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(54) **Two-step roller finger cam follower**

(57) A two-step roller finger follower assembly for shifting between high-lift and low-lift valve modes in a valve train of an internal combustion engine includes a body having side members defining coaxially disposed shaft orifices, a pallet end, a socket end, a slider arm aperture, and a latch pin channel. The socket end is mountable to a hydraulic lash adjuster, and the pallet end is matable with a valve stem. A slider arm for engaging a high-lift cam lobe is disposed in the aperture, is pivotably mounted to a rotatable cross-shaft extending through the shaft orifices, and includes a slider tip for selectively engaging a latch pin to latch or unlatch the slider arm from the body. Dual rollers on the cross-shaft follow dual low-lift cam lobes. Preferably, the slider arm has a compound radial surface to provide compound lost motion of the slider arm, thereby minimizing rotational inertia.

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Description

TECHNICAL FIELD

[0001] The present invention relates to roller finger followers used for variable valve actuation in overhead cam type internal combustion engines; and more particularly, to a roller finger follower assembly having a body supportive of an axle shaft for dual outboard rollers for following a corresponding pair of cam lobes, and a central slider arm for following a central cam lobe between the pair of lobes; and most particularly, to such an assembly wherein the slider is pivotably mounted on the axle shaft.

BACKGROUND OF THE INVENTION

[0002] Roller Finger Followers (RFFs) are widely used in overhead cam internal combustion engines to sequentially open and close the cylinder intake and exhaust valves. In a typical application, the RFF assembly serves to transfer and translate rotary motion of a camshaft eccentric lobe into a pivotal motion of the RFF assembly to thereby open and close an associated valve.

[0003] It is known that, for a portion of the duty cycle of a typical multiple-cylinder engine, the performance load can be met by a functionally smaller engine having fewer firing cylinders, and that at low-demand times fuel efficiency can be improved if one or more cylinders of a larger engine can be withdrawn from firing service. It is also known that at times of low torque demand, valves may be opened to only a low lift position to conserve fuel, and that at times of high torque demand, the valves may be opened wider to a high lift position to admit more fuel. It is known in the art to accomplish this by de-activating a portion of the valve train associated with pre-selected cylinders in any of various ways. One way is by providing a special two-step RFF assembly having a variably activatable and deactivatable central slider arm which may be positioned for contact with a high lift lobe of the camshaft. Such a two-step RFF typically is also configured with rollers disposed at each side of the slider arm for contact with low lift lobes of the cam shaft on either side of the high-lift lobe. Thus, the two-step RFF causes low lift of the associated valve when the slider arm of the RFF is in a deactivated (unlatched) mode, and high lift of the associated valve when the slider arm of the RFF is an activated (latched) mode to transmit motion of the high lift lobe of the camshaft.

[0004] A typical prior art two-step roller finger follower is disclosed in US Patent No. 6,755,167 B2, issued June 29, 2004, the relevant disclosure of which is incorporated herein by reference. In this roller finger follower, an elongate body having first and second side members defines coaxially disposed shaft orifices. A pallet end and a socket end interconnect with the first and second side members to define a central slider arm aperture and a latch pin channel. The socket end is adapted to mate with a mounting element such as an hydraulic lash adjuster, and the pallet end is adapted to mate with a valve stem, pintle, lifter, or the like. A slider arm for engaging a high-lift cam lobe is disposed in the slider arm aperture and has first and second ends, the first end of the slider arm being pivotally mounted to the pallet end of the body and the second end defining a slider tip for engaging an activation/deactivation latch pin. The latch pin is slidably disposed in the latch pin channel, the latch pin having a nose section for selectively engaging the slider tip. A spool-shaped roller comprising a shaft and opposed roller elements fixedly attached to ends of the shaft is rotatably disposed in the shaft orifices, the roller being adapted to cause the RFF body to follow the surface motion of a low-lift cam lobes. Preferably, the shaft is journalled in roller or needle bearings which extend between and through both the first and second shaft orifices, being thus exposed to normal copious oil flow through central regions of the RFF. A coil torsion spring mounted on the slider arm pivot pin urges the slider into continuous contact with the central cam lobe.

[0005] US Published Patent Application No. 20060249110, the relevant disclosure of which is incorporated herein by reference, discloses a similar two-step RFF assembly except that the latch pin channel and latch pin are inclined to the pivot axis of the slider arm to improved latching reliability, and the coil torsion spring is replaced by a compression coil spring disposed within a well in the slider arm.

[0006] See also US Patent No. 6,925,978, the relevant disclosure of which is incorporated herein by reference.

[0007] A drawback of all such prior art two-step RFF assemblies is that the mass of the central slider, and therefore the moment of rotational inertia, is undesirably high, which increases the force requirements of the lost motion and valve springs.

[0008] Another drawback is that the overall volume, and therefore the engine space consumed, is undesirably large.

[0009] Still another drawback is that the range of lost motion of the central slider is constrained by practical limits of mechanical strength imposed by the arcuate slot in the central slider for accommodating the axle of the low-lift rollers.

[0010] Still another drawback is that the number of components is undesirably large, resulting in relatively high component manufacturing and assembly costs.

[0011] Still another drawback is that provision for a rotational stop to limit leakdown of an associated HLA requires special manufacturing and assembly components and procedures.

[0012] International Publication No. WO 2007/035673 A2 discloses a finger follower assembly having a central roller follower for following a central cam lobe, the central roller follower being mounted on a shaft passing through the assembly body and supporting a linked pair of lateral slider followers for following dual cam lobes on either side of the central lobe. The lateral slider followers are mounted eccentrically on the shaft and thus may be ro-

tated between a latched high-lift (valve actuating) position and an unlatched low-lift (valve deactivating or lost motion) position. The lateral slider followers are latched and unlatched by a hydraulic piston latching mechanism in the assembly body. Thus, the central roller follower is engaged for low-lift or no-lift valve events, and the lateral sliders are engaged for high-lift valve events and are disengaged for low-lift or no-lift valve events.

[0013] A serious drawback of this two-step RFF assembly is that it requires complicated component shapes and features to implement the locking function. Further, packaging and assembly of the slider bias springs is difficult and problematic.

[0014] What is needed in the art is a simplified two-step RFF assembly having fewer components, lower mass, lower volume, and greater range of lost motion than comparable prior art RFF assemblies.

[0015] It is a principal object of the present invention to reduce the cost, complexity, and mass of a two-step RFF assembly.

[0016] It is also an object of the invention to reduce the volume and rotational inertia of a two-step RFF assembly.

SUMMARY OF THE INVENTION

[0017] Briefly described, a roller finger follower for use in conjunction with a cam shaft of an internal combustion engine comprises an elongate body having first and second side members defining coaxially disposed shaft orifices. A pallet end and a socket end interconnect with the first and second side members to define a slider arm aperture and a latch pin channel. The socket end is adapted to mate with a mounting element such as an hydraulic lash adjuster, and the pallet end is adapted to mate with a valve stem, pintle, lifter, or the like.

[0018] A spool-shaped roller comprising a shaft and opposed roller elements attached to the shaft is disposed in the shaft orifices, the rollers being adapted to follow the surface motion of the low-lift cam lobes. Preferably, the shaft is journalled in roller or needle bearings which extend between and through both the first and second shaft orifices, being thus exposed to normal copious oil flow through central regions of the RFF.

[0019] A slider arm for engaging a high-lift cam lobe is disposed in the slider arm aperture and is pivotally mounted on a common axis with the roller shaft and includes a slider tip for engaging an activation/deactivation latch pin. The latch pin is slidably and at least partially disposed in the latch pin channel and has a nose section for extending from the channel to selectively engage the slider tip, to switch modes of the RFF assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The foregoing and other objects, features, and advantages of the invention, as well as presently preferred embodiments thereof, will become more apparent from a reading of the following description in connection with the accompanying drawings in which:

FIG. 1 is a cross-sectional view of a prior art roller finger follower substantially as disclosed in US Patent No. 6,755,167 B2, showing the slider tip engaged by the latch pin;

FIG. 2 is a cutaway elevational view of a valve train incorporating a two-step RFF assembly in accordance with the invention;

FIG. 3 is an isometric view of a complete two-step RFF assembly in accordance with the invention;

FIG. 4 is an isometric view of a first partial assembly of the RFF assembly shown in FIG. 3;

FIG. 5 is an isometric view of a central slider for use in the two-step RFF assembly shown in FIG. 3;

FIG. 6 is an isometric view of a second partial assembly showing the central slider shown in FIG. 5 installed on the first partial assembly shown in FIG. 4;

FIG. 7 is a cutaway view of the first partial assembly shown in FIG. 4;

FIG. 8 is a cutaway view of the second partial Assembly shown in FIG. 6;

FIG. 9 is a schematic view showing a compound radius central slider on the base circle portion of a cam lobe; and

FIG. 10 is a schematic view like that shown in FIG. 9 showing the compound radius central slider on the eccentric portion of the cam lobe.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0021] The benefits and advantages of a two-step RFF assembly in accordance with the present invention may be better appreciated by first considering a prior art two-step RFF assembly.

[0022] Referring to FIG. 1, prior art two-step RFF assembly 10 is substantially as shown in US Patent No. 6,755,167 B2. Pallet end 12 of prior art RFF 10 is provided for engaging a valve stem 11 and socket end 14 is provided for engaging the hemispherical head of a hydraulic lash adjuster 15. RFF 10 includes body assembly 16, slider arm assembly 18, spool roller assembly 20, lost motion spring 22, and latch assembly 24.

[0023] Body assembly 16 includes elongate body 26 and roller bearing 28 disposed in bearing orifices 30. Elongate body 26 includes a slider arm aperture 32 bounded by body side walls 34 defining bearing orifice 30 therethrough. The diameter of bearing orifice 30 is sized to press-fittedly receive roller bearings 28. A cross-shaft 36 is rotatably disposed in bearing 28 and is supportive of roller 38 on the end thereof for following a low-lift cam lobe. Of course, a second body sidewall, bearings, roller, and the like are all present in an actual RFF assembly but are not visible in the cross-sectional view shown in FIG. 1.

[0024] Slider arm assembly 18 includes slider arm 40 and slider shaft 42, having mutual axes 43, for pivotably

attaching arm 40 to body 26. Slider arm 40 defines slider surface 44 for following a high-lift cam lobe, and further includes slider tip 46 and elongated roller shaft clearance aperture 48. It should be noted that prior art slider arm assembly, because it pivots from shaft 42, includes substantial mass between aperture 48 and shaft 42 which exists for no purpose other than to allow the slider arm assembly to pivot from a pivot axis disposed over valve stem 11 and pallet end 12. It is an important benefit of the improved two-step RFF assembly as disclosed and claimed herein that most of this portion of a slider arm assembly is eliminated and therefore the rotational mass of an improved slider arm assembly, as described below, is substantially reduced.

[0025] In prior art RFF 10, latch pin axis 54 is substantially perpendicular to, and passes through, pivot pin axis 43. Thus axis 54 lies on a radius 55 of the rotational arc of slider arm 40 (i.e., axis 54 forms an included angle 57 of 180° with an extension of radius 55), causing slider tip 46 to be traveling in a direction substantially orthogonal to axis 54 at the point of engagement with latch pin 52.

[0026] Referring now to FIG. 2, a valve train 100 for an internal combustion engine 102 includes a valve 104, either intake or exhaust, having a valve stem 11 as in FIG. 1 engaged by a pallet end 112 of a two-step RFF assembly 110 in accordance with the invention. A hydraulic lash adjuster 15 as in FIG. 1 is mounted in the head 106 of engine 102 for supporting RFF assembly 110 via a socket 114 therein. A camshaft 90 includes a low-lift cam lobe 92 for actuating RFF assembly 110 via an outboard roller 138, and further includes a high-lift cam lobe 94 for actuating RFF assembly 110 via a central slider arm 140 of slider arm assembly 118.

[0027] Referring now to FIGS. 3 through 8, in improved two-step RRF assembly 110, the slider arm is mounted on and pivots about the same axis as the outboard rollers, thereby shortening both the length of the slider arm and the RFF body.

[0028] Improved RFF assembly 110 includes body assembly 116, central slider arm 140, spool roller assembly 120, lost motion spring 122, and latch assembly 124.

[0029] Body assembly 116 includes elongate body 126 and roller bearings 128. Elongate body 126 includes a slider arm aperture 132 bounded by body side walls 134 defining bearing orifices 130 formed in bosses 131 of sidewalls 134. The diameter of bearing orifice 130 is sized to press-fittedly receive roller bearings 128. A cross-shaft 136 is rotatably disposed in bearings 128 and is supportive of rollers 138 on the ends thereof for following first and second outboard low-lift cam lobes 92 (FIG. 2).

[0030] Slider arm 140 defines a slider surface 144 for following high-lift cam lobe 94, and further includes slider tip 146 (FIG. 2), for engaging a latch pin 161, and roller shaft apertures 148. Slider arm 140 is disposed on a slider bushing 142 that itself is mounted in the sidewall bearing orifices. Bushing 142 preferably includes ports 143 to allow oil to enter the bushing and move along the surface of shaft 136 to help in lubricating bearings 128. Slider arm 140 may be fixedly mounted on bushing 142 which rotates within the sidewall bearing orifices; or slider arm 140 may be rotatably mounted on bushing 142 which is fixed to the sidewall bearing orifices. In either configuration, slider arm 140 is rotatable about the axis of cross-shaft 136 and with respect to RFF body 126. RFF assembly 110 as noted above includes a bias spring 122 which engages both RFF body 126 and slider arm 140 to urge the slider arm into continuous contact with high-lift cam lobe 94, as shown in FIG. 2. Slider arm 140 may thus rotate until stopped by rotational limiters 147 extending from slider arm 140 that engage RFF body 126, thus preventing excessive leakdown of HLA 15 (FIG. 2).

[0031] Referring now to FIGS. 2, 5, 9, and 10, in a currently preferred embodiment of slider arm 140, surface 144 of slider arm 140 comprises a compound surface comprising a plurality of surface portions which may be planar but preferably are arcuate. In one aspect of the invention, a first surface portion 144a is formed at a larger radius 151 a of a circle 153a as shown in FIGS. 9 and 10. A second surface portion 144b is formed at a smaller radius 151 b of a circle 153b contained within circle 153a, the two surface portions being tangentially joined at line 155. Thus, a portion 157 of circle 153a is not present in slider arm 140, thereby defining a relieved area 159 of the slider arm into which the eccentric nose of cam lobe 94 extends during rotation of the camshaft when RFF assembly 110 is in lost motion (valve deactivation) mode, thereby reducing the required rotational lost motion of slider arm 140.

[0032] In operation, during lost motion slider arm 140 pivots about axis 161 of shaft 136, and cam lobe 94 engages slider arm 140 on surface 144b. During valve actuation, of course, slider arm 140 does not rotate about axis 161 but rather is latched at lip 146 to latch pin 161 and thus is integral with RFF body 126.

[0033] While the invention has been described by reference to various specific embodiments, it should be understood that numerous changes may be made within the spirit and scope of the inventive concepts described. Accordingly, it is intended that the invention not be limited to the described embodiments, but will have full scope defined by the language of the following claims.

Claims

1. A roller finger follower assembly for use in conjunction with a cam shaft and valve train of an internal combustion engine, the camshaft having at least one first lobe and at least one second lobe, said roller finger follower assembly comprising:

   a) a body having a first side member and a second side member defining coaxial first and second shaft orifices, said body further defining a slider arm aperture;

   b) a shaft supported in said shaft orifices and

extending across said slider arm aperture and supportive of at least one roller for engaging said first cam lobe;

c) a slider arm disposed in said slider arm aperture and mounted for pivotal motion about an axis of said shaft and having a surface for engaging said second cam lobe and having an end; and

d) a latch pin disposed in said latch pin channel for selectively engaging said slider end to switch modes of the roller finger follower assembly.

2. A roller finger follower assembly in accordance with Claim 1 wherein said first cam lobe is a low-lift lobe and said second cam lobe is a high-lift lobe.

3. A roller finger follower assembly in accordance with Claim 2 comprising two of said rollers for following two of said low-lift cam lobes.

4. A roller finger follower assembly in accordance with Claim 3 wherein said shaft extends through said body and wherein said two rollers are disposed on said shaft on opposite sides respectively of said body.

5. A roller finger follower assembly in accordance with Claim 1 further including a bushing disposed between the shaft and at least one of said shaft orifices.

6. A roller finger follower assembly in accordance with Claim 5 wherein said bushing is fixed in said at least one of said shaft orifices to prevent relative rotational motion between said bushing and said at least one of said shaft orifices.

7. A roller finger follower assembly in accordance with Claim 1 wherein said slider arm surface is a compound surface.

8. A roller finger follower assembly in accordance with Claim 7 wherein said compound surface comprises a plurality of arcuate portions having differing radii.

9. A roller finger follower assembly in accordance with Claim 1 wherein at least one of said body and said slider arm includes at least one rotational limiter.

10. A roller finger follower assembly in accordance with Claim 1 further comprising a bias spring grounded to said body and said slider arm.

11. A camshaft-engaging element in a two-step roller finger follower assembly comprising a slider surface for making contact with a cam lobe, said slider surface having a compound surface.

12. An element in accordance with Claim 11 wherein said compound surface comprises a plurality of arcuate sections having differing radii.

13. An internal combustion engine including a camshaft having high-lift and low-lift cam lobes, comprising a roller finger follower assembly for selectively adjusting the lift of an associated engine valve, wherein said roller finger follower assembly includes,

a body having a first side member and a second side member defining coaxial first and second shaft orifices, said body further defining a slider arm aperture,

a shaft supported in said shaft orifices and extending across said slider arm aperture and supportive of at least one roller for engaging said first cam lobe,

a slider arm disposed in said slider arm aperture and mounted for pivotal motion about an axis of said shaft and having a surface for engaging said second cam lobe and having an end, and

a latch pin disposed in said latch pin channel and for selectively engaging said slider end to switch modes of said roller finger follower assembly.

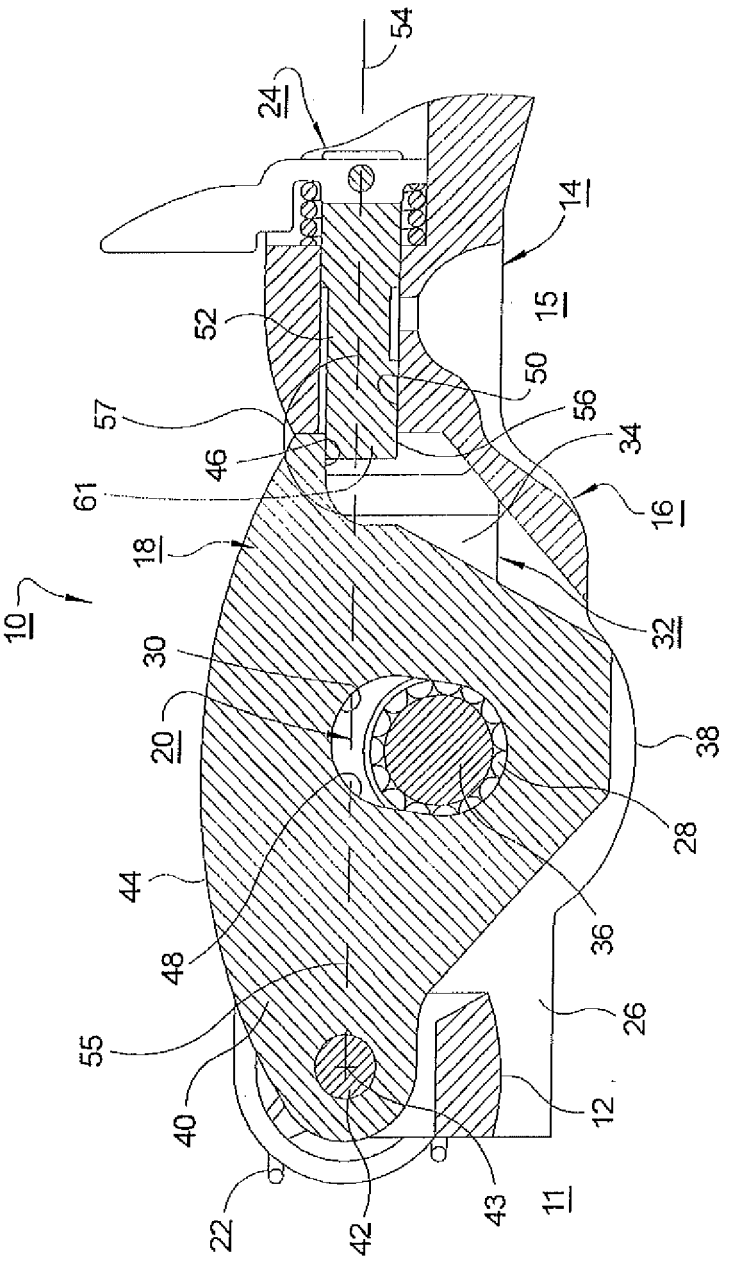

FIG. 1.
(PRIOR ART)

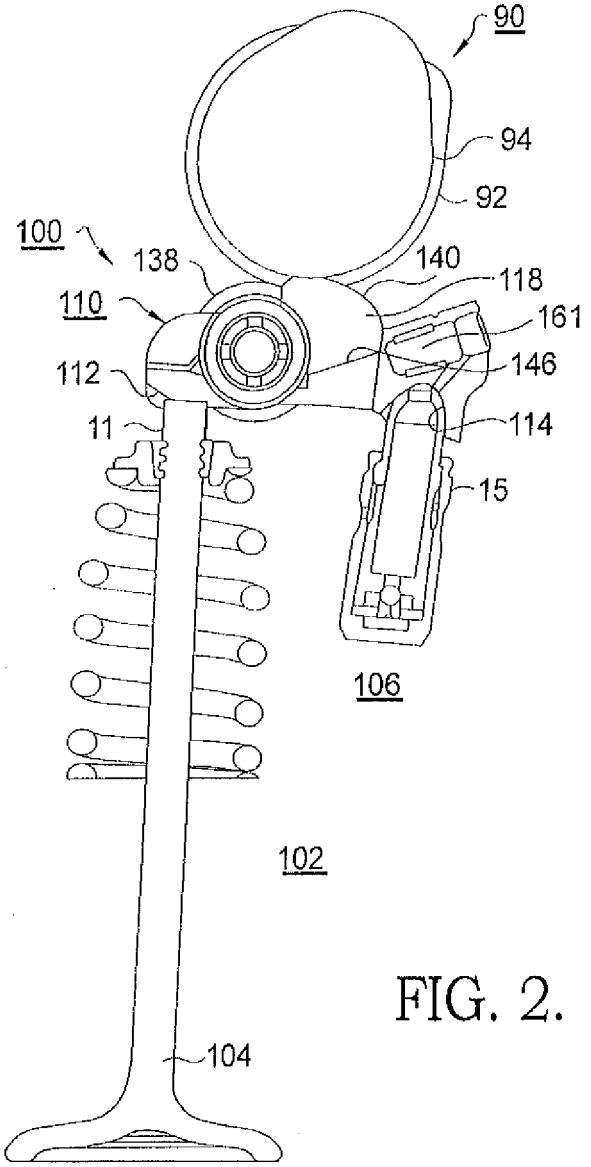

FIG. 2.

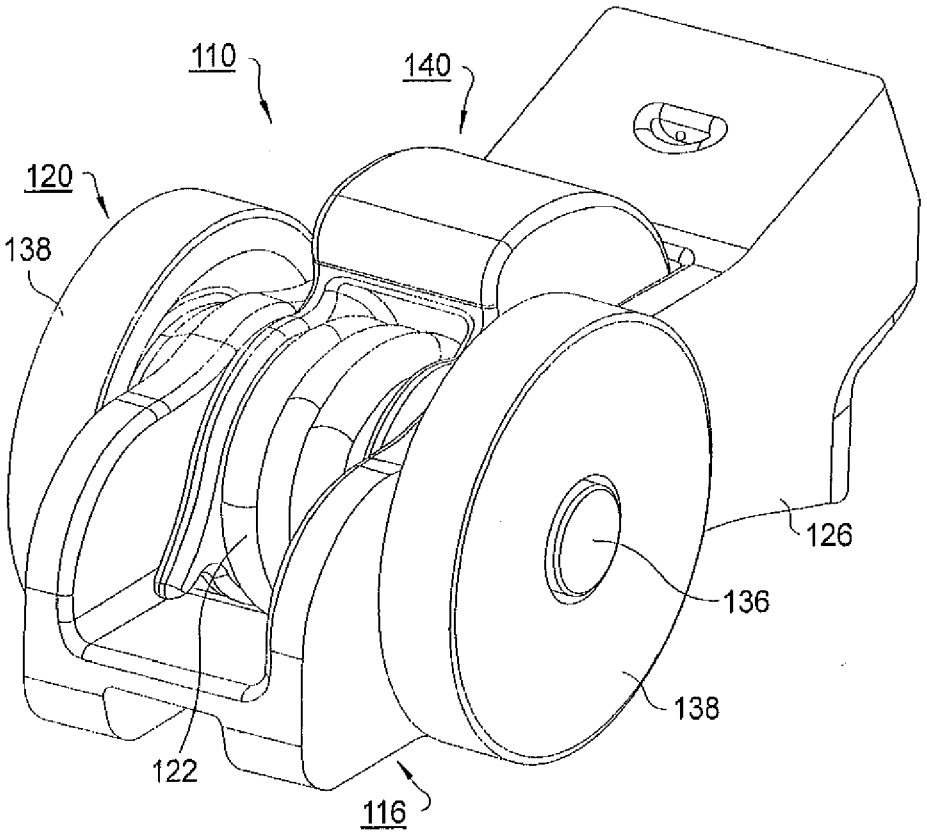

FIG. 3.

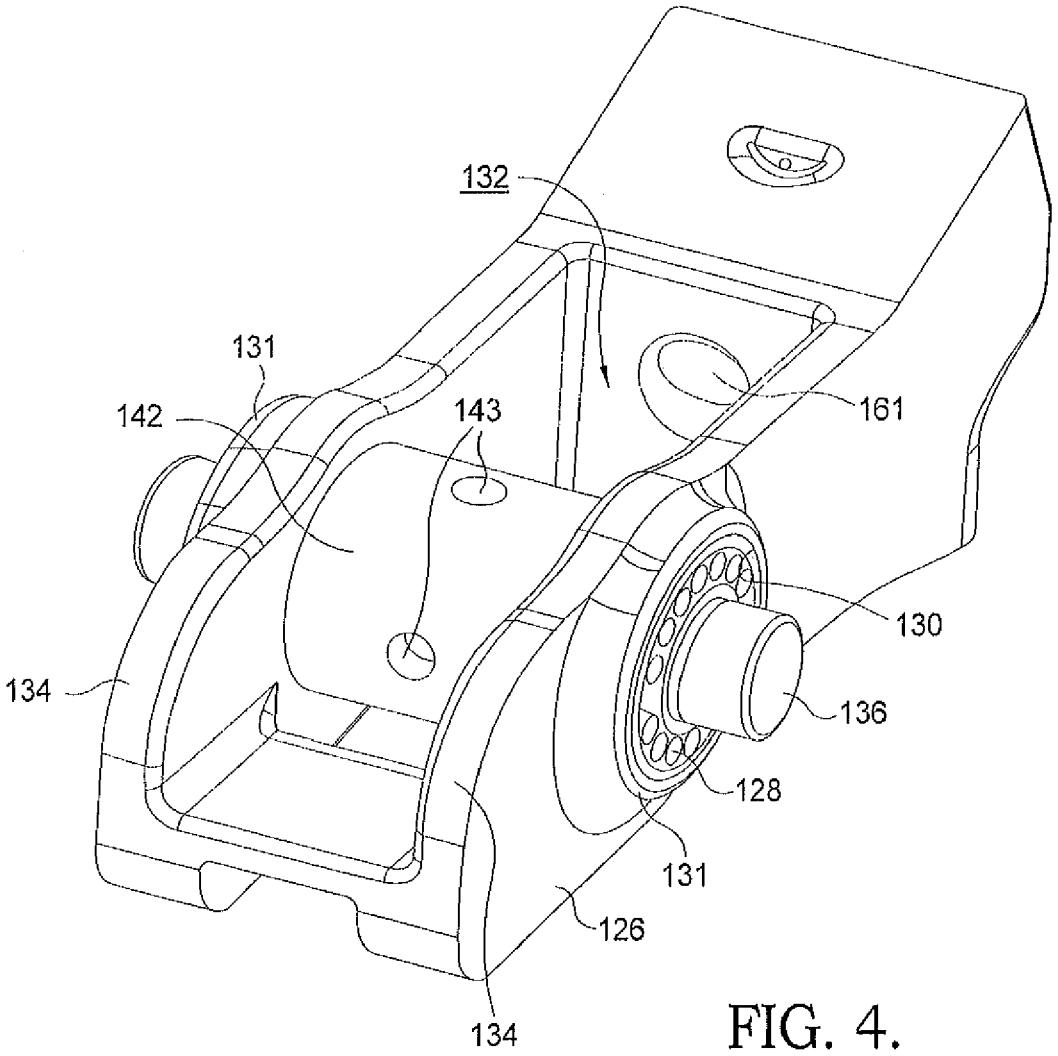

FIG. 4.

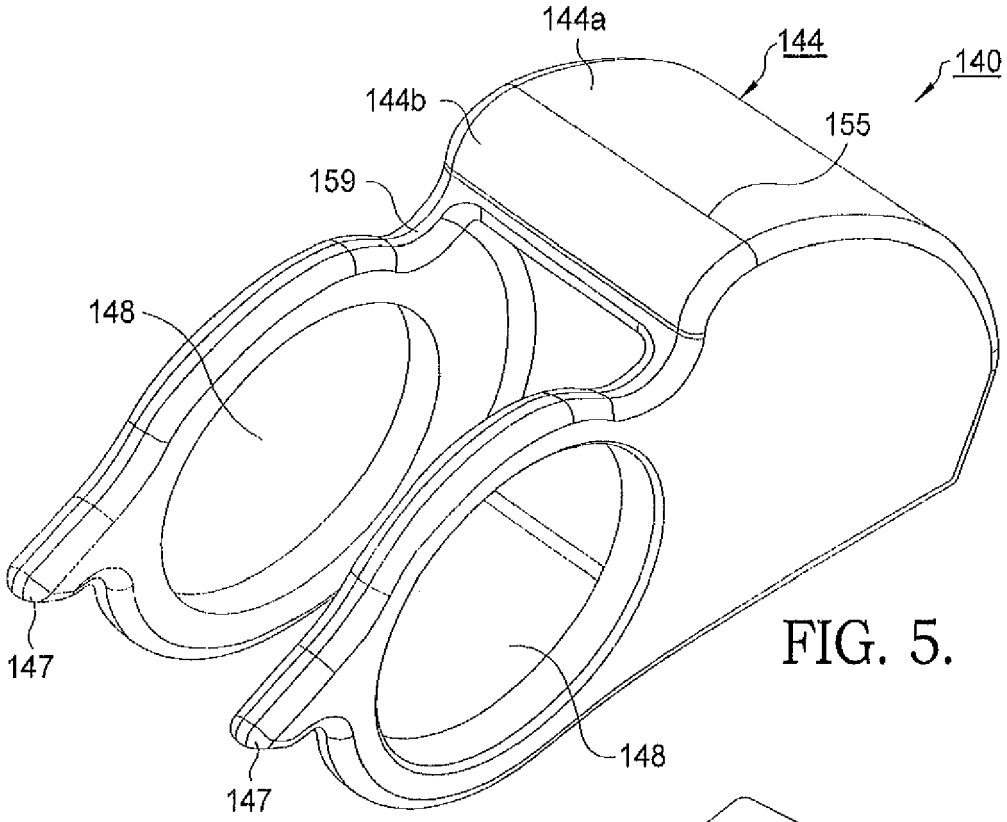
144a
144
140
144b
155
159
148
147
148
147

FIG. 5.

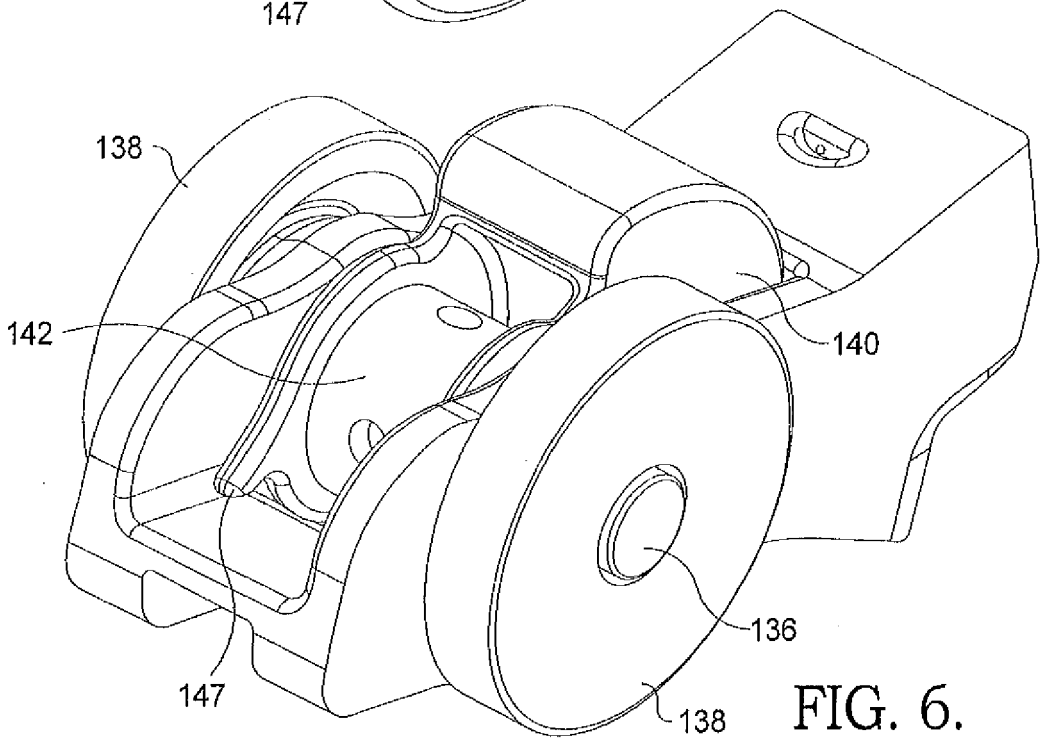
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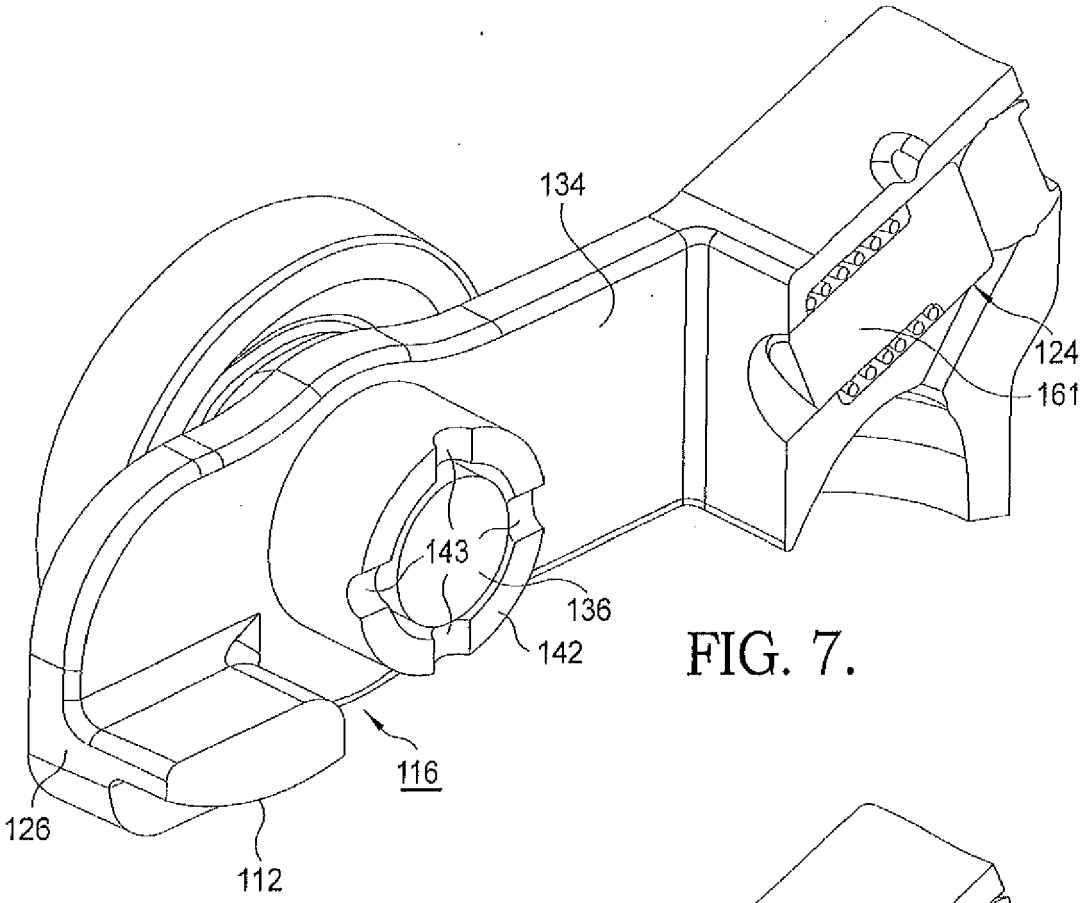
FIG. 6.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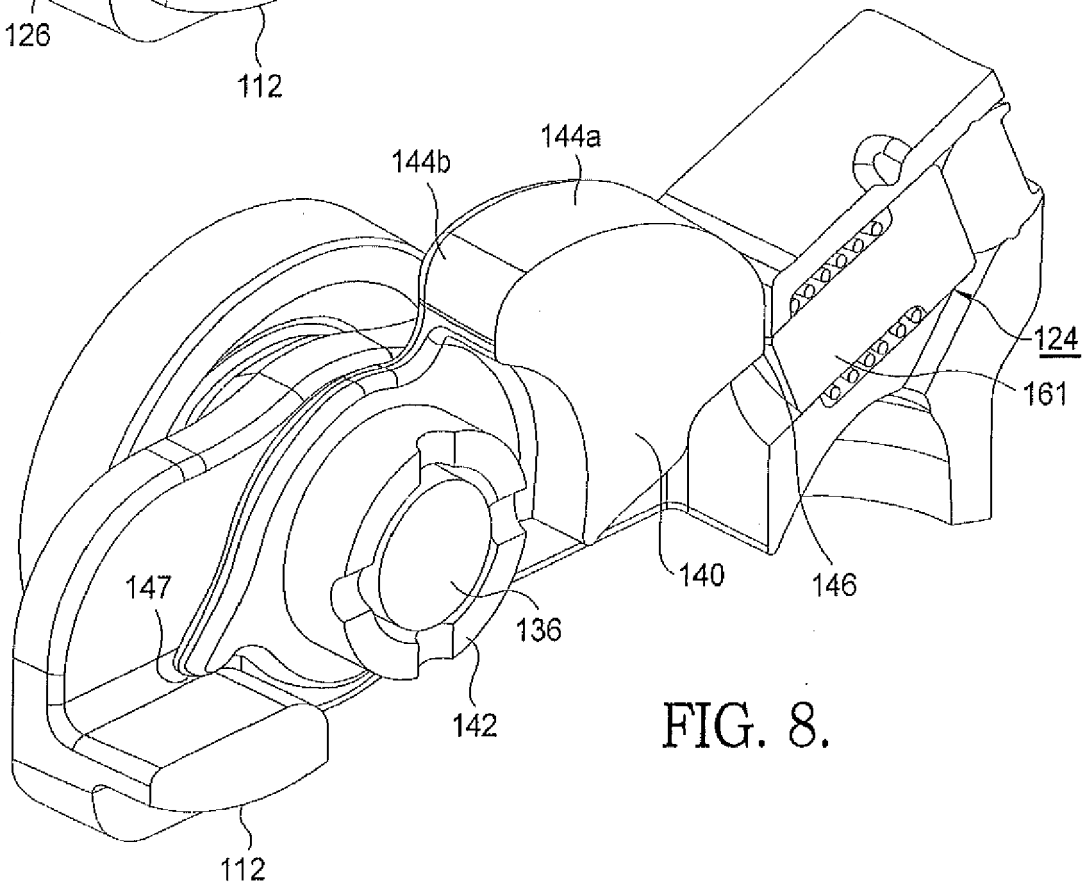
142
116
126
112

FIG. 7.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144b
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161
147
140
146
136
142
112

FIG. 8.

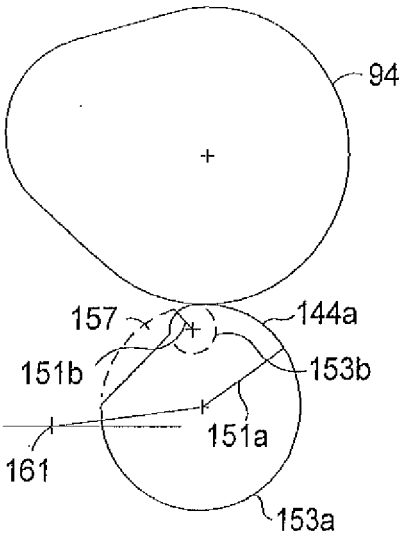
94
157
144a
151b
153b
151a
161
153a

FIG. 9.

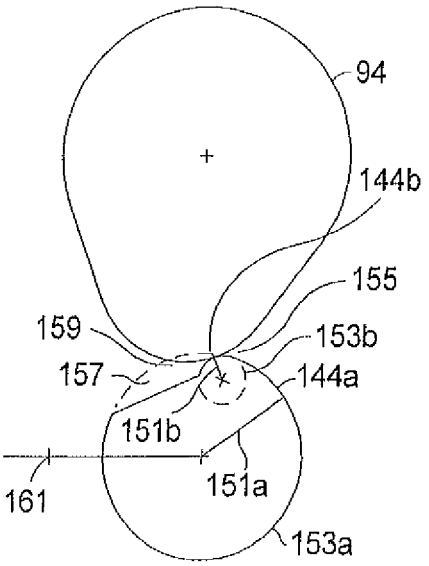
94
144b
155
159
153b
157
144a
151b
151a
161
153a

FIG. 10.

REFERENCES CITED IN THE DESCRIPTION

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- US 20060249110 A **[0005]**
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- WO 2007035673 A2 **[0012]**