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(72) Inventor: **Cecur, Majo**

Rivarolo Canavese

Torino 10086 (IT)

(74) Representative: **Burke, Steven David et al**

R.G.C. Jenkins & Co.

26 Caxton Street

London SW1H 0RJ (GB)

(71) Applicant: **Eaton S.r.l.**

10086 Rivarolo Canavese (TO) (IT)

(54) **Roller rocker arm with valve bridge as integral part of the roller rocker arm**

(57) A valve control system for an engine having a pair of poppet valves (11, 13), the system including a rocker arm (25) having a first end (25a), and a bridge member (43; 143) in engagement therewith. A shaft member (39) fixes the lateral position of the bridge member relative to the rocker arm to define an axis (A). The bridge member cooperates with the poppet valves to define first and sec-

ond contact points (CP5, CP6). As the rocker arm engages in pivotal movement, the lateral distances from the axis (A) to the contact points (CP5, CP6) remain substantially constant and equal, thus insuring that the forces transmitted to the poppet valves by the bridge member remain substantially constant and equal, and further insuring that the valve velocity curves of the two valves will conform to the "desired" valve velocity (Vo).

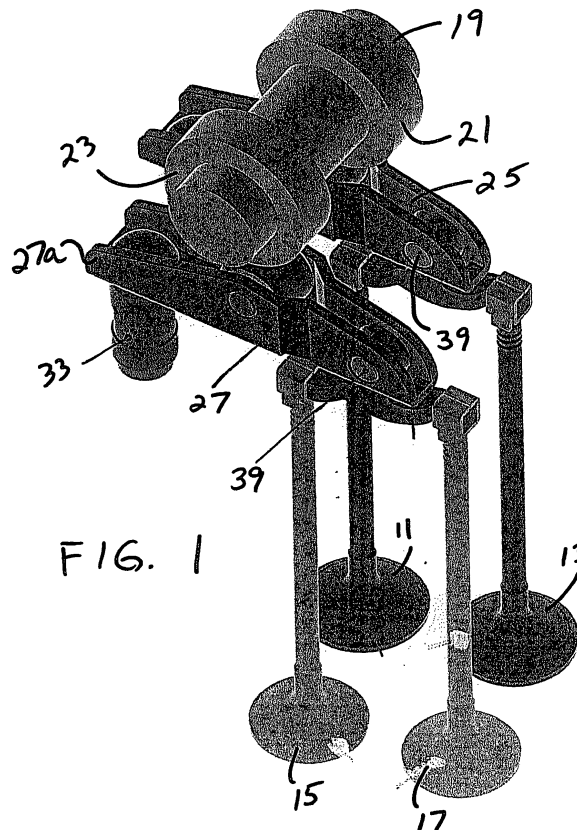


FIG. 1

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Description

BACKGROUND OF THE DISCLOSURE

[0001] The present invention relates to a valve control system for an internal combustion engine, and more particularly, to such a system which moves a pair of engine poppet valves simultaneously, by means of a bridge member.

[0002] Valve control systems of the type to which the present invention relates typically include a poppet valve which is moveable between an open position and a closed position in response to pivotal movement of a rocker arm. One end of the rocker arm engages some sort of "fulcrum" type member, such as, but not limited to, a hydraulic lash adjuster, such that the pivotal movement of the rocker arm is about the fulcrum member, and occurs in response to rotation of a cam shaft, in a manner generally well known in the art.

[0003] In an attempt to achieve a greater power density from modern internal combustion engines, engine designers have, in some situations, provided each cylinder with two intake poppet valves and/or with two exhaust poppet valves. As is understood by those skilled in the art, when there are two poppet valves of the same "type", whether intake or exhaust, it is typical to design the valve control system such that both poppet valves open and close simultaneously (i.e., each of the poppet valves has the same "lift", timing, and valve event duration).

[0004] One of the approaches utilized by those skilled in the valve control art for actuating two poppet valves simultaneously is to provide a bridge member which engages the stem tip portions of both of the valves. Another portion of the valve control system (for example, the end of the rocker arm opposite the fulcrum member) engages the bridge member, typically at a location intermediate the two poppet valves such that the valve control system is able to move both poppet valves simultaneously, simply by moving the bridge member.

[0005] However, it has been recognized by those skilled in the art that, in order to utilize a bridge member, and provide a properly functioning valve control system, it is important for the bridge member to be able to impart the same force and the same movement ("lift") to each of the poppet valves with which the bridge member is associated. In some valve control systems, this objective of equal movement of the poppet valves by the bridge member has been achieved by providing some sort of guidance structure for the bridge member. For example, it is known from U.S. Patent No. 5,535,710 to provide a valve bridge with a guide pin received within a mating bore in the cylinder head, such that the vertical movement of the valve bridge is guided or constrained in such a way that the opposite axial ends of the valve bridge inherently have the same vertical movement, and therefore, the valves in contact therewith also have the same vertical movement.

[0006] Unfortunately, in many applications for such a

valve control system, utilizing a bridge member, there is insufficient space available for use of a guide pin received within a bore in the cylinder head, or equivalent structure. Even if there is enough space, such a guide pin arrangement adds substantially to the cost of such a valve control system, both in terms of the additional cost of machining the bores in the cylinder head, as well as the cost of providing the guide pins which then must be rigidly attached to the bridge members. Also, if the valve control system is being utilized in conjunction with a diesel engine having a fuel injector disposed approximately coincidental with the axis of the cylinder, it may be impossible to package, within the available space, four poppet valves, two guide pins and the fuel injector.

[0007] In those valve control systems for which it is desirable to use a bridge member, but wherein the bridge member must be of the "unguided" type, such as for the reasons mentioned above, it has been typical practice for the bridge member to be laterally "fixed" relative to the stem tip portions of the engine poppet valves, and then to have the adjacent end of the rocker arm provided with some sort of a cylindrical pad engaging an upper, flat surface on the bridge member. Although the conventional, above-described arrangement for imparting cyclical movement of the rocker arm to the unguided bridge member has been generally satisfactory in many engine applications, it has been observed in connection with the development of more recent valve control systems that, at relatively higher engine speeds, certain aspects of the dynamic behavior of the engine cannot be controlled to the extent desirable, a detailed discussion of which is beyond the scope of the present application.

[0008] In connection with the development of the present invention, it has been observed and determined that, in the conventional bridge arrangement as described previously, whereas the contact between the cylindrical (curved) pad on the rocker arm and the bridge member is nominally equidistant from the contact points defined between the bridge member and the poppet valves, in reality, the movement of the cylindrical pad in a generally arcuate path (as the rocker arm pivots during valve actuation), results in the point of contact with the bridge member not remaining equidistant between the points of contact with the poppet valves. For example, in one particular valve control system being developed in connection with the present invention, it was observed that the point of contact between the cylindrical pad on the rocker arm and the upper surface of the bridge member moves laterally along the bridge member by as much as several millimeters during the cyclical movement of the rocker arm.

BRIEF SUMMARY OF THE INVENTION

[0009] Accordingly, it is an object of the present invention to provide an improved valve control system of the type which utilizes a bridge member, wherein the improved valve control system overcomes the above-de-

scribed problems of the prior art.

[0010] It is a more specific object of the present invention to provide such an improved valve control system which achieves the above-stated object, and in which the bridge member is able to impart substantially identical lift movements to each of the poppet valves, throughout substantially the entire range of movement of the rocker arm.

[0011] It is a more specific object of the present invention to provide such an improved valve control system in which the distance, laterally, between the contact point between the rocker arm and the bridge member and the point of contact with each of the poppet valves remains substantially equidistant during the cyclical movement of the rocker arm.

[0012] The above and other objects of the invention are accomplished by the provision of an improved valve control system for an internal combustion engine including a cylinder head, first and second poppet valves moveable relative to the cylinder head between open and closed positions, and a cam shaft having a cam profile formed thereon. The valve control system comprises a rocker arm having first and second axially opposite ends and a cam follower disposed intermediate the ends of the rocker arm and adapted for engagement with the cam profile. The first end is operably associated with a fulcrum member which is generally stationary relative to the cylinder head, whereby the rocker arm engages in pivotal movement of the second end about the fulcrum member in response to rotation of the cam shaft. A bridge member is in engagement with the first and second poppet valves and operably associated with the second end of the rocker arm, whereby the poppet valves move between the open and closed positions as the rocker arm engages in the pivotal movement.

[0013] The improved valve control system is characterized by means operable to fix the lateral position of the bridge member relative to the second end of the rocker arm to define an axis. The bridge member cooperates with the first and second poppet valves to define, respectively, first and second contact points, whereby, as the rocker arm engages in the pivotal movement, the lateral distances from the axis to the first contact point and to the second contact point remains substantially constant and equal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 is a perspective view of a valve control system made in accordance with the present invention, with the cylinder head omitted for ease of illustration.

[0015] FIG. 2 is a fragmentary, transverse cross-section of the valve control system shown in perspective in FIG. 1, but including a fragmentary portion of the cylinder head as a point of reference.

[0016] FIG. 3 is an enlarged, fragmentary view, similar to FIG. 2, illustrating in greater detail one aspect of the present invention.

[0017] FIG. 4 is a further enlarged, fragmentary view

similar to FIG. 3 but illustrating an alternative embodiment of the present invention.

[0018] FIG. 5 is a schematic representation of the geometry of the conventional, prior art bridge arrangement, illustrating the change in lateral distance between the rocker arm contact with the bridge member and the contact points with the poppet valves

[0019] FIG. 6 is a schematic representation of the geometry on the present invention, illustrating the improved ability to maintain equidistance to the poppet valve contact points.

[0020] FIG. 7 is a graph of valve lift and valve velocity, as a function of cam angle, in degrees, illustrating the "designed" or intended velocity as opposed to the actual valve velocity, utilizing the prior art valve bridge.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] Referring now to the drawings, which are not intended to limit the invention, FIG. 1 illustrates a perspective view of a valve control system made in accordance with the present invention. It should be noted that in FIG. 1 no portion of the cylinder head is included, for ease of illustration. It should also be noted in FIG. 1 that, what is shown is, in effect, one complete valve control system for all the valves of one cylinder, including a pair of intake valves 11 and 13 and a pair of exhaust valves 15 and 17.

[0022] The valve control system includes a cam shaft 19 having an intake cam profile 21 and an exhaust cam profile 23, each of the cam profiles including a base circle portion and a lift portion, as is well known to those skilled in the art. Valve actuation motion is imparted to the intake valves 11 and 13, from the intake cam profile 21, by means of an intake rocker arm 25, while valve actuation motion is imparted to the exhaust valves 15 and 17, from the exhaust cam profile 23, by means of an exhaust rocker arm 27.

[0023] Referring now to FIG. 2 in conjunction with FIG. 1, the intake rocker arm 25 has an end 25a supported on an intake hydraulic lash adjuster ("HLA") 29, which is received within a bore 30 defined in an engine cylinder head 31, and is shown in external plan view in FIG. 2. As may best be seen in FIG. 3, the HLA 29 includes a moveable plunger portion 29P, as is well known in the HLA art. Similarly, the exhaust rocker arm 27 has an end 27a which is supported on an exhaust hydraulic lash adjuster 33 (see FIG. 1). For the remaining description of the present invention, reference will be made to only the intake poppet valves 11 and 13, the intake cam profile 21, and the intake rocker arm 25, it being understood that, for purposes of the present specification, the exhaust poppet valves 15 and 17, the exhaust cam profile 23, and the exhaust rocker arm 27 are, or may be, substantially identical in configuration and operation, except for the necessary differences in timing of the opening and closing of the valves.

[0024] Therefore, referring now primarily to FIG. 2, the rocker arm 25 includes an axially opposite end 25b (i.e., axially opposite the end 25a), and a cam follower 35 (also referred to typically as a "roller follower"), disposed intermediate the ends 25a and 25b of the rocker arm 25. The cam follower 35 is preferably maintained in operable engagement with the intake cam profile 21, as is conventional, and well known in the engine valve train art. Disposed toward the end 25b of the rocker arm 25 is a cylindrical opening 37 defined by the two side walls of the rocker arm 25, and disposed within the opening 37 is a cylindrical shaft member 39, also referred to hereinafter in the appended claims as a "pivot member". The shaft member 39 is received within a mating saddle surface 41 (see FIG. 3) defined by a bridge member, generally designated 43, the saddle surface 41 also being referred to hereinafter in the appended claims as a "pivot member receiving portion". It should become apparent from a reading and understanding of the remainder of the specification that, although the present invention is illustrated with the rocker arm 25 including the pivot member 39, and the bridge member defining the pivot member receiving portion 41, such an arrangement could be reversed, as long as the bridge member is laterally fixed relative to the rocker arm.

[0025] Referring now primarily to FIG. 3, in which the cylinder head 31 is not shown, but the intake HLA 29 is shown in cross-section, the bridge member 43 will be described in some further detail. The engagement of the cylindrical shaft member 39, which defines an axis A, with the saddle surface 41, insures that the bridge member 43 will not move "laterally", i.e., left-to-right, or right-to-left in FIG. 3, relative to the axis A, and relative to the end 25b of the rocker arm 25. The bridge member 43 includes axially opposite valve-engaging portions 45 and 47, in engagement with the intake valves 11 and 13, respectively, the details of such engagement to be described in greater detail in connection with a subsequent embodiment.

[0026] Referring now primarily to FIG. 4, there is illustrated an alternative embodiment of the invention, in which like elements bear the same reference numerals, and modified elements bear the same reference numeral, plus "100". Therefore, in the alternative embodiment of FIG. 4, there is shown a bridge member, generally designated 143, which is preferably, but not necessarily, formed as a flat, stamped steel member, although it should be apparent that other metals, or even other forming processes, could be utilized to manufacture the bridge member 143. The bridge member 143 defines a circular opening 141, also referred to hereinafter as the "pivot member receiving portion", and disposed within the opening 141 is the cylindrical shaft member 39.

[0027] The bridge member 143 includes, in the same manner as in the first embodiment, a pair of axially spaced-apart valve-engaging portions 145 and 147, in engagement with the intake valves 11 and 13, respectively. Preferably, each of the valve-engaging portions

145 and 147 includes an engagement surface, in direct engagement with the valve stem tip, which is both radiused and crowned, for reasons to be described in greater detail subsequently. For example, and as is best seen in FIG. 6, the valve-engaging portions 145 and 147 each include an engagement surface 149 which, preferably, defines a slight curve in the plane of FIGS. 4 and 6, and a slight crown in a plane perpendicular to that of FIGS. 4 and 6. Thus, the contact point (generically, "CP") of the engagement surface 149 with the valve stem tip surface will tend to remain at substantially the same distance from the axis A of the cylindrical shaft member 39.

[0028] Referring now primarily to FIGS. 5 and 6, there is presented a schematic comparison of the "Prior Art" (FIG. 5) and the "Invention" (FIG. 6). In the Prior Art device, the contact point of each valve engaging portion with its respective valve stem tip (labeled "CP2" and "CP3" in FIG. 5) is relatively fixed, but the point of contact ("CP1") of the rocker arm ("ROCKER ARM") and the bridge member ("BRIDGE") moves laterally (back-and-forth between the valves 11 and 13) as the rocker arm pivots, during the lift event. As the contact point CP1 between the rocker arm and the bridge moves laterally, the distance ("X2") between CP1 and CP2 increases, whereas the distance ("X3") between CP1 and CP3 decreases, or vice versa. Thus, the forces applied by the prior art bridge member to the valves will vary, inversely to the changes in the distances between CP1 and CP2 and CP3. As mentioned in the Background of the Disclosure, such changes in the forces applied to each of the pair of valves will have an undesirable effect on the dynamic behavior of the valve train.

[0029] Referring now primarily to FIG. 6, illustrating the geometry of the present invention, the point of contact ("CP4") between the rocker arm (actually, between the shaft member 39) and the bridge member 143 is fixed as the rocker arm pivots during the lift event. At the same time, the contact point ("CP5") of the valve-engaging portion 145 with the stem tip of the valve 11 remains "fixed" on the portion 145, but moves laterally relative to the stem tip of the valve 11. In the same manner, the contact point ("CP6") of the valve-engaging portion 147 with the stem tip of the valve 13 remains "fixed" on the portion 147, but moves laterally relative to the stem tip of the valve 13. However, the distance from CP4 to CP5, and the distance from CP4 to CP6, both remain substantially constant, and therefore, the forces transmitted by the bridge member 143 to the valves 11 and 13 will remain substantially constant, as the rocker arm pivots during a lift event.

[0030] As may best be seen in the graphs of FIG. 7, although both valves (11 and 13, or 15 and 17) which are intended to move as a pair, are designed to have the same valve velocity (V_D), such does not occur in actual practice. Instead, as the distances X2 and X3 vary, the valve velocities (V_{V1} and V_{V2}) will differ from the designed valve velocity (V_D), and will vary from each other, as shown. One adverse result is shown in the region of the

graph in FIG. 7 identified as "Valve Close", wherein it may be seen that the varying velocities of the two valves results in quite different "profiles" just before closing of the valves.

[0031] By utilizing the present invention, the same bridge member (43 or 143) and the same rocker arm 25 design (i.e., the same "part number") could be used for both the intake poppet valves 11 and 13 and for the exhaust poppet valves 15 and 17. The above statement is true even if the intake valves 11 and 13 are disposed at a somewhat different distance from each other than are the exhaust valves 15 and 17. This is one additional benefit of the engagement surfaces 149 being radiused, such that if, for example, the separation of the intake poppet valves 11 and 13 is slightly greater than that of the exhaust poppet valves 15 and 17, the crowns of the engagement surfaces 149 will merely engage the stem tips of the valves 11 and 13 slightly "inside" of their center lines, while the engagement surfaces 149 will engage the stem tips of the valves 15 and 17 slightly "outside" of their center lines. However, in accordance with an important aspect of the invention, such slight changes in geometry will not effect the resulting forces applied to the valves, or the dynamics associated therewith.

[0032] The bridge member of the present invention may engage the shaft member 39 about only 180 degrees (i.e., the saddle surface 41), as shown in FIGS. 2 and 3, or the bridge member may, alternatively, wrap all around the shaft member, as shown in FIGS. 1, 4, and 6. It is anticipated that the version of the invention in which the shaft member 39 merely passes through an opening (as at 141) in the bridge member may represent and improve, in terms of production and assembly cost.

The invention has been described in great detail in the foregoing specification, and it is believed that various alterations and modifications of the invention will become apparent to those skilled in the art from a reading and understanding of the specification. It is intended that all such alterations and modifications are included in the invention, insofar as they come within the scope of the appended claims.

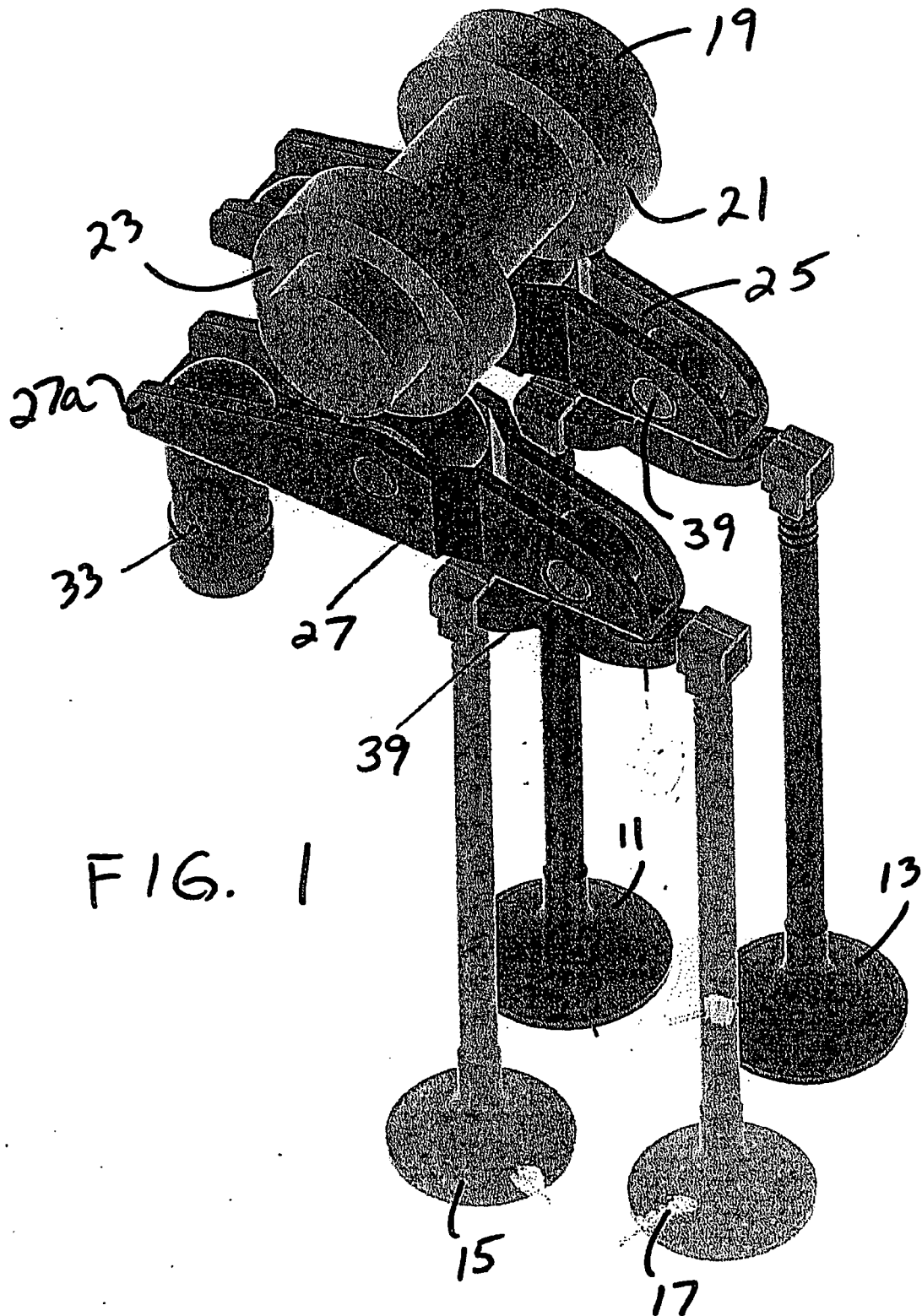
Claims

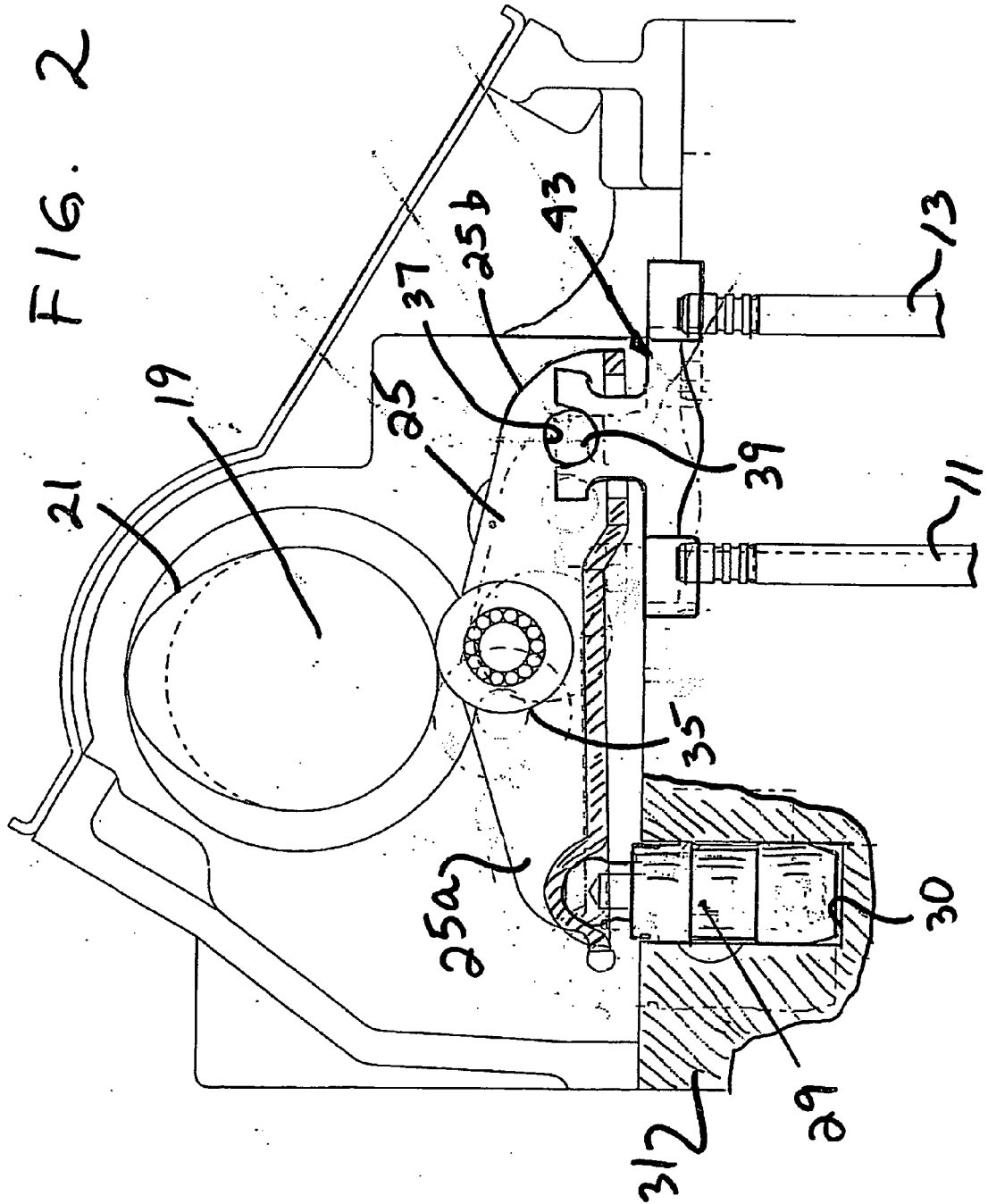
1. A valve control system for an internal combustion engine including a cylinder head (31), first (11) and second (13) poppet valves moveable relative to said cylinder head between open (FIG. 1) and closed (FIG. 2) positions; a camshaft (19) having a cam profile (21) formed thereon; said valve control system comprising a rocker arm (25) having first (25a) and second (25b) axially opposite ends and a cam follower (35) disposed intermediate said ends of said rocker arm (25) and adapted for engagement with said cam profile (21); said first end (25a) being operably associated with a fulcrum member (29) which is generally stationary relative to said cylinder head

(31) whereby said rocker arm (25) engages in pivotal movement of said second end (25b) about said fulcrum member (29) in response to rotation of said camshaft (19); a bridge member (43;143) in engagement with said first (11) and second (13) poppet valves and operably associated with said second end (25b) of said rocker arm whereby said poppet valves move between said open and closed positions as said rocker arm engages in said pivotal movement, **characterized by**:

- (a) means (39) operable to fix the lateral position of said bridge member (43;143) relative to said second end (25b) of said rocker arm (25) to define an axis (A);
- (b) said bridge member (43;143) cooperating with said first (11) and second (13) poppet valves to define, respectively, first (CP5) and second (CP6) contact points;
- (c) whereby, as said rocker arm (25) engages in said pivotal movement, the lateral distances from said axis (A) to said first contact point (CP5) and to said second contact point (CP6) remain substantially constant and equal.

2. A valve control system as claimed in claim 1, **characterized by** said fulcrum member comprising a hydraulic lash adjuster (29) disposed within a bore (30) defined by said cylinder head (31), said lash adjuster (29) including a moveable plunger (29P), said first end (25a) of said rocker arm (25) being in engagement with said plunger (29P).
3. A valve control system as claimed in claim 1, **characterized by** said means operable to fix the lateral position of said bridge member (43;143) relative to said second end (25b) comprises one of said bridge member (43;143) and said second end (25b) defining a pivot member (39) and the other of said bridge member and said second end (25b) defining a pivot member receiving portion (37).
4. A valve control system as claimed in claim 3, **characterized by** said pivot member comprising a generally cylindrical member (39) and said pivot member receiving portion defining a saddle surface (41;141) adapted to receive and engage said generally cylindrical member (39) over at least a substantial portion thereof.
5. A valve control system as claimed in claim 4, **characterized by** said generally cylindrical member (39) comprises said second end (25b) of said rocker arm (25), and said bridge member (43;143) defines said saddle surface (41;141), receiving said cylindrical member and closely spaced apart relative thereto.





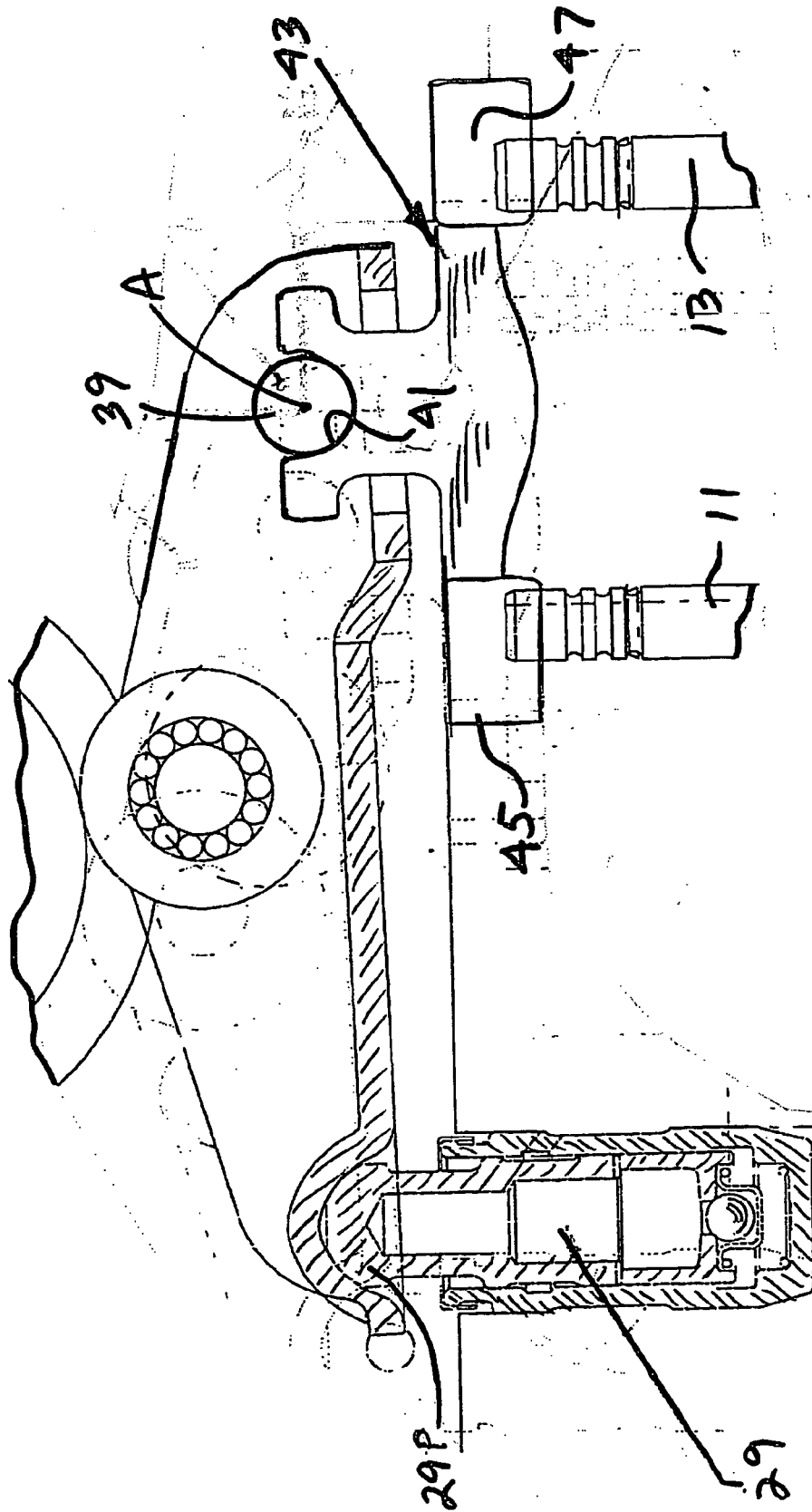
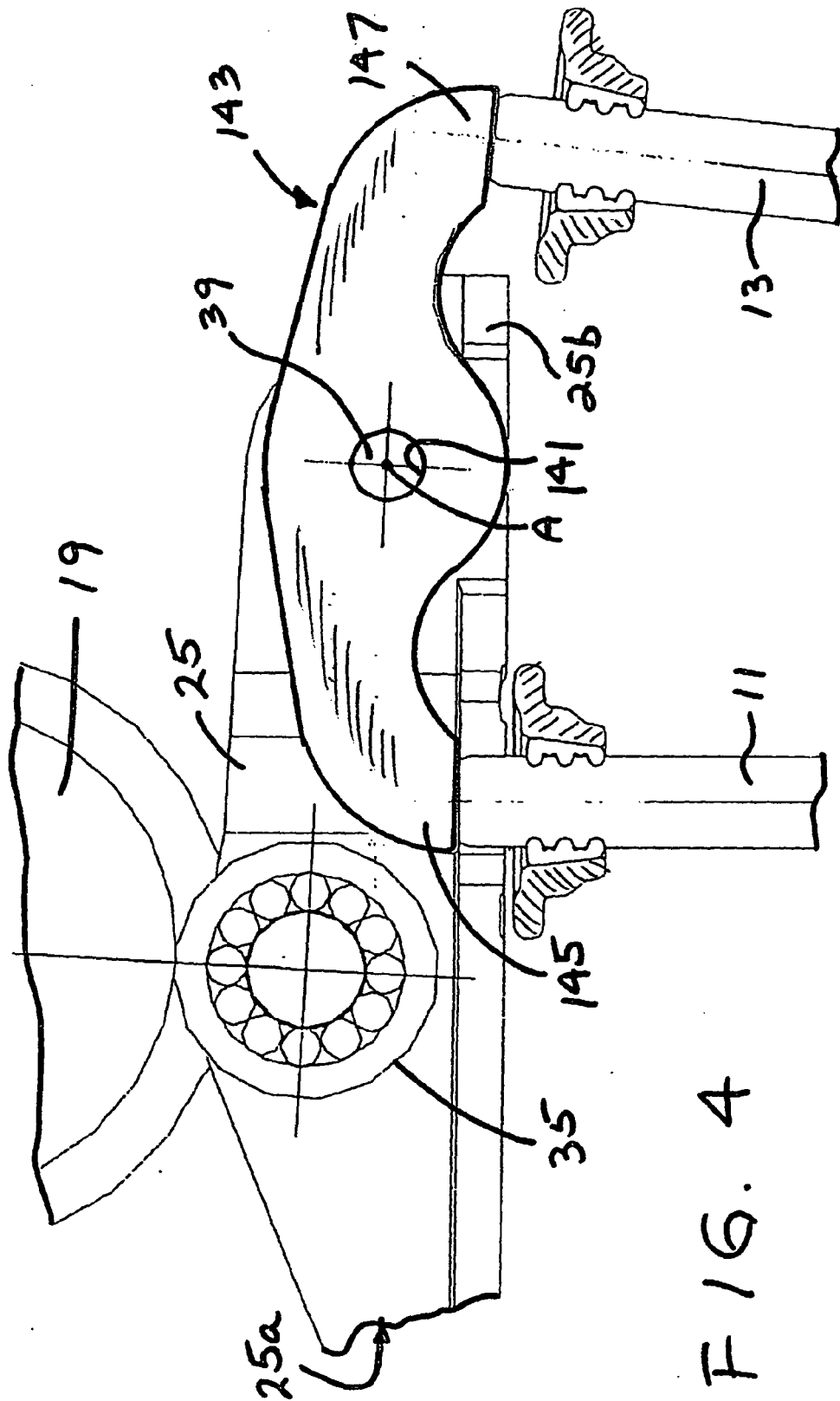


FIG. 3



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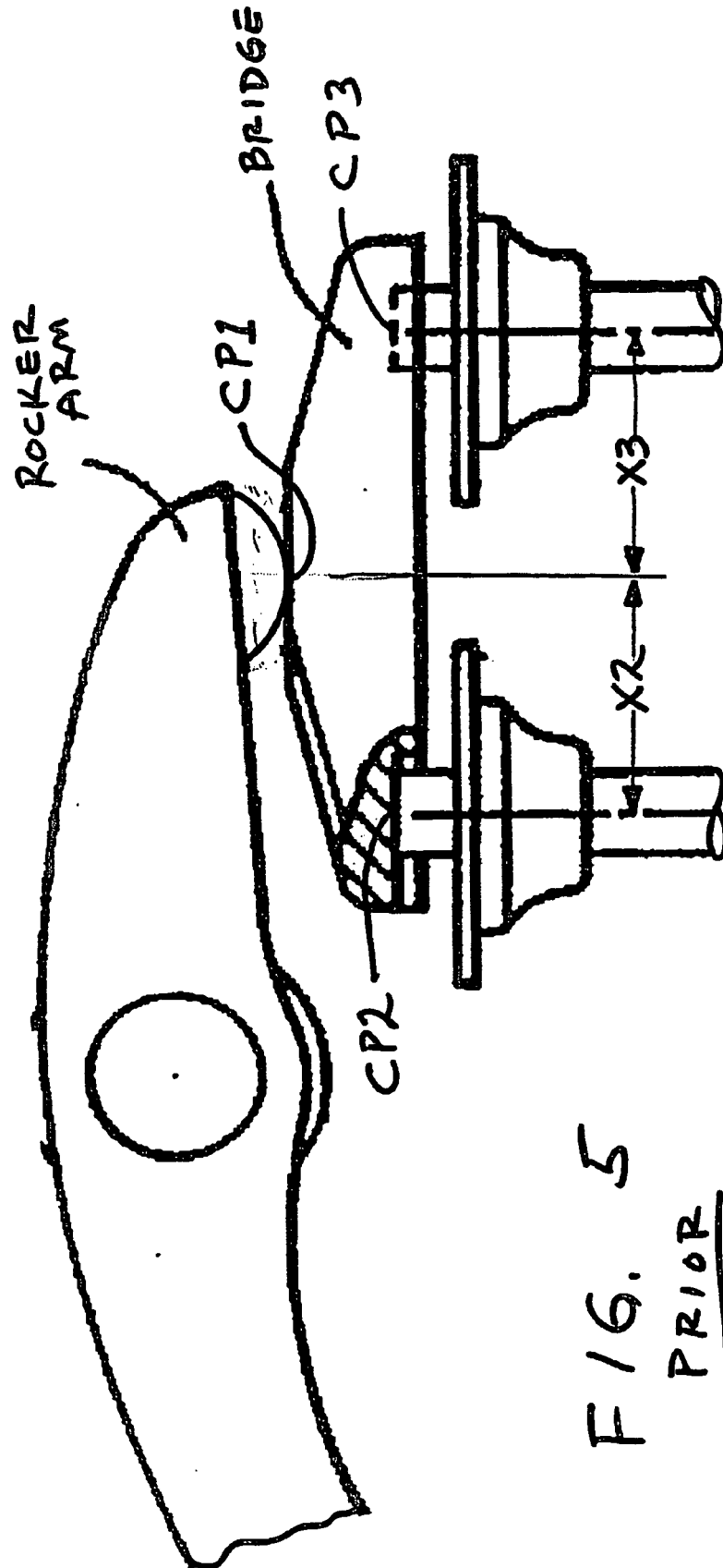


FIG. 5
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ART

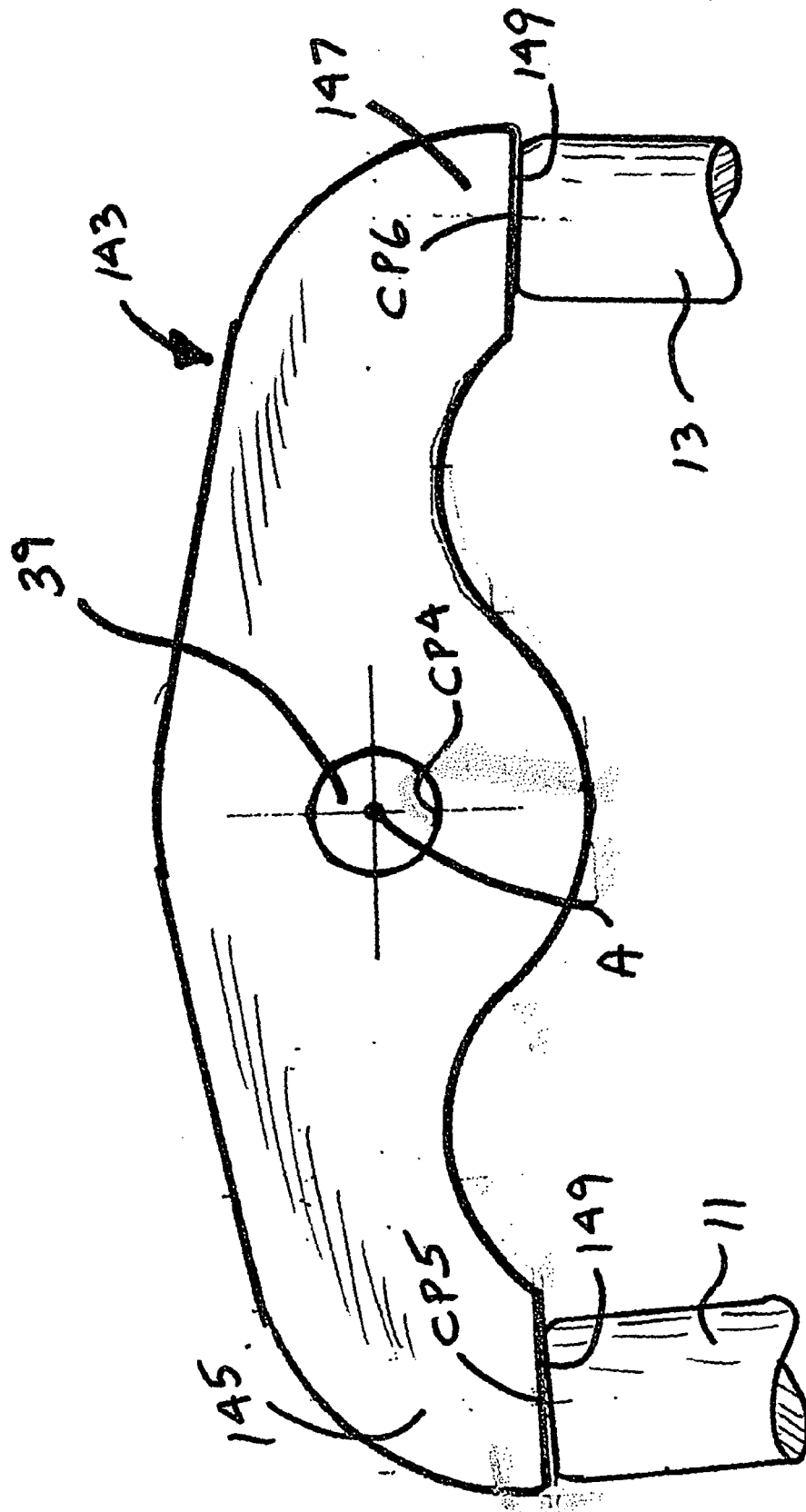


FIG. 6

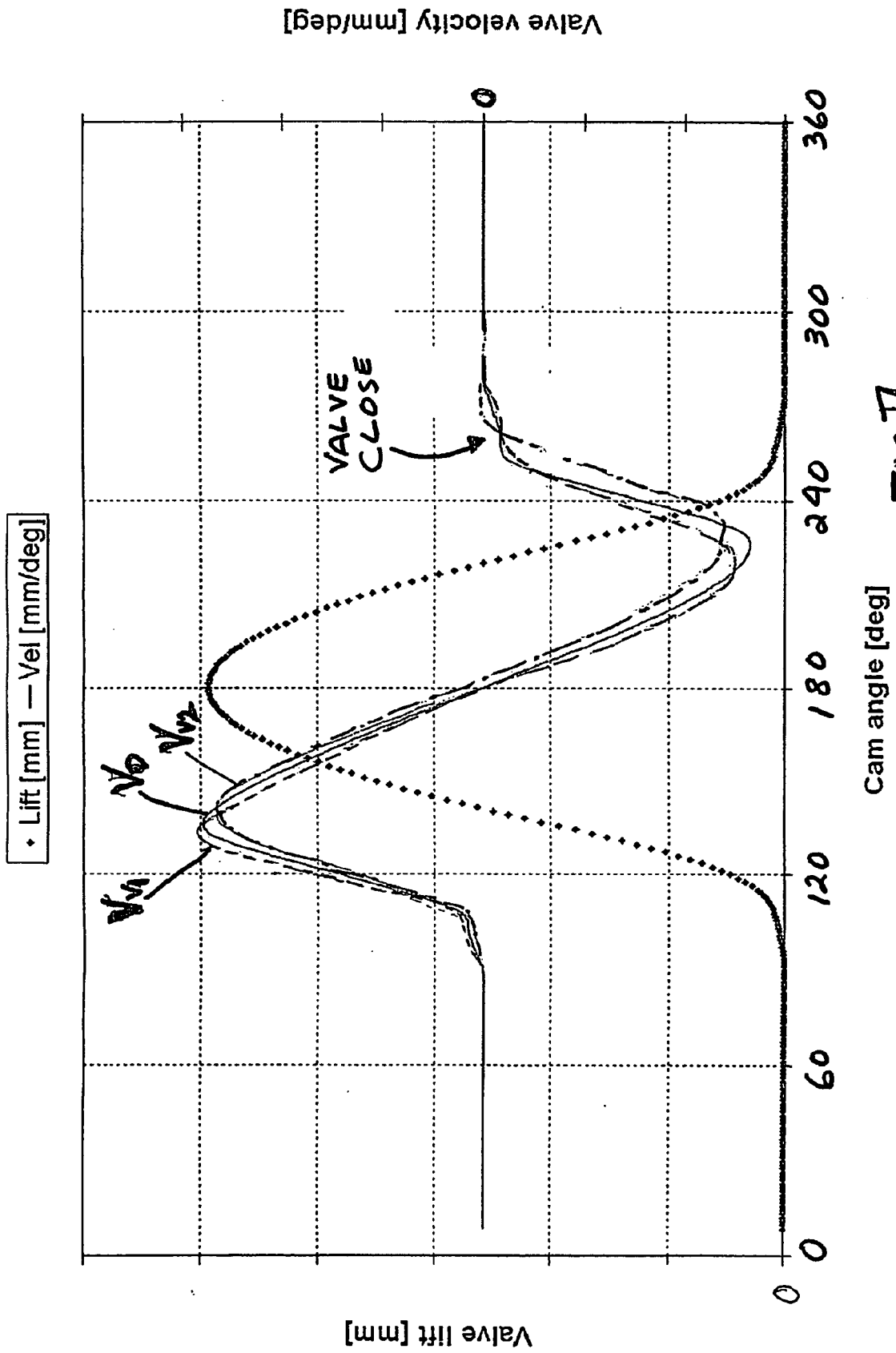


Fig. 7



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 25 6306

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
D,X	US 5 535 710 A (ZOSCHKE ET AL) 16 July 1996 (1996-07-16)	1,2	INV. F01L1/26 F01L1/053 F01L1/18
Y	* column 4, lines 37-45; figures 1-3 *	3-5	
Y	US 4 924 821 A (TEERMAN ET AL) 15 May 1990 (1990-05-15) * column 2, line 63 - column 3, line 20; figure 1 *	3	
Y	US 1 996 807 A (HALLETT GEORGE E. A) 9 April 1935 (1935-04-09) * column 3, lines 1-9; figure 1 *	3	
Y	EP 0 263 794 A (FIAT AUTO S.P.A) 13 April 1988 (1988-04-13) * column 1, lines 48-54; claim 1; figure 1 *	4,5	
Y	US 3 021 826 A (FEZZY ALBERT DE ET AL) 20 February 1962 (1962-02-20) * figure 1 *	3	
A	US 3 140 698 A (VOORHIES CARL) 14 July 1964 (1964-07-14) * figure 1 *	1	TECHNICAL FIELDS SEARCHED (IPC)
A	US 6 474 282 B1 (PRYBA STANLEY J ET AL) 5 November 2002 (2002-11-05) * figure 1 *	1	F01L
A	EP 0 682 171 A (CUMMINS ENGINE COMPANY, INC; TOSHIBA CORPORATION) 15 November 1995 (1995-11-15) * claim 1; figures 1,2,6-11 *	1	
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 17 March 2006	Examiner Clot, P
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 05 25 6306

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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17-03-2006

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5535710	A	16-07-1996	DE 9405442 U1	03-08-1995
US 4924821	A	15-05-1990	AU 603307 B2	08-11-1990
			AU 4715789 A	19-07-1990
			BR 8906724 A	11-09-1990
			CA 2004623 A1	22-06-1990
			ES 2018988 A6	16-05-1991
			KR 9307445 B1	11-08-1993
			ZA 8909589 A	28-08-1991
US 1996807	A	09-04-1935	NONE	
EP 0263794	A	13-04-1988	DE 3767266 D1	14-02-1991
			IT 1195192 B	12-10-1988
			US 4773359 A	27-09-1988
US 3021826	A	20-02-1962	NONE	
US 3140698	A	14-07-1964	NONE	
US 6474282	B1	05-11-2002	NONE	
EP 0682171	A	15-11-1995	DE 69506775 D1	04-02-1999
			DE 69506775 T2	20-05-1999
			JP 2731366 B2	25-03-1998
			JP 8061021 A	05-03-1996
			US 5410995 A	02-05-1995

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 5535710 A [0005]