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(54) **DIRECT-ACTION VALVE LIFTER FOR INTERNAL COMBUSTION ENGINE**

(57) **OBJECTS:**

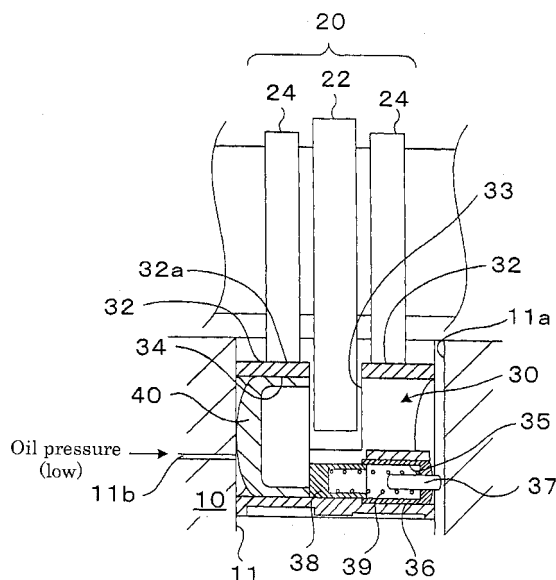
To provide a direct-acting type valve lifter that is simple in structure, involves a small number of components, and is capable of switching its valve lift between a high and a low lift.

MEANS FOR CARRYING OUT THE INVENTION:

The valve lifter is mounted between a cam unit (20) and a valve stem (15). The cam unit (20) comprises a high-lift cam (22) and a low-lift cam (24) integrated to the high-lift cam. The valve lifter (30) is equipped with a side lifter (32) for slidably lifting the low-lift cams (24), a center lifter (40) for slidably lifting the high-lift cam, and hydraulic means (oil groove) (11b) for sliding the center lifter (40) so as to switch the valve lift in two levels, i.e. to switch between a high and a low lift. A cylindrical body of the valve lifter is provided on the top end thereof with a slit (33) for allowing the high-lift cam to freely rotate therein, and with sliding surfaces (32a) serving as a side lifter (32) to be in sliding contact with the low lift cam. Formed in the body of the valve lifter (lifter body) is a through-hole 34 perpendicular to the slit (33), which accommodate therein the piston type center lifter (40) such that the center lifter (40) can be slidably moved by a hydraulic pressure. When the center lifter (40) is located at a position aligned with the slit (33), the cam unit assumes a high lift mode. On the other hand, at a position well offset from the slit (33), the cam unit assumes a low lift mode.

Thus, the valve lifter of the invention is composed of a small number of components, so that dimension tolerance demanded for the respective components are much relaxed, which permits easy assembly of the parts.

Fig.2



Description

[0001] This invention relates to the cylindrical direct-acting type valve lifter provided between the cam and the valve stem which constitute a valve mechanism of an internal-combustion engine, and more particularly, to a direct-acting type valve lifter for use with an internal combustion engines, said valve lifter comprising: a side lifter having a sliding surface to be in sliding contact with a low-lift cam of a cam unit; and a center lifter having a sliding surface to be in contact with a high-lift cam integral with the low-lift cam, such that the valve lifter is capable of switching the valve lift between a high and a low lift.

BACKGROUND ART

[0002] A typical direct-acting type valve lifter is disclosed in, for example, a patent document 1 cited below, and as shown in Fig. 11. This prior art valve lifter is provided with: a cylindrical body (referred to as lifter body) 1 separated into a central center lifter 2 having a circular sliding surface 2a to be in sliding contact with a low-lift center cam and a cylindrical side lifter 3 having a ring-shaped sliding surface 3a to be in contact with high-lift side cams; a first link pin provided in through-holes 4a and 4b that extend through the center lifter 2 and the side lifter 3; and a second link pin 5b provided in through-holes 4b and 4c that extend through the center lifter 2 and the side lifter 3. Reference numeral 6 refers to a spring member for returning the first and second link pins 5a and 5b, respectively, back to their predetermined positions. Reference numeral 7 refers to a spring member provided between a spring bearing 2b at the end of the center lifter 2 and the spring bearing 3b of the side lifter 3 to support the center lifter 2 at a predetermined vertical position relative to the side lifter 3.

[0003] When the first link pin 5a is located within the through-hole 4a, the center lifter 2 and the side lifter 3 are separated in the axial direction of the valve lifter (vertical direction in Fig. 11) (such that the side lifter 3 can 'sink' relative to the center lifter 2, as shown in Fig. 11), thereby causing the movement of the center cam (undergoing a low-lift cam movement) to be transmitted to the lifter body 1 via the sliding surface 2a. On the other hand, under hydraulic pressure, when the first and second link pins 5a and 5b, respectively, are moved (to the right in Fig. 11) against the biasing force of the spring 7 to the respective positions where the first link pin 5a lies in the through-hole 4a and 4b and the second link pin 5b lies in the through-hole 4b and 4c, the center lifter 2 and the side lifter 3 are operably coupled in the axial direction of the valve lifter via the first and second link pins 5a and 5b, respectively, thereby transmitting the movement of the side cam (undergoing a high lift cam operation) to the lifter body 1 via the sliding surface 3a. Patent document 1: Pat Table 2002-509219 (Figs. 1 and 2)

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0004] However, in the prior art as disclosed in the above-mentioned patent document 1, the cylindrical lifter body 1 accommodates many components including the center lifter 2, side lifter 3, first link pin 5a, second link pin 5b, and spring members 6 and 7.

[0005] Therefore, in order for this lifter to be smoothly operable, the link pins and through-holes must have a high degree of accuracy regarding their relative positions. To attain this accuracy, the dimensions of the shaped lifter body 1 and all other components mounted in the lifter body 1 including the first link pin 5a, a receiver that abuts on the link pin 5a, the second link pin 5b, and the through-holes, must be of high precision. Therefore, mass production of high precision valve lifters is difficult and not cost effective.

[0006] Moreover, since the spring member 7 is inevitable between the center lifter 2 and the side lifter 3 to hold the center lifter 2 at a predetermined vertical position relative to the side lifter 3, a further problem exists in that the spring force exerted by the spring member 7 always adds extra sling friction to the valve lifter, thereby preventing smooth operation of the lifter, particularly when the cam is in a high-speed rotational motion in a low-lift mode (in which the center lifter 2 and the side lifter 3 are operably disconnected in the axial direction so that the side lifter 3 can sink with respect to the center lifter 2).

[0007] In view of the problems pertinent to the prior art, the present invention seeks to provide a direct-acting type valve lifter for use with an internal combustion engine, said valve lifter comprising a small number of components arranged in a simple configuration and capable of switching its valve lift between a high lift and a low lift, thereby enabling smooth operation of the valve lifter.

MEANS FOR SOLVING THE PROBLEMS

[0008] To fulfill the object above, there is provided, in accordance with one aspect of the invention as recited in claim 1, a direct-acting type cylindrical valve lifter of an internal combustion engine to be mounted between the cam unit and the valve stem that together constitute a valve mechanism of the internal combustion engine, said cam unit formed of a high-lift cam and a pair of low-lift cams integral with said high-lift cam, said valve lifter having: a side lifter that can be in sliding contact with said low-lift cams; a center lifter in sliding contact with said high-lift cam; and hydraulic means for actuating said center lifter to switch the valve lift of said valve lifter between a high and a low lift, said valve lifter characterized in that said cylindrical valve lifter is provided with:

a slit (referred to as center cam slit) for allowing said center cam to freely rotate therein, said center cam slit formed in the top end of the body of the valve

lifter (referred to as lifter body) and extending in the direction of the sliding motion of said center cam; sliding surfaces formed on the top end of said side lifter for said low-lift cams;

a through-hole formed in said lifter body, extending in the direction perpendicular to said center cam slit; and

a piston type center lifter, slidably fitted in said circular through-hole under hydraulic pressure.

[0009] (Function) The piston type center lifter is adapted to slide in the through-hole when actuated by a hydraulic pressure. At the position where the center lifter is well aligned with the slit, the high-lift cam comes into contact with the center lifter, thereby giving a high-lift to the valve stem via the center lifter and the side lifter (lifter body). On the other hand, when the center lifter comes to a position where it is well offset from the slit, the high-lift cam freely rotates in the slit, while the low-lift cams come into sliding contact with the side lifter, thereby giving a low-lift to the valve stem via the side lifter (lifter body).

[0010] Thus, the center lifter is slid in the through-hole by hydraulic pressure, and takes on either a first state where it can be in contact with the center_cam or a second state where it does not come to contact with the center cam.

[0011] Thus, the valve lifter is composed of a small number of components. It is composed mainly of:

a cylindrical body of the lifter (referred to as valve lifter body) serving as the side lifter; and
a piston type center lifter slidably fitted in the through-hole formed in the valve lifter body and actuated by hydraulic pressure. As a result dimension tolerance demanded for the respective components are much relaxed, thereby permitting easy assembly of the parts.

[0012] Moreover, unlike prior art valve lifters, no spring member is used to support the center lifter in position relative to the lifter body (side lifter). Hence, no spring force will act on the valve lifter as a load. As a consequence, in the low-lift mode, where the high-lift cam is not involved in cam motion, smooth valve lifter motion can be secured for the cam undergoing a high-speed rotation.

[0013] In the direct-acting valve lifter for use with an internal combustion engine as recited in claim 1, the through-hole may have a circular cross section and said center lifter may have a cylindrical shape, as recited in claim 2. (Function) Because the cylindrical piston type center lifter has a curved sliding surface that comes into contact with the center cam, the sliding surface has a minimum length to give a predetermined lift, which enables the center lifter to have a minimum size in the direction of the cam movement. This adds more degrees of freedom to the design of the center cam.

[0014] The width of the high-lift cam slit recited in claim 1 or 2 may be substantially the same as the width (thickness) of the high-lift cam, as recited in claim 3.

[0015] (Function) It is in general necessary to provide the cylindrical lifter body with rotation stopping means (for example, a protrusion formed on the lifter body for slidable engagement with a longitudinal groove formed in the cylinder bore). In the invention, however, if the cam is designed to have such profile that the center cam is in engagement with the high-lift cam slit at all times, the high-lift cam slit and the center cam work together as rotation stopping means for stopping the rotation of the lifter body relative to the cylinder bore, since the width of the high-lift cam slit is substantially the same as the width (thickness) of the center cam.

RESULTS OF THE INVENTION

[0016] As will be apparent from the description given above, the direct-action type valve lifter of the invention has a small number of components, as recited in claim 1, so that the dimension tolerance demanded for the respective components is greatly relaxed, and assembling these components is very simple, thereby enabling manufacture of cost-effective valve lifters.

[0017] Further, the invention can secure smooth motion of the valve lifter even in a high-speed cam operation in a low-lift mode, thereby circumventing a conventional problem that hinders smooth operation of lifters in a low-lift mode and preventing the lopsided wear problem pertinent to existing valve lifters. In addition, since no spring member is needed to hold the high-lift valve lifter in position, there is no need to worry about limitations of the rotational frequency of cams imposed by a spring force and permanent set in fatigue of the spring, which also adds more degrees of freedom to the design of engines.

[0018] As recited in claim 2, since the size of the center cam can be reduced in the direction of the sliding motion thereof as recited in claim 2, the size of the valve lifter can be also reduced accordingly, thereby adding more degrees of freedom to the design of cams and valve lifters.

[0019] Given a high-lift cam configured to fit in the high-lift cam slit at all times as recited in claim 3, the lifter body can be prevented from rotating with respect to the cylinder bore without any rotation stopping means between the body of the lifter and the cylinder bore. Then, the body of the lifter and cylinder bore can be simplified in structure accordingly.

BEST MODE FOR CARRYING OUT THE INVENTION

[0020] Preferred embodiments of the invention will now be described with reference to the accompanying drawings.

[0021] Figs. 1-5 are cross sections of a first embodiment of the invention, with Fig. 1 showing a cross section of a direct-acting type valve lifter and its surrounding com-

ponents of a valve mechanism for use with an internal-combustion engine in accordance with a first embodiment of the invention; Fig. 2 showing a cross section of the valve lifter, with a center lifter being well offset from the slit of the side lifter; Fig. 3 showing a side elevation view of the valve lifter (as seen from the right in Fig. 2); Fig. 4 showing an exploded perspective view of the valve lifter; and

Fig. 5 showing a cross section of the valve lifter, with the center lifter being well aligned with the slit of the side lifter.

[0022] In these figures, reference numeral 12 refers to an air intake port formed in the cylinder head 10 of an automobile engine; numeral 14 to an inlet valve provided in the air intake port 12. The valve stem 15 of the air intake valve 14, extending in the cylinder bore 11 near the air intake port 12, is urged by the spring force of a compressed coil spring 16 in one direction to close the air intake port 12.

[0023] Reference numeral 20 refers to a cam unit formed of low-lift side cams 22 and 24 integrated to the opposite sides of a high-lift center cam 22. The cam unit 20 is arranged on the top end of the cylinder bore 11. Provided between the cam unit 20 and the valve stem 15 is a valve lifter 30 that is vertically slidable in the bore 11.

[0024] As shown in Fig. 4, the valve lifter 30 is mainly provided with: a slit 33 (referred to as center cam slit) for allowing the center cam 22 to rotate freely therein; a side lifter (lifter body) 32 having a pair of side cam sliding surfaces 32a; a piston type center lifter 40 that is slidable in a through-hole 34 formed in the side lifter 32 in the direction perpendicular to the vertical slit 33; and a compression spring 39 for holding the center lifter 40 in position. The through-hole 34 has a circular cross section. The center lifter 40 is a hollow circular cylinder having a closed end and slidably engages the through-hole 34. The outer peripheral surface of the center lifter 40 serves as a sliding surface 40a for the center cam.

[0025] Reference numeral 36 refers to a plug (serving as a spring bearing) force fitted in a bore 35 formed near the lower opening of the through-hole 34 in parallel to the through-hole 34. The plug 36 is a hollow cylinder and has a closed end. Projecting from one end of the plug 36 is a pin (rotation stopping pin) 37 which engages with the longitudinal groove 11a formed in the wall of the cylinder bore 11 to serve as rotation stopping means for stopping the rotation of the valve lifter 30 relative to the cylinder bore 11 and cams 22 and 24.

[0026] Provided inside the plug 36 is a cylindrical hollow slide pin 38 that has a closed end and is slidable in the axial direction of the plug 36. A compression spring 39 is arranged between the plug 36 and the slide pin 38 to urge the center lifter 40 away from the plug 36 (to the left in Fig. 2).

[0027] Reference numeral 11b refers to an oil groove formed in the cylinder head 10. The oil groove 11b has an opening in the cylinder bore 11 in opposition to the longitudinal groove 11a formed in the cylindrical bore 11

(the opening facing the center lifter 40 of the valve lifter 30). Under the hydraulic pressure of the engine oil supplied from this oil groove 11b, the center lifter 40 can slide in the through-hole 34 to change the lift of the valve 14.

[0028] That is, under a (high) hydraulic pressure applied to the center lifter 40 via the oil groove 11b, the center lifter 40 slides in the through-hole 34 against the spring force exerted by the spring 39. When the center lifter 40 assumes a position where it is aligned with the slit 33 as shown in Fig. 5, the high-lift center cam 22 comes into sliding contact with (the sliding surface of) the center lifter 40. As a consequence, a high lift is given to the valve stem 15 via the center lifter 40 and the side lifter 32 (lifter body).

[0029] On the other hand, as the hydraulic pressure acting on the center lifter 40 is reduced, the center lifter 40 returns to its home position where the center lifter 40 is well offset from the slit 33 by the spring force exerted by the spring 39, thereby permitting the high-lift center cam 22 to freely rotate in the slit 33, as shown in Fig. 2. At the same time, the low-lift side cam 24 comes into sliding contact with (the sliding surface of) the side lifter 32, thereby transmitting a low lift to the valve stem 15 via the side lifter (lifter body) 32.

[0030] In this way, in response to the hydraulic pressure acting on the center lifter 40, the center lifter 40 selectively assumes one position where it is in sliding contact with the center cam 24 or the other position where it does not come into contact with the center cam 24.

[0031] It is noted that, because the center lifter 40 is formed to have an arcuate cylindrical sliding surface 40a, the length of the sliding surface 40a can be short for a given cam lift, so that the size of the center lifter 40 in the direction of the cam movement thereof, or equivalently the outer diameter of the center lifter 40, can be reduced accordingly. Hence, the degrees of freedom in the design of the center cam 24 and valve lifter 30 can be increased.

[0032] Referring to Figs. 6 and 7, there is shown a direct-acting type valve lifter for use with an internal combustion engine in accordance with a second embodiment of the invention. More particularly, Fig. 6 shows a cross section of the valve lifter with its center lifter well aligned with the center cam slit formed in the side lifter, and Fig. 7 shows a cross section of the valve lifter with the center lifter completely offset from the center cam slit.

[0033] As compared with a first embodiment described above which is provided with the rotation stopping means for stopping the rotation of the valve lifter 30 (and side lifter 32) that consists of the rotation stopping pin 37 and the longitudinal groove 11a of the cylinder bore 11, the present embodiment requires no such rotation stopping means (no longitudinal groove 11a nor rotation stopping pin 37) due to the fact that, in this embodiment, the width d of the high-lift cam slit 33 for the center cam is configured to have substantially the same width (thickness) t of the center cam 22 and that the center cam 22 is configured to have a profile that engages the slit 33 at all times, so that the slit 33 and the center cam 22 together

serve as the rotation stopping means for stopping the rotation of the valve lifter 30 relative to the cylinder bore 11 (or relative to the cam unit 20). As a result, the structures of the valve lifter 30A and the cylinder bore 11 are simplified accordingly.

[0034] It will be recalled that in the first embodiment the piston type center lifter 40 is initially held at the position well offset from the slit 33 by the spring force of the compressed coil spring 39 when no (high) hydraulic pressure acts on the center lifter 40, as shown in Fig. 2. (Thus, the low-lift side cams 24 are in operation in the low-lift transmission mode). When a (high) hydraulic pressure is applied to the center lifter 40, it is moved to the position where it is well aligned with the slit 33, thereby placing the high-lift side cam 22 in the high-lift transmission mode. It is noted that in the second embodiment described herein, two lift transmission modes are switched over by the hydraulic pressure in the opposite manner as compared with the first embodiment. That is, in the initial stage where no hydraulic pressure is applied onto the center lifter 40A, it is held by the spring force of the compressed coil spring 39 at the position where it is well aligned with the slit 33 (where driving power of the high-lift side cam 22 is available), as shown in Fig. 6. On the other hand, when a hydraulic pressure acts on the center lifter 40A, it is moved to the position well offset from the slit 33, thereby placing the low-lift side cam 24 in operation in the low-lift transmission mode, as shown in Fig. 7.

[0035] A cylindrical slide pin 38A arranged in the bore 35 has a closed end. There is provided in the cylinder head 10 an oil groove 11c, which has an opening in the wall of the cylinder bore 11 facing the slide pin 38A of the valve lifter 30A (or the bore 35). Located at one end of the through-hole 34, remote from the slide pin 38A, is a cap 44 having a substantially semi-spherical outer surface. A compression coil spring 39 is provided between the cap 44 and the piston type center lifter 40A to cause the center lifter 40A to abut against the slide pin 38A. As a consequence, the center lifter 40A is held at a predetermined position where it is well aligned with the slit 33.

[0036] Specifically, when a (high) hydraulic pressure is applied onto the slide pin 38A via the oil groove 11c, the center lifter 40A is caused to slide in the through-hole 34 against the spring force of the spring 39A, and reaches a position where the slide pin 38A is well offset from the slit 33 as shown in Fig. 7. Then, the high-lift center cam 22 undergoes free rotation in the slit 33 and the low-lift side cams 24 come into sliding contact with the side lifter 32, thereby transmitting a low lift to the valve stem 15 via the side lifter (lifter body 32). On the other hand, as the hydraulic pressure acting on the slide pin 38A is reduced, the slide pin 38A is returned by the spring force of the spring 39 to the home position where it is well aligned with the slit 33, so that the high-lift center cam 22 comes into sliding contact with the center lifter 40A as shown in Fig. 6, thereby transmitting a high lift to the valve stem 15 via the center lifter 40A and side lifter (lifter body) 32.

[0037] The rest of the operation of this cam unit is the

same as those of the first embodiment. To avoid duplication of description, like components in the two embodiments are respectively indicated by like reference numerals, and further details of the second embodiment will be omitted.

[0038] Referring to Figs. 8 and 9, there is shown a direct-acting type valve lifter for use with an internal combustion engine in accordance with a third embodiment of the invention. More particularly, Fig. 8 shows a cross section of the valve lifter with its center lifter well offset from the side lifter slit. Fig. 9 shows a side elevation view of the valve lifter shown in Fig. 8.

[0039] This third embodiment is an improved variation of the first embodiment. It will be recalled that in the first embodiment the spring force of the compression coil spring 39 acts on the piston type center lifter 40 via the slide pin 38. In the third embodiment shown herein, a plug 36 having a rotation stopping pin 37 that projects from one end of the cylindrical plug 36 is adapted to slide in the bore 35 formed along the central axis of the through-hole 34. The center lifter 40B is provided at the axial center thereof with a spring bearing 41 that projects to engage the plug 36 such that the resilient force of the compression coil spring 39 directly acts on the center lifter 40B. Thus, the valve lifter 30B has less constituents than the preceding embodiments.

[0040] It is noted that the sliding motion of the center lifter 40B is smooth since the spring force of the compression spring 39 acts on the central section of the center lifter 40B.

[0041] The rest of the features of the third embodiment are the same as those of the first embodiment. To avoid duplication of description, like components in the two embodiments are respectively indicated by like reference numerals, and further details of the third embodiment will be omitted.

[0042] It should be understood, however, that although the through-holes 34 and the center lifters 40, 40A, and 40B of the first-third embodiments are shown to have cylindrical cross sections, they can be formed to have square cross sections.

[0043] In the first-third embodiments, although the resilient force of a spring is employed along with hydraulic pressure to actuate the piston, the spring can be removed by applying a hydraulic pressure to the piston from the opposite side of the piston.

[0044] The invention has been described above in connection with a valve lifter that constitutes the valve mechanism for use with an air inlet valve installed in an air inlet port in accordance with the first through third embodiments. It will be apparent, however, that the invention can be equally applied to the valve lifter that constitutes the valve mechanism for use with an exhaust valve installed in an air exhaust port.

BRIEF DESCRIPTION OF THE DRAWINGS

[0045]

Fig. 1 is a cross section of a direct-acting type valve lifter and its surrounding components of a valve mechanism for use with an internal-combustion engine in accordance with a first embodiment of the invention.

Fig. 2 is a cross section of the valve lifter shown in Fig. 1, with the center lifter well offset from the side lifter slit.

Fig. 3 is a side elevation view of the valve lifter (as seen from the right in Fig. 2).

Fig. 4 is an exploded perspective view of the valve lifter.

Fig. 5 shows a cross section of the valve lifter, with the center lifter well aligned with the center cam slit formed in the lifter body.

Fig. 6 shows a cross section of a direct-acting type valve lifter for use with an internal combustion engine in accordance with a second embodiment of the invention, with the valve lifter well aligned with the center cam slit formed in the lifter body.

Fig. 7 is a cross section of the valve lifter with the center lifter well offset from the center cam slit formed in the lifter body.

Fig. 8 is a cross section of a direct-acting type valve lifter for use with an internal combustion engine in accordance with a third embodiment of the invention, with the center lifter well offset from the center cam slit formed in the lifter body.

Fig. 9 is a right side elevation view of the valve lifter of Fig. 8.

Fig. 10 is a cross section of the valve lifter of Fig. 9, with the center lifter well aligned with the center cam slit formed in the lifter body.

Fig. 11 is a cross section of a conventional valve lifter.

DESCRIPTION OF THE SYMBOLS

[0046]

10	CYLINDER HEAD
11	CYLINDER BORE
11a	LONGITUDINAL GROOVE
11b & 11c	OIL GROOVES
14	AIR INLET VALVE CONSTITUTING A VALVE MECHANISM
15	VALVE STEM
20	CAM UNIT CONSTITUTING A VALVE MECHANISM
22	HIGH-LIFT CENTER CAM
24	LOW-LIFT SIDE CAMS

30, 30A, 30B	DIRECT-ACTING TYPE VALVE LIFTER
32	LIFTER BODY (SIDE LIFTER)
32a	SLIDING SURFACE OF THE SIDE CAM
33	SLIT FOR ALLOWING FREE ROTATION OF CENTER CAM (CENTER CAM SLIT)
34	THROUGH-HOLE
39	COMPRESSION COIL SPRING
40, 40A, 40B	PISTON TYPE CENTER LIFTER
40a	SLIDING SURFACE OF THE CENTER CAM
d	WIDTH OF CENTER CAM SLIT
t	WIDTH (THICKNESS) OF CENTER CAM

Claims

1. A cylindrical direct acting type valve lifter for use with an internal-combustion engine, provided between the cam unit and the valve stem constituting a valve mechanism of said internal combustion engine, said cam unit formed of a high-lift cam (center cam) and a pair of low-lift cams integral with said high-lift cam, and said valve lifter having: a side lifter that can be in sliding contact with said low-lift cams; a center lifter that can be in sliding contact with said high-lift cam; and hydraulic means for actuating said center lifter to switch the valve lift of said valve lifter between a high and a low lift, said valve lifter **characterized in that** said cylindrical valve lifter is provided with:
 - a center cam slit for allowing said center cam to freely rotate therein, said center cam slit formed in the top end of the lifter body and extending in the direction of the sliding motion of said center cam;
 - sliding surfaces formed on the top end of said side lifter for said low-lift cams;
 - a through-hole formed in said lifter body, extending in the direction perpendicular to said center cam slit; and
 - a piston type center lifter slidably fitted in said through-hole under hydraulic pressure.
2. The direct-acting type valve lifter according to claim

1, **characterized in that** said through-hole has a circular cross section and said center lifter has a cylindrical shape.

3. The direct-acting type valve lifter according to claim 1 or 2, **characterized in that** the width of said high-lift cam slit is substantially the same as the width (thickness) of said high-lift cam.

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Fig.1

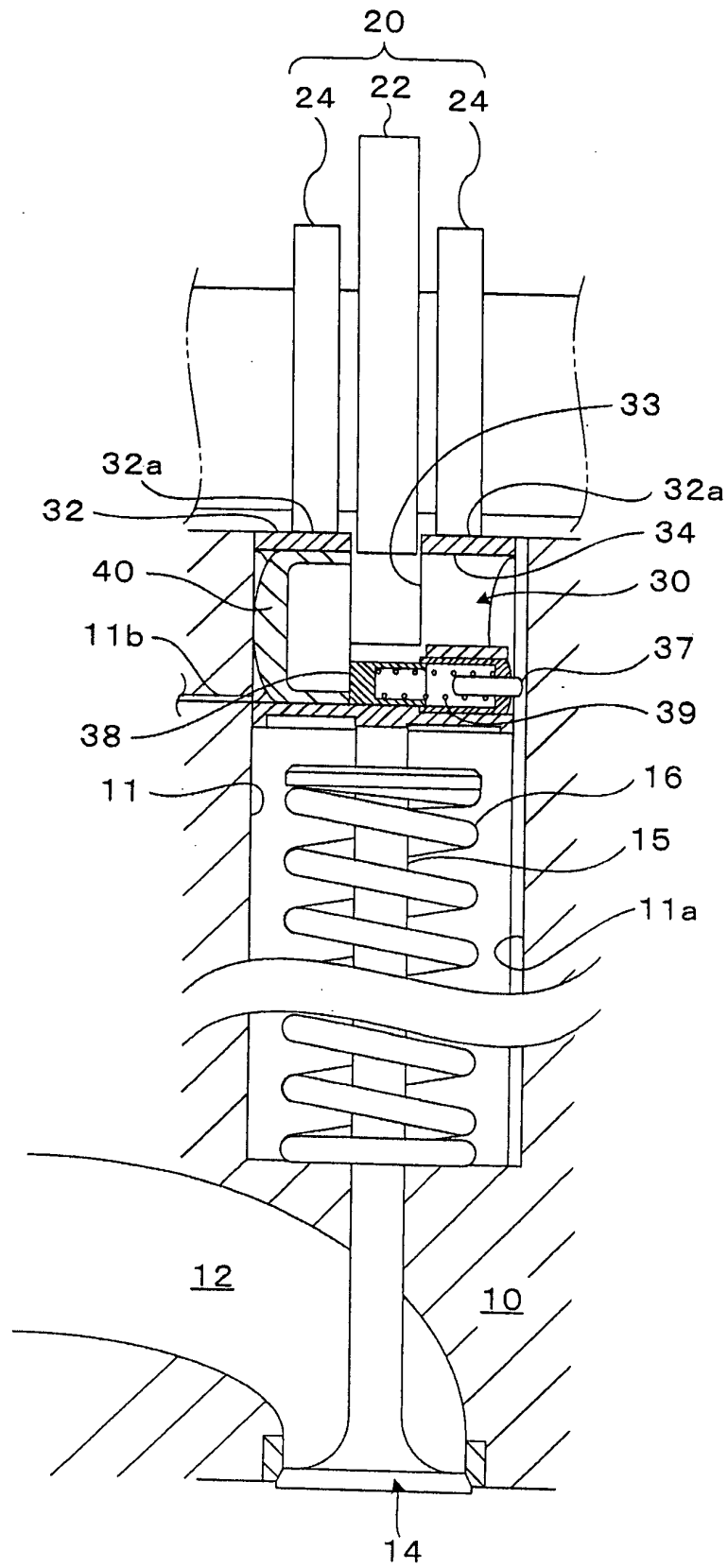


Fig.2

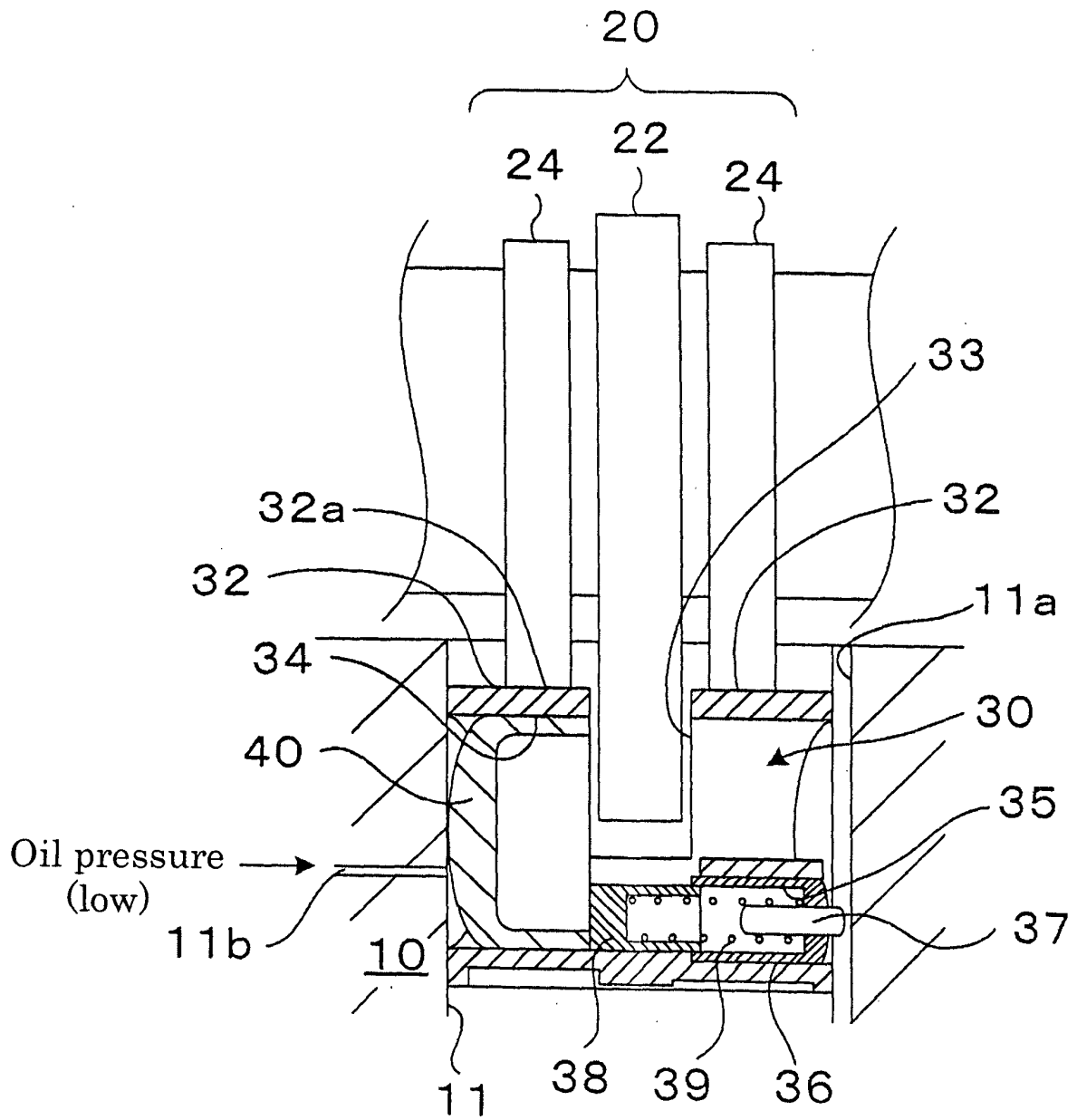


Fig.3

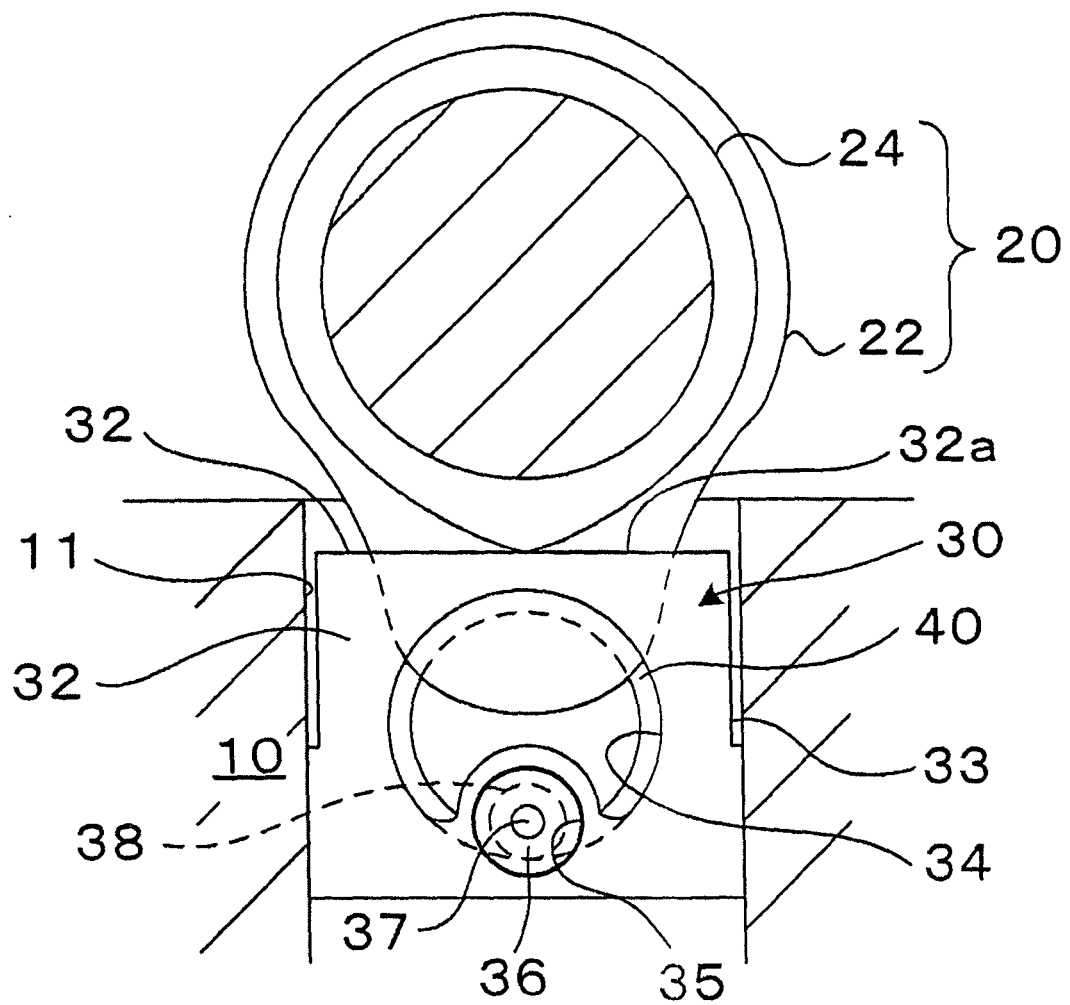


Fig.4

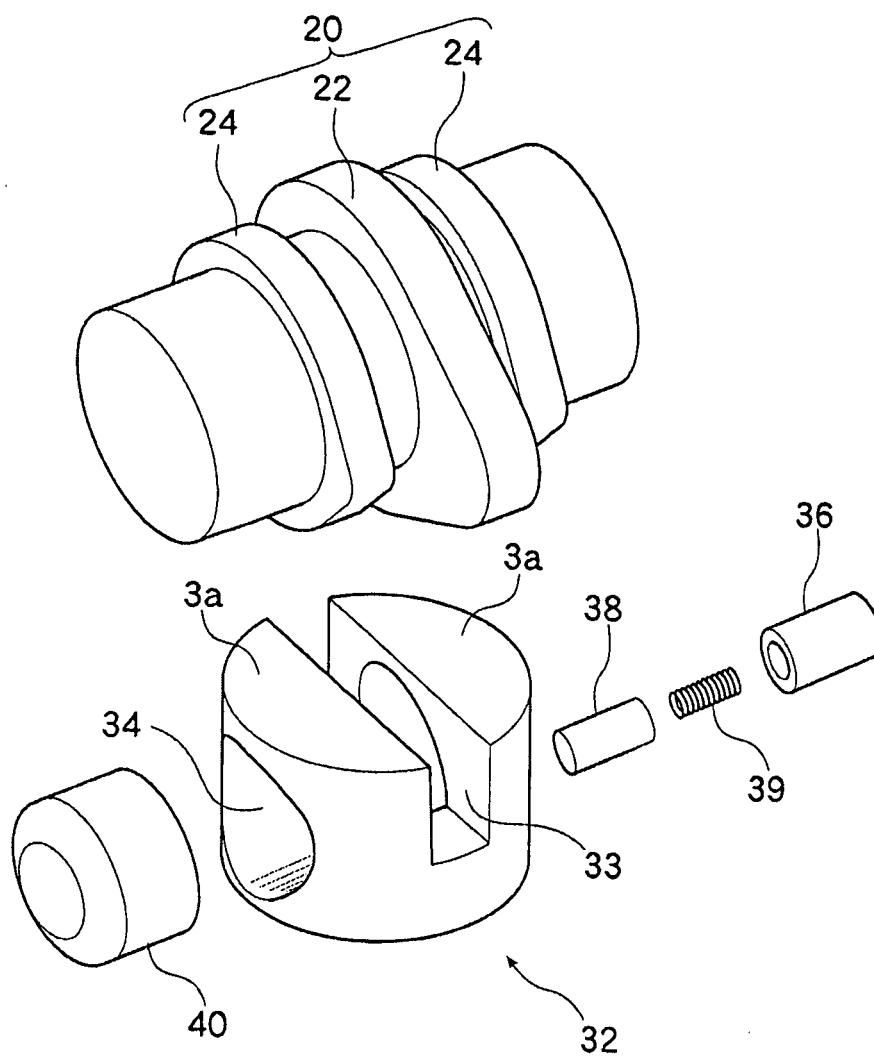


Fig.5

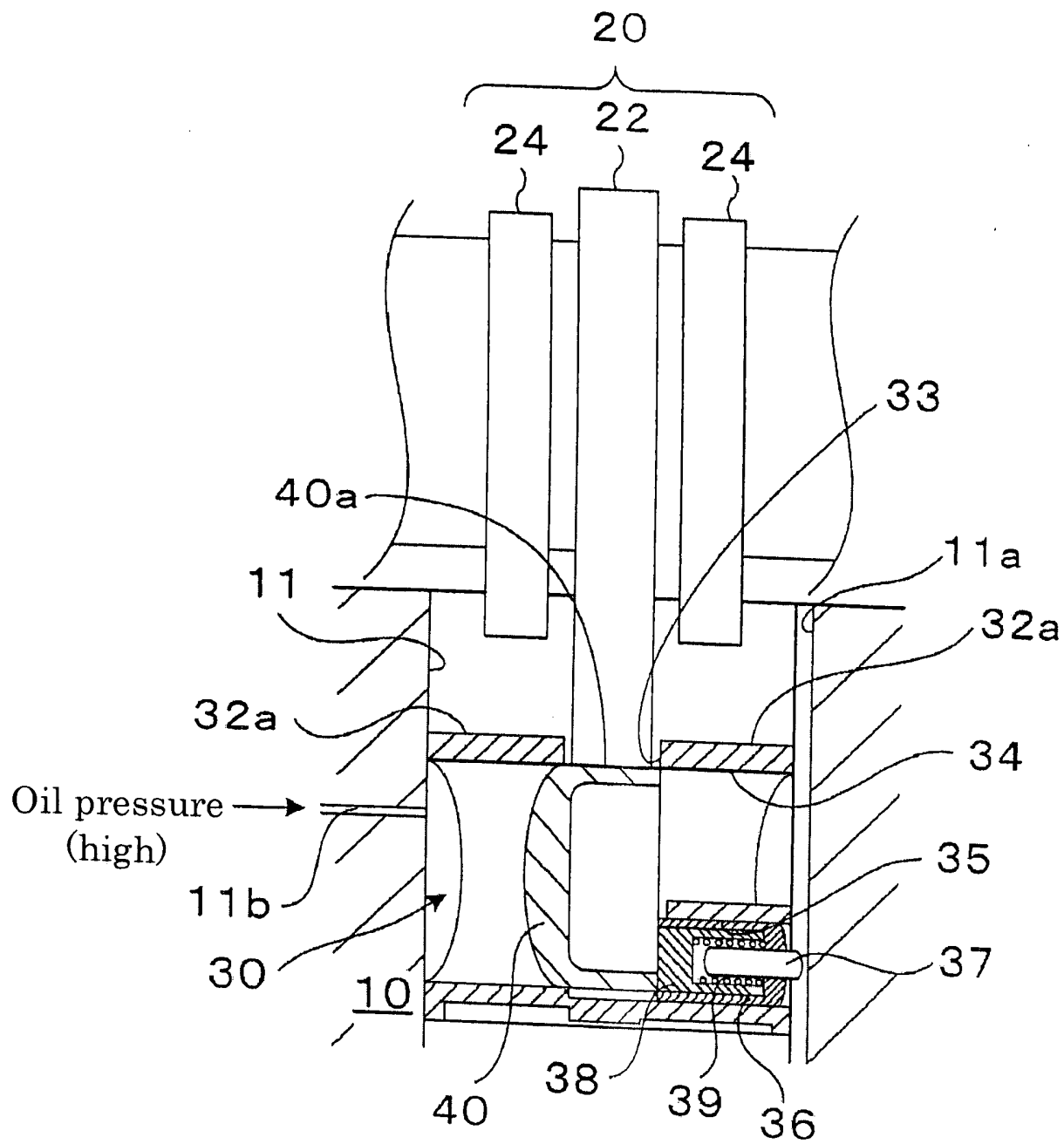


Fig.6

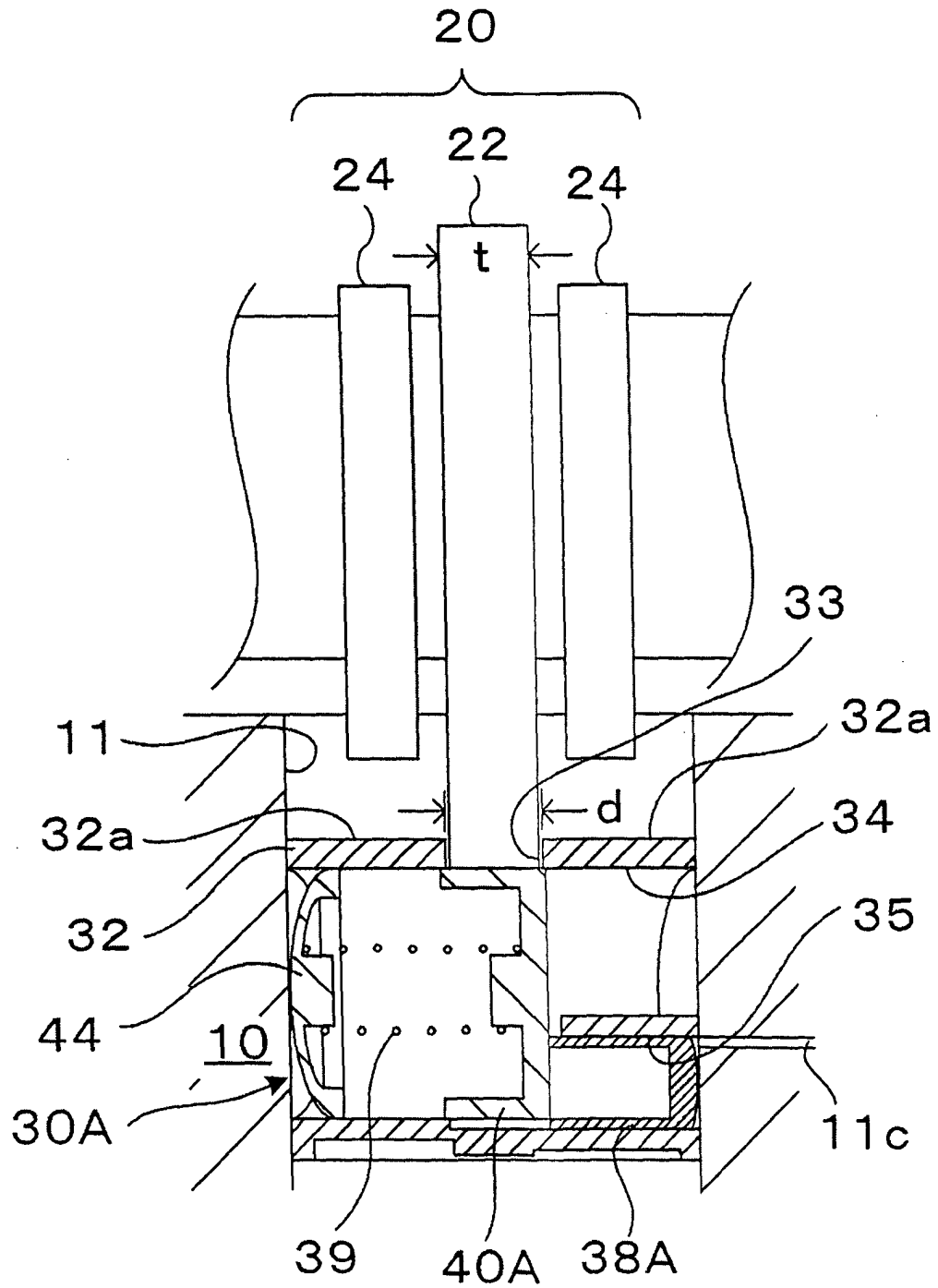


Fig.7

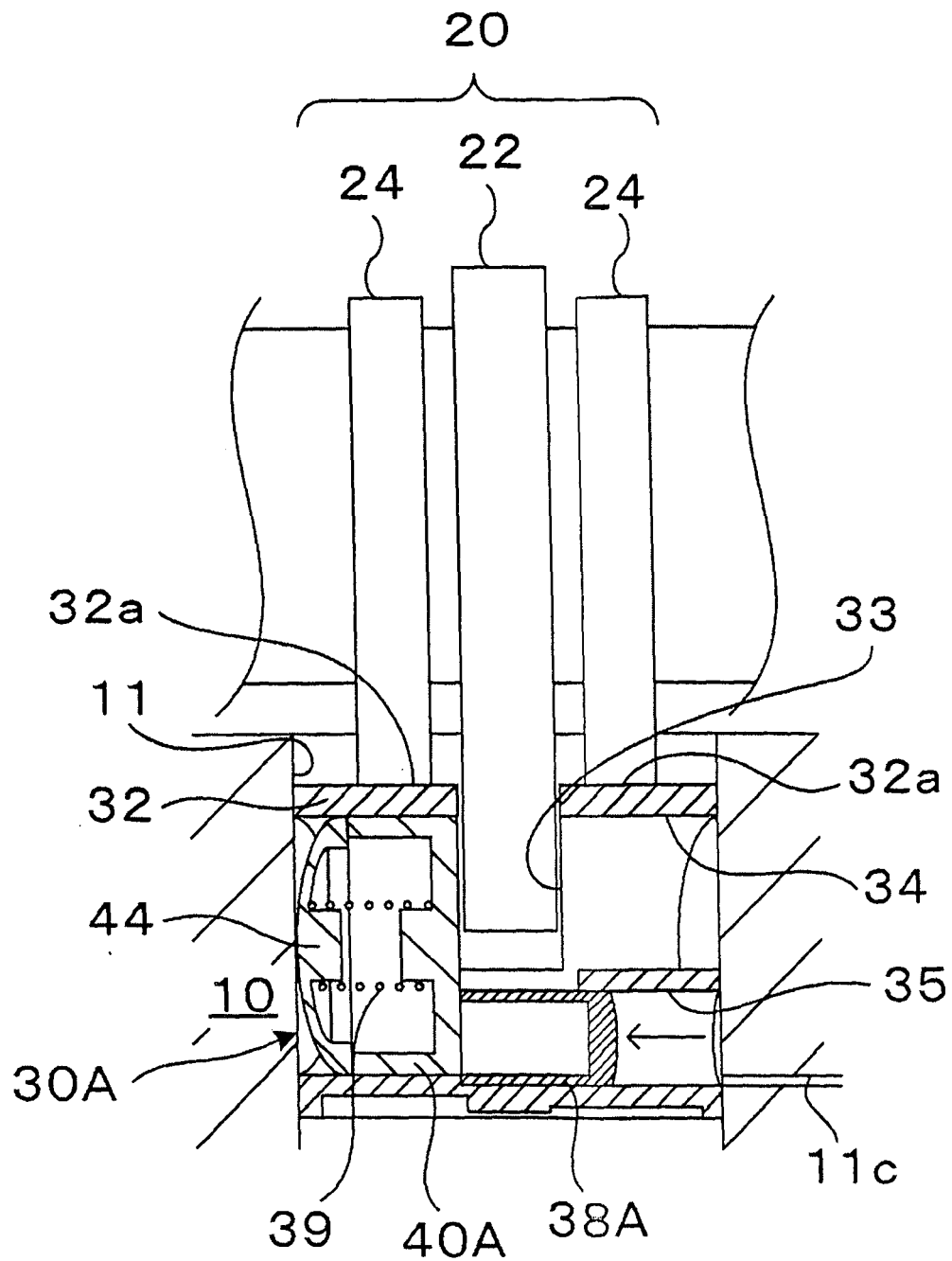


Fig.8

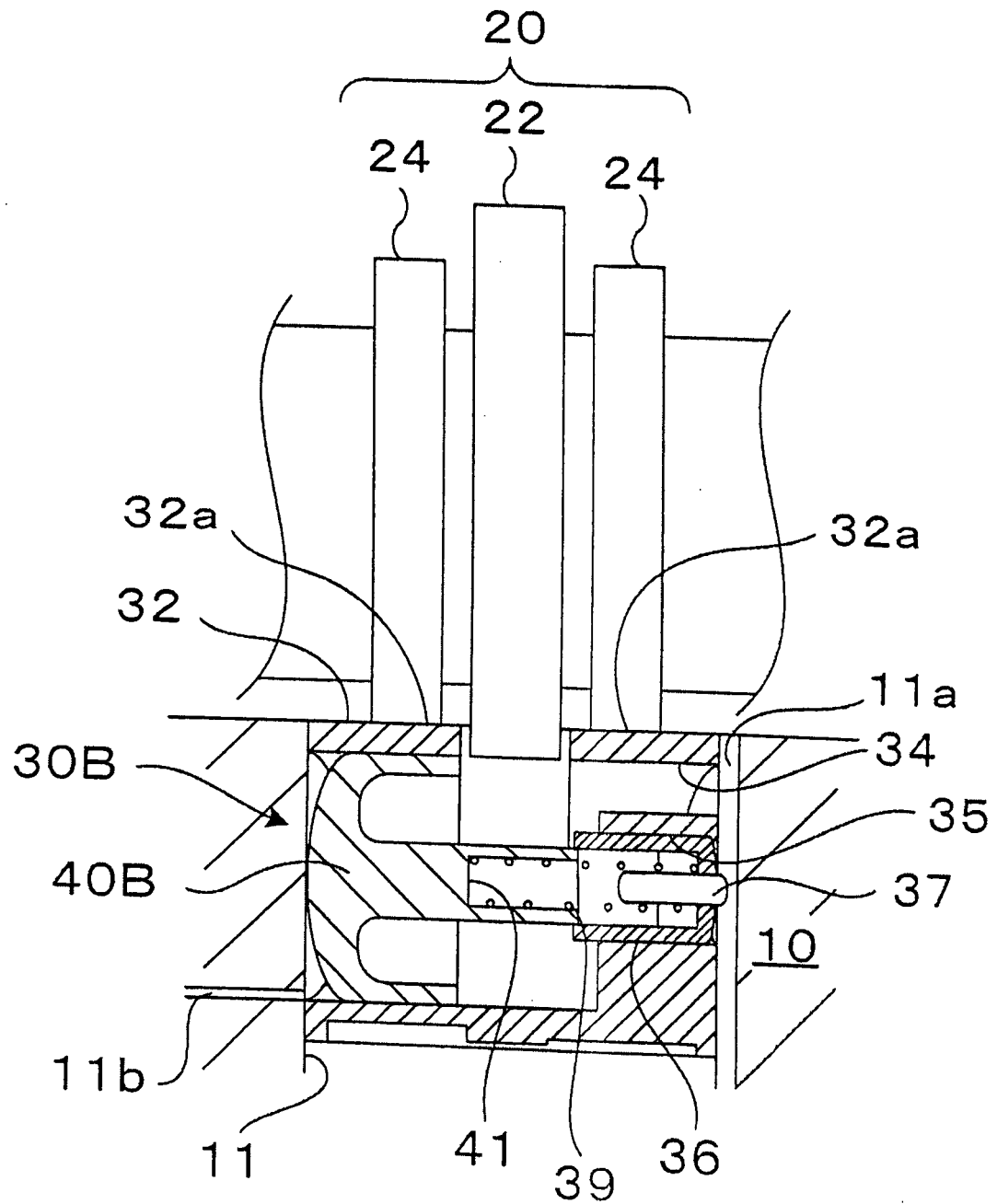


Fig.9

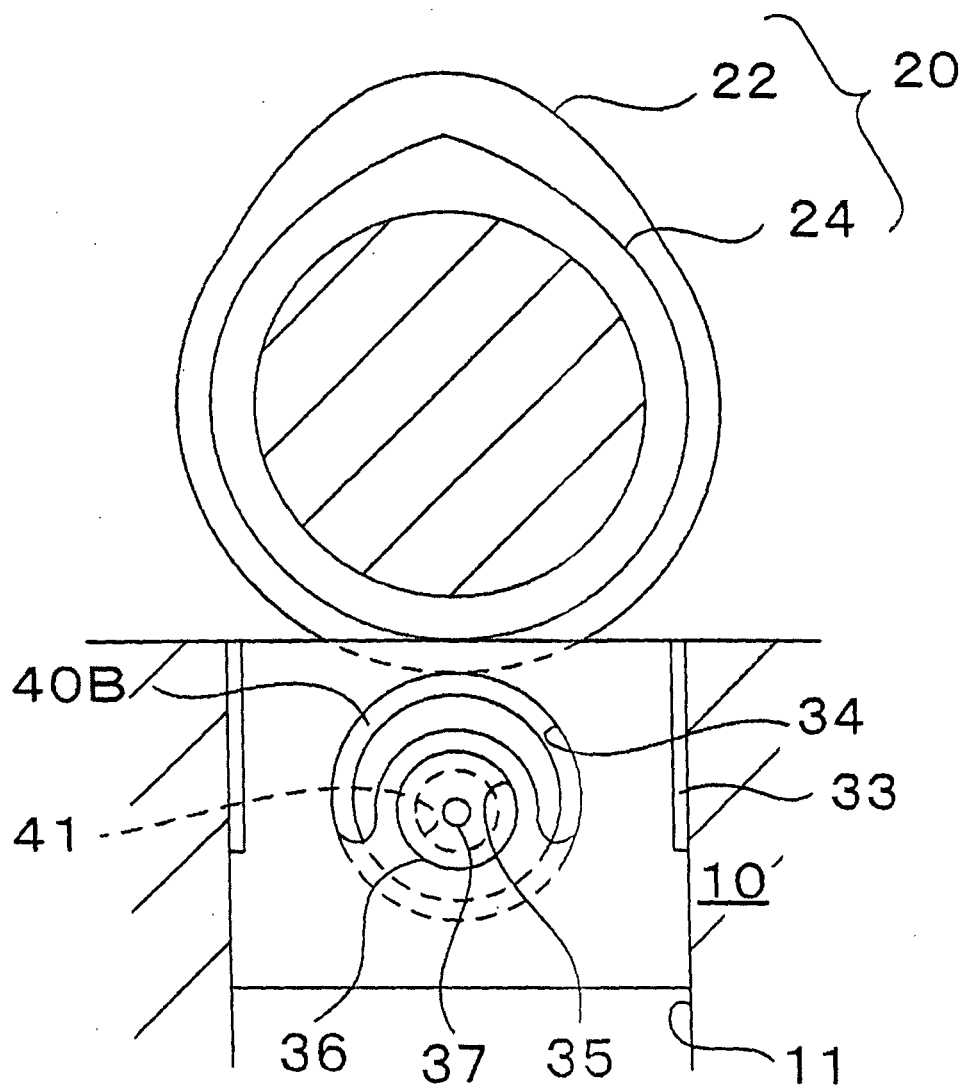


Fig.10

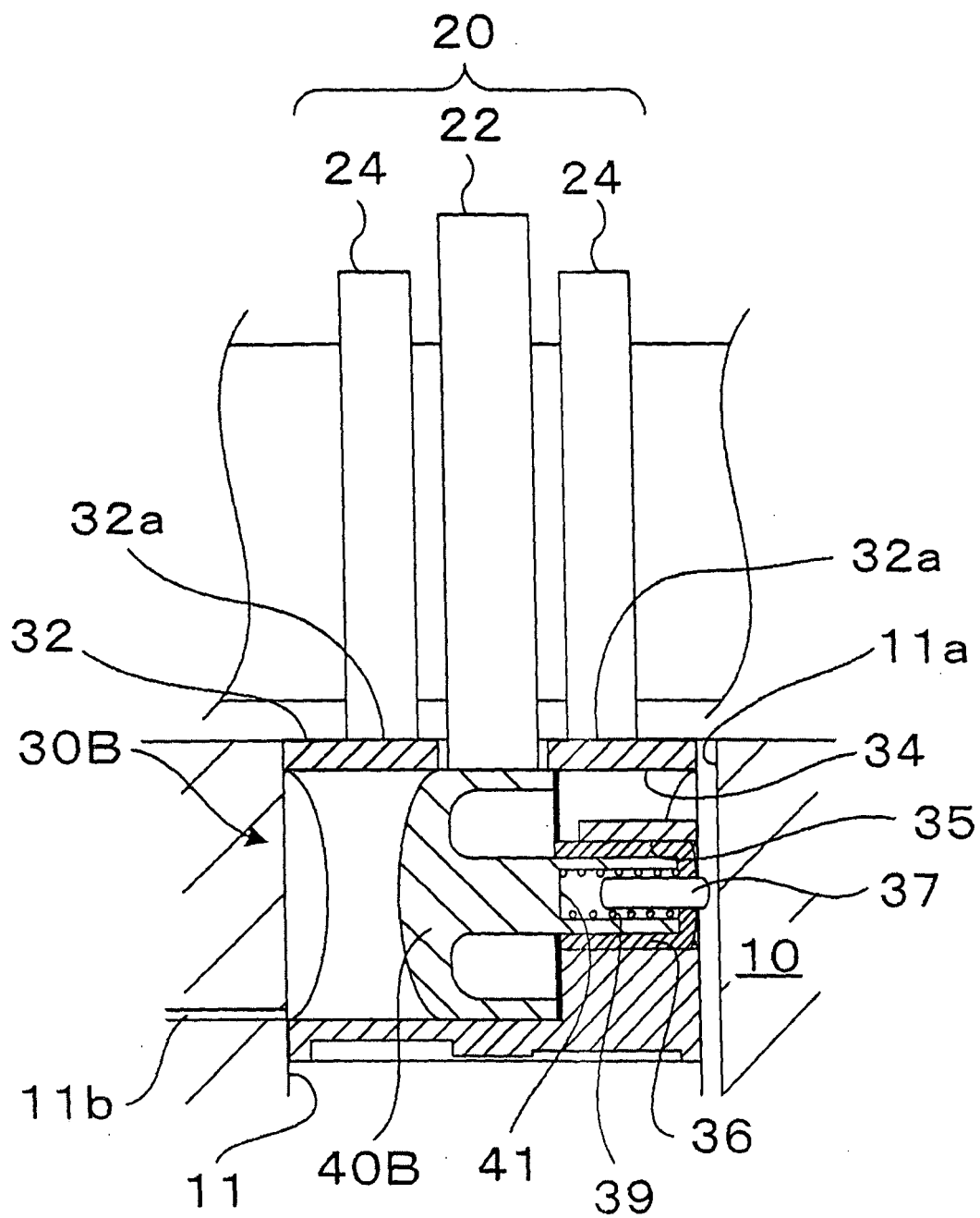
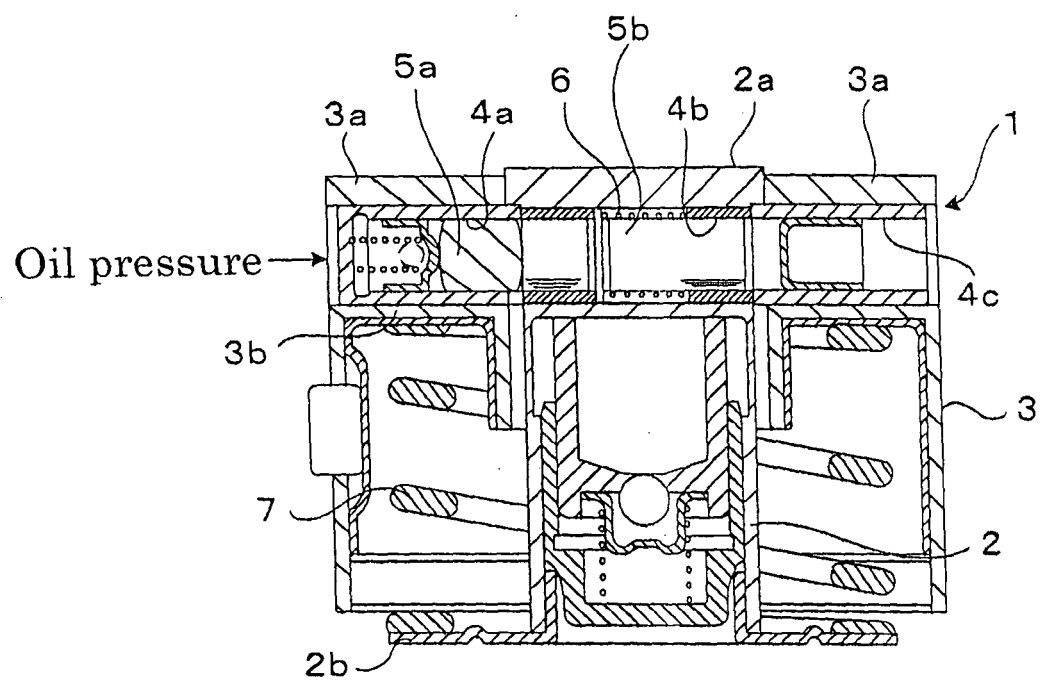


Fig.11



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/015520

A. CLASSIFICATION OF SUBJECT MATTER

F01L13/00 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F01L13/00 (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2005
Kokai Jitsuyo Shinan Koho	1971-2005	Toroku Jitsuyo Shinan Koho	1994-2005

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 8-177426 A (Unisia Jecs Corp.), 09 July, 1996 (09.07.96), Par. Nos. [0018] to [0039]; Figs. 1 to 3, 6 & US 5743226 A & DE 19540133 A1	1-3
X	JP 8-284628 A (Unisia Jecs Corp.), 29 October, 1996 (29.10.96), Par. Nos. [0015] to [0038]; Figs. 1 to 3 (Family: none)	1-3
X	JP 9-170412 A (Unisia Jecs Corp.), 30 June, 1997 (30.06.97), Figs. 1, 3 (Family: none)	1-3

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
07 November, 2005 (07.11.05)Date of mailing of the international search report
22 November, 2005 (22.11.05)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/015520

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 9-177525 A (Unisia Jecs Corp.), 08 July, 1997 (08.07.97), Figs. 1, 6 (Family: none)	1-3

Form PCT/ISA/210 (continuation of second sheet) (April 2005)