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(58) Field of search
F1B
F2V
Selected US specifications from IPC sub-class F01L

(54) Rotary valve device for internal combustion engines

(57) An intermittently or continuously rotated valve 23 has spherical surfaces which co-operate with seats 19,20 having spherical surfaces 21a,22a. Flats 26 on the valve in conjunction with clearance areas 18 between the seats may provide flow paths around the valve when the valve is not engaging the seats. The valve through bore 25 may be of substantially square cross-section (Figs. 8 and 10). A pair of valves in respective intake and exhaust passages which are operated intermittently through 90° by a cam, rocker and gear segment mechanism (Figs. 3 and 4) are biased by a torsion spring (66, Fig. 15) to eliminate drive clearances.

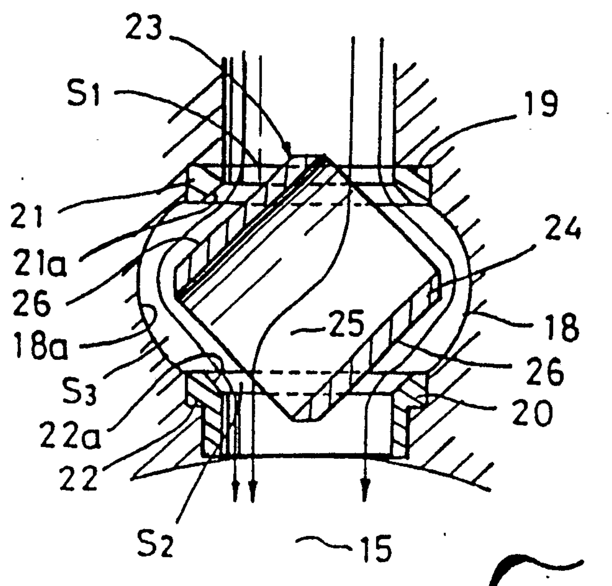

FIG. 2.

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The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

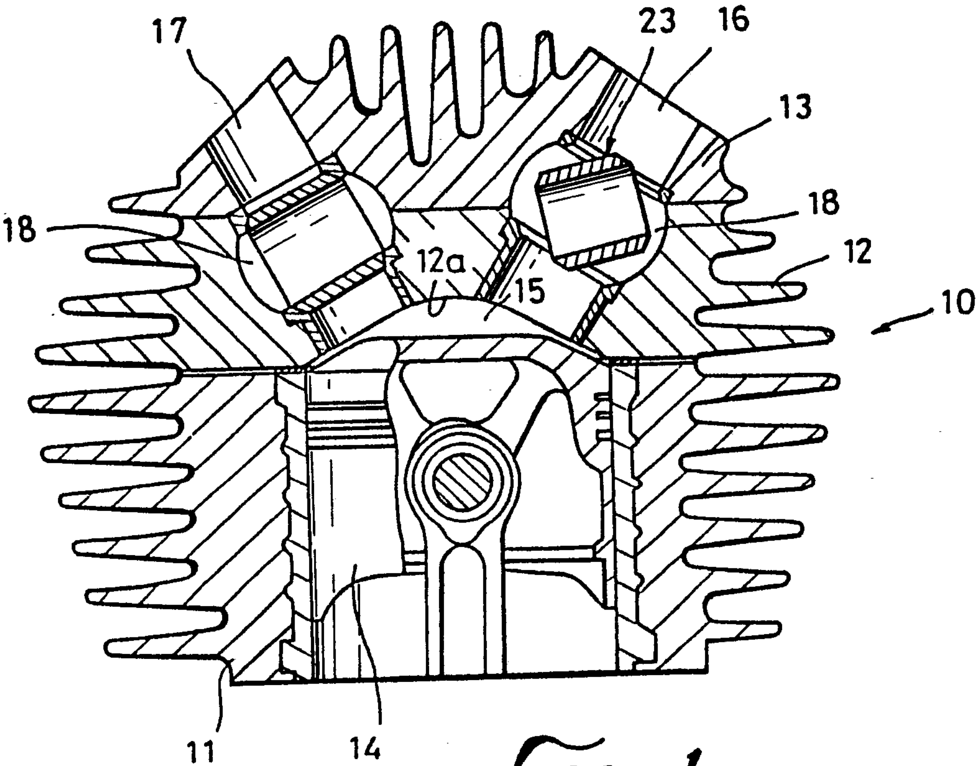
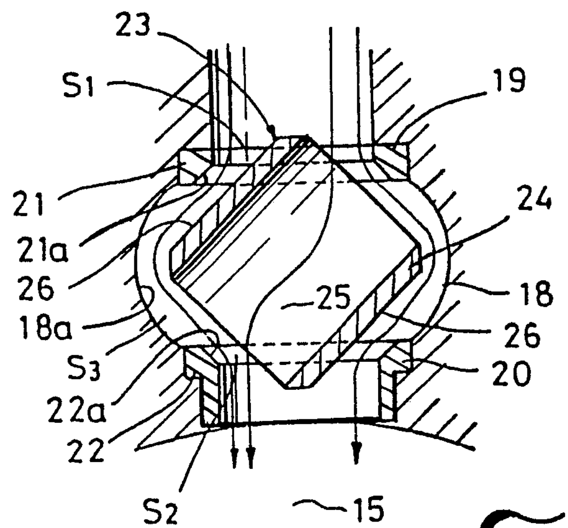

17
23
16
13
18
18
12a
15
12
10
11
14

FIG. 1.


23
S1
19
21
24
21a
26
25
18
18a
26
S3
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22a
22
S2
15

FIG. 2.

FIG.3.

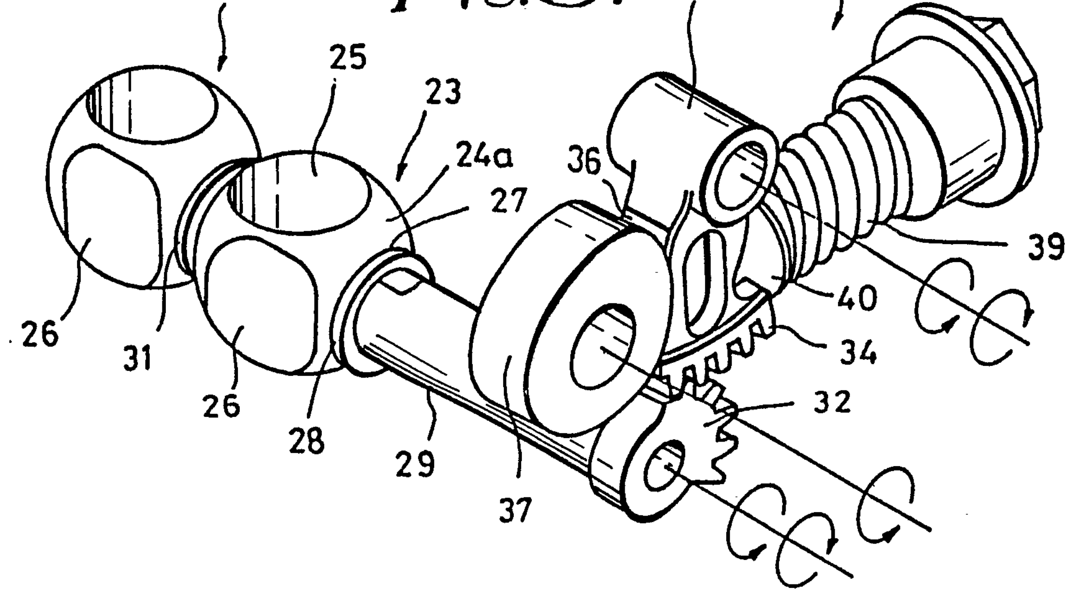


FIG. 4.

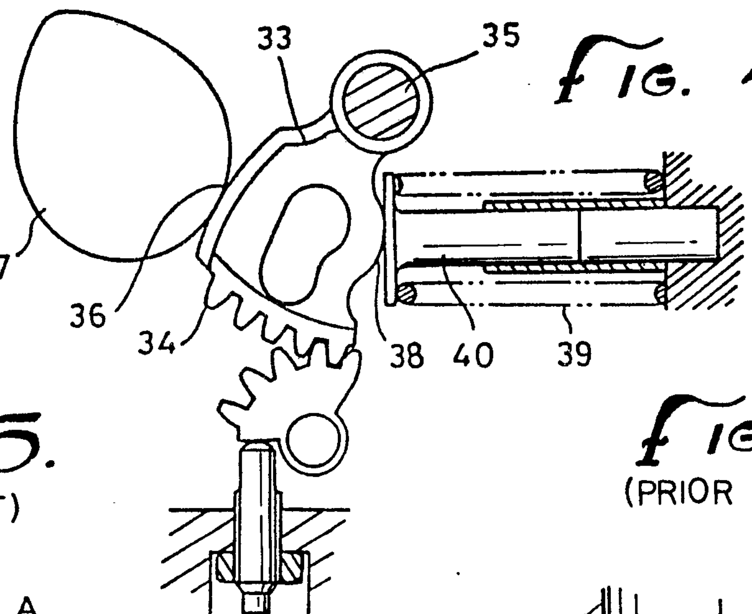


FIG.5.
(PRIOR ART)

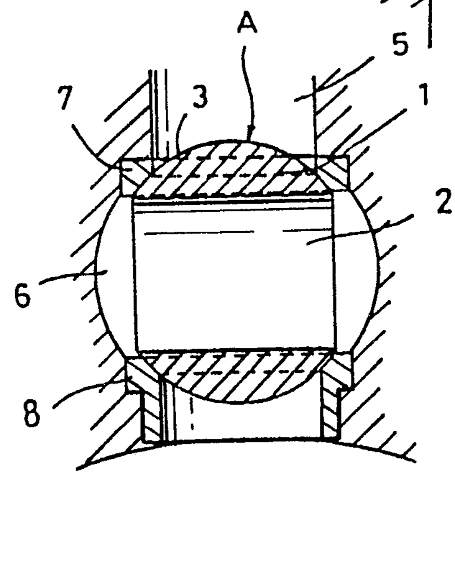
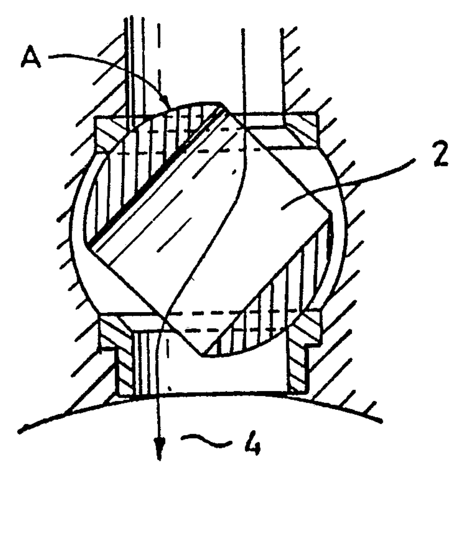


FIG.6.
(PRIOR ART)



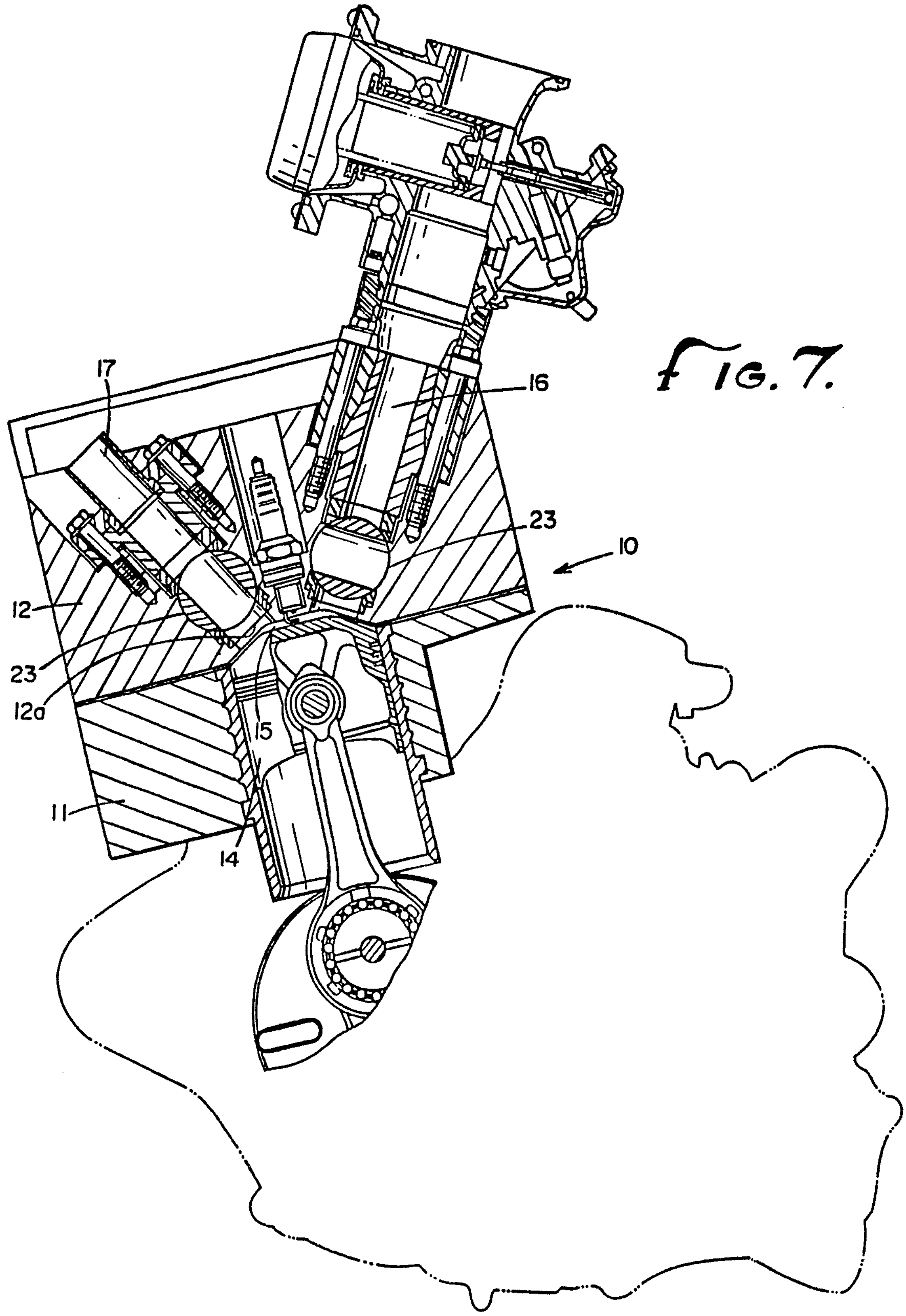


FIG. 7.

FIG. 8.

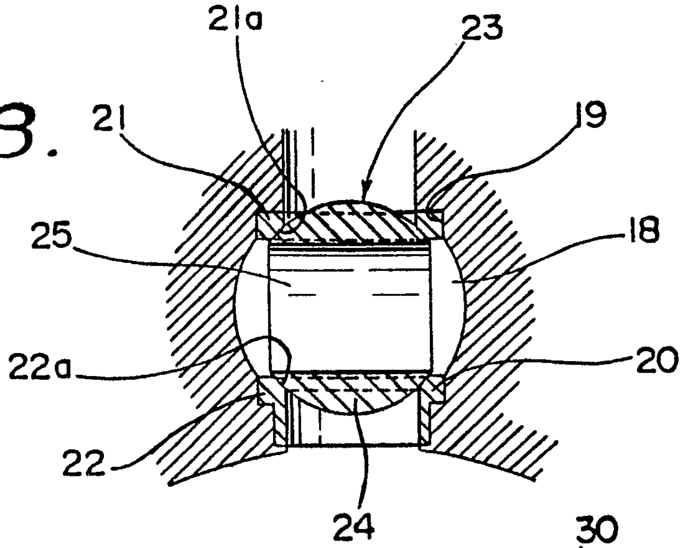
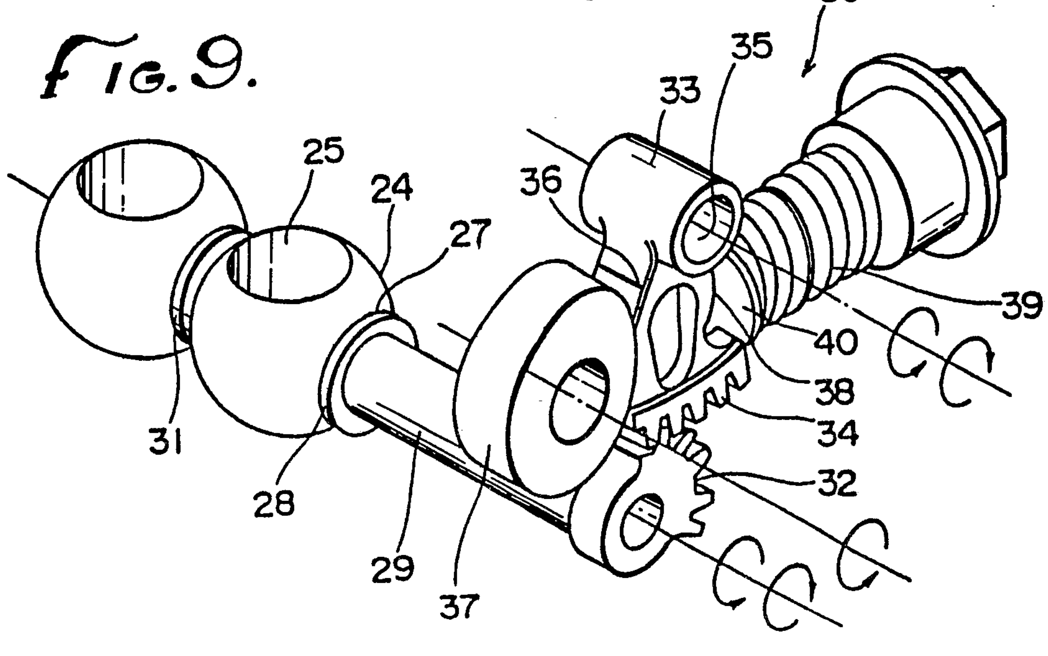


FIG. 9.



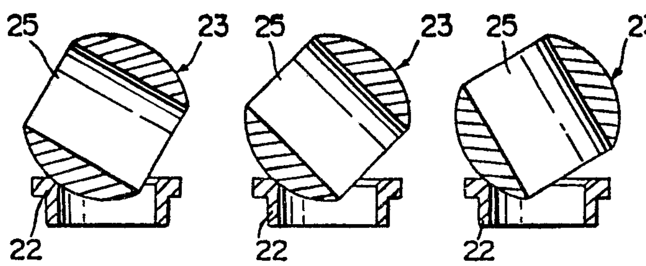


FIG. 10.

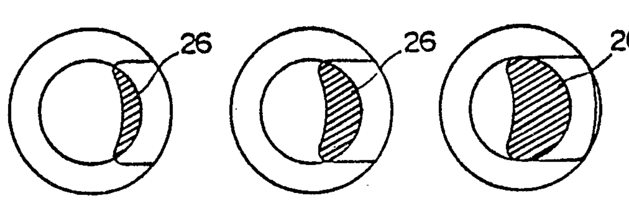


FIG. 11.

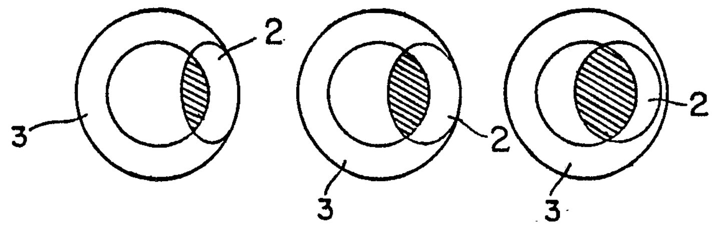


FIG. 12.

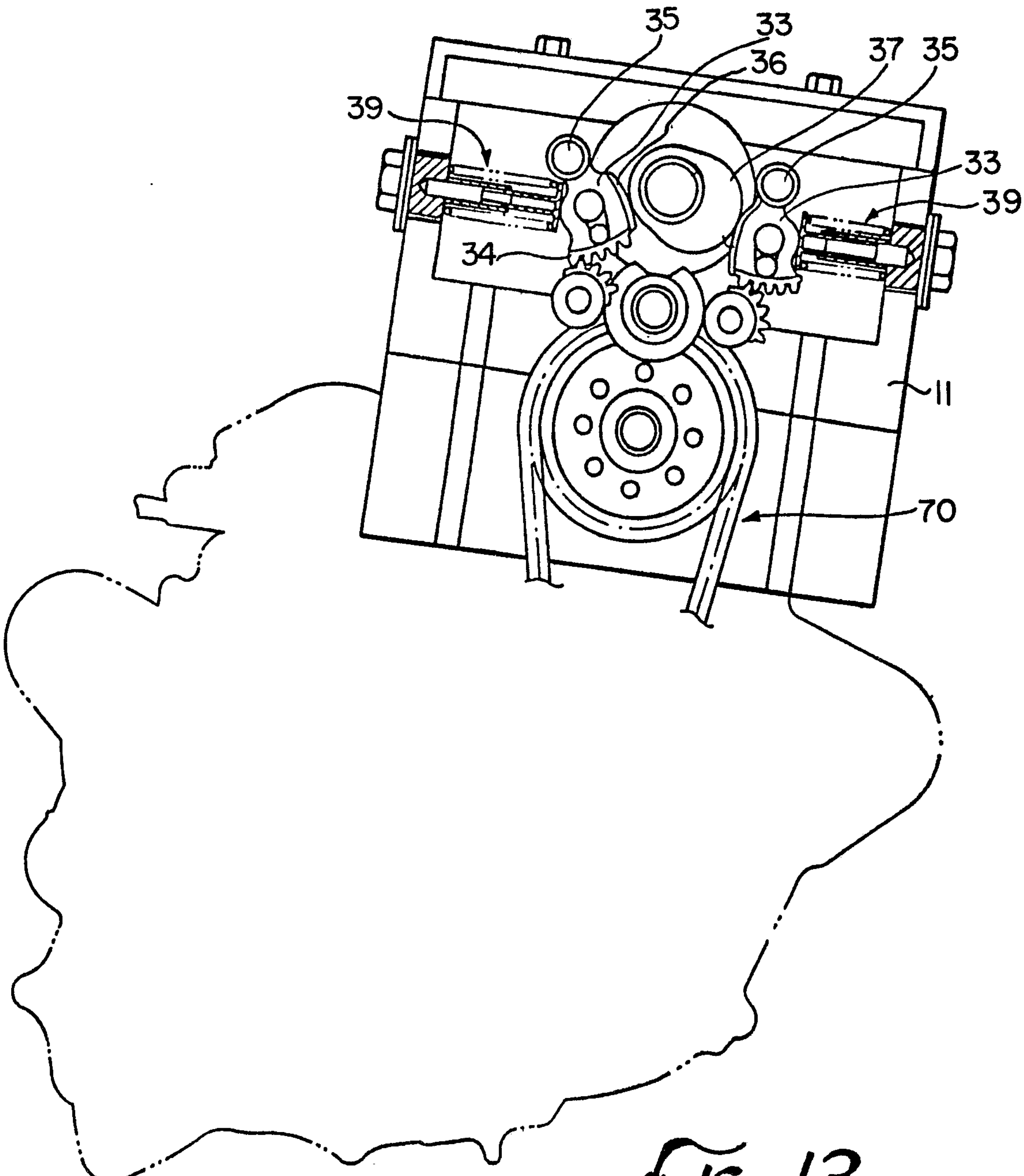


FIG. 13.

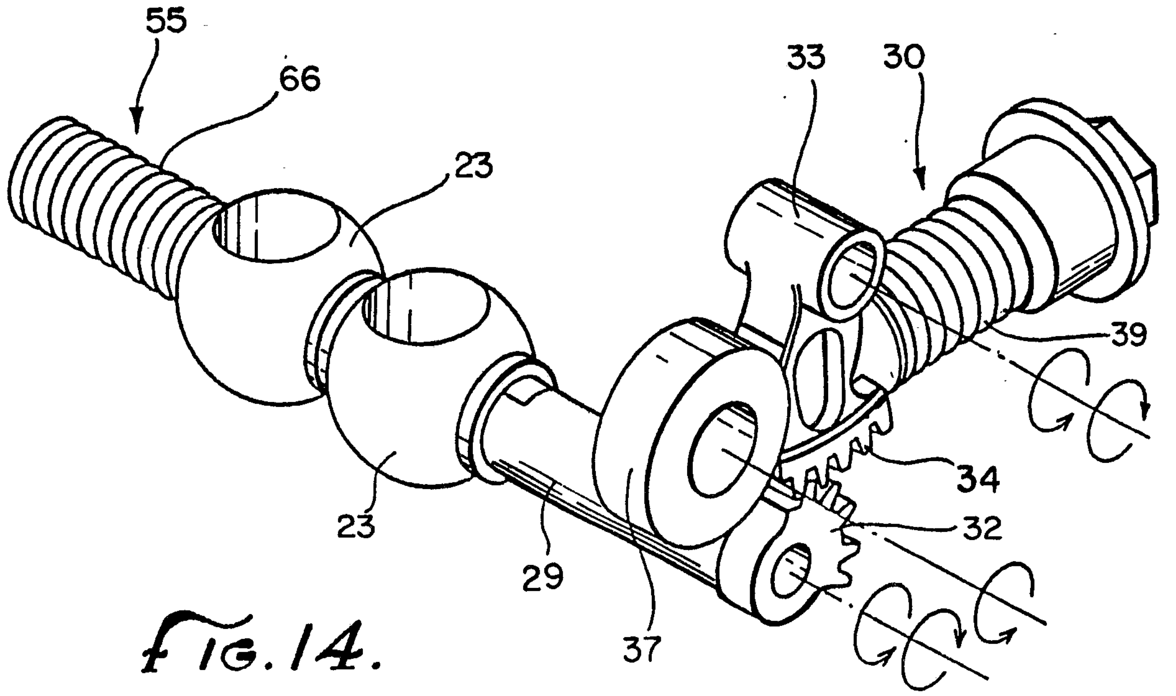


FIG. 14.

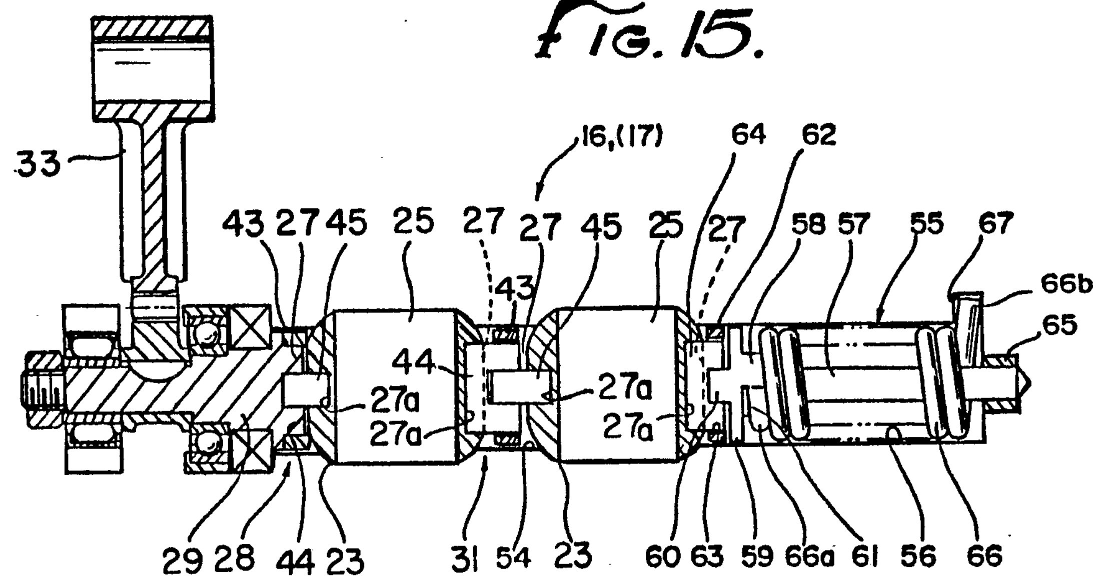


FIG. 15.

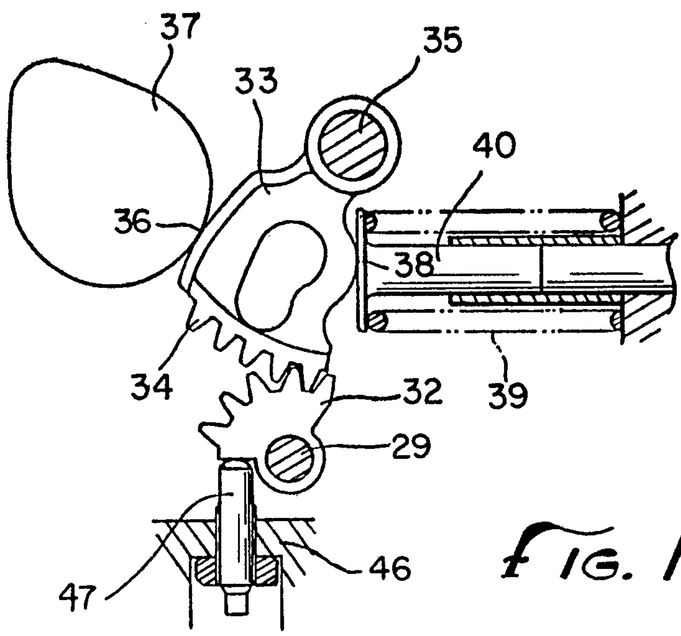


FIG. 16.

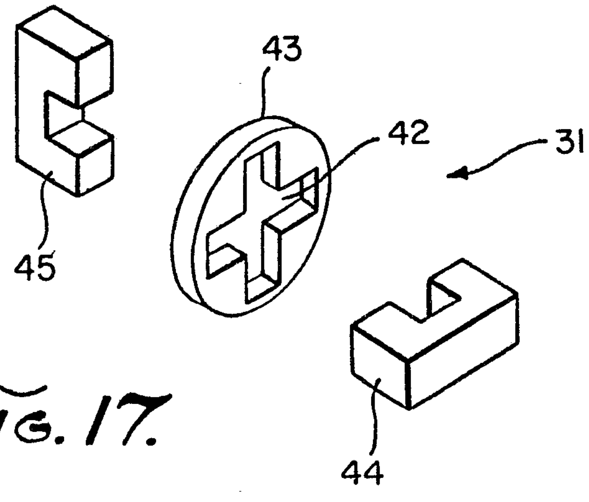


FIG. 17.

SPECIFICATION

Rotary valve device for internal combustion engines

The invention relates to valve systems for internal combustion engines and, more specifically rotary valve systems.

Poppet valves have been almost universally employed on four-stroke internal combustion engines, principally because of good sealing properties. However, with modern high-speed engines, poppet valves exhibit certain disadvantages as well. Exhaust poppet valves constantly facing the combustion chamber can become overheated and promote preignition. The requirement that such valves have both valve shafts and valve heads always located in the opening and passage of the porting affects intake and exhaust efficiencies. Furthermore, disadvantageous flow characteristics result from the circuitous flow path required by such valve configurations. Such valves also develop substantial impact noise upon closing.

To solve the foregoing difficulties with poppet valves, recurring efforts have been undertaken toward constructing rotary or sleeve valves. Such efforts have been directed to ball valves, cylinder valves, conical valves, disc valves and the like. However, such valves which are sufficiently compact for internal combustion engines tend to have inefficiencies in the relative portion of time during which such valves are opening and closing as distinguished from remaining open.

One such prior valve is illustrated in Figs. 5 and 6. A ball-type valve body 1 includes a through bore 2 with an outer spherical sliding surface 3 around the bore. The rotary valve A thus constituted is rotatably held in the seat members 7 and 8 and the spherical sliding surface 3 contacts the upper and lower seat members 7 and 8 in the receiving area of the intake or exhaust passage 5.

In the device illustrated in Figs. 5 and 6, the rotary valve A is rotated intermittently by a driving means. When the valve rotates, air/fuel mixture in the case of an intake passage may flow into the combustion chamber 4 via the through bore 2. However, the air/fuel mixture must flow entirely through the through bore 2 which, as oriented in Fig. 6, exhibits a relatively small effective cross-sectional flow area. Consequently, the opening and closing times are such that the rate of flow limits efficiency. The circular nature of the conventional through bore 2 in combination with the circular seat associated therewith presents a small cross-sectional opening as the valve is opening or closing. The cross-sectional area of the opening associated with such a conventional valve is illustrated in Fig. 12.

Oldham coupling devices have been employed in rotary valve applications in internal combustion engines to provide a rotational interlock between the driving mechanism and the valve body. Such devices allow for axial misalignment between components and, to that end, require some clearance for movement of the components transverse to the rotational axis of the valve. With such clearances and through the use of meshing gears for driving such a system, backlash with the inherent impacts on the components associated therewith can also become a problem in rotary valve mechanisms.

Viewed from a first aspect, the invention provides a valve device for an internal combustion engine having intake and exhaust passages, comprising an outside seat and an inside seat in one of the passages, said seats defining common internal spherical surface portions; clearance areas in the passage between said seats being of greater width than said seats; and a rotary valve between said seats having a sliding surface defining common external spherical surface portions arranged to mate with said common internal spherical surface portions, and the rotary valve having a through bore and side cut portions from said sliding surface, the side cut portions being arranged to face the clearance areas to allow flow about the rotary valve when the spherical portions are not in mating relationship.

With such an arrangement, the side cut portions of the rotary valve can cooperate with the clearance areas in the passage to provide for flow throughout a substantial portion of the opening and closing movements of the valve around the outside of the valve body as well as through the central bore. In this way, flow area can be increased and efficiency correspondingly increased, thus achieving efficient and reliable operation. In general, the rotary valve is arranged to rotate about an axis transverse to the passage.

Viewed from another aspect the invention provides a valve device for an internal combustion engine having intake and exhaust passages, comprising an outside seat and an inside seat in at least one of the passages, said seats defining common internal spherical surface portions; and a rotary valve between said seats having a sliding surface defining common external spherical surface portions arranged to mate with said common internal spherical surface portions and a through bore, said through bore being substantially square in cross section. The employment of a substantially square through bore in the valve body can significantly increase the cross-sectional area of flow during the opening and closing movements of the valve.

Viewed from a further aspect the invention provides a valve device for an internal combustion engine having intake and exhaust passages, comprising rotary valves in the passages disposed about a common rotary axis; a drive shaft aligned along the common rotary axis to one side of said rotary valves; connecting members between said drive shaft and one of said rotary valves and between said rotary valves, said connecting members being slidable transversely and fixed rotationally relative to said rotary valves; and torque bias means for biasing said rotary valves in a first rotational direction, said means being to the other side of said rotary valves from said drive shaft along the common rotary axis. In a preferred embodiment the bias means closes any clearances by biasing the drive train in one direction so that impact between the drive train and the valve components can be minimized or eliminated.

Certain preferred embodiments of the invention will now be described by way of example and with reference to the accompanying drawings, in which:–

Figure 1 is a cross-sectional elevation of a first embodiment of the present invention.

Figure 2 is a detail cross-sectional elevation of the device of Fig. 1.

Figure 3 is an oblique view of the drive train and valve mechanisms of the device of Fig. 1.

Figure 4 is an end view of the mechanism of Fig. 3.

Figure 5 is a detail cross section of a prior art rotary valve.

Figure 6 is a detail cross section of the device of Fig. 5.

Figure 7 is a cross-sectional view of a second embodiment of the present invention.

Figure 8 is a detail cross-sectional view of the second embodiment of the present invention.

Figure 9 is an oblique view of the second embodiment of the present invention.

Figure 10 is a cross-sectional schematic illustrating movement of a rotary valve in three views.

Figure 11 is a bottom plan schematic of the second embodiment of the present invention with views corresponding to those illustrated in Fig. 10.

Figure 12 is a schematic view as in Fig. 11 illustrating a prior art embodiment with views corresponding to the views of Fig. 10.

Figure 13 is a cross-sectional elevation of an engine drive train of the embodiments of the present invention.

Figure 14 is an oblique view of the drive mechanism and rotary valves of a third embodiment of the present invention.

Figure 15 is a cross-sectional elevation of the drive shaft and valves of the embodiment of Fig. 14.

Figure 16 is a cross-sectional end view of the drive train of Fig. 15.

Figure 17 is an exploded oblique view of an oldham mechanism as employed in the embodiment of Fig. 14.

Turning in detail to the drawings, Fig. 1 illustrates an internal combustion engine, generally designated 10, including a cylinder block 11 upon which cylinder heads 12 and 13 are affixed. The cylinder heads 12 and 13 are provided with an intake passage 16 and an exhaust passage 17 extending to a combustion chamber 15. The combustion chamber 15 is defined by an upper end surface of a piston 14 and a recess 12a of the cylinder head 12. A rotary valve cavity 18 is positioned near the combustion chamber in each of the intake and exhaust passages, 16 and 17, respectively. Turning to Fig. 2, an outside valve seat 19 and an inside valve seat 20 are provided to either side of each of the rotary valve cavities 18. The valve seats 19 and 20 are shown to be formed of separate inserts 21 and 22 forming rings. The rings define parallel spherical segments of a common internal spherical surface. Thus, the valve seats 19 and 20 are each symmetrical about the centerline of each of the passages. The seats 21 and 22 have surfaces 21a and 22a of a concave spherical shape to conform to the foregoing internal sphere.

A rotary valve 23 is mounted within each of the rotary valve cavities 18 and is slidably held by the seat members 21 and 22. The rotary valve 23 is provided with a spherical valve body 24 defining an outer spherical surface in which a through bore 25 extends. Side cut portions 26 forming flat surfaces are provided diametrically opposed on the outer surfaces of the valve bodies 24. The surfaces are positioned so as to have a common normal which is perpendicular to both the centerline of the through bore and the axis of rotation of the rotary valve. Looking to Fig. 3, connecting portions 27 are formed on the outer surface of the valve body 24 about the axis of rotation of the valve body which is perpendicular to the through bore 25 and also perpendicular to the common normal of the side cut portions.

The remaining portions 24a of the sliding surface of the valve body 24 are spherical. These portions 24a surround the openings of the through bore 25 to define spherical segments capable of mating with the valve seats 21 and 22. The spherical portions 24a also surround each of the side cut portions such that they may also be placed in mating engagement with the valve seats 21 and 22. The spherical portions 24a also surround the connecting portions 27 to act with the engine head for rotational mounting of the valve bodies 24.

Accordingly, the rotary valve mechanisms 23 are adapted to slidably contact with the seat surfaces 21a and 22a of the seat members 21 and 22 by virtue of the sliding surface portions 24a. In this way, the valve body 24 is held by the seat members 21 and 22 to rotate within the rotary valve cavity 18 to provide sealing with at least the valve body oriented such that the through bore may extend transversely to the flow passages 16 or 17.

The bore valve 23 is connected to a drive shaft 29 of a valve motion mechanism 30 at one of the connecting portions 27. The coupling is made through the employment of an oldham coupling 28. The rotary valves 23 are also mutually connected by an oldham coupling 31.

The drive train or valve motion mechanism 30 as shown in Figs. 3 and 4 is provided with a drive shaft 29 on which a segment gear 32 is fixed. The segment gear 32 is meshed with a segment gear 34 of a rocker arm 33. The rocker arm 33 is caused to rock about a supporting shaft 35 forming a fulcrum. A cam surface 36 of the rocker arm 33 is adapted to engage and follow a cam 37. A second surface 38 on the opposite side of the rocker arm 33 from the cam surface 36 is shown to engage an abutting member 40. The abutting member 40 is biased toward the rocker arm 33 by means of a spring 39. The cam 37 is driven by a chain or gear train from the crankshaft of the associated engine.

In operation, the rotation of the cam 37 causes the rocker arm 33 to engage in a rocking movement. The abutting member 40 returns the rocker 33 such that it follows the cam surface. The segment gear 34 of the rocker arm 33 engages the segment gear 32 such that the latter rocks in a 90 degree segment. By the rocking of the segment gear 32, the rotary valve 23 performs intermittent rocking driven by the drive shaft 29.

When the rotary valve 23 begins to open through the rocking rotation, the bore 25 communicates with the intake passage 16 or exhaust passage 17. The side cut portions 26 are spaced from the clearance areas of the rotary valve cavity 18 so that communication also exists between the surface of the clearance areas and the side cut portions of the rotary valves. As a result, flow areas S_1 and S_2 open up and are connected by the intermediary space S_3 between the clearance area surface 18a of the rotary valve cavity 18 and the rotary valve 23.

Accordingly, air/fuel mixture or exhaust flowing through the passages 16 or 17 pass through the through bore 25 of the rotary valve 23 but also bypass the valve as shown by arrows in Fig. 2. As an alternative to the embodiment of Fig. 1, the space S_3 may be formed within the wall surface 18a as a groove rather than an expanded space.

Other features may include a Geneva stop mechanism rather than a cam valve motion mechanism.

Looking then to the embodiment of Figs. 7 through 11, a valve mechanism is illustrated which incorporates a novel feature in the through bore 25. The through bore 25 has a substantially square cross section. For strength and manufacturing reasons, the substantially square cross-sectional shape is rounded at the corners. Figs. 10, 11 and 12 illustrate the advantage of a substantially square through bore 25. Fig. 10 illustrates three orientations of the valve 23 relative to the seat 22. Fig. 11 corresponds to the foregoing orientations illustrating in the shaded area 25a the amount of opening at those orientations. Fig. 12 illustrates a prior art device having a bore 2, a seat 3 and the shaded portion illustrating the lesser openings as compared with the device of Fig. 11. The square shape may be provided only at the upper opening portion in the case of an intake valve without requiring the square shape throughout the full length of the bore 25. In the case where a rotary valve continues to rotate in a single direction rather than rock, it is advantageous to have the entire through bore exhibit the substantially square cross section.

Turning then to the embodiment of Figs. 13 through 17, common reference numerals with the prior embodiments illustrate identical or equivalent elements. Better illustrated in this embodiment are the oldham couplings 28 and 31. The oldham coupling 31 is constituted as illustrated in Fig. 17 by inserting joint members 44 and 45 in cross grooves 42 in an intermediate member 43. The joint members 44 and 45 are oriented at 90 degrees from one another to fit within the cross grooves 42. The rotary valves 23 are connected by engaging one of the joint members 44 of the oldham coupling 31 in the engaging groove 27a of the connecting portion 27 of the valve 23. The other joint member 45 of the oldham coupling 31 is engaged in the groove 27a of the other valve 23.

Another oldham coupling 28 is employed between the drive shaft 29 and the valve 23 most adjacent the drive shaft. The oldham coupling 28 consists of a joint member 44 which is integrally formed with the drive shaft 29. Another joint member 45 is positioned within a groove 27a of the valve 23. An intermediate member 43 having cross grooves couples the two joint members together.

A bracket 46 is fixed relative to the cylinder head so as to mount a stop bolt 47. The stop bolt 47 is adapted to abut against the side surface of the segment gear 32 so as to provide a stop to the movement of the valve mechanism.

On the cylinder head there is provided a receiving portion 56 for accommodating a bias means for biasing the valve mechanism. The biasing means includes a spring mechanism 55 arranged at the end of a receiving portion 54 for the rotary valve mechanisms 23. The spring mechanism 55 is provided with a shaft body 57 at one end of which is a large diameter portion 58. A flange 59 and a joint portion 60 are formed to cooperate with an engaging groove 61. Joint portion 60 is inserted into a cross groove 63 of an intermediate connecting member 62. A joint member 64 is slidably inserted into a groove 27a at one end of the outermost valve 23. The other end of the shaft body 57 is inserted into a bearing 65 provided in an end wall of the receiving portion 56.

A torsion spring 66 of the spring mechanism 55 includes ends 66a and 66b. The end 66b engages the groove 67 to retain that end fixed relative to the cylinder head. The end 66a engages the groove 61 of the shaft body 57 so as to require rotation with the valve 23.

The bias spring mechanism 55 is located at one end of the drive mechanism associated with the valves 23. The mechanism thus biases the valve mechanism to eliminate clearances. Consequently, when the drive shaft is actuated, there is no clearance across which the components must move to impact against the valves. Consequently, reliability and longevity of the overall system is improved.

Thus, a rotary valve system is contemplated which provides increased cross-sectional flow area particularly during opening and closing cycles of the valves. Additionally, increased reliability and longevity of such systems are contemplated. Accordingly, an improved and more efficient rotary valve system for internal combustion engines is provided.

It is to be clearly understood that there are no particular features of the foregoing specification, or of any claims appended hereto, which are at present regarded as being essential to the performance of the present invention, and that any one or more of such features or combinations thereof may therefore be included in, added to, omitted from or deleted from any of such claims if and when amended during the prosecution of this application or in the filing or prosecution of any divisional application based thereon.

CLAIMS

1. A valve device for an internal combustion engine having intake and exhaust passages, comprising an outside seat and an inside seat in one of the passages, said seats defining common internal spherical surface portions; clearance areas in the passage between said seats being of greater width than said seats; and a rotary valve between said seats having a sliding surface defining common external spherical surface portions arranged to mate with said common internal spherical surface portions, and the rotary valve having a through bore and side cut portions from said sliding surface, the side cut portions being arranged to face the clearance areas to allow flow about the rotary valve when the spherical portions are not in mating relationship.

2. A valve device as claimed in claim 1, wherein said seats are separate insert members.

3. A valve device a claimed in claim 1 or 2, wherein said side cut portions are flat surfaces parallel to the axis of said through bore.

4. A valve device as claimed in claim 1, 2 or 3, wherein said clearance areas are to each side of said rotary valve in a direction transverse to the rotary axis thereof.

5. A valve device as claimed in any preceding claim, wherein said internal spherical surface portions include two parallel spherical segments.

6. A valve device as claimed in claim 5, wherein said spherical segments are symmetrically disposed about the centerline of the passage.

7. A valve device as claimed in claim 5 or 6, wherein said spherical segments are displaced from and generally parallel to the rotary axis of said rotary valve.

8. A valve device as claimed in any preceding claim, wherein said external spherical surface portions include two parallel spherical segments.

9. A valve device as claimed in claim 8, wherein the external spherical segments are symmetrically disposed about an axis normal to the rotary axis of said rotary valve.

10. A valve device as claimed in claim 8 or 9, wherein the external spherical segments are displaced from and generally parallel to the rotary axis of said rotary valve.

11. A valve device as claimed in claim 8, 9 or 10, wherein said external spherical surface portions further include two lateral spherical segments symmetrically disposed about the rotary axis of said rotary valve, said through bore and said side cut portions being between said lateral spherical segments.

12. A device as claimed in any preceding claim, wherein said through bore is substantially square in cross section.

13. A valve assembly for an internal combustion engine having intake and exhaust passages, comprising a pair of valve devices as claimed in any preceding claim, one such device being provided in each of the passages.

14. A valve assembly as claimed in claim 13, further comprising a drive shaft aligned along a common rotary axis of the rotary valves to one side of said rotary valves, connecting members between said drive shaft and one of said rotary valves and between said rotary valves, said connecting members being slidable transversely and fixed rotationally relative to said rotary valves and a torque bias means for biasing said rotary valves in a first rotational direction, said means being to the other side of said rotary valves from said drive shaft along the common rotary axis.

15. A valve device for an internal combustion engine having intake and exhaust passages, comprising an outside seat and an inside seat in at least one of the passages, said seats defining common internal spherical surface portions; and a rotary valve between said seats having a sliding surface defining common external spherical surface portions ar-

ranged to mate with said common internal spherical surface portions and a through bore, said through bore being substantially square in cross section.

16. A valve device as claimed in claim 15, wherein said rotary valve further has side cut portions from said sliding surface, said side cut portions being flat surfaces parallel to the axis of said through bore.

17. A valve device for an internal combustion engine having intake and exhaust passages, comprising rotary valves in the passages disposed about a common rotary axis; a drive shaft aligned along the common rotary axis to one side of said rotary valves; connecting members between said drive shaft and one of said rotary valves and between said rotary valves, said connecting members being slidable transversely and fixed rotationally relative to said rotary valves; and torque bias means for biasing said rotary valves in a first rotational direction, said means being to the other side of said rotary valves from said drive shaft along the common rotary axis.

18. A valve device as claimed in claim 17, wherein said torque bias means includes a torsion spring coupled to one of said rotary valves at a first end of said spring, the other end of said spring being fixed relative to the engine.

19. A valve device as claimed in claim 17 or 18, wherein said connecting members form an oldham coupling.

20. A valve device as claimed in claim 17, 18 or 19, further comprising drive means for intermittently rocking said drive shaft in timed relation with the speed of the engine.

21. A valve device substantially as hereinbefore described with reference to Figs. 1 to 4 or Figs. 1 to 4 and 13 to 17 of the accompanying drawings.

22. A valve device substantially as hereinbefore described with reference to Figs. 7 to 11 or Figs. 7 to 11 and 13 to 17 of the accompanying drawings.

23. A valve device substantially as hereinbefore described with reference to Figs. 13 to 17 of the accompanying drawings.

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