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(54) Valve operating mechanism for internal combustion engine.

(57) A valve operating mechanism for operating at least one valve of an internal combustion engine, includes a camshaft (2) rotatable in synchronism with rotation of the internal combustion engine and having a pair of low- and high-speed cams (3,5) of different cam profiles, a rocker shaft (6), and a pair of first and second rocker arms (7,8) rotatably mounted on the rocker shaft and operable selectively by the low- and high-speed cams for operating the valve according to the cam profiles of the cams. A selective coupling (21) is operatively disposed in and between the first and second rocker arms for interconnecting the first and second rocker arms in high-speed operation of the engine and for disconnecting the first and second rocker arms from each other in low-speed operation of the engine.

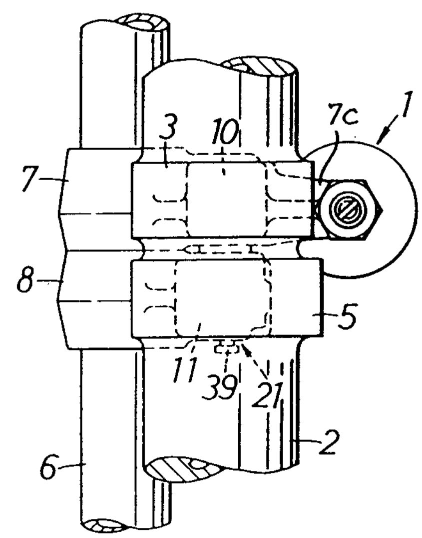

Fig.9.

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The present invention relates to a valve operating mechanism for an internal combustion engine, including a camshaft rotatable in synchronism with the rotation of the internal combustion engine and having integral cams for operating a pair of intake or exhaust valves, and rocker arms angularly movably supported on a rocker shaft for opening and closing the intake or exhaust valves in response to rotation of the cams.

Valve operating mechanisms used in internal combustion engines are generally designed to meet requirements for high-speed operation of the engines. More specifically, the valve diameter and valve lift are selected not to exert substantial resistance to the flow of an air-fuel mixture which is introduced through a valve into a combustion chamber at a rate for maximum engine power.

If an intake valve is actuated at constant valve timing and valve lift throughout a full engine speed range from low to high speeds, then the speed of flow of an air-fuel mixture into the combustion chamber varies from engine speed to engine speed since the amount of air-fuel mixture varies from engine speed to engine speed. At low engine speeds, the speed of flow of the air-fuel mixture is lowered and the air-fuel mixture is subject to less turbulence in the combusion chamber, resulting in slow combustion therein. Therefore, the combustion efficiency is reduced and so is the fuel economy, and the knocking margin is lowered due to the slow combustion.

One solution to the above problems is disclosed in Japanese Laid-Open Patent Publication No. 59(1984)-226216. According to the disclosed arrangement, some of the intake or exhaust valves remain closed when the engine operates at a low speed, whereas all of the intake or exhaust valves are operated, i.e., alternately opened and closed, during high-speed operation of the engine. Therefore, the valves are controlled differently in low-and high-speed ranges.

In the prior valve operating mechanism described above, those intake valves which are not operated in the low-speed range may remain at rest for a long period of time under a certain operating condition. If an intake valve remains at rest for a long time, carbon produced by fuel combustion tends to be deposited between the intake valve and its valve seat, causing the intake valve to stick to the valve seat. When the engine starts to operated in the high-speed range, the intake valve which has been at rest is forcibly separated from the valve seat. This causes the problem of a reduced sealing capability between the intake valve and the valve seat. Furthermore, fuel tends to be accumulated on the intake valve while it is held at rest, with the result that when the intake valve is opened, the air-fuel mixture introduced thereby is excessively enriched by the accumulated fuel.

According to the present invention there is provided a valve operating mechanism for operating at least one valve of an internal combustion engine, comprising a camshaft rotatable in synchronism with rotation of the internal combustion engine and having a pair of low- and high-speed cams of different cam profiles, a pair of first and second rocker arms operable selectively by said low- and high-speed cams for operating the valve(s)

according to the cam profiles of the cams, and means operatively disposed between said first and second rocker arms for interconnecting said first and second rocker arms in high-speed operation of the engine and for disconnecting said first and second rocker arms from each other in low-speed operation of the engine.

In one embodiment the first and second rocker arms are held in sliding contact with the low- and high-speed cams, respectively, for operating a pair of valves, respectively.

In another embodiment the first and second rocker arms are held in sliding contact with the low- and high-speed cams, respectively, the first rocker arm having a pair of arms for operating a pair of valves, respectively.

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

FIG. 1 is a vertical cross-sectional view of a valve operating mechanism according to an embodiment of the present invention, the view being taken along line I - I of FIG. 2;

FIG. 2 is a plan view of the valve operating mechanism shown in FIG. 1;

FIG. 3 is a cross-sectional view taken along line III - III of FIG. 1, showing the first and second rocker arms interconnected;

FIG. 4 is a cross-sectional view similar to FIG. 3, showing the first and second rocker arms disconnected from each other;

FIG. 5 is a vertical cross-sectional view of a valve operating mechanism according to another embodiment of the present invention, the view being taken along line V - V of FIG. 6;

FIG. 6 is a plan view of the valve operating mechanism shown in FIG. 5;

FIG. 7 is a cross-sectional view taken along line VII - VII of FIG. 5, showing the first and second rocker arms interconnected;

FIG. 8 is a cross-sectional view similar to FIG. 7, showing the first and second rocker arms disconnected from each other; and

FIG. 9 is a plan view of a valve operating mechanism according to still another embodiment of the present invention.

Like or corresponding parts are denoted by like or corresponding reference characters throughput the views.

FIGS. 1 and 2 show a valve operating mechanism according to an embodiment of the present invention. The valve operating mechanism is incorporated in an internal combustion engine including a pair of intake valves 1a, 1b in each engine cylinder for introducing an air-fuel mixture into a combustion chamber defined in an engine body.

The valve operating mechanism comprises a camshaft 2 rotatable in synchronism with rotation of the engine at a speed ratio of 1/2 with respect to the speed of rotation of the engine crankshaft. The camshaft 2 has a low-speed cam 3 and a high-speed cam 5 which are integrally disposed on the circumference of the camshaft 2. The valve operating mechanism also has a rocker shaft 6 extending parallel to the camshaft 2, and first and second rocker arms 7, 8 angularly movably supported on the rocker shaft 6 and held against the low-speed cam 3 and the high-speed cam 5, respectively, on the camshaft 2. The intake valves 1a, 1b are selectively operated by the first and second rocker arms 7, 8 actuated by the low- and high-speed cams 3, 5.

The camshaft 2 is rotatably disposed above the engine body. The high-speed cam 5 is disposed in a position corresponding to an intermediate position between the intake valves 1a, 1b, as viewed in FIG. 2. The low-speed cam 3 is disposed in alignment with the intake valve 1a. The low-speed cam 3 has a cam lobe 3a projecting radially outwardly to a relatively small extent to meet low-speed operation of the engine, and the high-speed cam 5 has a cam lobe 5a projecting radially outwardly a greater extent than the cam lobe 3a to meet high-speed operation of the engine, with the cam lobe 5a also having a larger angular extent than the cam lobe 3a.

The rocker shaft 6 is fixed below the camshaft 2. The first rocker arm 7 pivotally supported on the rocker shaft 6 is aligned with the low-speed cam 3, and the second rocker arm 8 pivotally supported on the rocker arm 6 is aligned with the high-speed cam 5. The rocker arms 7, 8 have on their upper surfaces cam slippers 10, 11 respectively, held in sliding contact with the cams 3, 5, respectively. The first and second rocker arms 7, 8 have arms 7a, 8a extending above the intake valves 1a, 1b, respectively. Tappet screws 12, 13 are adjustably threaded through the distal ends of the arms 7a, 8a and have tips engagable respectively with the upper ends of the valve stems of the intake valves 1a, 1b.

Flanges 14, 15 are attached to the upper ends of the valve stems of the intake valves 1a, 1b. The intake valves 1a, 1b are normally urged to close the intake ports by compression coil springs 16, 17 disposed under compression around the valve stems between the flanges 14, 15 and the engine body.

As shown in FIG. 4, the first and second rocker arms 7, 8 have confronting side walls held in sliding contact with each other. A selective coupling 21 is operatively disposed in and between the first and second rocker arms 7, 8 for selectively disconnecting the rocker arms 7, 8 from each other for relative displacement and also for interconnecting the rocker arms 7, 8 for their movement in unison.

The selective coupling 21 comprises a piston 23 movable between a position in which it interconnects the first and second rocker arms 7, 8 and a position in which it disconnects the first and second rocker arms 7, 8 from each other, a circular stopper 24 for limiting the movement of the piston 23, and a coil spring 25 for urging the stopper 24 to move the piston 23 toward the position to disconnect the first and second rocker arms 7, 8 from each other.

The first rocker arm 7 has a first guide hole 26 opening toward the second rocker arm 8 and extending parallel to the rocker shaft 6. The first rocker arm 7 also has a smaller-diameter hole 28 near the closed end of the first guide hole 26, with a step or shoulder 27 being defined between the smaller-diameter hole 28 and the first guide hole 26. The piston 23 is slidably fitted in the first guide hole 26. The piston 23 and the closed end of the smaller-diameter hole 28 define therebetween a hydraulic pressure chamber 29.

The first rocker arm 7 has a hydraulic passage 30 defined therein in communication with the hydraulic pressure chamber 29. The rocker shaft 6 has a hydraulic passage 31 defined axially therein and coupled to a source (not shown) of hydraulic pressure through a suitable hydraulic pressure control mechanism. The hydraulic passages 30, 31 are held in communication with each other through a hole 32 defined in a side wall of the rocker shaft 6, irrespective of how the first rocker arm 7 is angularly moved about the rocker shaft 6.

The second rocker arm 8 has a second guide hole 35 opening toward the first rocker arm 7 in registration with the first guide hole 26 in the first rocker arm 7. The circular stopper 24 is slidably fitted in the second guide hole 35. The second rocker arm 8 also has a smaller-diameter hole 37 near the closed end of the second guide hole 35, with a step or shoulder 36 defined between the second guide hole 35 and the smaller-diameter hole 37 for limiting movement of the circular stopper 24. The second rocker arm 8 also has a through hole 38 defined coaxially with the smaller-diameter hole 37. A guide rod 39 joined integrally and coaxially to the circular stopper 24 extends through the hole 38. The coil spring 25 is disposed around the guide rod 39 between the stopper 24 and the closed end of the smaller-diameter hole 37.

The piston 23 has an axial length selected such that when one end of the piston 23 abuts against the step 27, the other end thereof is positioned just between and hence lies flush with the sliding side walls of the first and second rocker arms 7, 8, and when the piston 23 is moved into the second guide hole 35 until it displaces the stopper 24 into abutment against the step 36, said one end of the piston 23 remains in the first guide hole 26 and hence the piston 23 extends between the first and second rocker arms 7, 8. The piston 23 is normally urged toward the second rocker arm 8 under the resiliency of a coil spring 33 disposed in the hydraulic pressure chamber 29 and acting between the piston 23 and the closed bottom of the smaller-diameter hole 28. The resilient force of the spring 33 set under compression in the hydraulic pressure chamber 29 is selected to be smaller than that of the spring 25 set in place under compression.

Operation of the valve operating mechanism will be described with reference to FIGS. 3 and 4. When the engine is to operate in a low-speed range, the selective coupling 21 is actuated to disconect the first and second rocker arm 7, 8 from each other as illustrated in FIG. 4. More specifically, the hydraulic pressure is released by the hydraulic pressure control mechanism from the hydraulic pressusre chamber 29, thus allowing the stopper 24 to move toward the first rocker arm 7 under the resiliency of the spring 25 until the piston 23 abuts against the step 27. When the piston 23 engages the step 27, the mutually contacting ends of the piston 23 and the stopper 24 lie flush with the sliding side walls of the first and second rocker arms 7, 8. Therefore, the first and second rocker arms 7, 8 are held in mutually sliding contact for relative angular movement.

With the first and second rocker arms 7, 8 being thus disconnected, the first rocker arm 7 is angularly moved in sliding contact with the low-speed cam 3, whereas the second rocker arm 8 is angularly moved in sliding contact with the high-speed cam 5. Therefore, the intake valve 1a alternately opens and closes the intake port at the valve timing and valve lift according to the profile of the low-speed cam 3, and the intake valve 1b alternately opens and closes the intake port at the valve timing and valve lift according to the profile of the high-speed cam 5.

Since the intake valves 1a, 1b are operated at different valve timings and lifts, the turbulence of the air-fuel mixture in the combustion chamber is increased for greater resistance against a reduction in the density of the air-fuel mixture. This also helps improve fuel economy.

For high-speed operation of the engine, the first and second rocker arms 7, 8 are interconnected by the selective coupling 21, as shown in FIG. 3. More specifically, the hydraulic pressure chamber 29 of the selective coupling 21 is supplied with hydraulic pressure to cause the piston 23 to push the stopper 24 into the second guide hole 35 against the resiliency of the spring 25 until the stopper 24 engages the step 36. The first and second rocker arms 7, 8 are now connected to each other for angular movement in unison.

Inasmuch as the second rocker arm 8 held in sliding contact with the high-speed cam 5 swings to a greater extent than the first rocker arm 7, the first rocker arm 7 is caused to swing with the second rocker arm 8. Therefore, the intake valves 1a, 1b alternately open and close the respective intake ports at the valve timing and valve lift according to the profile of the high-speed cam 5. The intake efficiency is now increased for higher engine output power and torque.

In the low- and high-speed ranges of engine operation, the intake valves 1a, 1b are operated at all times. Therefore, no carbon will be deposited between the intake valves 1a, 1b and their valve seats, and no fuel will be accumulated on the intake valves 1a, 1b.

FIGS. 5 and 6 are illustrative of a valve operating mechanism according to another embodiment of the present invention. The valve operating mechanism shown in FIGS. 5 and 6 differs from the valve operating mechanism of FIGS. 1 and 2 in that the first rocker arm 7 has a pair of arms 7a, 7b jointly shaped in a V, and the tappet screws 12, 13 are adjustably threaded through the distal ends of the arms 7a, 7b for engagement with the upper ends of the valve stems of the intake valves 1a, 1b. The second rocker arm 8 has no arm for directly acting on the intake valves 1a, 1b. As shown in FIG. 5, a bottomed cylindrical lifter 19 is disposed in abutment against a lower surface of the second rocker arm 8. The lifter 19 is normally urged upwardly by a compression spring 20 of relatively weak resiliency interposed between the lifter 19 and the engine body for resiliently biasing the cam slipper 11 of the second rocker arm 8 slidably against the high-speed cam 5.

The valve operating mechanism shown in FIGS. 5 and 6 has a selective coupling 21 which, as shown in FIG. 7, is structurally identical to the selective coupling 21 shown in FIG. 3.

Operation of the valve operating mechanism of FIGS. 5 and 6 will be described with reference to FIGS. 7 and 8. When the engine is to operate in a low-speed range, the selective coupling 21 is actuated to disconnect the first and second rocker arm 7, 8 from each other as illustrated in FIG. 8. The first and second rocker arms 7, 8 are now held in mutually sliding contact for relative angular movement.

With the first and second rocker arms 7, 8 being thus disconnected, the first rocker arm 7 is angularly moved in sliding contact with the low-speed cam 3, whereas the second rocker arm 8 is angularly moved in sliding contact with the high-speed cam 5. Therefore, the intake valves 1a, 1b are actuated by the respective arms 7a, 7b of the first rocker arm 7 to alternately open and close the respective intake ports at the valve timing and valve lift according to the profile of the low-speed cam 3. Since the second rocker arm 8 is disconnected from the first rocker arm 7, the angular movement of the second rocker arm 8 does not affect operation of the intake valves 1a, 1b. Any frictional loss of the valve operating mechanism is relatively low because the second rocker arm 8 is held in sliding contact with the high-speed cam 5 under the relatively small resilient force of the spring 20.

During low-speed operation of the engine, therefore, the intake valves 1a, 1b alternately open and close the respective intake ports at the valve timing and valve lift according to the profile of the low-speed cam 3. Accordingly, the air-fuel mixture flows into the combustion chamber at a rate suitable for the low-speed operation of the engine, resulting in improved fuel economy and prevention of knocking.

For high-speed operation of the engine, the first and second rocker arms 7, 8 are interconnected by the selective coupling 21, as shown in FIG. 7. The first rocker arm 7 is now caused to swing in unison with the second rocker arm 8 which is held in sliding contact with the high-speed cam 5.

The intake valves 1a, 1b are operated by the arms 7a, 7b of the first rocker arm 7 to alternately open and close the respective intake ports at the valve timing and valve lift according to the profile of the high-speed cam 5. The intake efficiency is now increased for higher engine output power and torque.

FIG. 9 shows a valve operating mechanism according to still another embodiment of the present invention. The valve operating mechanism of FIG. 9 is essentially the same as those shown in FIGS. 5 to 8 except that it operates only one intake valve 1 per engine cylinder. The first rocker arm 7 has an arm 7c for operating the intake valve 1.

While the intake valves 1a, 1b are shown as being operated by each of the valve operating mechanisms, exhaust valves may also be operated by the valve operating mechanisms according to the present invention. In such a case, unburned components due to exhaust gas turbulence can be reduced in low-speed operation of the engine, whereas high engine output power and torque can be generated by reducing resistance to the flow of an exhaust gas from the combustion chamber in high-speed operation of the engine.

It will thus be seen that the present invention, at least in its preferred forms, provides valve operating mechanism for an internal combustion engine, which increases the turbulence of an air-fuel mixture in the combustion chamber during low-speed operation of the engine for improving fuel economy and increasing resistance against a reduction in the density of the air-fuel mixture, and which is designed to meet the problems which would otherwise occur due to an intake valve being continuously closed.

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 operating mechanism for operating a valve of an internal combustion engine comprising:

a camshaft (2) rotatable in synchronism with rotation of the internal combustion engine and having a pair of low- and high-speed cams (3,5) of different cam profile, there being only two such cams;

a pair of first and second rocker arms (7,8) operable selectively by said low- and high-speed cams for operating the valve according to the cam profiles of said cams; and

coupling means (21) operatively disposed between said first and second rocker arms and arranged to interconnect said first and second rocker arms in high-speed operation of the engine to effect operation of the valve by the high-speed cam, the coupling means being further arranged to disconnect said first and second rocker arms from each other for independent movement in low-speed operation of the engine, the second rocker arm being operated by the high-speed cam during both high-and low-speed operation of the engine;

characterised in that there are only two such rocker arms (7,8) and only one valve (1), and in that during said low-speed operation of the engine the first rocker arm (7) is operated by the low-speed cam (3) to effect operation of the single valve (1) according to the cam profile of said low-speed cam (3), whereby the valve is not continuously closed.

2. A valve operating mechanism as claimed in claim 1, wherein said first and second rocker arms (7,8) are held in sliding contact with said low- and high-speed cams (3,5), respectively, said first rocker arm having an arm for operating the single valve (1).

3. A valve operating mechanism as claimed in claim 2, including lifter means (19) for normally urging said second rocker arm (8) resiliently into sliding contact with said high-speed cam (5).

4. A valve operating mechanism as claimed in claim 1, 2 or 3, wherein said coupling means comprises a selective coupling (21) composed of a first guide hole (26) defined in said first rocker arm (7), a second guide hole (35) defined in said second rocker arm (8) in registration with said first guide hole, a piston (23) slidably fitted in said first guide hole (26), a spring (25) disposed in said second guide hole (35) for normally urging said piston (23) into said first guide hole (26), and means (29,30,31,32) for applying hydraulic pressure to said piston (23) to move the same to a position between said first and second guide holes (26,35) against the resiliency of said spring (25).

Claims for the following Contracting State : DE

1. A valve operating mechanism for operating a valve of an internal combustion engine comprising:

a camshaft (2) rotatable in synchronism with rotation of the internal combustion engine and having a pair of low- and high-speed cams (3,5) of different cam profile, there being only two such cams;

a pair of first and second rocker arms (7,8) operable selectively by said low- and high-speed cams for operating the valve according to the cam profiles of said cams; and

coupling means (21) disposed in and between said first and second rocker arms and arranged to interconnect said first and second rocker arms in high-speed operation of the engine to effect operation of the valve by the high-speed cam, the coupling means being further arranged to disconnect said first and second rocker arms from each other for independent movement in low-speed operation of the engine, the second rocker arm being operated by the high-speed cam during both high-and low-speed operation of the engine;

characterised in that there are only two such rocker arms (7,8) and only one valve (1), and in that during said low-speed operation of the engine the first rocker arm (7) is operated by the low-speed cam (3) to effect operation of the single valve (1) according to the cam profile of said low-speed cam (3), whereby the valve is not continuously closed.

2. A valve operating mechanism as claimed in claim 1, wherein said first and second rocker arms (7,8) are held in sliding contact with said low- and high-speed cams (3,5), respectively, said first rocker arm having an arm for operating the single valve (1).

3. A valve operating mechanism as claimed in claim 2, including lifter means (19) for normally urging said second rocker arm (8) resiliently into sliding contact with said high-speed cam (5).

4. A valve operating mechanism as claimed in claim 1, 2 or 3, wherein said coupling means comprises a selective coupling (21) composed of a first guide hole (26) defined in said first rocker arm (7), a second guide hole (35) defined in said second rocker arm (8) in registration with said first guide hole, a piston (23) slidably fitted in said first guide hole (26), a spring (25) disposed in said second guide hole (35) for normally urging said piston (23) into said first guide hole (26), and means (29,30,31,32) for applying hydraulic pressure to said piston (23) to move the same to a position between said first and second guide holes (26,35) against the resiliency of said spring (25).

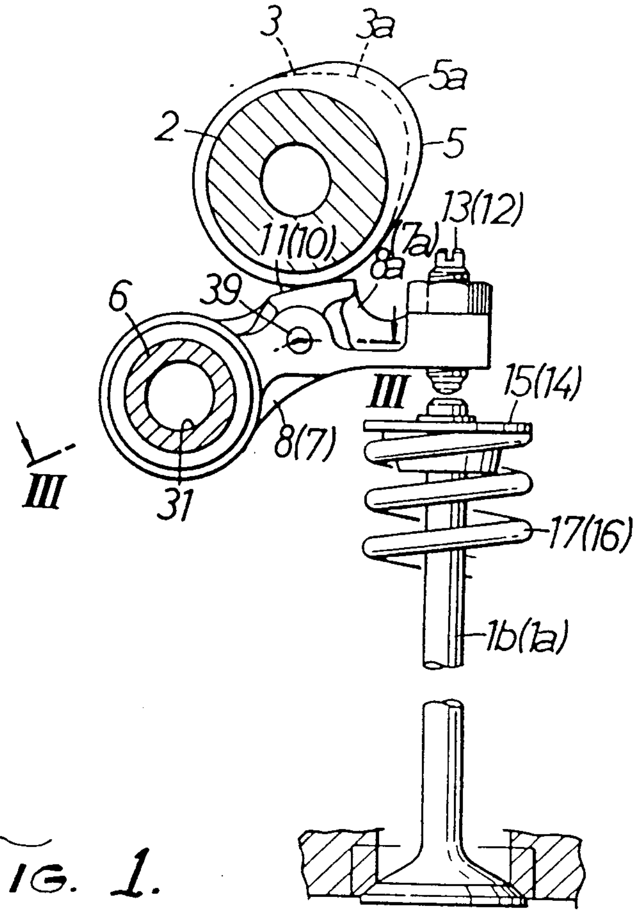
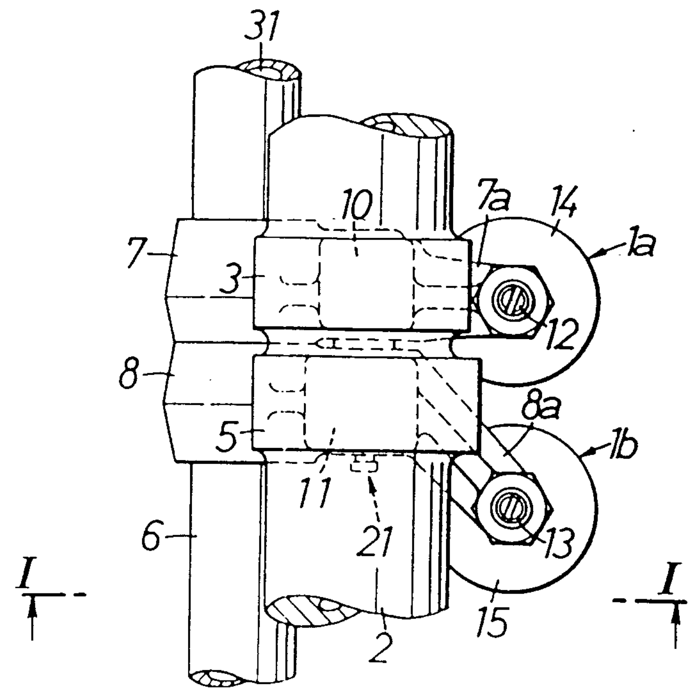

3
3a
5a
2
5
13(12)
11(10)
(7a)
8a
39
6
15(14)
III
8(7)
III
31
17(16)
1b(1a)

FIG. 1.


31
10
7a
14
1a
7
3
12
8
8a
1b
5
11
13
6
21
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2
15

FIG. 2.

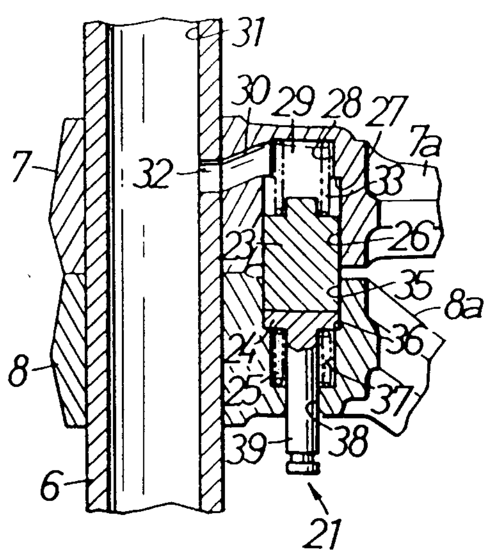

FIG. 3.

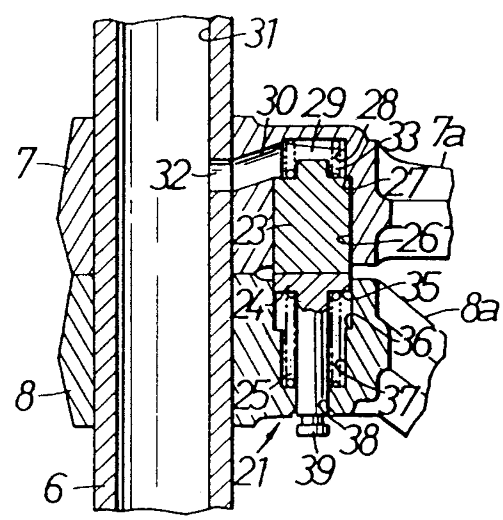

FIG. 4.

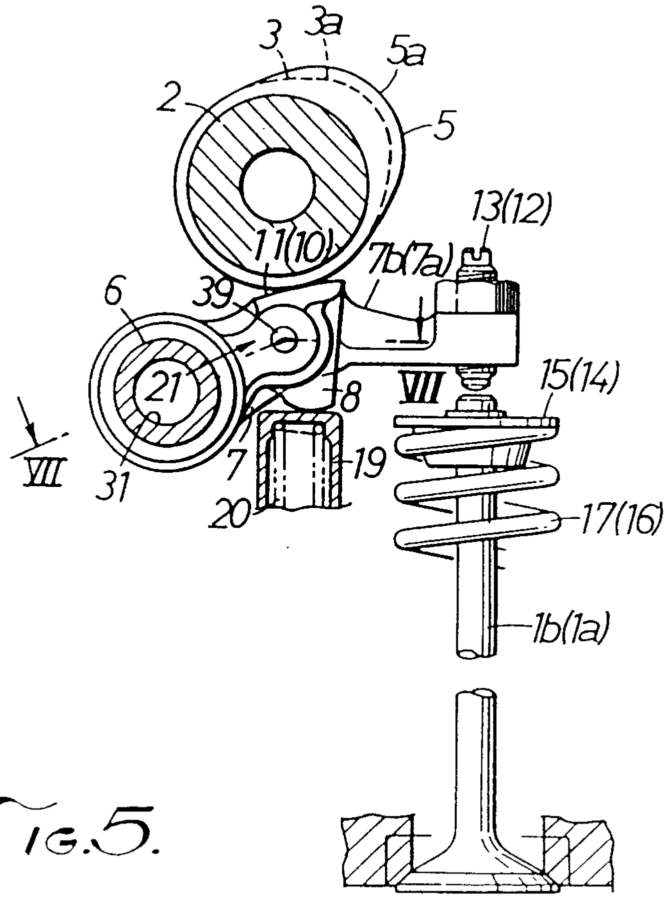

FIG. 5.

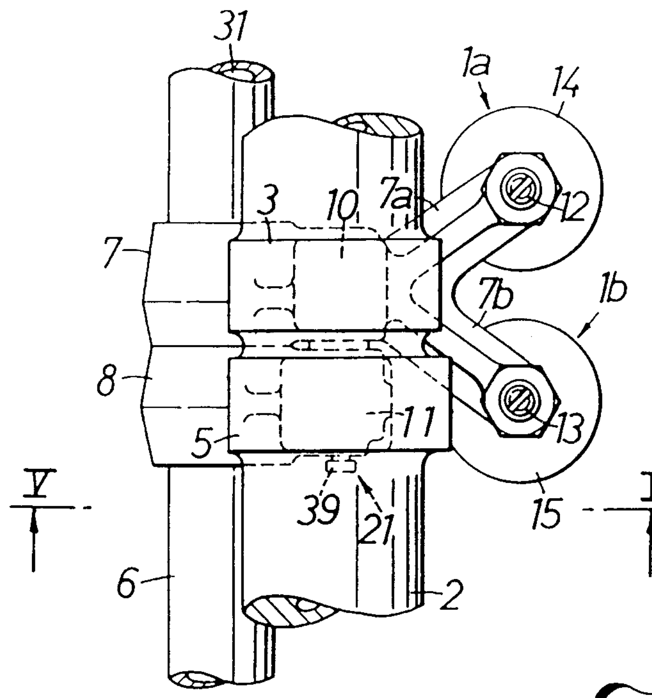

FIG.6.

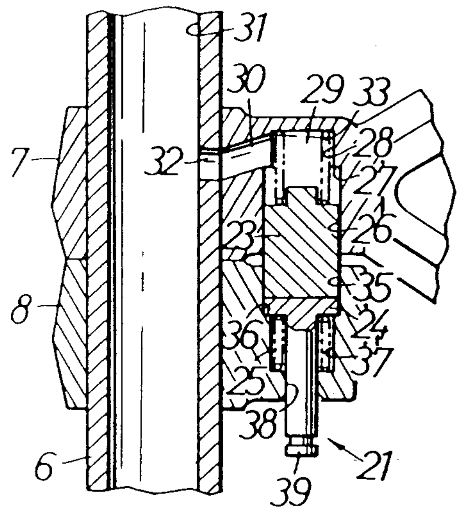

FIG.7.

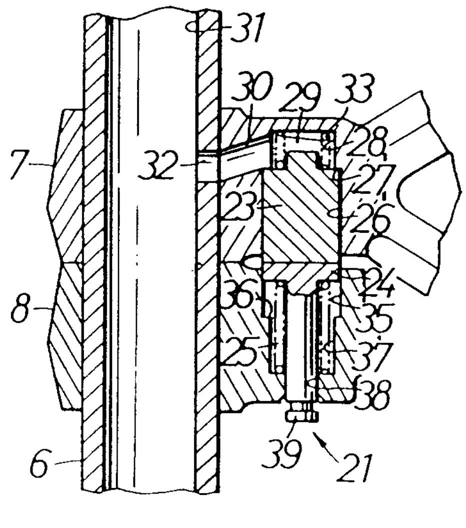

FIG.8.

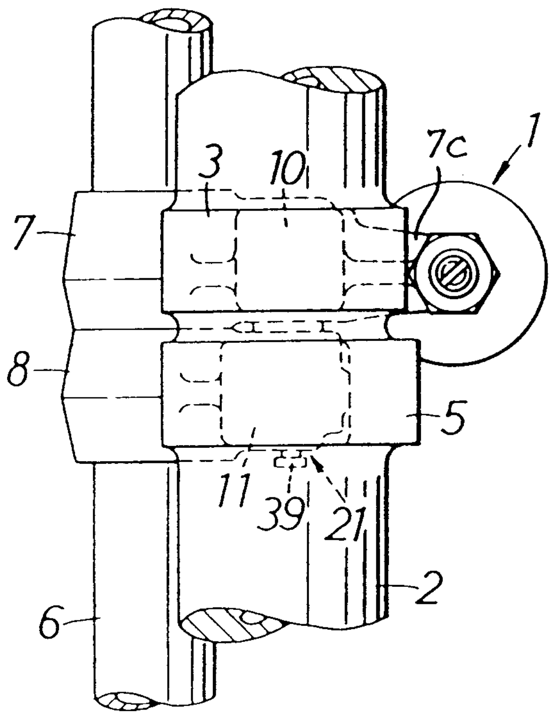

fig.9.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 11 0385

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	PATENT ABSTRACTS OF JAPAN vol. 11, no. 10 (M-552)(2457) 10 January 1987 & JP-A-61 185 604 (SUZUKI) 19 August 1986 * abstract *	1-3	F01L1/26 F01L31/22
A		4	
X	FR-A-2 510 182 (RENAULT) * page 2, line 10 - line 38 * * figures 1,2 *	1-3	
A	DE-A-3 119 133 (PFEIFER) * page 5, line 1 - line 23 * * figure *	1,2	
D,A	GB-A-2 141 172 (HONDA) * page 3, line 88 - page 4, line 38 * * figure 3 *	4	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

F01L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13 OCTOBER 1992	LEFEBVRE L.J.F.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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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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