March 23, 1971 T. J. LESTER 3,572,299

VALVE-ACTUATING TRAIN FOR MACHINERY HAVING A CYCLICLY OPERATED POPPET VALVE

Filed Dec. 15, 1969 2 Sheets-Sheet 1

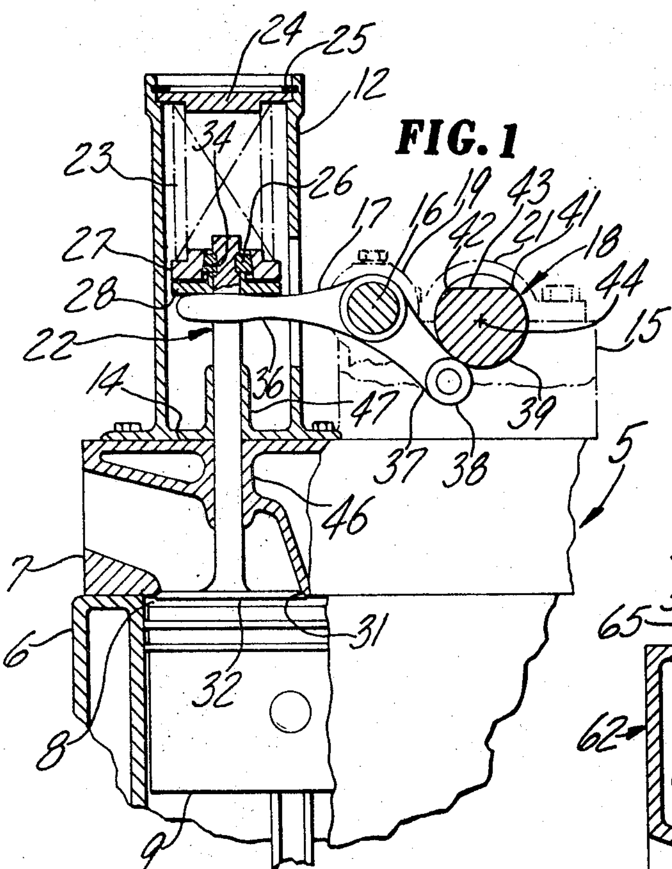

FIG. 1

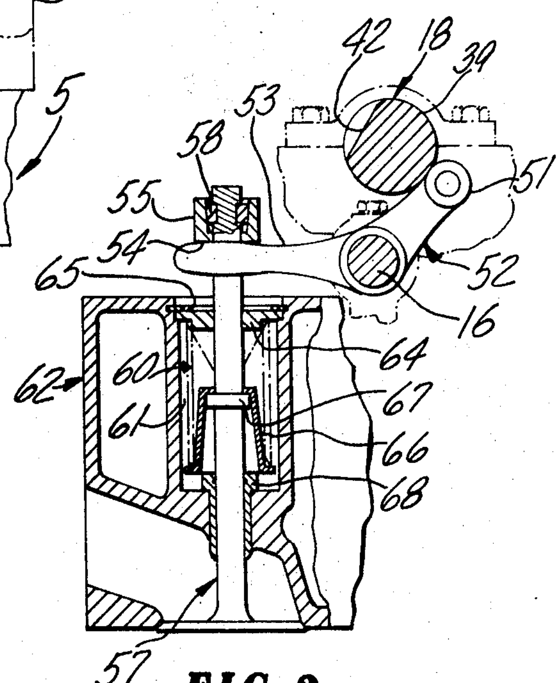

FIG. 2

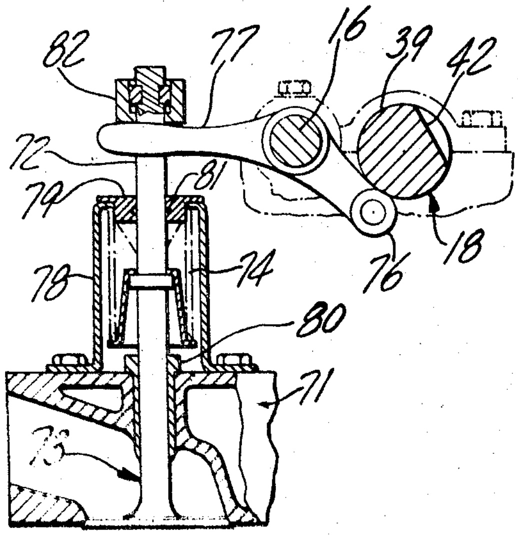

FIG. 3

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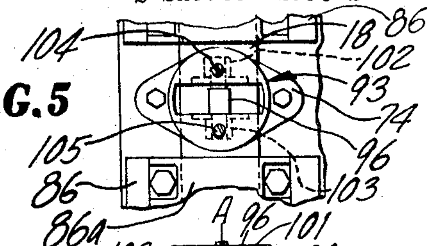

FIG.5

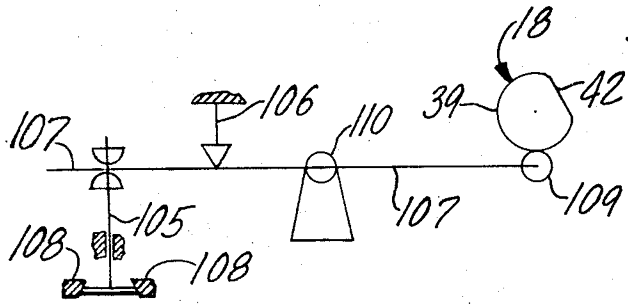

FIG.6

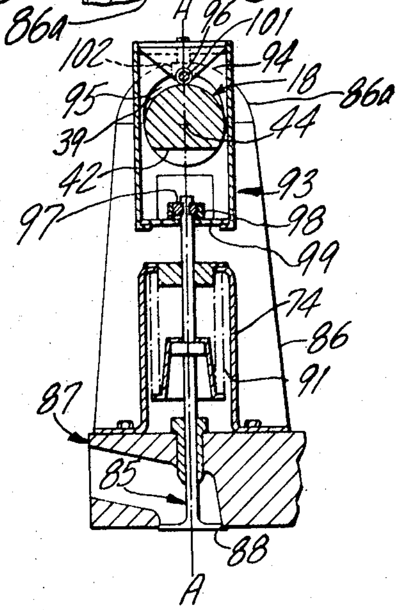

FIG.4

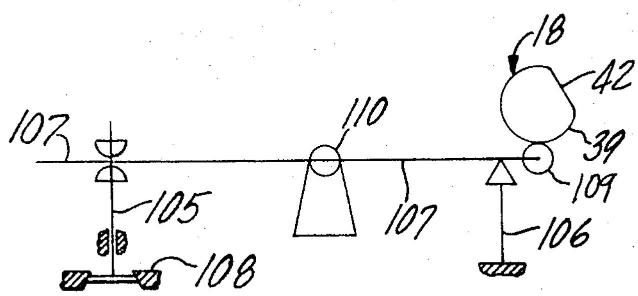

FIG.7

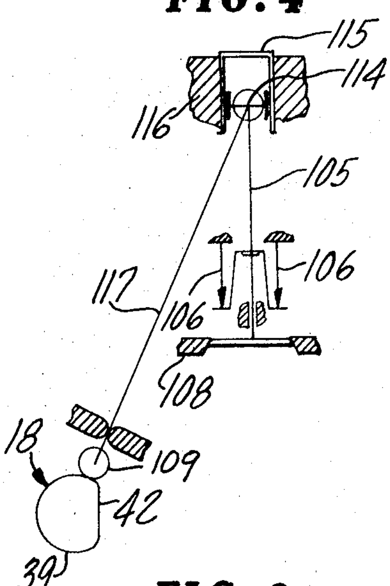

FIG.9

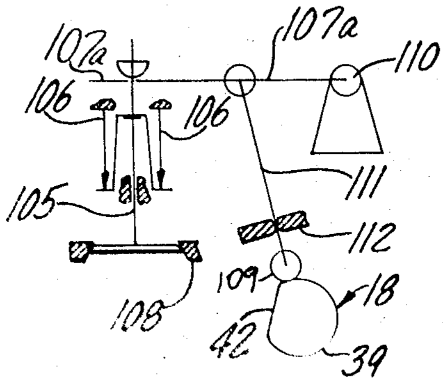

FIG.8

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1

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VALVE-ACTUATING TRAIN FOR MACHINERY HAVING A CYCLICLY OPERATED POPPET VALVE

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U.S. Cl. 123—90.25 14 Claims

ABSTRACT OF THE DISCLOSURE

An engine, especially of the internal-combustion valve-in-head type, wherein a valve controlling cam and a cam follower of a valve train act positively on the valve to hold it closed against a seat facing inwardly of the combustion chamber except when the cam rotates through a minor portion of each revolution to release the remainder of the valve train for valve opening whereupon a spring or other resilient means forces the valve open.

Various technical advances in design and metallurgy have made possible the operation of internal combustion engines at ever greater rotative speeds. However, an effective limitation to high engine speeds at any reasonable expense continues to be a lack of dependable valve mechanisms.

In most automobile engines the valve is free, except for the valve spring, to move further inwardly of the cylinder than the rocker arm or cam stroke requires. If the kinetic energy absorbed by the valve train is sufficient, excessive valve entry into the cylinder may, and frequently does, occur. In an engine having a conventional mechanism wherein the valve is positively opened in oppostion to a spring for closing the valve, performance is inevitably limited to some speed at which precise control of the valve is lost and the valve remains open at unwanted times during the piston cycle. This is simply because the inertia of the valve train is greater than the valve spring can overcome in maintaining the valve in engagement with the rocker arm or other cam follower in returning the valve to a seated position. This is commonly known as "valve floating" and may result in engagement of the valve head and the piston. Severe collision of the valve with the piston may cause separation of the valve head from the stem with disastrous effect on the engine. Another reason for valve bending or breakage is high frictional drag or sticking of the stem relative to its guide. Valve damage may result as a combination of frictionally retarded closing action and high rotational speeds. Another common hazard which is aggravated by high engine speed is valve spring breakage. Because of the loss of return or closing force resulting from a broken spring, valve and piston collision is almost inevitable in a valve-in-head engine.

Where a simple practical alternative is available, desmodromic valve trains may not be desired because of complexity and cost of parts, structure needed to overcome the disadvantages of thermal expansion of parts, the high wear rate versus the fitting precision of parts needed for optimum efficiency of the engine.

Accordingly, an important object of the invention is to provide a simply constructed poppet valve train by which the valve position may be controlled in a manner to minimize or eliminate valve "float" and to render virtually impossible any collisions of a piston and a valve head.

Another object is to control positively the extent of entry of the valve into a cylinder.

A further object is to minimize detriment to the functioning of a multiple cylinder engine due to the malfunctioning of a valve train at one cylinder of conventional spring-closed valve engines by providing valve train mechanism by which a malfunctioning valve may remain closed rather than open. This is of considerable importance in high-compression engines in which the clearances are too small to avoid collision of the piston with a valve which is open at an improper time.

2

It is also an object to provide valve train mechanism which avoids spring-closing constructions and desmodromic constructions and places the valve under positive control during a preponderant portion of its opening and closing cycle and, especially, obtains more accurate valve closure than occurs in engines with spring-closed valves.

These objects and others which will be apparent from the present disclosure are achieved in a poppet valve train in which the valve thereof is positively closed during operation of the parent machine from a calibrated opened position and held shut by a substantially rigid non-resilient mechanical linkage until engine operation requires that the valve be opened. The valve is then forced open by resilient means, such as a spring or fluid pressure, in a precisely controlled manner.

In a preferred embodiment, apparatus typified by an engine or compressor, or other internal combustion equipment defining an expansible chamber or cylinder having a closed but ported end through which gasses are transferred by one or more poppet valves comprises: (1) a cam having a continuous surface extending around an axis of cam rotation of which a preponderant portion is an arcuate area and the remaining portion is a non-concentric area extending from one end of the arcuate area to the other at radii from the cam axis less than that of the arcuate area; (2) a spring or other medium acting between a fixed portion of the engine and the stem of the valve to unseat the valve and urge it to its open position; (3) a cam member, such as a camshaft; and (4) cam-following mechanism, such as a rocker arm or cage extension of the valve stem in continuous engagement with the cam surface with the arcuate area related with the valve and cam-following mechanism to correspond to the closed position of the valve and the non-concentric area corresponding to the partially or wholly opened positions of the valve.

In the drawing with respect to which the invention is described:

FIG. 1 is an elevation in section of engine head structures taken along a plane which contains the axis of a poppet valve and extends in transverse relation to camshaft and rocker arm axes;

FIG. 2 is an elevation in section of modified engine head structure differing primarily from FIG. 1 in the disposition of the valve opening spring and the configuration of the rocker arm illustrated;

FIG. 3 is an elevation in section of another modification of engine structure taken also along a plane containing the valve axis and intersecting the rocker arm and camshaft axes;

FIGS. 4 and 5 are elevation in section and plan views, respectively, of engine head structure incorporating an overhead cam arrangement in which a camshaft is received in a cage extension of a valve stem as cam-following mechanism;

FIGS. 6, 7, 8, and 9 are diagrammatic elevations of various configurations possible in connecting a camshaft in actuating relation with a poppet valve operated in accordance with this invention.

FIG. 1 illustrates one embodiment of the invention wherein an engine **5** comprises a block **6** and a head **7** which define a closed-end expansible cylinder chamber **8** traversed by a piston **9** as typically found in an internal combustion engine. As head structure including the head, a valve housing **12** removable from the top surface 14 of the block, a bearing support 15, a rocker arm shaft 16, a rocker arm 17, a camshaft 18, bearing caps 19, 21, a poppet valve 22, a valve spring 23, a spring locating cap 24, a lock ring 25, an annular split lock washer 26, a stepped spring retainer 27, and a stepped bearing washer 28 are also included as assembled in FIG. 1.

As shown, the spring 23 stands between the cap 24 and the retainer 27 to urge the valve 22 into the cylinder chamber 8 and away from a seat 31 for the valve head 32. The cap 24 is locked into place by the ring 25 shown received in a groove along the inner surface of the housing 12.

The spacing between the retainer washer 27 and the bearing washer 28 indicates that the two independently and separately engage the split lock washer 26. As shown, an inner annular upstanding flange of the washer 28 engages the underside of the washer 26 whereas the retainer 27 has an interior frustoconical surface 34 conforming to the outer frustoconical surface of the washer 26 with which it wedges under initial and operating compression forces continuously exerted by the spring 23. The term "initial" means that the spring 23 is under substantial compression at the most relaxed condition of its cycle, i.e., when the roller 38 is at midpoint along area 43.

The underside of the washer 28 is constantly engaged by lever portion 36 of the rocker arm 17 as the result of being in constant engagement with the cam 18 through its other lever portion 37 and a roller 38 rotatably supported thereon. The cam as an arcuate area 39 extending from the point 41 to point 42. The cam surface continues from 42 to 41 as an area 43 which is non-concentric with respect to the axis 44 of the camshaft. As shown, area 43 is a flat surface although it may be of other non-concentric, non-flat contour of less radii than the arcuate area 39. The area 43 may in fact be shaped to effect any desired pattern of valve opening since the valve is opened only during engagement of this surface with the roller 38. The head 7 and the housing 12 may be constructed with suitable sleeves 46, 47, respectively, to maintain the valve end in constant concentrically with its intended axis of travel.

FIG. 2 again illustrates the principle of maintaining a valve closed by the camshaft 18 through engagement of its arcuate area 39 with the roller 51 of a rocker arm 52 having its lever position 53 in constant engagement with a surface 54 of a bearing sleeve 55. As the surface 54 faces in the direction for opening the valve 57, the rocker arm acts to hold the valve closed when engaged by area 39 of the camshaft. The sleeve 55 is held in proper axial position by engagement of its inner frustoconical surface to the outer frustoconical surface shown of a split ring 58 (similar to ring 26 of FIG. 1) partially extending into a groove of the stem of valve 57 near the end of the stem for interlocking relation therewith.

A notable difference between the embodiment of FIG. 1 and FIG. 2 is that the valve 57 of FIG. 2 is opened by a spring 60 housed within a chamber 61 therefor within the engine head 62. Th spring 60 is under an initial compression between a locating cap 64 secured by spring ring 65 to an annular seat formed in the upper end of the head wall defining the chamber 61. Thrust to the valve stem in a direction for opening the valve is imparted by the spring as it bears on an elongately stepped spring seat washer 66. A split ring 67 fitting the interior of the smaller end portion of the washer 66 and received in a groove on the stem of the valve 57 provides a shoulder on which the washer 66 seats and locates the washer at a proper point along the length of the valve 57. As shown, the larger end of the waser 66 is free to move in an axial direction past the upper portion of a removable valve guide 68 as the valve moves to open position during contact of the cam area 42 with the roller 51.

The arrangement of FIG. 2 provides an advantageous valve guide arrangement in that the cap 64 may be made as thick as desired in the lengthwise direction of the valve stem to incerase the lateral bearing area. The substantial spacing of the cap 64 and the guide 68 afford exceptional freedom from valve wobble and lateral wear on the guide surfaces.

FIG. 3 illustrates an adaptation of the invention to a head 71 of relatively flat design and valve train elements arranged to connect with the stem 72 of a valve 73 disposed outwardly of the head and extending beyond the valve spring. This embodiment further illustrates the principle of employing a spring 74 to thrust the valve 73 to its open position as the area 42 of the cam 18 rotates into engagement with a roller 76 of the rocker arm 77. The embodiment of FIG. 3 differs from that of FIG. 1 primarily in the location of the valve spring in respect to the valve stem. In the case of FIG. 2, both FIG. 3 and FIG. 2 valve trains have the valve spring acting on an intermediate valve stem portion but in FIG. 3, the valve spring chamber, in addition to the distal portion of the valve spring acted on by the rocker arm, is disposed outwardly of the engine head. Structure for securing the valve spring is slightly different from either the two earlier described embodiments in that the upper end of the spring 74 seats on an inner end surface of the housing 78 and an annular guide element 79, secured to the upper end of the housing 78 with a step portion extending inwardly of the housing, functions as a guide to the valve stem and a radial locator for the spring 74. The guide 79 in combination with the more conventional guide 80 seated within the head 71 provide unusual lateral valve support and freedom from wear and valve wobble. The guide 79 may further function in conjunction with a resilient O-ring 81 received in a groove along its inner surface as an oil seal. The bearing structure 82 shown fixed to the distal end of the valve acted on by the rocker arm is of construction similar to that described with respect to FIG. 2 for a similar purpose.

FIGS. 4 and 5 illustrate valve-in-head engine-head structure of overhead cam construction wherein the camshaft 18 is supported with its axis 44 in perpendicular intersecting relation with the longitudinal axis A—A of a valve 85 by bearing and support structure 86 of the engine head 87. The valve 85 is thrust to its open position in a direction away from its seat 88 by a spring 91 contained in the houpsing 74 and associated structure as described with respect to FIG. 3 and now attached to the head 87.

The cam following mechanism for connecting the valve 85 to the camshaft 18 comprises a cage 93 having a bearing block 94 formed with an opening 95 sufficiently elongate in the lengthwise direction of valve axis A—A to afford relative movement of the cage with the camshaft which at least equals the opening stroke of the valve 85. The cage further comprises a roller 96 supported on an axis of rotation in fixed relation with the block 94 having the function of maintaining engagement with areas 39 and 42 of the camshaft. The distal end of the valve stem is attached as shown by a split ring 97 interlocking with an annular recess of the valve stem and engaging an annular flange 98 secured or resting on a lower plate 99 of the cage 93. The plate 99 may be of spring steel and flexible for the purpose of assuring positive seating of the valve. The roller 96 is provided with axles or trunnions 101 which receive bearings 102, 103 over the upper halves thereof. The bearings 102, 103 may be adjusted upwardly or downwardly by set screws 104, 105, respectively, which continuously engage the bearings. The set screws are in threaded relation with an upper wall of the cage 93.

FIGS. 4 and 5 illustrate that the camshaft 18 may be of generally cylindrical or rod shape except for recesses forming the areas 42, and constructed with a uniform diameter along those portions extending through the cage 93 and a camshaft bearing and support structure 86 including a bearing cap **86***a*. Thus, the camshaft may be economically machined from rod stock providing excellent rigidity with substantial savings over the cost of conventional multi-lobe camshafts. Moreover, the camshaft is relatively stiffer and whip-free.

FIGS. 6, 7, 8, and 9 diagrammatically illustrate various arrangements for carrying out the invention, i.e., utilizing the cam **18** to maintain a valve **105** in closed position and a spring **106** acting on a rocker arm **107** or a push rod, such as push rods **111**, **117** (FIGS. 8 and 9), to maintain the valve **105** in open position relative to its seat **108** when the cam area **42** engages the rocker arm roller **109**. The fulcrum for the rocker arm, normally the rocker arm shaft, is indicated by numeral **110**. FIGS. 6 and 7 indicate that the spring **106** may be at a remote position not directly associated with the valve stem in order to secure the desired operation.

FIG. 8 indicates that an end-fulcrumed lever **107***a* may be in pivotal, slidable relation with, and actuated by, a push rod **111** actuated by the camshaft **18** located at any practical location spaced from the lever **107***a*. The reciprocal action of the push rod is implemented by laterally supporting guides **112**.

FIG. 9 indicates that the distal end **114** of the valve **105** may be in guide relation with a guide **115** attached to a fixed engine part **116** permitting the valve **105** to be maintained in a closed position by the cam **18** by use of an elongate push rod **117** in pivotal, slidable relation with the distal end **114** of the valve **105**.

From the foregoing description, certain advantages of the invention should be apparent, such as (1) the impossibility of collision between a valve and a piston as the result of valve "float," or sticky or stuck valves encountered in spring-closed valve engines; (2) the opening of poppet valves to a precise distance; (3) the establishment of precise valve positioning at all stages of the valve opening and closing cycle; (4) improved utilization of valve forces through the use of a valve spring at its maximum compression to open the associated valve; (5) the tendency of a mal-functioning valve to remain in its closed position rather than an open position; (6) especially in connection with intake valves, the utilization of suction and lighter valve springs to open the valves; (7) simplified, less expensive camshaft manufacture providing a stiffer, more whip-free camshaft; (8) inherently reduced risk of engine self-destruction at high operational speeds; (9) more accurately timed closure of the valve at high operational speeds especially when compared to valve springs of conventional spring-closing valves which have deteriorated to a weakened or broken condition; and (10) in some designs, utilization of widely spaced valve guide areas along the length of the valve stem to reduce valve stem friction, reduce valve wobble, and enable flat cylinder head design.

What is claimed is:

1. In a poppet valve engine having head structure enclosing one end of an expansible chamber, means in said engine defining a gas duct terminating in a seat for a valve facing inwardly of said chamber, a valve train comprising:

a poppet valve having a head and a stem joined together, said engine having guide means in guide relation with the stem with respect to which the valve is reciprocated along a valve axis to cause said valve to sealingly engage said seat and move away from the seat inwardly of said chamber;

rotatable cam means providing a continuous cam surface extending around an axis of rotation in fixed relation with engine portions defining said chamber, said cam surface comprising an arcuate area concentric to said cam axis and a non-concentric area extending from one end of the arcuate area to the other at radii from said axis less than that of said arcuate area;

cam following means engaged with said cam surface and operatively connected with said stem; and

resilient means operatively disposed between seat means supported in fixed relation with said engine portions and an assembly of said cam following means and the valve, said resilient means acting on said assembly to maintain engagement of the cam means and the cam following means;

said valve train being constructed and arranged to maintain said valve head on said valve seat during engagement of said arcuate area with the cam following means, and said spring means acting on said assembly to traverse the valve head inwardly of said chamber to an extent limited by movement of said cam following means in maintaining engagement with said non-concentric area.

2. The engine of claim **1** wherein:

said head structure comprises a removable cylinder head and said valve is in guide relation therewith; and

the resilient means comprises a spring operatively disposed between the stem and a spring seat as said seat means on said head structure.

3. The engine of claim **1** wherein:

said resilient means is a spring;

said means is disposed outwardly lengthwise of said valve axis beyond said stem; and

said valve train comprises a spring retainer secured to said stem and said spring is confined between the retainer and the seat means with its length disposed substantially beyond the outward end of the stem.

4. The engine of claim **3** wherein:

said valve is disposed in said head structure; and

said head structure comprises a housing for said spring which comprises a spring seat as said seat means.

5. The engine of claim **1** comprising:

a cylinder head within said head structure receiving said valve in guide relation therewith;

a spring in concentric relation with said stem as said resilient means;

a housing for said spring extending outwardly from and in fixed relation with said head;

a spring retainer secured to a portion of said stem withing said housing and serving as a seat inside said housing for said spring;

said seat means being secured to said housing in outward axial relation with said retainer with said spring confined therebetween.

6. The engine of claim **5** wherein:

said stem has a laterally extending shoulder located intermediately along the length of said housing and the retainer has a central apertured portion seating on an axially outward-facing surface of said shoulder, and a larger diameter portion providing an axially outward-facing seat for said spring spaced axially inward from said apertured portion;

said seat means is secured within the outward end portion of said housing;

said stem extends outwardly beyond said housing into connection with said cam following means.

7. The engine of claim **5** wherein:

said seat means comprises a guide portion in conforming relation with said stem, and said head comprises a valve guide located inwardly of the head with said spring disposed between the seat means and said valve guide.

8. The engine of claim **1** wherein:

said head structure comprises a cylinder head;

said head defines a recessed valve spring chamber terminating at a wall having a valve guide extending from the chamber into said gas duct in coaxial relation with said valve head seat;

said seat means is a spring seat secured at the outer entrance of the valve chamber;

said stem has a laterally extending shoulder located intermediately along the length of said valve chamber; and

said valve train comprises a retainer having a frustoconical wall concentric to said stem terminating at its smaller end in an apertured annular flange resting on an axially outward surface of the shoulder, and at the larger end, in an annular outward extending larger flange providing an axially outward-facing surface as a spring seat, said larger flange being spaced from the inner end of the valve chamber to permit a desired opening ambit for said valve.

9. The engine of claim **1** wherein:

the cam axis is in perpendicular intersecting relation with the valve axis, said cam means is in alignment with the valve axis, and said cam following means is a cage fixed to said stem and having an opening receiving said cam means;

said opening permitting relative movement of the cage and cam means lengthwise of the valve axis, said cage having means in the end of said opening which is further away from the valve seat to engage said non-concentric cam area; and

said engine comprises guide means confining said cage to movement lengthwise of the valve axis.

10. The engine of claim **9** wherein:

said cage comprises a bearing block providing said opening for the cam means and the width of the opening transversely of said valve axis equals the diameter of the cam means; and

said means in the end of the opening is a roller supported on an axis in fixed relation with the block for maintaining constant engagement with the cam means, said opening being oblong to an extent enabling relative movement of the cage and the cam means lengthwise of the valve axis.

11. The engine of claim **1** wherein:

said cam means comprises a camshaft and said engine comprises bearing means for supporting the camshaft, said camshaft being generally of uniform diameter except for recessed portions defining said non-concentric areas.

12. The engine of claim **1** wherein:

said valve guide means comprises means adjacent the distal or outward end of said stem; and

said cam following means comprises a push rod having one portion in following relation with the cam means and in another position in pivotal relation with said stem adjacent said distal end.

13. The engine of claim **1** wherein:

said cam following means comprises a push rod reciprocated by said cam means, and a lever with spaced portions pivoted with respect to an engine portion and said push rod, and connected with said stem to reciprocate the valve in correspondence with said push rod.

14. The engine of claim **1** wherein:

said head structure comprises a head with said valve stem extending therethrough, and a removable housing in generally concentric relation with said stem fixed to an outer surface of the head;

said valve guide comprises a cap for the outer end portion of said housing in secured relation therewith, and additional guide means supported internally of said head; and

said housing has an internal end surface provided by said end portion forming a seat for a valve spring acting as said resilient means.

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AL LAWRENCE SMITH, Primary Examiner

U.S. Cl. X.R.

74—567; 123—90.26, 90.44, 90.6, 90.65

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,572,299 Dated March 23, 1971

Inventor(s) Thomas J. Lester

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 47 "tures" should read --ture--.

Column 3, line 31 "as" should read --has--.

Column 3, line 42 "concentrically" should read --concentricity--.

Column 4, line 47 "houpsing" should read --housing--.

Column 6, line 26 "said means" should read --said seat means--.

Signed and sealed this 17th day of August 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER,
Commissioner of Patei