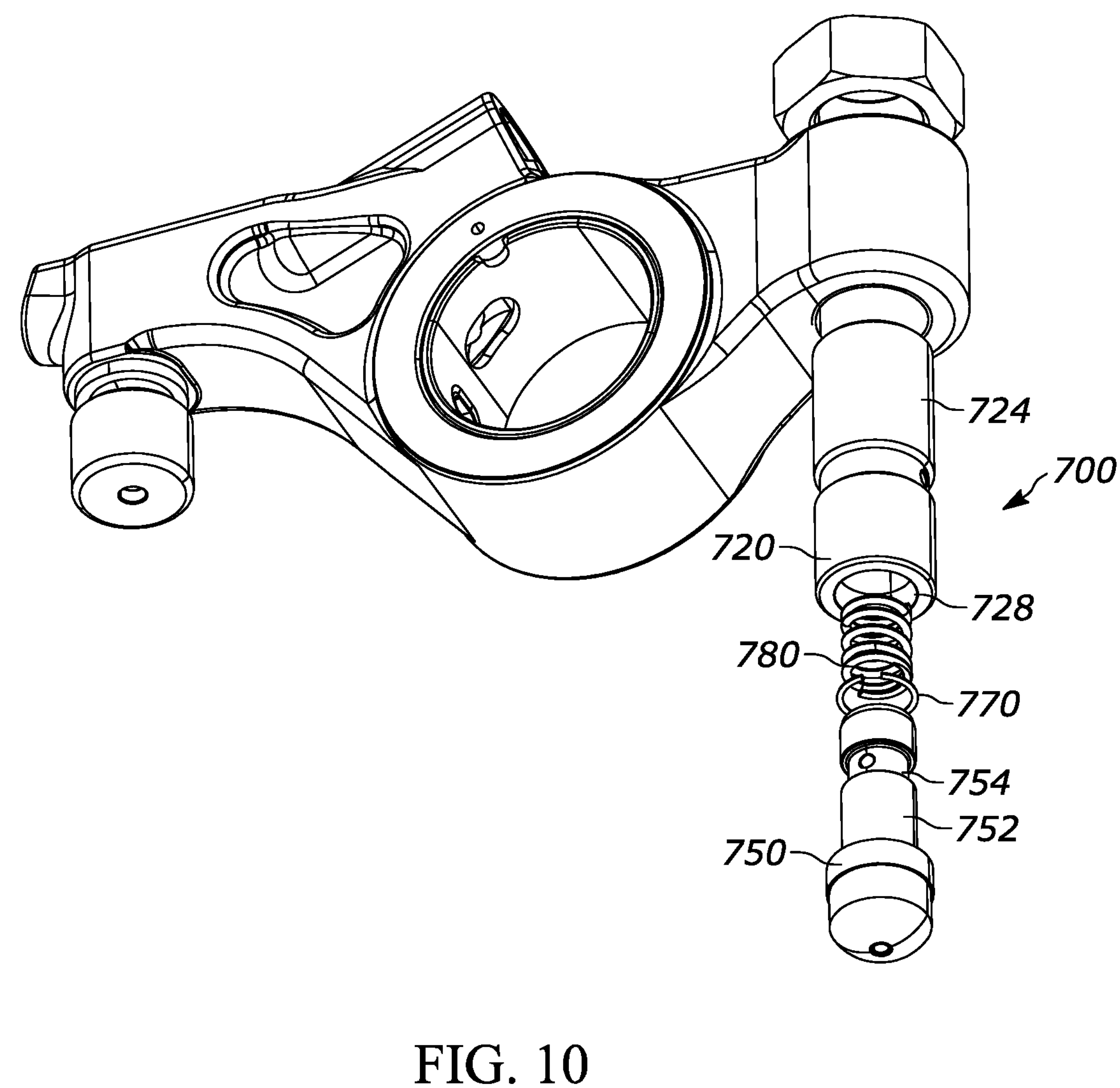

FIG. 10

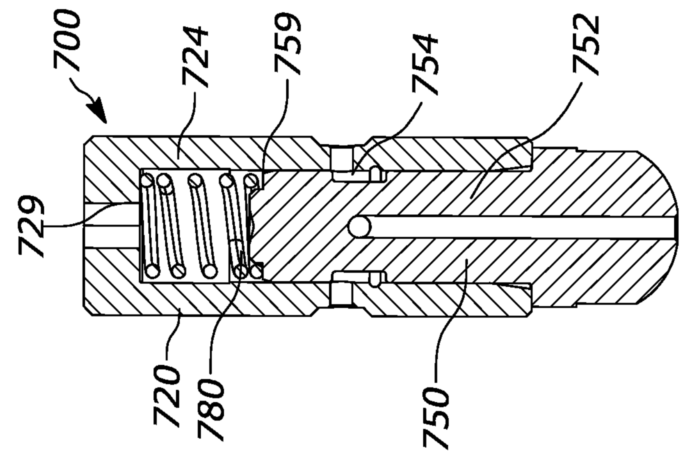
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FIG. 12

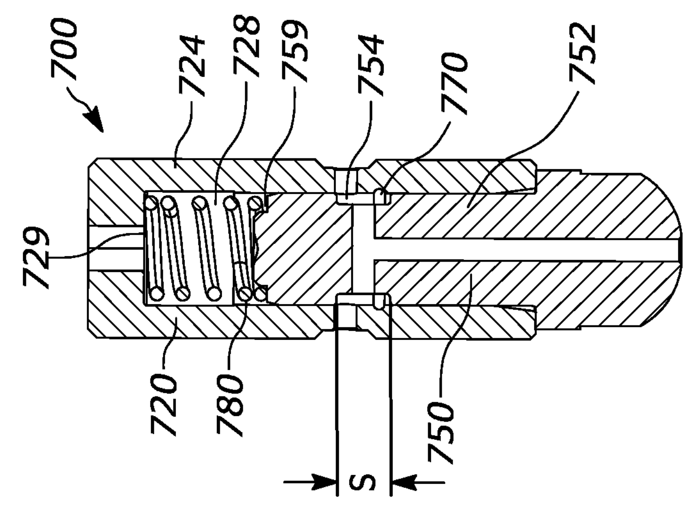
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FIG. 11

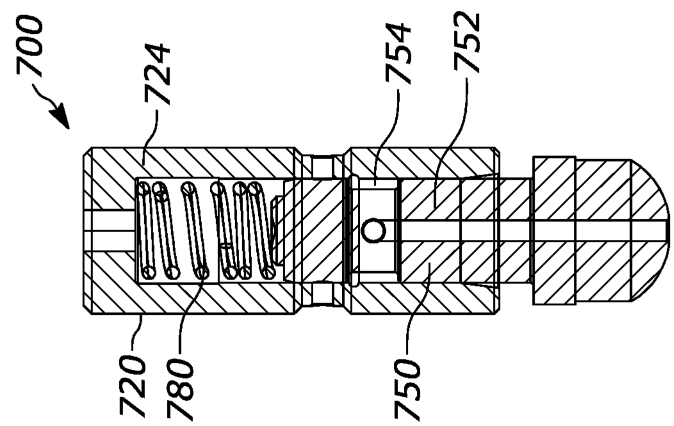

FIG. 14

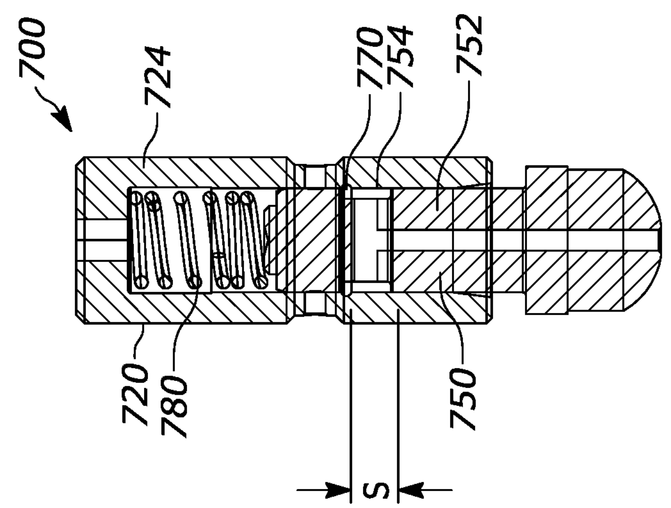

FIG. 13

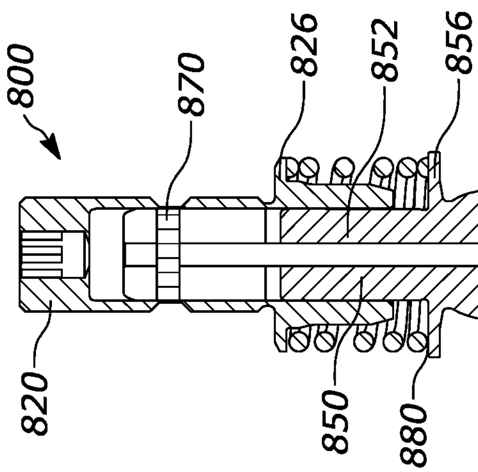
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FIG. 16

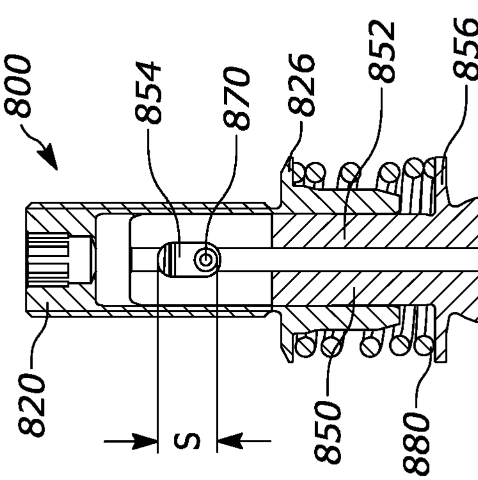
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FIG. 15

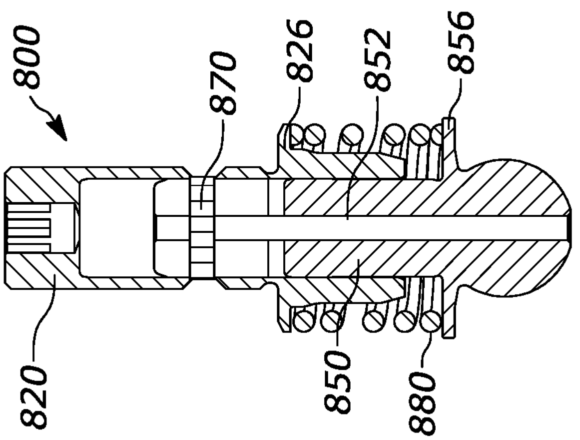
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FIG. 18

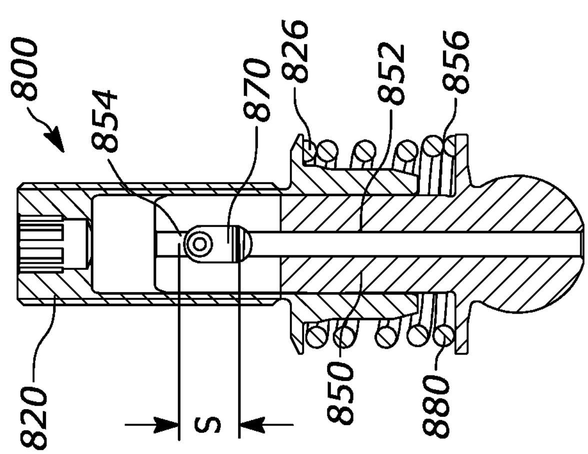
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FIG. 17

LOST MOTION ROCKER BRAKE BIASING AND STROKE LIMITING SYSTEMS

RELATED APPLICATIONS AND PRIORITY CLAIM

[0001] This application claims priority to U.S. provisional application No. 63/266,505, filed Jan. 6, 2022, and titled LOST MOTION ROCKER BRAKE BIASING AND STROKE LIMITING SYSTEMS. This application also claims priority to international application PCT/IB2021/053904 (WO2022106907), filed May 7, 2021, and titled ROCKER CONTROL IN LOST MOTION ENGINE VALVE ACTUATION SYSTEMS, which claims priority to U.S. provisional application Ser. No. 63/198,902, filed Nov. 20, 2020, and titled LOST MOTION ROCKER BRAKE BIASING SYSTEM. The subject matter and specifications of the above listed applications are incorporated by reference herein in their entirety.

FIELD

[0002] The present disclosure relates generally to systems for actuating valves and relates generally to lost motion rocker brakes for internal combustion engines. The present disclosure also relates to systems and components for controlling rocker arm motion and to stroke-limiting and biasing of lost motion rocker brake valvetrain components.

BACKGROUND

[0003] Internal combustion engines require valve actuation systems to control the flow of combustible components, typically fuel and air, to one or more combustion chambers during operation. Such systems control the motion and timing of intake and exhaust valves during engine operation. In a positive power mode, intake valves are opened to admit fuel and air into a cylinder for combustion and exhaust valves are subsequently opened to allow combustion products to escape the cylinder. This operation is typically called a “positive power” operation of the engine and the motions applied to the valves during positive power operation are typically called “main event” valve actuation motions. Auxiliary valve actuation motion, such as motion that results in engine braking (power absorbing), may be accomplished using “auxiliary” events imparted to one or more of the engine valves.

[0004] Valve movement during main event positive power modes of operation is typically controlled by one or more rotating cams as motion sources. Cam followers, push rods, rocker arms and other elements disposed in a valvetrain provide for direct transfer of motion from the cam surface to the valves. The use of a valve bridge may impart motion to plural valves from a single upstream valvetrain. For auxiliary events, “lost motion” devices may be utilized in the valvetrain to facilitate auxiliary event valve movement. Lost motion devices refer to a class of technical solutions in which valve motion is modified compared to the motion that would otherwise occur because of actuation by a respective cam surface alone. Lost motion devices may include devices whose length, rigidity or compressibility is varied and controlled to facilitate the selective occurrence of auxiliary events in addition to, or as an alternative to, main event operation of valves. Auxiliary events may also be facilitated by dedicated cam systems in which a separate auxiliary or braking cam and valvetrain may be used to impart auxiliary motion to one or more valves to facilitate the selective occurrence of auxiliary events.

[0005] In braking, and other auxiliary lost motion applications, multiple valve events may be incorporated into the same cam lobe and different events activated or deactivated, based on the selective extension or retraction of a lost motion element, such as an actuator piston. Lost motion cam systems typically use at least one cam with different profiled lift sections on the same cam lobe to impart motion for respective main event and one or more auxiliary events. These different profiled lift sections are activated or deactivated using a separate lost motion mechanism, such as a piston or actuator, located in the valvetrain. Example auxiliary events include engine braking, early exhaust valve opening (EEVO), late intake valve closing (LIVC) lift events, and internal exhaust gas recirculation events (IEGR) and can be imparted to one or more valves in a valve set (i.e., two exhaust valves for a respective cylinder). Lost motion auxiliary valve lift systems, such as lost motion braking systems, may employ a single rocker associated with the lost motion cam and a valve bridge associated with the rocker for actuating two engine valves in main event motion. Auxiliary valve lift or braking motion on one of the valves is facilitated by an auxiliary valve lift or braking actuator, which is a lost motion device that may be housed in the rocker and may selectively impart auxiliary or braking motion to the valve by way of a bridge pin disposed in the bridge. The bridge pin provides independent motion of one of the two engine valves relative to another one of the two engine valves. The auxiliary valve lift or braking actuator may be selectively activated such that the auxiliary or braking event lift profile section or lobe on the lost motion cam causes movement of the bridge pin and auxiliary or braking motion of the one engine valve when desired.

[0006] Some lost motion valve actuation systems may utilize sub-base circle lost motion profiles on one or more cams. In such systems, a main event valve lift profile may be provided on the cam above the cam base circle, whereas lost motion profiles are provided on the same cam below the cam base circle. During main event motion, with the lost motion actuator deactivated, a lost motion gap is produced in the valvetrain, and the sub-base circle profiles are, as a result, lost and not passed on to the engine valve(s). When the lost motion actuator is activated, the lost motion gap in the valvetrain is taken up, and the auxiliary motion profile(s) may be conveyed to the engine valve(s).

[0007] Existing solutions for rocker control in such lost motion environments have utilized biasing mechanisms, which may bias a cam side of the rocker towards the cam so that the rocker cam follower is in constant contact with the cam, even during events that would otherwise cause gaps in the valvetrain, thus preventing uncontrolled motion of the rocker during these events. Biasing mechanisms that achieve these results may include spring bars, actuator piston springs or an undermounted rocker bias spring.

[0008] Cam side rocker biasing solutions in the prior art are not without disadvantages. For example, in such solutions, particularly when sub-base circle auxiliary events are utilized, strong biasing forces, on the order of several hundred Newtons of force, and appropriately designed biasing components may be required to maintain contact between the cam roller (follower) and cam lobe in the brake off condition—when the auxiliary motion lift actuator is in a deactivated state. Such biasing forces are required because, with the auxiliary motion lift actuator deactivated, the full mass of the rocker arm is typically exposed to the acceleration and deceleration forces generated by the cam and, as a result, the rocker arm and cam follower may otherwise tend to separate from the cam surface.

[0009] Lost motion rocker brakes are generally known in the art of valvetrain and valve actuation system design for internal combustion engines. Lost motion systems allow profiles for multiple valve events to be incorporated into the same exhaust cam lobe and the different events activated or deactivated based on selective extension or retraction of a lost motion element, such as a lost motion actuator piston.

[0010] One concern with lost motion rocker brakes is that when the brake is in the deactivated or "off" state, there may be a large gap created by the retraction of the lost motion element. More specifically, a gap may be created between the lost motion element and other valvetrain components, such as a motion source or cam. This gap may leave the rocker brake unloaded or unconstrained and may therefore allow uncontrolled motion of the rocker brake. Past solutions intended to address this concern have utilized biasing mechanisms that bias the lost motion rocker brake towards the valves to keep the rocker brake in constant contact with the valve bridge and avoid uncontrolled motion in the valvetrain.

[0011] The instant disclosure will describe details of additional embodiments for biasing and stroke limiting that are particularly adaptable to lost motion rocker brake systems. The embodiments of the instant disclosure are particularly adaptable to e-foot, push rod and other valvetrain components and environments.

SUMMARY

[0012] Responsive to the foregoing challenges, and according to one aspect, the instant disclosure provides various embodiments of valve actuation systems with features for controlling rocker motion, which features may be applied in lost-motion systems. More particularly, the disclosure describes systems in which a biasing component is arranged and adapted to bias a cam side of the rocker in a direction that is towards the cam. Additional aspects may provide biasing components on an e-foot that cooperates with a valve bridge to eliminate gaps and further enhance control of the rocker and valve bridge. The e-foot may further be provided with a defined stroke to facilitate the formation of a gap between valvetrain components to permit a layer of oil to form during the valve cycle. The e-foot may further be provided with a retaining feature to maintain the e-foot in an assembled state even when the e-foot is not in contact with another valvetrain component (i.e., a valve bridge). The described systems facilitate rocker control even during deactivation of a lost motion component, improved lubrication, and ease of assembly.

[0013] According to an aspect, the disclosure provides system for actuating at least one of two or more engine valves in an internal combustion engine, the system comprising: a motion source defining a main event motion profile and an auxiliary motion profile; a valvetrain for conveying motion from the motion source to the at least one engine valve, the valvetrain having at least two valvetrain components; a biasing component arranged to apply a biasing force to maintain at least one of the valvetrain components in a controlled state; and a stroke limited component cooperating with the biasing component and adapted to create a lash gap between the at least two valvetrain components. According to a further aspect, the system may comprise a lost motion component cooperating with the valvetrain, the lost motion component being configurable to a first mode, in which the lost motion component absorbs the auxiliary motion, and a second mode, in which the lost motion component conveys the auxiliary motion.

[0014] According to a further aspect, the biasing component may be a spring arranged as part of an e-foot assembly. In a further aspect, the e-foot assembly may include an extendable portion and the spring may be arranged to bias the extendable portion towards an extended position. In a further aspect, the e-foot assembly may include a telescoping portion.

[0015] According to a further aspect, the stroke limited component may be an e-foot assembly. The e-foot assembly may include an extendable portion. The extendable portion may include a stop for limiting the extension of the extendable portion.

[0016] According to a further aspect, the biasing component may be a spring arranged as part of a push rod assembly. In a further aspect, the push rod assembly may include an extendable portion. In a further aspect, the spring may be arranged to bias the extendable portion towards an extended position. In a further aspect, the push rod assembly may include a telescoping portion.

[0017] According to a further aspect, the stroke limited component may be a pushrod assembly. In a further aspect, the pushrod assembly may include an extendable portion and the extendable portion may include a stop for limiting extension of the extendable portion. According to a further aspect, the biasing component may be arranged to bias a motion source (cam) side of the rocker towards a motion source (cam).

[0018] According to a further aspect, the system further comprises an e-foot biasing component for maintaining the e-foot in contact with other valvetrain components.

[0019] According to a further aspect, the e-foot is configured to be extendable in length to define a stroke. According to a further aspect, the biasing component or stroke limited component may comprise an e-foot assembly comprising a screw boss, a swivel boss, a pin, a cap and a bias spring. According to a further aspect the biasing component or stroke limited component may comprise a pushrod assembly comprising a screw boss, a swivel boss, a push rod boss, a pin and a bias spring. In another aspect, the stroke limited component may comprise a pushrod adjustment screw. In a further aspect, the stroke limited component may comprise a pin, a lip, a c-clip or a step for limiting extension of an extendable portion. According to a further aspect, the biasing component may be arranged to control inertial forces of the rocker arm to prevent a no follow condition between a sub-base and base circle of a cam. According to a further aspect, the biasing component may be adapted to provide a zero bias load gap between a rocker and a valve bridge at sub-base circle of a cam.

[0020] According to a further aspect, the valvetrain may be a Type 3 overhead cam valvetrain or a Type 4 valvetrain or a Type 5 valvetrain.

[0021] Other aspects and advantages of the disclosure will be apparent to those of ordinary skill from the detailed description that follows, and the above aspects should not be viewed as exhaustive or limiting. The foregoing general description and the following detailed description are intended to provide examples of the inventive aspects of this disclosure and should in no way be construed as limiting or restrictive of the scope defined in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The above features and attendant advantages, and others thereof will become apparent from consideration of the following detailed description, taken in conjunction with the accompanying drawings. One or more embodiments are now described, by way of illustrative example only, and not intended to be limiting to the scope of invention set forth in the claims appended hereto, with reference to the accompanying drawings wherein like reference numerals represent like elements and in which:

[0023] FIG. **1** is a perspective view of an assembled lost motion rocker brake system with a biasing stroke-limited e-foot assembly in accordance with the instant disclosure;

[0024] FIG. **2** is a perspective view of the lost motion rocker brake system of FIG. **1**, showing the biasing stroke-limited e-foot assembly in an exploded view;

[0025] FIG. **3** is a cross-sectional view showing internal features of the example lost motion rocker and e-foot of FIG. **1**, cooperating with a valve bridge and cam, with a lost motion component in a deactivated state;

[0026] FIG. **4** is a cross-sectional view showing internal features of the example lost motion rocker and e-foot of FIG. **1**, cooperating with a valve bridge and cam, and with a lost motion component in an activated state;

[0027] FIG. **5** is a cross-sectional view of the biasing stroke-limited e-foot assembly of FIGS. **1**-**4** in an assembled, extended configuration;

[0028] FIG. **6** is a cross-sectional view of the biasing stroke-limited e-foot assembly of FIG. **5**. In a plane that is orthogonal to that of FIG. **5**;

[0029] FIG. **7** is a cross-sectional view of the biasing stroke-limited e-foot assembly of FIG. **5**, in an assembled, retracted configuration;

[0030] FIG. **8** is a cross-sectional view of the biasing stroke-limited e-foot assembly of FIG. **6**;

[0031] FIG. **9** is a perspective view of a lost motion rocker brake with a biasing stroke limited push rod shown in exploded view;

[0032] FIG. **10** is another perspective view of the lost motion rocker brake with a biasing stroke limited push rod of FIG. **9**;

[0033] FIG. **11** is a cross-sectional view of a biasing stroke limited push rod in accordance with an aspect of the instant disclosure;

[0034] FIG. **12** is a cross-sectional view of the biasing stroke limited push rod of FIG. **7**, viewed in a plane that is orthogonal to that of FIG. **11**;

[0035] FIG. **13** is a cross-sectional view of the push rod of FIG. **11** in an extended state;

[0036] FIG. **14** is a cross-sectional view of the push rod of FIG. **12** in an extended state;

[0037] FIG. **15** is a cross-sectional view of a second embodiment of a biasing stroke limited push rod in accordance with an aspect of the instant disclosure;

[0038] FIG. **16** is a cross-sectional view of the biasing stroke limited push rod of FIG. **9**, viewed in a plane that is orthogonal to that of FIG. **15**;

[0039] FIG. **17** is a cross-sectional view of the push rod of FIG. **15** in an extended state; and

[0040] FIG. **18** is a cross-sectional view of the push rod of FIG. **16** in an extended state.

DETAILED DESCRIPTION

[0041] FIGS. **1**-**8** illustrate an example lost motion rocker brake with an integrated biasing stroke limited e-foot assembly according to aspects of the instant disclosure. As will be recognized, the disclosure features components for providing a biasing force on the rocker arm, in a direction such that a motion receiving (follower) side of the rocker brake is biased towards the motion source/cam side of the engine and away from the valves. The disclosure also features components for limiting the stroke of the e-foot assembly or other valvetrain components. While the stroke-limiting and biasing features are described in combination with one another in the embodiments, it will be recognized that these features and related teachings may be utilized separately to improve control of lost motion rocker brakes according to aspects of the disclosure.

[0042] Referring particularly to FIGS. **1**-**4**, an example valve actuation system may include a rocker **100**, lost motion component **200** and an e-foot assembly **600** with an e-foot or pedestal **690** adapted to contact a valve bridge **310**. Rocker **100** may include a valve side **110** and a cam side **120** on opposite sides of a rocker shaft journal **102**. Further details of the rocker **100** and related components are described below.

[0043] Still referring to FIGS. **1**-**4**, an example valve actuation system **10** may include a rocker **100**, a lost motion component **200**, a valve bridge and e-foot assembly **600**, and a rocker biasing component **680**. Rocker **100** may include a main rocker body **104**. Rocker cam side **120** may include a cam roller or follower **122** which may receive motion from a motion source in the form of a cam **500** (see FIGS. **3** and **4**). Cam follower **122** may be secured to the main rocker body **104** by a follower shaft **124**. As previously mentioned, rocker main body **104** may include integral bores and cavities for housing the lost motion component **200**, as well as control components and passages for controlling hydraulic fluid used to activate and deactivate the lost motion component **200**, as is generally known in the art.

[0044] Valve side **110** of the rocker **100** may include an e-foot assembly **600** and a valve bridge **310**. The e-foot assembly may constitute a portion of a main event load path for conveying main event motion from the rocker **100** to a valve bridge **310**, and ultimately to two engine valves (see FIG. **4**) that are arranged to receive motion from the valve bridge **310**. A bridge pin **312** may extend within a bridge bore **314** to transmit motion from the lost motion component **200** (when activated) to one of the engine valves, thereby providing for auxiliary events and auxiliary motion of the one engine valve.

[0045] As best seen in FIGS. **3** and **4**, lost motion component **200** may include an actuator piston **210**, which, when extended in an activated mode, engages and transmits motion to an end of the bridge pin **312**. Actuator piston **210** may cooperate with a lost motion actuator post **220**, and a lost motion actuator spring to bias the actuator piston **210** relative to the rocker **100**. Actuator piston **210** may extend under hydraulic pressure when the lost motion component **200** is activated and retract under force of the lost motion actuator spring when the lost motion component **200** is deactivated. The lost motion actuator post **220** may be secured to the rocker **100** with a threaded fastener **222**, in a manner that permits adjustment of the axial position of the lost motion actuator post **220** relative to the rocker **100**. As will be recognized from this disclosure, lost motion component **200** may constitute a portion of an auxiliary load path, which, when the lost motion component **200** is activated, will convey auxiliary motion from the rocker **100** to the bridge pin **312** and to one of the engine valves to support auxiliary motion of the one engine valve. FIG. **3** shows an example state of the e-foot assembly **600** when the lost motion component **200** is in a deactivated state, with piston **210** retracted into the rocker **100**. FIG. **4** shows an example state of the e-foot assembly **600** when the lost motion component **200** is in an activated state, in which piston **210** may extend from the rocker **100** and may engage the bridge pin **312**, which may, in turn, be displaced (downward) relative to the valve bridge **310**. Although shown in a horizontal position in FIG. **4**, the valve bridge **310** may undergo a slight tilt (bridge pin/braking valve side lower than the opposite, non-braking valve side) and the e-foot assembly may accommodate such tilt and be in a near-fully but not fully compressed state.

[0046] As will be recognized from the disclosure, when the lost motion component **200** is activated, sub-base circle auxiliary motion profiles of a motion source may be conveyed to one of the engine valves. As shown in FIGS. **3** and **4**, an example motion source **500** may include a cam **510** having a main event profile **520** extending radially beyond a base circle **530** to define main event valve motion. Auxiliary event profiles **540** and **550**, which may define auxiliary events, may be provided within (beneath) base circle **530**. In FIGS. **3** and **4**, cam **500** is shown schematically. It will be recognized that the rotational position of cam **500**, and the orientation of rocker **100** and e-foot assembly **600** may be different from that illustrated at different times in the engine and/or braking cycle. For example, the auxiliary event profile **540** may engage cam follower **122** during a braking mode of operation in which piston actuator **210** is in an extended position. When the lost motion component **200** is deactivated, only main event motion is conveyed from the cam **510**. In the deactivated state of the lost motion component, when the sub-base circle surface of the cam **500** encounters cam follower **122**, a gap will tend to be formed between the cam roller **122** and the motion source **500** such that the sub-base circle auxiliary motion defined by auxiliary motion profiles **540** and **550** will not be conveyed to the rocker **100**. On the other hand, when the lost motion component **200** is activated, the auxiliary motion profiles **540** and **550** will engage the cam follower **122** such that the auxiliary motion defined thereby will be conveyed via the bridge pin **312** to one of the engine valves.

[0047] Referring additionally to FIGS. **5-8**, a biasing component may be integrated into an e-foot assembly **600**. E-foot assembly **600** may include an upper part **620** and a lower part **650** arranged and adapted to move relative to one another in telescoping fashion. Upper part **620** may include a cylindrical fastening post **624** to be received within a bore in the rocker **100** and thereby fastened to the rocker **100** in conjunction with a threaded fastener (nut) **322** (FIGS. **3** and **4**). Upper part **620** may include an annular shoulder **626** which provides additional mounting support as well as an upper seating surface for a biasing component, such as spring **680**. Upper part **620** may also include a lower annular skirt **630** having an axially extending cavity or bore **628** (see FIGS. **5** and **6**) for receiving a complementary-shaped projection **652** of lower part **650**. Lower part **650** may include an annular shoulder **656**, which provides a lower seat for spring **680**. Lower part **650** and upper part **620** thus provide an extendable, telescoping e-foot post, which may be biased to the extended position by spring **680** to exert a biasing force on the rocker, the biasing force tending to move the motion source side of the rocker toward the motion source. Thus, a rocker biasing component may be integrated into the e-foot assembly by virtue of the features of this embodiment.

[0048] According to aspects of the disclosure, a stroke limited component may also be integrated into the e-foot assembly **600**. The projection **652** of lower part **650** may be provided with an axially extending slot or channel **654**. The upper part **620** may be provided with a transverse bore **658**, which receives a retaining pin **670**. Retaining pin **670** extends through both the transverse bore **658** and the slot **654** in lower part **650**, thus retaining the lower part **650** within the upper part **620** and limiting the movement of lower part **650** relative to upper part **620**. A stroke length “S” may be defined by the range of movement of lower part **650** relative to upper part **620**, which may in turn be defined by the contact of different parts. For example, an upper extent of travel of lower part **650** within upper part **620** may be defined by the dimensions of the lower annular skirt **630** of upper part **620**, which may impact the shoulder **656** to define an upper travel limit of lower part **650** within upper part **620**. FIGS. **7** and **8** show the lower part **650** at an upper limit of travel. Alternatively, projection **652** may bottom out in the bore **628** to define an upper travel limit. A lower travel limit for lower part **650** relative to upper part **620** may be defined by the impact of retaining pin **670** with an upper surface of slot **654**, as shown in FIGS. **5** and **6**. As will be recognized, the stroke “S” may be configured to achieve desirable absorption and conveyance of respective portions of motion defined on the motion source (cam) and thus to achieve corresponding desired modification of valve motion, particularly in combination with the sub-base circle portions of cam **500**. For example, the stroke may be limited such that when the cam follower is engaged by the sub-base circle portion of the motion source, a gap may form between the e-foot and bridge and/or the cam follower and cam to permit a lubrication film to develop during that portion of the valve motion cycle. The stroke length of the e-foot assembly may be selected and adjusted such that only a small gap or zero bias load gap is formed, thereby avoiding a gap size or play in the valvetrain that would result in loss of control of the rocker position.

[0049] Thus, in this and other embodiments, and consistent with aspects of the disclosure, the stroke limited e-foot may be configured to provide for a small gap between the e-foot and valve bridge when the rocker encounters a sub-base circle portion of the cam. This configuration permits unloading of the e-foot and allows for the formation or reformation of a lubrication layer within the e-foot assembly, such as between the e-foot cap and bushing, and at other locations (valvetrain component interfaces) in the valvetrain. This configuration may also provide for reduction or negation of any valve spring pre-load. The e-foot assembly may also be configured such that the mechanism bottoms out after stroking between sub-base and base circle of the cam.

[0050] As will be recognized from the instant disclosure, lost motion rocker brake systems, such as those described above, bias the rocker brake towards the cam of the engine and away from the valves. This has several benefits, including a reduction in the components needed to assemble the rocker brake into the valvetrain. Additionally, the stroke limited e-foot reduces valve bridge and e-foot cap wear due to the lost motion gap where extra oil can penetrate. Furthermore, the stroke limited feature reduces bushing wear which occurs from loading the bushing area during 100% of the rocker's duty cycle.

[0051] The following operational description will serve to further illustrate aspects of the disclosure and interaction of the described components. In a "brake off" mode, when the cam follower encounters a sub-base circle portion of the cam and the actuator piston is retracted, the e-foot assembly may be in an extended position to maintain engagement with the valve bridge. When the system is still in a brake off mode, but when the cam follower encounters a base circle portion of the cam (with the actuator piston still retracted), the e-foot assembly may undergo partial compression from its extended position, with compression of the e-foot assembly spring and the e-foot still maintaining contact with the valve bridge and biasing of the rocker cam side toward the cam.

[0052] In a "brake on" mode, with the actuator piston extended (but possibly not touching the bridge pin), and the cam follower encountering a sub-base circle portion of the cam, the e-foot assembly may be in an extended position to maintain contact between the e-foot and the valve bridge. Still in a "brake on" mode, with the actuator piston extended, the valve bridge may undergo a slight tilt due to contact with the bridge pin. The e-foot assembly may be in a compressed state to maintain contact of the e-foot with the valve bridge.

[0053] According to aspects of the disclosure, biasing and stroke limiting features may be integrated into valvetrain components other than an e-foot assembly, as described above. For example, biasing and stroke limiting features may be integrated into components of a push rod configuration as shown in the two embodiments in FIGS. **9-18**. Referring particularly to FIGS. **9-14**, a push rod biasing and stroke limiting assembly **700** may include an upper part **720** which receives a projection **752** of a lower part **750** for sliding, telescoping movement. Upper part **720** may include a fastening post **724**, which fits within a bore on the rocker. Lower part **750** may include a channel **754** formed on projection **752**. A circular (outwardly biased) spring clip **770** may be installed in an internal groove on the inner wall of upper part **720** such that the spring clip **770** is positioned within channel **754** and thereby limits movement of the lower part **750** relative to the upper part **720**. That is, channel **754** permits limited movement of the lower part **750** but otherwise cannot move up or down beyond the limits defined by the position of spring clip **770**. In this manner, spring clip **770** and channel **754** define a limited stroke "S" (FIG. **11**)

[0054] A biasing component may be implemented in the embodiment of FIGS. **9-14** as well. A coil spring **780** may be housed within a bore **728** of the upper part **720**, with an upper interior wall **729** of the bore **728** of upper part **720** defining an upper spring seating surface. An upper surface **759** of the lower part **750** may define a lower spring seating surface. Coil spring **780** may thus bias the lower component **750** into an extended position relative to upper part **720**. FIGS. **11** and **12** show a contracted position or state of the push tube assembly while FIGS. **13** and **14** show an extended position or state of the push tube assembly.

[0055] FIGS. **15-18** illustrate another embodiment of biasing and stroke limited components suitable for push rod environments. In this configuration, a biasing and stroke limiting push rod assembly **800** may include an upper part **820** and lower part **850** arranged and adapted for telescoping relative movement. A transversely extending retaining pin **870** extends through a transverse bore on the upper part **820** and through an axially extending slot **854** in the lower part **850**. In a manner like the embodiment of FIGS. **1-8**, pin **870** limits axial movement of the lower part **850** relative to the upper part **820** and thereby provides a limited stroke "S" of the push rod component. In this embodiment, a biasing feature may include an external coil spring **880** seated between respective annular shoulders **826** and **856** of upper part **820** and lower part **850** to bias the push rod assembly into an extended position. FIGS. **15** and **16** show the push rod assembly in a contracted or compressed position or state while FIGS. **17** and **18** show the push rod assembly in an extended position or state.

[0056] It will be recognized that the stroke-limiting and biasing configurations of the push rod embodiments of FIGS. **5-10** may be adapted to other valvetrain components, including the previously described e-foot environment. For example, the spring clip **770** and channel **754** in the embodiment of FIGS. **5-8** could be adapted to replace the pin and slot limiting configuration in the embodiment of FIGS. **1-4**. In this regard, the various mechanical implements for limiting stroke and for biasing should be viewed as interchangeable and adaptable to different valvetrain components beyond the e-foot and push rod environments described herein.

[0057] As will be recognized from the instant disclosure, lost motion rocker brake systems, such as those described above, bias the rocker brake towards the valve-side of the engine and away from the cam. This has several benefits, including a significant reduction in the biasing force needed to control the rocker brake in a brake off condition. The valvetrain becomes easier to design with less biasing force required on the push rod side. With a lighter biasing force, the overall system can be lighter with potential lower costs as well.

[0058] The stroke limiting features described above also provide advantages. The stroke limiting functionality provides for a predefined stroke in the valvetrain which, in combination with the biasing component, may facilitate the adjustment of e-foot or push rod position for all operating conditions, including brake "off" (or lost motion deactivated) states of operation. This in turn may allow for a desirable gap formation between the e-foot and valve bridge or between other valvetrain components. In addition, the stroke limiting features may function as retaining features that allow a preassembled e-foot or push rod system to be assembled and shipped as an assembled component that may be easily installed in a larger engine environment without separate installation or assembly steps in the field.

[0059] While particular embodiments have been shown and described, those skilled in the art will appreciate that changes and modifications may be made without departing from the instant teachings. It is therefore contemplated that all modifications, variations, or equivalents of the above-described teachings fall within the scope of the basic underlying principles disclosed above.

[0060] For example, while the above examples have been described in the context of a Type 3 valvetrain (center pivot) rocker or a Type 5 valvetrain (pushrod), it will be recognized that the described biasing components and stroke limited components may be implemented in other valvetrain types, such as Type 2 (end pivot rocker) or Type 4 (center pivot rocker with follower).

[0061] Further, while the disclosed biasing components and stroke limited components are explained using the illustrative embodiments of an e-foot and pushrod, it will be recognized that the described biasing components and stroke limited components may be implemented as part of other valvetrain components, such as cam followers, for example.

[0062] Still further, while the disclosed embodiments may feature a lost motion component as part of the valvetrain, it will be recognized that the biasing and stroke limiting features of the disclosed embodiments may be utilized in valvetrain systems that do not incorporate lost motion components.

What is claimed is:

1. A system for actuating at least one of two or more engine valves in an internal combustion engine, the system comprising:

a motion source defining a main event motion profile and an auxiliary motion profile;

a valvetrain for conveying motion from the motion source to the at least one engine valve, the valvetrain having at least two valvetrain components;

a biasing component arranged to apply a biasing force to maintain at least one of the valvetrain components in a controlled state; and

a stroke limited component cooperating with the biasing component and adapted to create a lash gap between the at least two valvetrain components.

2. The system of claim **1**, wherein the biasing component is a spring arranged as part of an e-foot assembly.

3. The system of claim **2**, wherein the e-foot assembly includes an extendable portion and wherein the spring is arranged to bias the extendable portion towards an extended position.

4. The system of claim **2**, wherein the e-foot assembly includes a telescoping portion.

5. The system of claim **1**, wherein the stroke limited component is an e-foot assembly.

6. The system of claim **5**, wherein the e-foot assembly includes an extendable portion and wherein the extendable portion includes a stop for limiting extension of the extendable portion.

7. The system of claim **1**, wherein the biasing component is a spring arranged as part of a push rod assembly.

8. The system of claim **7**, wherein the push rod assembly includes an extendable portion and wherein the spring is arranged to bias the extendable portion towards an extended position.

9. The system of claim **7**, wherein the push rod assembly includes a telescoping portion.

10. The system of claim **1**, wherein the stroke limited component is a pushrod assembly.

11. The system of claim **10**, wherein the pushrod assembly includes an extendable portion and wherein the extendable portion includes a stop for limiting extension of the extendable portion.

12. The system of claim **1**, where in the valvetrain is a Type 3 overhead cam valvetrain.

13. The system of claim **1**, wherein the biasing component or stroke-limiting component comprise e-foot assembly, wherein the e-foot assembly comprises a screw boss, a swivel boss, a pin, a cap, and a bias spring.

14. The system of claim **1** wherein the stroke limited component is a pushrod adjustment screw.

15. The system of claim **1**, where in the valvetrain is a Type 4 overhead valve valvetrain.

16. The system of claim **1**, wherein the biasing component or stroke-limiting component comprise a pushrod assembly, wherein the pushrod assembly comprises a screw boss, a push rod boss, a pin, and a bias spring.

17. The system of claim **1**, where in the stroke limited component comprises a pin, a lip, a c-clip or a step for limiting extension of an extendable portion.

18. The system of claim **1**, where in the biasing component is arranged to control inertial forces of the rocker arm to prevent a no follow condition between sub-base and base circle of a cam.

19. The system of claim **1**, wherein the biasing component is adapted to provide a zero bias load gap between a rocker and a valve bridge at sub-base circle of a cam.

20. The system of claim **1**, further comprising a lost motion component cooperating with the valvetrain, the lost motion component being configurable to a first mode, in which the lost motion component absorbs the auxiliary motion, and a second mode, in which the lost motion component conveys the auxiliary motion.

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