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(54) **SPRING-LESS VALVE TRAIN FOR INTERNAL COMBUSTION ENGINE**

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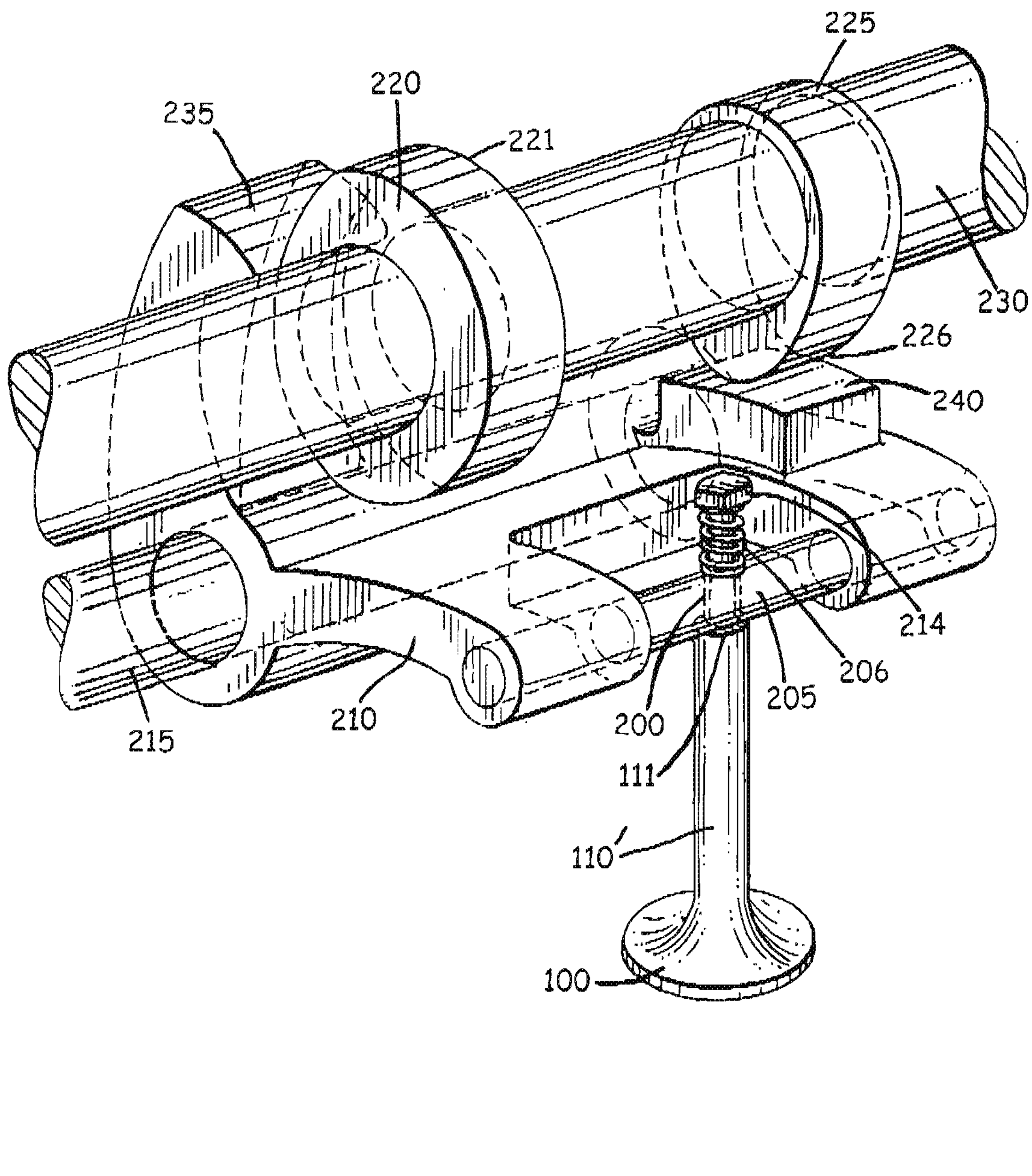
(57) **ABSTRACT**

A rocker arm (**210**) for use in a reciprocating, internal combustion engine includes a tip (**235**) and a seat (**240**). The tip and seat are urged to move by cams (**220**, **225**) on a shaft (**230**). As the shaft rotates, the cams alternately apply force to the tip and the seat, causing the rocker arm to rotate about a pivot shaft (**215**). A valve (**100**) and valve stem (**110'**) are attached to the rocker arm. The valve is urged to open and close by motion of the rocker arm. Thus the valve is opened and closed through the use of positive camming and reciprocating forces only. No conventional valve spring is required to close the valve. Thus valve floating at high engine speeds is prevented and engine performance is improved.



(PRIOR ART)

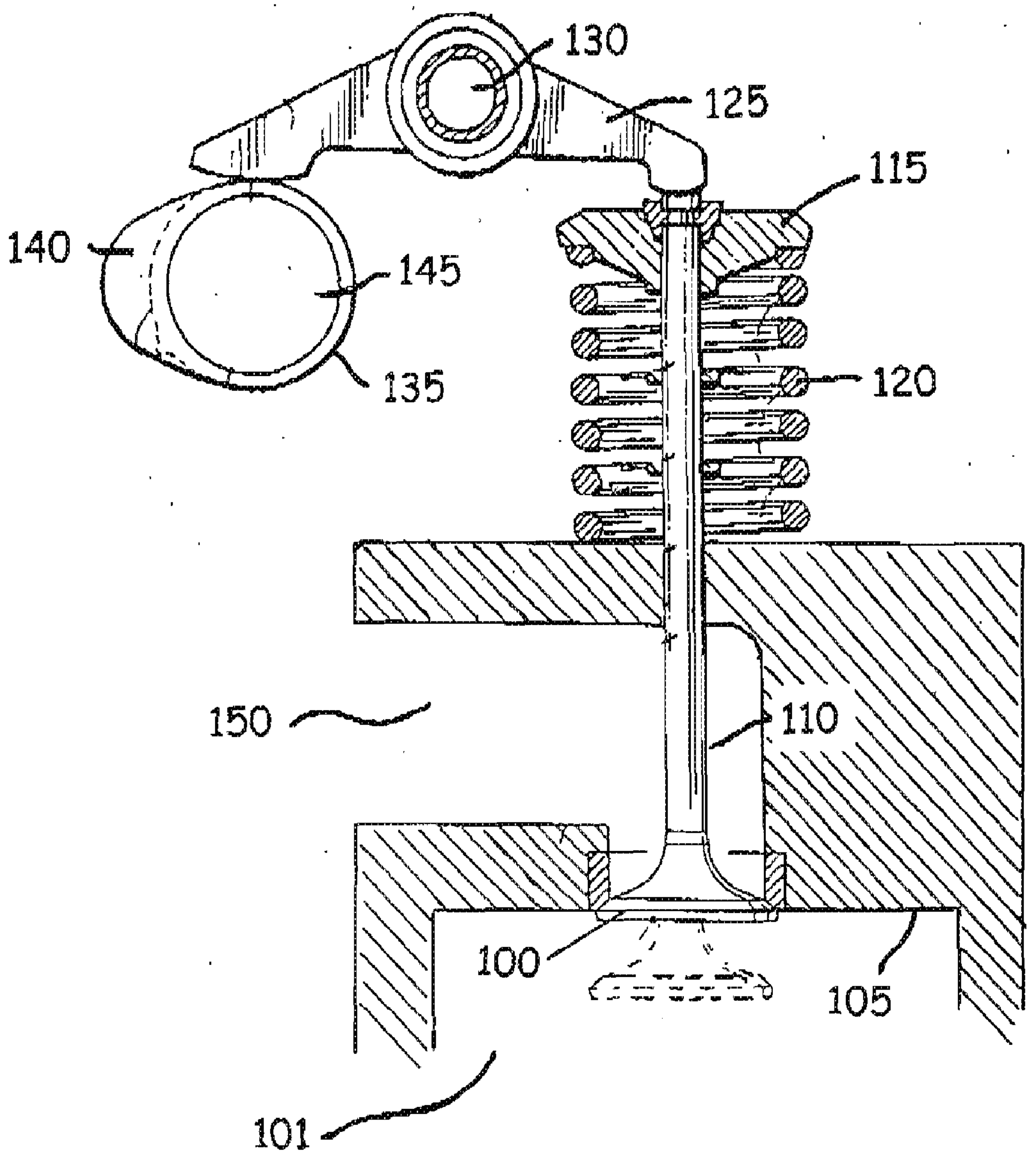


FIG. 1

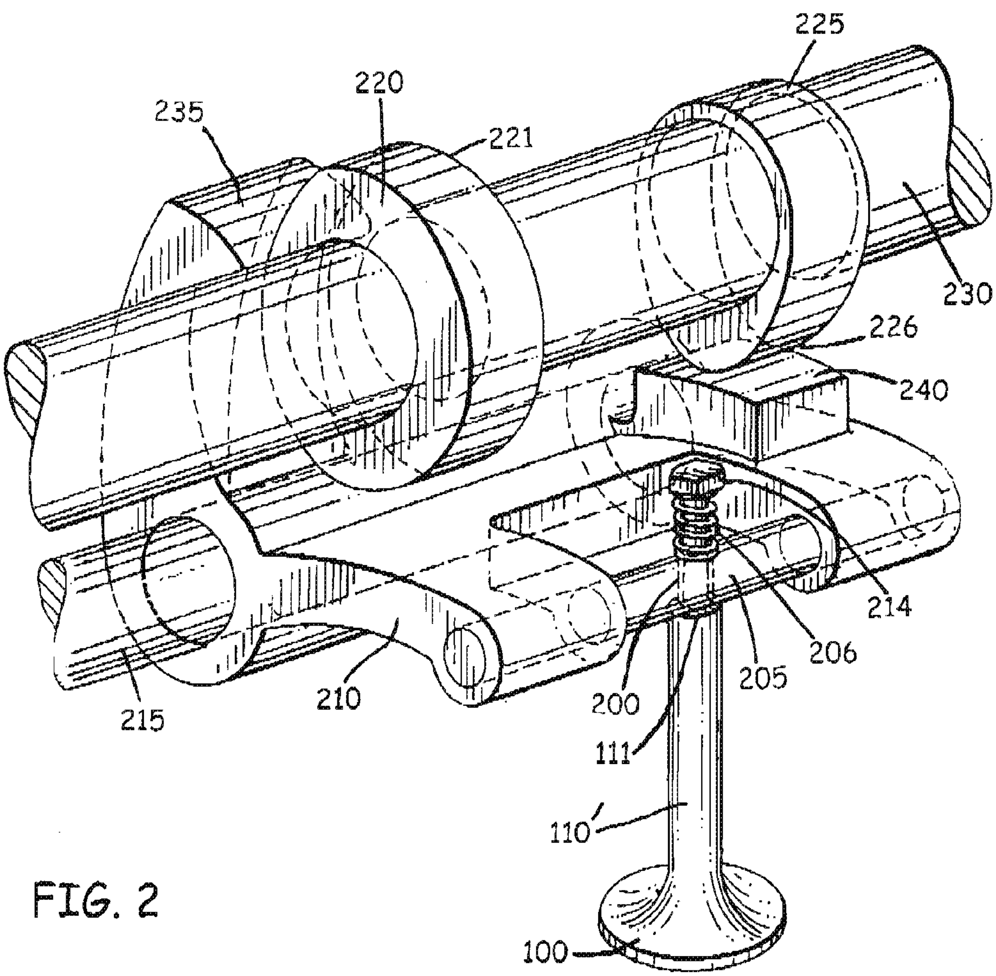
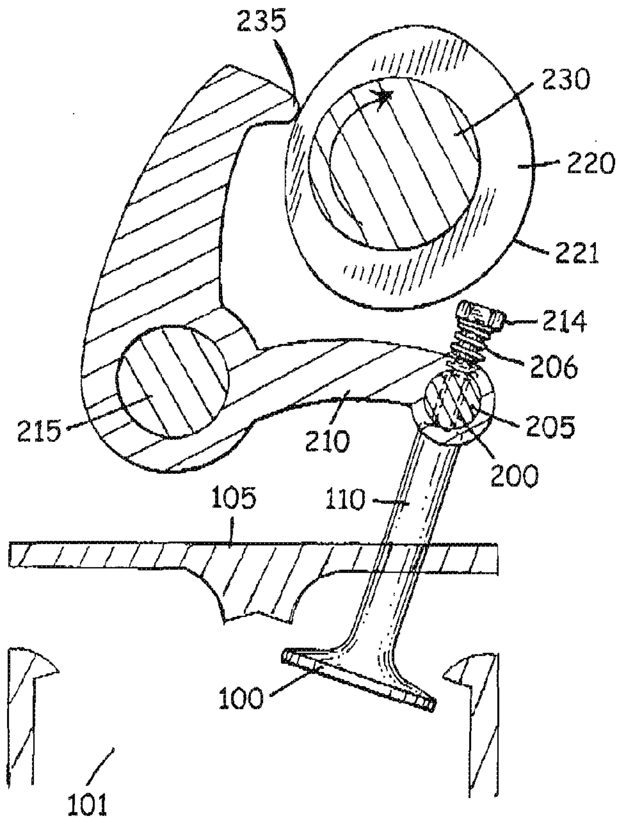


FIG. 2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101

FIG. 3

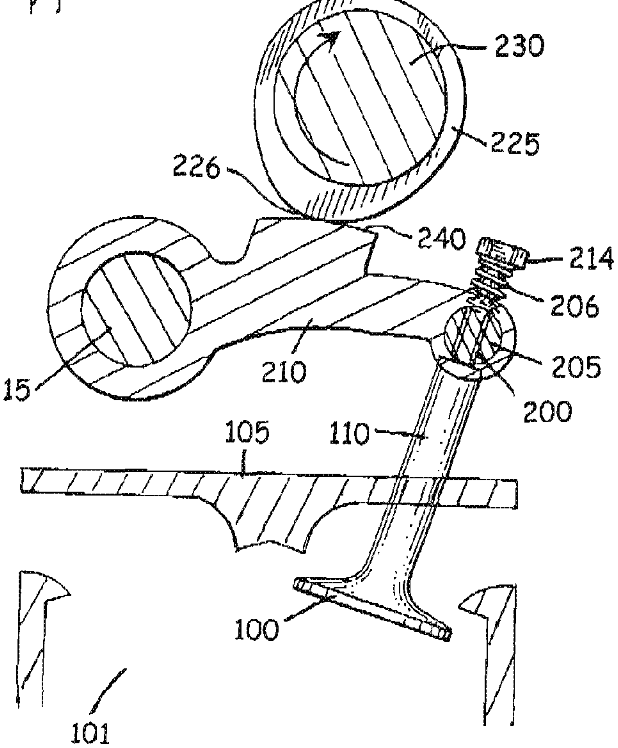
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FIG. 4

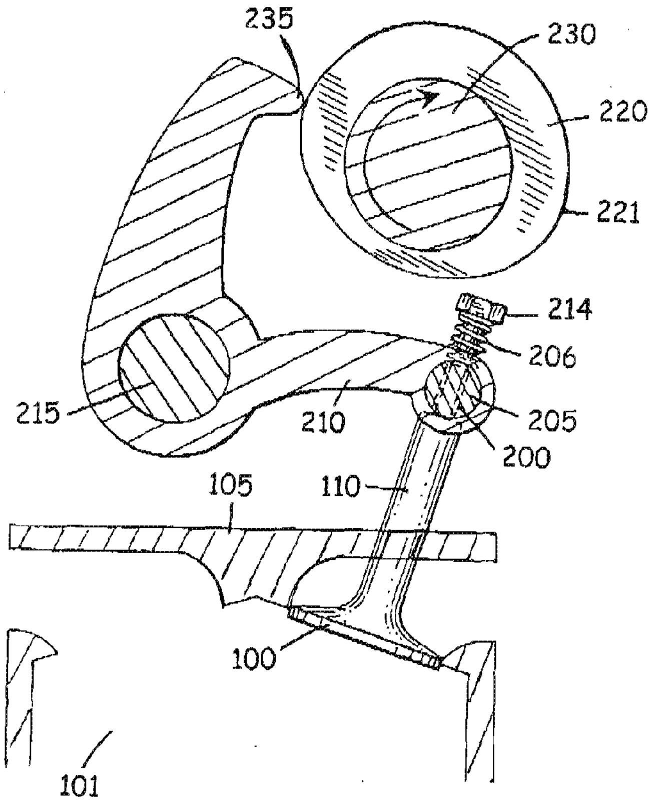
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FIG. 5

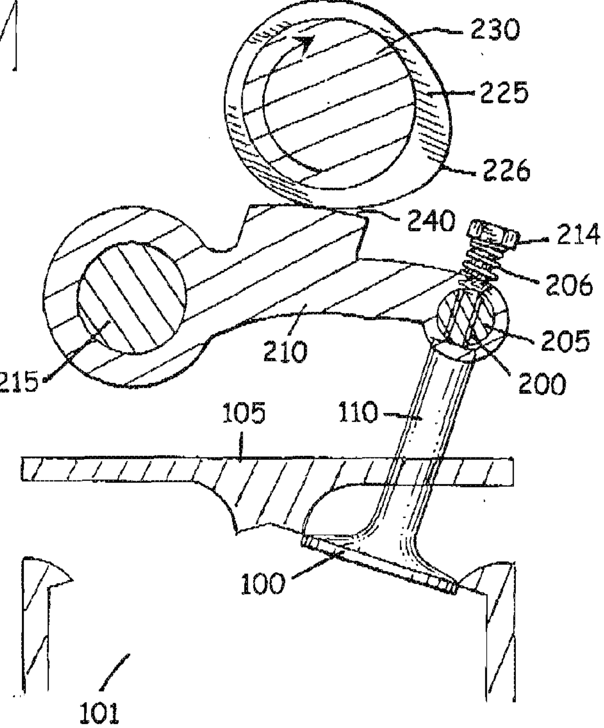
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FIG. 6

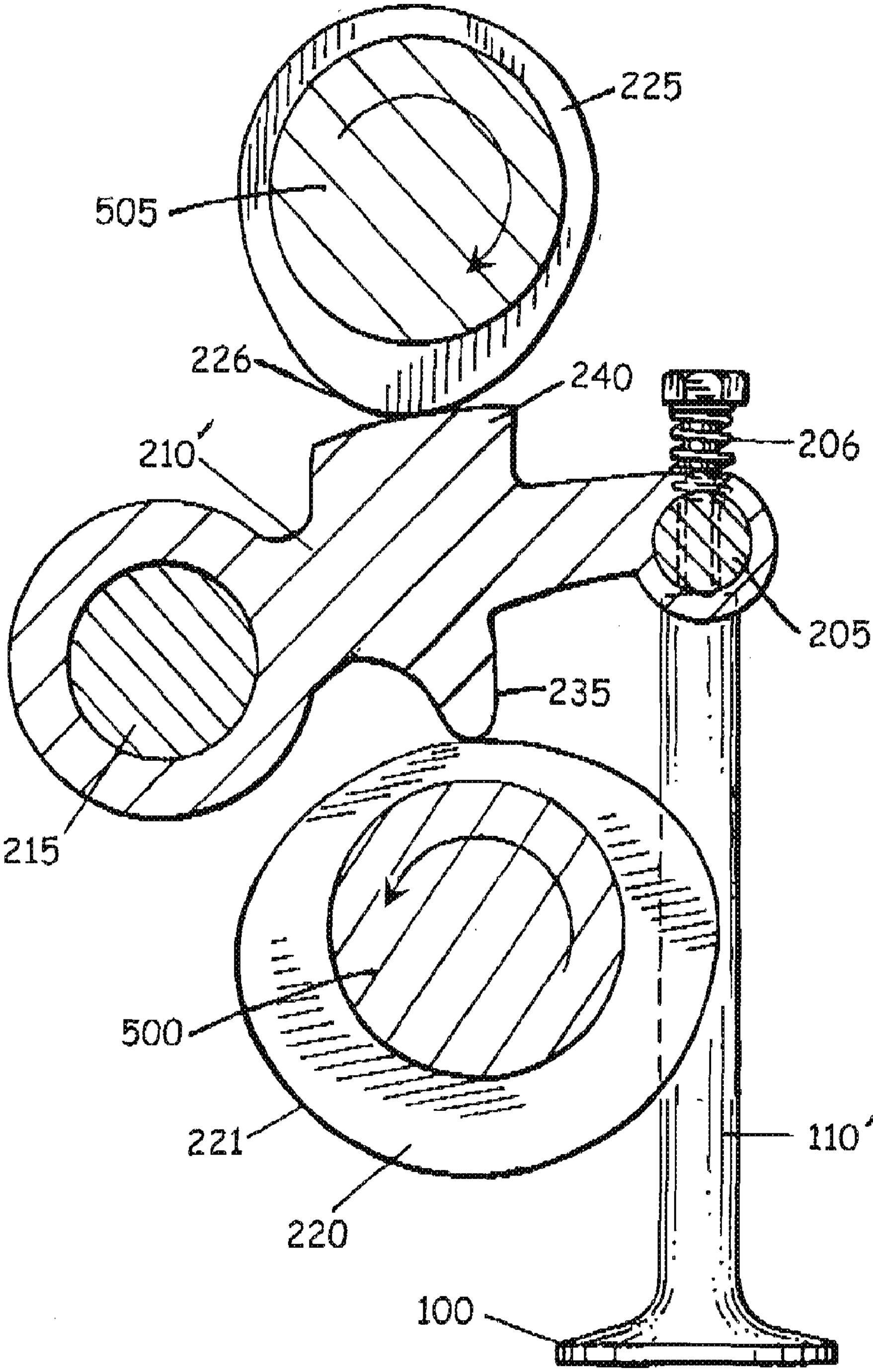

FIG. 7

SPRING-LESS VALVE TRAIN FOR INTERNAL COMBUSTION ENGINE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] My U.S. Pat. No. 7,228,829, granted 2007 Jun. 12, shows a valve timing adjustment system.

BACKGROUND

[0002] 1. Field

[0003] The field is internal combustion engines and in particular valve trains therefor.

[0004] 2. Prior Art

[0005] Internal combustion engines generally comprise an engine block with one or more cylinders. Each cylinder contains a reciprocating piston and at least two openings that are opened and closed by valves. An inlet valve admits a fuel-air mixture and an outlet valve permits exhaust gases to escape. Both valves are held normally closed by strong springs to prevent the unwanted escape of gases during the compression and power strokes of the engine. During operation of the engine, each valve is repeatedly pushed open at predetermined times and rates by lobes on a camshaft that cam, either directly or indirectly, the ends of the valve stems, in well-known fashion. In many cases, the camshaft lobes cam on one end of a rocker arm that pivots about a central axis; the other end of the rocker arm opens the valve. In either arrangement, the camshaft works against the force of the springs to open the valves periodically; the valves are closed by the springs when they are not cammed open.

[0006] FIG. **1** shows a side view of a prior-art valve **100** that seats within a cylinder **101** in an engine block **105**. Valve **100** has a stem **110** that extends upward from block **105**. The upper end of stem **110** is secured to a bushing **115** that holds a spring **120** in compression against the top of block **105**, thereby holding valve **100** in a normally-closed (up) position as shown. A rocker arm **125** pivots on a shaft **130**. A cam **135** having a lobe **140** rotates on a camshaft **145** that is connected to the crankshaft by a timing belt or chain (not shown) so that the camshaft rotates in synchronism with the engine's crankshaft (not shown). When lobe **140** rotates from the side position shown to an upward position (not shown) it pushes upward against the left side of rocker arm **125**, causing arm **125** to rotate in a clockwise (CW) direction about shaft **130**. Arm **125** pushes downward on valve stem **110**, thereby opening valve **100**, as indicated by dashed lines. When valve **100** is open gases can pass to or from cylinder **101** via an inlet or exhaust port **150**. Each cylinder has a minimum of two such valves, an inlet and an outlet. The diameter of valve **100** is typically between 1.5 and 10 cm, depending upon the size of the engine. In an engine with a valve diameter of three cm, the travel of valve **100** between its open and closed conditions is about one cm.

[0007] Pushing the inlet and exhaust valves open against the opposing force of the springs uses energy that is derived from the combustion cycle of the engine. Friction at all points between the cam lobes and the valve stems contributes to wear and heating of the engine and adds strain to the engine's timing belt, motor oil, and starter. This energy is lost and not available at the engine's crankshaft. Also it creates additional heat in the engine. This results in a reduction in engine efficiency that is measurable in terms of shorter engine life and increased fuel consumption. In addition, when the engine is operated at very high speeds, the springs lack adequate force to close the valves before they are to be opened again. When this happens, the rocker arm separates from contact with the valve stem and the valves are said to float, i.e. remain open. In this condition, engine output and efficiency drop to nearly zero.

SUMMARY

[0008] In accordance with an aspect of one embodiment, an internal combustion engine uses no strong springs to hold the inlet and exhaust valves closed. Instead, the valves are opened and closed at predetermined times and rates by a camshaft that applies both opening and closing forces to the inlet and exhaust valve stems. Removing the requirement to compress the valve springs during engine operation results in improved engine efficiency that is realized in reduced fuel consumption, a lighter engine, lower engine wear, less heat, and improved engine performance. Since the valves are forced open and closed by the camshaft, floating of the valves at high speeds is prevented.

DRAWING FIGURES

[0009] FIG. **1** shows a prior-art valve system.

[0010] FIGS. **2** through **6** show aspects of a first embodiment.

[0011] FIG. **7** shows an alternative embodiment.

REFERENCE NUMERALS

[0012]

100	Valve	101	Cylinder	105	Block
110	Stem	111	Shoulder	115	Bushing
120	Spring	125	Arm	130	Pivot
135	Cam	140	Lobe	145	Shaft
150	Port	200	Hole	205	Pin or rod
206	Spring	210	Arm	214	Fastener
215	Shaft	220	Cam	221	Lobe
225	Cam	226	Lobe	230	Shaft
235	Tip	240	Seat	500	Shaft
505	Shaft				

FIRST EMBODIMENT

Description—FIGS. 2 through 4

[0013] FIG. **2** is a perspective view of a cam, rocker arm, and valve assembly. In one aspect of a first embodiment, a valve **100** seats in a cylinder **101** (FIGS. **3** through **6**) of an internal combustion engine (not shown). A valve stem **110'** extends upward from valve **100**. The diameter of the upper end of stem **110'** is reduced and passes through a hole **200** in a pin or rod **205** that is rotatably secured within a rocker arm **210**. Stem **110'** has a shoulder **111** in where the diameter of the upper portion of stem **110'** decreases. This prevents the lower portion of stem **110'** from passing into hole **200**. The upper end of stem **110'** extends above pin **205**. The top of pin **205** and a fastener **214** hold a spring **206** in compression. Fastener **214** preferably is a bolt head that is secured to the top of stem **110'** but can also be a bushing, clevis, etc. Fastener **214** can be adjustable, as in the case of a screw or bolt that screws into the upper end of stem **110'**, or non-adjustable as in the case of a clip. Thus valve **100** and its stem **110'** are springably held captive in pin **205**. Spring **206** is pushed upwardly when rod

205 is moved upwardly by the rocker arm and in turn pushes fastener **214** and hence valve **100** upwardly to a closed position. Spring **206** also accommodates tolerance variations and holds valve **100** in a closed position as the engine wears or changes dimensions due to heating and cooling. Thus spring **206** and shoulder **111** form a pair of facing shoulders that are pushed up and down, respectively, by rod **205**. The strength and compression of spring **206** is significantly less than that of spring **120** (FIG. **1**). As such, the energy spent in further compressing spring **206** during operation of the engine is negligible.

[0014] Two cams **220** and **225** having lobes **221** and **226**, respectively, extend radially from a camshaft **230** that turns in synchronism with the engine's crankshaft (not shown). Camshaft **230** is turned by a timing belt or chain (not shown) in conventional fashion. The shapes of cams **220** and **225** are complimentary, i.e., they work in concert to control the opening and closing of valve **100**. Cam **220** varies in thickness from a low point to a long lobe **221** of uniform thickness. Cam **225** varies in thickness from a uniform low region to a relatively short lobe **226**. In this example, cams **220** and **225** are shown in positions that cause valve **100** to be open. As lobe **226** of cam **225** forces seat **240** downward, cam **225** causes valve **100** to open and thus is an opening cam. When lobe **221** of cam **220** forces tip **235** to the left, in turn causing arm **210** to rotate CCW, cam **220** causes valve **100** to close and thus is a closing cam. Closing cam **220** has a relatively long lobe **221** that extends circumferentially approximately 180 degrees around cam **220**, thereby holding valve **100** closed during the compression and combustion portions of the engine cycle. Opening cam **225** has a relatively short lobe **226** that extends circumferentially about 90 degrees around cam **225** resulting in a shorter open time for valve **100**, suitable for the relatively shorter-duration intake and exhaust portions of the engine cycle. The difference in height between the low point and the high points of cams **220** and **225** is preferably about one cm, although other heights can be used. Other cam profiles are possible and provide for different opening and closing rates and travel of valve **100**, as will be apparent to those skilled in the art.

[0015] Rocker arm **210** pivots about its central point on a shaft **215**. Rocker arm **210** includes two cam follower surfaces: a tip **235** and a seat **240**. Tip **235** is positioned to contact and follow cam **220**. Seat **240** is positioned to contact and follow cam **225**. All parts are made of steel, although other materials can be used. Tip **235**, cams **220** and **225**, and seat **240** are made of hardened steel.

Operation—FIGS. 3 and 4

[0016] FIGS. **3** through **6** show cross-sectional views of rocker arm **210** at various positions of cams **220** and **225**, respectively. FIGS. **3** and **4** show the position of the various components at the instant when valve **100** is fully open. FIGS. **5** and **6** show the position of the components when valve **100** is fully closed. FIGS. **3** through **6** each show a valve in order to indicate operation of the valve assembly. However, only one valve is present for each pair of cams **220** and **225**.

[0017] FIGS. **3** and **4** show the valve opened: lobe **221** (FIG. **3**) of closing cam **220** is at its lowest point relative to shaft **230** and tip **235** of the rocker arm bears against the non-lobed portion of closing cam **220**. At the same point in time, the highest point of lobe **226** (FIG. **4**) cams seat **240**, urging arm **210** to rotate CW about shaft **215** and forcing rod **205** to its lowest position, thereby moving shoulder **111** and hence valve **100** down to the valve's most open position.

[0018] FIGS. **5** and **6** show the valve closed: as shaft **230** rotates CW, lobe **221** of closing cam **220** rotates from its lowest point (FIG. **3**) to its highest point (FIG. **5**) where it cams tip **235** of arm **210**, thereby causing arm **210** to rotate counter-clockwise (CCW) on shaft **215** and urging rod **205** in an upward direction, thereby forcing spring **206** and hence fastener **214** and valve **100** upwardly so that valve **100** seats in its closed position in block **105**. At the same time, lobe **226** of cam **225** (FIG. **6**) has rotated so that its lowest point relative to shaft **230** bears against seat **240**, thereby permitting valve **100** to close.

[0019] Thus as shaft **230** turns CW, opening cam **225** and seat **240** urge rocker arm **210** to rotate CW about shaft **215**, forcing valve **100** to open, and then closing cam **220** and tip **235** urge rocker arm to rotate CCW about shaft **215**, forcing valve **100** to close, and so on. Thus the timing of the opening and closing of valve **100** is determined entirely by the shapes of closing and opening cams **220** and **225**. The maximum height of closing cam **220** is chosen to cause arm **210** to rotate CCW sufficiently to compress spring **206** slightly, thereby assuring that valve **100** will fully close despite manufacturing tolerances and dimensional changes in the engine (not shown) as it heats and cools.

[0020] Closing cam **220** and tip **235** of rocker arm **210** ensure that valve **100** will fully close with each compression and combustion cycle of the engine. This prevents valve floating at high engine speeds.

FIRST ALTERNATIVE EMBODIMENT

Description and Operation FIG. 7

[0021] FIG. **7** shows one aspect of an alternative embodiment. Instead of being displaced side-by-side on rocker arm **210** (FIG. **2**), tip **235** and seat **240** lie in the same vertical plane. Instead of rotating on a single camshaft **230** (FIG. **2**), closing and opening cams **220** and **225** rotate on separate shafts **500** and **505**, respectively. A timing belt or chain (not shown), well-known in the art, causes shafts **500** and **505** to rotate in synchronism with the engine's crankshaft (not shown).

[0022] As shaft **505** rotates, lobe **226** of opening cam **225** cams seat **240**, forcing arm **210'** to rotate CW about shaft **215**, thereby opening valve **100**. As shaft **500** continues to rotate, lobe **221** of closing cam **220** cams tip **235** of arm **210'** to the left, causing arm **210'** to rotate CCW, thereby closing valve **100**, and so on.

[0023] As in the previous embodiment, the present arrangement ensures that valve **100** is opened and closed at the proper times, without the use of the prior-art spring.

SUMMARY, RAMIFICATIONS, AND SCOPE

[0024] The embodiments shown of my improved valve driving arrangements for internal combustion engines result in an engine having improved performance, less internal wear, fewer parts, less heat, and lower cost. Without the large and forceful (stiff) prior-art valve springs, many components, such as the cylinder head, starter motor, rocker arm, and cam lobe can be made smaller and lighter. Those skilled in the art can shape the contours of the cam lobes for optimum performance of each engine.

[0025] While the above description contains many specificities, these should not be considered limiting but merely exemplary. Many variations and ramifications are possible. For example, instead of a finger on the rocker arm, a roller bearing can be used. Instead of a coil spring to compensate for dimensional changes, a leaf spring or Belleville spring washer can be used. Instead of the stem of the valve having a narrowed portion and extending through the rod, the stem can have a uniform diameter with two projecting spaced shoulders or collars that can be pushed up and down (either directly or via one or two springs similar to spring **206**) by the rod. Also the rod can extend through a hole in the stem. While the description of the embodiments discusses one valve in one cylinder for ease and simplification of explanation, those skilled in the art will recognize that the embodiments will usually be used with and can readily be adapted to multiple-cylinder engines with multiple valves per cylinder.

[0026] While the present system employs elements which are well known to those skilled in the art of internal combustion engine design, it combines these elements in a novel way which produces one or more new results not heretofore discovered. Accordingly the scope of this invention should be determined, not by the embodiments illustrated, but by the appended claims and their legal equivalents.

1. An internal combustion engine having a rotatable camshaft, at least one cylinder having at least one valve coupled to said camshaft and arranged to open and close a port in said cylinder, an improvement comprising coupling means for coupling said valve to said camshaft such that rotation of said camshaft alternately (a) cams said valve to an open position that opens said port, and (b) cams said valve to an closed position that closes said port, whereby strong valve springs do not have to be compressed during engine operation, resulting in improved engine efficiency through reduced fuel consumption, a lighter engine, lower engine wear, less heat, and improved engine performance.

2. The internal combustion engine of claim **1** wherein said coupling means comprises at least one rocker arm that follows said camshaft and seesaws in response to rotation of said camshaft and thereby forces said valve between said open and closed positions in response to the seesaw movement of said rocker arm.

3. The internal combustion engine of claim **2** wherein said coupling means also comprises a rod that reciprocates with said seesaw movement of said rocker arm and couples said rocker arm to said valve, said valve having a stem that has a pair of facing shoulders that sandwich said rod, one of said rod and said stem having a hole therethrough, the other of said rod and said stem extending through said hole.

4. A rocker arm assembly for opening and closing a valve having a stem in a reciprocating, internal combustion engine, comprising:

a camshaft arranged to rotate with said engine and having first and second attached cams,

a rocker arm mounted on a pivot and having a pair of cam followers, namely a tip and a seat,

said tip of said rocker arm being arranged to follow said first cam, and said seat of said rocker arm being arranged to follow said second cam so that said rocker arm will rock back and forth in a seesaw movement when said engine runs,

a rod attached to said rocker arm and arranged to reciprocate in response to said seesaw movement of said rocker arm,

said stem of said valve being attached to said rod so that as said camshaft rotates, said second cam first urges said seat of said rocker arm and said rocker arm to move in a first direction, thereby causing said rod to open said valve, then said first cam urges said tip of said rocker arm and said rocker arm to move in the opposite direction, thereby closing said rod to close said valve

whereby strong valve springs do not have to be compressed during engine operation, resulting in improved engine efficiency through reduced fuel consumption, a lighter engine, lower engine wear, less heat, and improved engine performance.

5. The assembly of claim **4**, further including a spring interposed between the end of said stem and said pin.

6. The assembly of claim **4**, further including a fastener affixed to said stem for retaining said spring.

7. The assembly of claim **6** wherein said fastener is selected from the group consisting of adjustable and non-adjustable fasteners.

8. The assembly of claim **4** wherein said stem of said valve has a pair of facing shoulders that are moved in respectively opposite directions by said rod.

9. A rocker arm assembly for opening and closing a valve with a stem in a reciprocating, internal combustion engine, comprising:

a rocker arm mounted on a pivot and arranged to rock back and forth in a seesaw movement,

said rocker arm having a pair of cam followers, namely a tip and a seat,

a pin being attached to said rocker arm and arranged to reciprocate in response to said seesaw movement of said rocker arm,

said stem of said valve being attached to said pin,

said arm being arranged to rotate about said pivot,

said tip being arranged to follow a first cam,

said seat being arranged to follow a second cam,

said first cam being attached to a first camshaft,

said second cam being attached to a second camshaft, said first and said second camshafts being arranged to rotate synchronously with the crankshaft of said engine,

so that as said second camshaft rotates, said second cam urges said seat and said arm to move in a first direction, thereby opening said valve, and as said first camshaft rotates, said first cam urges said tip and said arm to move in the opposite direction, thereby rotating said arm in a second direction and closing said valve,

whereby strong valve springs do not have to be compressed during engine operation, resulting in improved engine efficiency through reduced fuel consumption, a lighter engine, lower engine wear, less heat, and improved engine performance.

10. The assembly of claim **9**, further including a spring interposed between the end of said stem and said pin.

11. The assembly of claim **9**, further including a fastener affixed to said stem for retaining said spring.

12. The assembly of claim **11** wherein said fastener is selected from the group consisting of adjustable and non-adjustable fasteners.

13. The assembly of claim **9** wherein said stem of said valve has a pair of facing shoulders that are moved in respectively opposite directions by said rod.

14. A method for opening a valve in a reciprocating, internal combustion engine, comprising:

providing a valve with a stem, said valve being arranged to close a port in a cylinder when said valve is in a closed position and open said port when said valve is in a closed position,

providing a rocker arm having two cam followers, namely, a tip and a seat, said rocker arm mounted on a first shaft and being arranged to pivot on said first shaft,

providing a first cam having a first lobe and arranged to rotate in response to operation of said engine,

providing a second cam having a second lobe and arranged to rotate in response to operation of said engine,

said tip and said seat of said rocker arm being arranged to follow said first and second lobes of said first and second cams so that said rocker arm reciprocates in response to rotation of said engine,

providing a rod, said rod being attached to said stem of said valve and said rocker arm and arranged to cause said valve to open and close in response to reciprocation of said rocker arm,

so that when said tip is urged by said first cam, said valve is urged into a closed position, and when said seat is urged by said second cam, said valve is urged into an open position,

whereby strong valve springs do not have to be compressed during engine operation, resulting in improved engine efficiency through reduced fuel consumption, a lighter engine, lower engine wear, less heat, and improved engine performance.

15. The method of claim **14**, further including a spring interposed between an end of said stem and said pin.

16. The method of claim **14**, further including a fastener affixed to said stem for retaining said spring.

17. The method of claim **16** wherein said fastener is selected from the group consisting of adjustable and non-adjustable fasteners.

18. The method of claim **14** wherein said stem of said valve has a pair of facing shoulders that are moved in respectively opposite directions by said rod.

19. The method of claim **14** wherein said first and second cams are mounted on a common camshaft.

20. The method of claim **14** wherein said first and second cams are mounted on first and second camshafts, respectively.

21. The method of claim **14** wherein said stem of said valve extends through a hole in said rod.

22. The method of claim **14** wherein one of said first and second lobes of said first and second cams is relatively long and the other of said lobes is relatively short.

* * * * *