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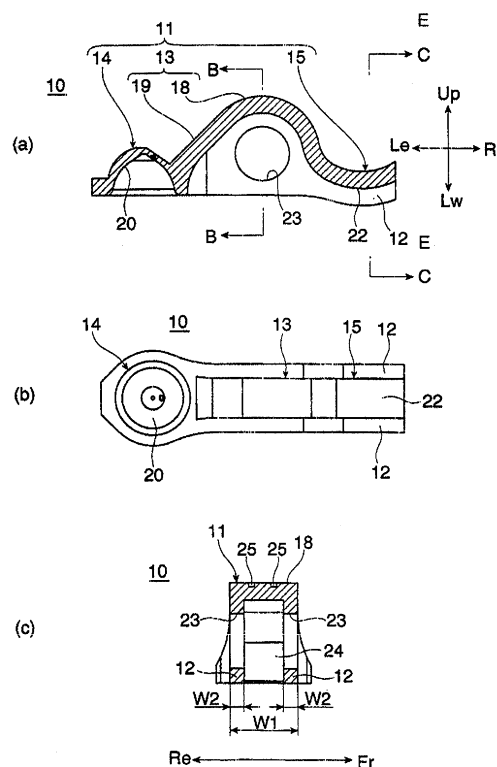
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(54) **ROCKER ARM FOR VALVE TRAIN**

(57) **OBJECT:** To provide a rocker arm for a valve control apparatus of an automobile engine, enabling downsizing of the valve control apparatus and improvement in fuel economy of the engine.

MEANS FOR ACHIEVING THE OBJECTS: A rocker arm for a valve control apparatus comprises a top plate and at least one upright wall section. The top plate is provided on top thereof with a cam slide section in contact with a cam of a camshaft; supported at one end thereof by a supporting member rockably about the rocking center of the supporting member; and is provided at the other end thereof with a pad face in contact with a valve system. Said at least one upright wall section has a smaller width than the top plate, and extends from the top plate at a substantially right angle.

Fig. 2



Description

FIELD OF THE INVENTION

[0001] This invention relates to a rocker arm for use with a valve control apparatus for controlling the valve open/close operation of an automobile engine via a rocker arm rocked by the cam of a camshaft, the rocker arm providing an improved the fuel economy of the engine and enabling down sizing of the valve control apparatus

BACKGROUND ART OF THE INVENTION

[0002] A rocker arm rocked by a cam driven by a camshaft of the engine for lifting and lowering an engine valve is disclosed in a patent document listed below The rocker lever (rocker arm) 1 of Patent Document 1 has a semi-spherical recess 2 engaged with the semi-spherical end 4 of a support member 3 for rockably supporting the rocker lever 1 in contact with the base section (or valve stem) of a gas exchange valve (engine valve) urged by a valve spring for closing the valve (not shown) Provided at the center of the rocker lever (rocker arm) 1 is a roller 6 in contact with a camshaft (not shown). The rocker lever 1 opens the engine valve by pushing down the roller 6 (not shown) and allows the engine valve to be closed by means of a valve spring (not shown) urging the valve.

PRIOR ART DOCUMENT

[0003] PATENT DOCUMENT: JPA Laid Open H10-37719

SUMMARY OF THE INVENTION

OBJECTS TO BE ACHIEVED BY THE INVENTION

[0004] In general a camshaft is subjected to a force of a valve spring urging the valve stem to close the valve and a frictional torque generated between the rocker arm and the cam pushing down the rocker arm in opposition to the force of the valve spring during a valve opening period This frictional torque impedes the rotation of the camshaft. Since this frictional torque lowers the fuel economy of the engine, the valve control apparatus of Patent Document 1 utilizes a rocker lever 1 having a roller 6 in contact with the cam so as to reduce the friction between the cam and the rocker arm, and hence the frictional torque acting on the camshaft.

[0005] However, although the roller 6 can reduce the friction between the cam and rocker lever 1, such roller 6 greatly increase the weight of the rocker lever 1, since the roller 6 requires needle bearings for example An increase in weight of the rocker lever 1 entails an increase in the inertial moment of the rocker lever 1, which implies that a stronger valve spring is required to close the valve However, a stronger valve spring will cause the roller 6 to exert a stronger force on the cam, thereby increasing

the frictional torque acting on the camshaft.

[0006] As a consequence, in spite the roller 6 can reduce the frictional torque, the rocker lever 1 having such roller 6 suffers from an increment of the frictional torque due to the increased spring force of the valve spring, Hence, reduction of the frictional torque by the use of cam in rolling contact with the roller 6 is overwhelmed by an increment of the frictional torque due to an increment of the valve force of the valve spring This is a serious problem from the point of the fuel economy of the engine. The use of a roller poses a further problem that it increases the dimensions of the rocker lever 1, making it difficult to downsize the valve control apparatus

[0007] In view of the problems mentioned above, the present invention is directed to an improved rocker arm operably coupled to the camshaft, which enables not only reduction of the disadvantageous frictional torque that impedes the rotation of the camshaft but also enables downsizing of the valve control apparatus, thereby facilitating improvement of the fuel economy of the engine.

MEANS FOR ACHIEVING THE OBJECTS

[0008] An inventive rocker arm for a valve control apparatus in accordance with claim 1 has a top plate and at least one upright wall section, wherein the top plate is:

provided on top thereof with a cam slide section in contact with a cam of a camshaft;
supported at one end thereof by a supporting member rockably about the rocking center of the supporting member; and
is provided at the other end thereof a pad face in contact with a valve system, and
said at least one upright wall section has a smaller width than the top plate, and extends from the top plate at a substantially right angle.

[0009] In the rocker arm of claim 1, in order to reinforce the top plate subjected to the reactive force of the valve spring acting on the pad face and the cam force acting on the cam slide section, said at least one upright wall section is integrated with the top plate.

[0010] (Function) In the rocker arm of the valve control apparatus of claim 1, the top plate has a minimum possible thickness, yet it is reinforced by the upright wall having a thickness less than that of the top plate, so that the weight and inertial moment of the rocker arm are significantly reduced As a consequence, the valve control apparatus equipped with the rocker arm of claim 1 can use an extremely light-weight valve spring, which in turn permits great reduction of the frictional torque arising from the force of the valve spring and applied to the camshaft. That is, a torque that would otherwise impede the rotation of the camshaft is greatly reduced

[0011] As a result, in the rocker arm of claim 1, reduction of the frictional torque due to the elimination of a roller and reduction of the weight (or the urging force) of

the valve spring outweighs generation of a minor frictional torque that takes place between the rocker arm and the cam sliding on the rocker arm.

[0012] In the rocker arm of the valve control apparatus of claim 1, at least one of the cam slide section and pad face of the rocker arm may be surface treated to reduce its frictional coefficient, as recited in claim 2

[0013] (Function) In the rocker arm of claim 2, the frictional coefficient of the surface treated section is reduced, thereby reducing the friction generated between the cam and the cam slide section or between the valve stem and pad face, which in turn further reduces the frictional torque acting on the camshaft.

[0014] In the rocker arm for a valve control apparatus of claim 1 or 2, the top plate may have at least one hole in a region except for the cam slide section, as recited in claim 3

[0015] (Function) In the rocker arm of claim 3, the weight of the rocker arm is further reduced by the formation of the hole. As a consequence the force of the valve spring transmitted to the cam, and hence the frictional torque applied to the camshaft, is further reduced.

[0016] In the rocker arm a valve control apparatus in accordance with any one of claims 1 through 3 may have at least one hole formed in the upright wall section, as recited in claim 4.

[0017] (Function) In the rocker arm of claim 4, the weight of the rocker arm is reduced still further that the frictional torque applied to the camshaft is reduced still further.

[0018] In the rocker arm for a valve control apparatus in accordance with claim 4, the hole formed in the upright wall section may be formed on the rocking trajectory of the cam slide section rocking about its rocking center, as recited in claim 5.

[0019] (Function) In the rocker arm of claim 5, the hole thus formed on the rocking trajectory of the cam slide section reduces the weight of that portion of the rocker arm in contact with the cam. Accordingly, the inertial moment of the cam pushing the rocker arm of claim 5 is reduced

[0020] In the rocker arm for a valve control apparatus in accordance with any one of claims 1 through 5, the cam slide section may be provided with oil grooves, as recited in claim 6.

[0021] (Function) In the rocker arm of claim 6, oil fed to the cam slide section in contact with the cam stays in the oil grooves and forms an oil film between the cam and cam slide section. As a result, the friction between the cam and cam slide section is reduced, which improves the wear resistances of the cam and cam sliding section

[0022] In the rocker arm for use with a valve control apparatus in accordance with any one of claims 1 through 6, at least one of the cam slide section and the pad face can be configured to have a convex transverse cross section, as recited in claim 7.

[0023] If both of the cam slide section and pad face

have flat transverse cross sections, the pad face is likely to be inclined relative to the valve spring in the event that the cam slide section is inclined relative to the cam due to a backlash of the rocker arm. In this case, a corner of the cam slide section may come into contact with the cam and cause an unexpected frictional force, while the pad face may come into contact with a corner of the valve stem and cause an unexpected frictional force. Such frictional forces will impede the rotation of the camshaft

[0024] (Function) If, on the other hand, at least one of the cam slide section and pad face has a convex transverse cross section, the corner of either the cam slide section or the valve stem is less likely to come into contact with the cam or pad face. As a consequence no corner-plane contact is less likely to take place between the cam and cam slide section or between the pad face and the valve stem. Thus, in the rocker arm of claim 7, the cam can push down the cam slide section of the rocker arm downward with a reduced inertial moment, thereby facilitating the stability of open/close operations of the engine valve

[0025] The rocker arm for use with a valve control apparatus in accordance with any one of claims 1 through 7, wherein the upright wall section has a pair of inner walls each spaced apart from the periphery of the valve stem by a distance in the range from 0.1 mm to 1 mm

[0026] (Function) Since in this case there is provided an adequate allowance between the valve stem and the upright walls, disadvantageous friction will not take place between them, thereby facilitating the stability of the open/close operations of the engine valve.

RESULTS OF THE INVENTION

[0027] The rocker arm of claim 1 has a greatly reduced weight and hence gives rise to much less frictional torques, and hence it has greatly improved the fuel economy of an engine as compared with conventional rocker arms. Further, since the rocker arm has no rollers, it can be downsized with less components. It is not troubled with abnormal wear of needle bearings and/or shaft

[0028] In the rocker arm according to any one of claims 2 through 4 a frictional torque acting on the camshaft is further reduced, thereby improving the fuel economy of the engine.

[0029] In the rocker arm of claim 5, the cam can push down the cam slide section of the rocker arm with a reduced torque, thereby reducing the frictional torque acting on the camshaft still further and improving the fuel economy of the engine still further.

[0030] In the rocker arm of claim 6, the frictional force that takes place between the cam and cam slide section is reduced, thereby further reducing the frictional torque acting on the camshaft and improving the fuel economy of the engine still further

[0031] In the rocker arm of claim 7, at least one of the frictional force that takes place between the cam and cam slide section and the frictional force that takes place be-

tween the pad face and the valve stem is reduced, thereby reducing the frictional torque acting on the camshaft still further and hence improving the fuel economy of the engine

[0032] With the rocker arm of claim 8, stability of the valve movement is facilitated by the fact that the friction between the valve and the upright walls is reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033]

Fig. 1(a) is a schematic perspective view of a rocker arm for a valve control apparatus and Fig. 1(b) is its plan view in accordance with a first embodiment of the invention.

Fig. 2(a) is a cross section of the rocker arm taken along line A-A of Fig. 1(b); Fig. 2(b) a bottom view of the rocker arm; and Fig 2(c) a transverse cross section of the cam slide section taken along line B-B of Fig 2 (a)

Fig. 2A(a) is a cross section of a modified cam slide section whose transverse cross section is convex as shown in Fig. 2(c) Fig. 2A(b) shows modified pad face and valve stem having convex cross sections taken along line E-E of Fig. 2(a)

Fig 3 is a schematic diagram illustrating movement of a valve control apparatus equipped with the rocker arm in accordance with a first embodiment of the invention

Fig. 4(a) is a perspective view of a rocker arm in accordance with a second embodiment of the invention; and Fig. 4(b) is plan view of the second rocker arm

Fig. 5(a) is a cross section of the second rocker arm of Fig 4(b) taken along line C-C of Fig 4(b); Fig. 5(b) is a bottom view of the second rocker arm; and Fig. 5(c) is a cross section taken along line D-D of Fig 5(a).

Fig 6 is a perspective view of a rocker arm in accordance with a third embodiment of the invention

BEST MODE FOR CARRYING OUT THE INVENTION

[0034] The invention will now be described in detail by way of example with reference to a first embodiment shown in Figs 1 through 3 In what follows the upper, lower, right, and left portion of a rocker arm shown in the respective figures will be denoted by symbols Up, Lw, Le, and Ri, respectively, and transverse (front-rear) direction by Fr-Re.

[0035] A rocker arm 10 of a valve control apparatus of the first embodiment has a metal top panel 11 and a pair of upright wall section 12. The top panel 11 consists of a protrusion 13 projecting upward, a semi-spherical engaging section 14 of the supporting member 16 contiguous to the left end of the protrusion 13, and a section 15, contiguous to the right end of the protrusion 13, sup-

ported by the valve stem 17a of an engine valve 17 (The section 15 will be hereinafter referred to as valve stem support section 15)

[0036] The protrusion 13 includes a cam slide section 18 (shaded area in Fig 1(a) and Fig. 3) on which the cam of the camshaft (not shown) slides, and a planar section 19 that extends between lines L1 and L2 in Fig. 3 The cam slide section 18 has an arcuate or convex surface projecting upward, while the planar section 19 extends downward from the left end of the cam slide section 18. The engaging section 14 of the supporting member 16 is contiguous to the left end of the planar section 19 and has a substantially semispherical shape that protrudes upward. Formed inside the semi-spherical engaging section 14 is a semi-spherical engaging face 20 for engagement with the semi-spherical top end of the supporting member 16

[0037] On the other hand, the supporting section 15 has an arcuate section, contiguous to the right end of the cam slide section 18 and protruding downward Formed below the supporting section 15 is a pad face 22 which abuts against the valve stem 17a. In order to reduce the friction coefficient, or enhance wear resistance and/or hardness, of at least one of the cam slide section 18 and the pad face 22, its surface is preferably surface treated with DLC coating for example This surface treatment reduces friction between the cam (not shown) and the cam slide section 18, or friction between the pad face 22 and valve stem 17a, which in turn reduces a frictional torque that acts on the camshaft to impede its rotation, thereby improving the fuel economy of the engine.

[0038] Although the cam slide section 18 can be a simple flat surface, it is preferably provided with a multiplicity of oil grooves 25 as shown in Fig. 1 In the first embodiment, the rocker arm is provided with a multiplicity of longitudinal linear parallel oil grooves 25. When a lubricant oil is supplied to the oil grooves 25, an oil film is formed between the cam and cam slide section 18, which increases their wear resistance

[0039] A pair of straight upright wall section 12 extend downward from the front and rear ends of the protrusion 13 and supporting section 15 The paired straight walls 12 are formed such that the total transverse thickness W2 of the upright walls is smaller than the transverse width W1 of the top panel 11. the rocker arm 10 has a generally inverted U-shape transverse cross section, so that it has a reduced weight because of a hollow section 24 under the U-shape section. Each of the paired upright wall section 12 is provided with a transverse through-hole 23 The through-holes 23 may be formed in a region of the top panel 11 excluding the planar section 19, cam slide section 18, and pad face 22. thus, the rocker arm 10 is reduced in weight by the through-holes 23 Such trimming of weight of the rocker arm 10 helps reduce the friction between the cam and cam slide section 18, which in turn reduces the frictional torque that acts on the camshaft to impede the rotation of the camshaft, thereby improving the fuel economy of the engine

[0040] Fig. 2A shows a modification of the cam slide section and pad face of the first embodiment A rocker arm 10' shown in Fig 2A has the same structure as the rocker arm 10 except for a cam slide section 18' and a pad face 22'. The cam slide section 18' of Fig 2A(a) has a convex transverse cross section, protruding upward towards the cam 9. The pad face 22' of the supporting section 15' of Fig. 2A(b) has a convex transverse cross section protruding towards the upper end 17e' of the valve stem 17a' of an engine valve 17'.

[0041] Because of backlashes of the cam 9, cam slide section 18', pad face 22', and valve stem 17a', it may happen that they incline in the transverse direction with respect to a vertical line L5 passing through the rocker arm. Should either one of the opposite corners 18a' and 18b' of the cam slide section 18' touch the slide face 9a of the cam 9, or of the opposite corners 17b' and 17c' of the upper end 17e' of the valve stem 17a' touch the pad face 22', frictional dragging forces would take place on the contact faces, which impedes smooth open/close operation of the engine valve.

[0042] In the example shown in Fig. 2A, the cam slide section 18' and pad face 22' are convexed in the transverse direction so that the corners 18a' and 18b' of the rocker arm 10' are less likely to touch the slide face 9a of the cam 9, and so are the corners 17b' and 17c' to touch the pad face 22'. Accordingly, the rocker arm 10' of Fig 2A has an advantage that it is free of friction that would otherwise take place between the cam slide section 18' and pad face 22' and impede the rotation of the camshaft

[0043] It is noted that the slide face 9a of the cam 9 and the upper section 17e' of the valve stem 17a' are also convex in the transverse direction as shown in Fig. 2A. In this case, the corners 9b and 9c of the cam 9 and the corners 18a' and 18b' of the cam slide section 18' will be less likely to touch the cam slide section 18' and slide face 9a, respectively, and so will be the corners 17b' and 17c' of the upper end 17e' of the valve stem 17a' to touch the pad face 22'.

[0044] Incidentally, it is preferable to provide spaces C1 and C2, or allowances, between the paired inner walls 12a' and 12b' of the upright wall section 12' of the rocker arm 10' and the periphery 17d' of a valve stem 17' as shown in Fig. 2A(b) This is also the case with other embodiments. It is preferred that the spaces C1 and C2 have a total width (C1+C2) in the range from 0.1 mm to 1 mm. With the rocker arm 10' having such appropriate spaces C1 and C2, open/close operation of the valve is stabilized.

[0045] With the engaging section 20 in engagement with the semi-spherical head 21, the rocker arm 10 is rockably supported by the supporting member 16 about a rocking center L0 of the semi-spherical head 21 as shown in Fig. 3. It is noted that in Fig. 3 only the rocker arm 10 is shown in cross section and that the top panel 11 is shown not hatched. The valve stem 17a of the valve, urged upward by a valve spring (not shown) for closing

the valve, forces the pad face 22 upward. As the pad face 22 is forced upward, it pushes the cam of the camshaft (not shown) located above the pad face 22. Thus, the cam is always in sliding contact with the cam slide section 18 while the camshaft is in rotation. The rocker arm 10 opens the engine valve 17 when pressed downward D1 as shown in Fig 3 by the rotating cam, and closes the valve when pushed upward D2 as shown in Fig. 3 by the valve spring which overrides the cam force of the rotating cam.

[0046] Thus, the cam slide section 18 (between line L1 and L2 of Fig. 3) rocks about the rocking center L0. The holes 23 of the upright wall section 12 are preferably formed in the region between dotted lines L3 and L4 where the dotted lines L3 and L4 are the trajectories of the rocking lines L1 and L2, respectively. In this case, the portions of the upright wall section 12 subjected to the cam force are reduced in weight. Then, the torque required for the cam to push down the rocker arm 10 is reduced, which in turn reduces the frictional torque that impedes the rotation of the camshaft, thereby improving the fuel economy of the engine.

[0047] Referring to Figs. 4 and 5, there is shown a rocker arm 29 of a valve control apparatus in accordance with a second embodiment of the invention. The rocker arm 29 are the same in structure as the rocker arm 10 of the first embodiment except that the upright wall section 31 is different in shape from the upright wall section 12 of the first embodiment and that the upright wall section 31 has a stiffening rib 32.

[0048] In addition to the upright wall section 31, the rocker arm 29 has a metallic top section 30. The top panel 30 is structurally the same as the top panel 11 of the first embodiment, and comprises a protruding portion 33, an engaging section 34 of a supporting member (not shown), and a section 35 supported by a valve stem (referred to as valve stem support section 35) of the valve stem (with reference numerals 13, 14, and 15 are renumbered as 33, 34, and 35, respectively, for the top panel 30). The protruding portion 33 has a cam slide section 36 and a planar section 37. The engaging section 34 is a substantial semi-sphere protruding upward, and contiguous to the left end of the planar section 37. Formed inside the engaging section 34 is a substantially semi-spherical engagement face 38 for engagement with the semi-spherical head of the supporting member (not shown). The valve stem support 35 is provided on the lower surface thereof with a pad face 39 for abutment with the valve stem (not shown) which is urged upward by a valve spring. To minimize friction between the cam slide section 36 and the pad face 39, at least one of the cam slide section 36 and the pad face 39 is preferably subjected to DLC coating, for example, for surface-treatment, as in the first embodiment. Also, as in the first embodiment, the cam slide section 36 is preferably provided with a multiplicity of oil grooves 42 to secure a lubricant film on the cam slide section 36.

[0049] In addition, a pair of upwardly projecting ribs 32

are formed on the top panel 30 integrally with the planar section 37 and engaging section 34. The ribs 32 reinforce the rocker arm 29 via the top panel 30, and adds more stiffness thereto, thereby improving the responsiveness of the valve control apparatus. These ribs 32 may be also provided between the planar section 19 and the semi-spherical engaging section 14 of the first embodiment.

[0050] The upright wall section 31 depends from the lower surface of the top panel 30. The upright wall section 31 shown in Fig. 5(b) consists of an upright wall 40 extending downward from the transverse center of the protruding portion 33, a pair of downward upright walls 41 extending between the rear and front ends of the valve stem support 35, and a U-shape section 43. The upright wall 40 is integral with the paired upright walls 41 and the U-shape section 43. The total sum of the transverse width W3 (front-to-rear width) of the wall 40 and the widths of the paired upright walls 41 (two times W4) is smaller than the width W1 of the top panel 30. The rocker arm 29 has a substantially T-shape transverse cross section as shown Fig 5(c) at a position where the wall 40 is formed, and has an inverted U-shape cross section as shown in Fig 2(c) at a position where the paired upright walls 41 are formed.

[0051] The upright wall 40 has a transverse through-hole 44. The transverse through-hole 44 can be formed anywhere in the rocker arm 29 except for the cam slide section 36 and pad face 39. The rocker arm 29 is reduced in weight by the transverse through-hole 44. To effectively reduce the weight of the portion of the rocker arm pushed by the cam, the transverse through-hole 44 is preferably formed within the upright wall section 31 on the trajectory of the cam slide section 36, as are formed the holes 23 in the upright walls 23 of the first embodiment.

[0052] Fig. 6 shows a rocker arm 50 in accordance with a third embodiment of the invention. The rocker arm 50 has essentially the same structure as the rocker arm 10 of the first embodiment except that the rocker arm 50 has oil grooves 51 different in shape from the oil grooves 25 shown in Fig 1. The rocker arm 50 is provided on the cam slide section 18' with a multiplicity of oil grooves 51 in the form of dimples. Such multiple oil grooves 51 can also retain much oil to form a strong oil film between the cam (not shown) and the cam slide section 18', thereby further improving the wear resistance of the elements involved.

REFERENCE NUMERALS AND

SYMBOLS

9	cam of camshaft
10	rocker arm
11	top panel
12 and 12'	upright walls
12a' and 12b'	inner wall surface
16	supportive member (for pivot type lash adjuster)

17a and 17a'	valve stem of engine valve
17d'	periphery of valve stem
18, 18', and 18''	cam slide sections
22 and 22'	pad faces
23	holes
25	oil grooves
29	rocker arm of valve control apparatus
30	top panel
31	upright walls
36	cam slide section
39	pad face
42	oil grooves
44	through-hole
50	rocker arm of valve control apparatus
51	oil grooves
L0	rocking center

Claims

1. A rocker arm for a valve control apparatus comprising a top plate and at least one upright wall section, **characterized in that:**

said top plate is:

provided on top thereof with a cam slide section in contact with a cam of a camshaft; supported at one end thereof by a supporting member rockably about the rocking center of the supporting member; and is provided at the other end thereof with a pad face in contact with a valve system, and

said at least one upright wall section has a smaller width than the top plate, and extends from the top plate at a substantially right angle.

2. The rocker arm according to claim 1, wherein said at least one of the cam slide section and pad face of the rocker arm has a surface-treated face having a reduced frictional coefficient.
3. The rocker arm according to claim 1 or 2, wherein the top plate has at least one hole formed in a region except for the cam slide section of the top plate.
4. The rocker arm according to any one of claims 1 through 3, comprising at least one hole in the upright wall section.
5. The rocker arm according to claim 4, wherein the hole formed in the upright wall section is formed on the rocking trajectory of the cam slide section rocking about the rocking center.
6. The rocker arm according to any one of claims 1 through 5, wherein the cam slide section has oil

grooves.

7. The rocker arm according to any one of claims 1 through 6, wherein at least one of the cam slide section and the pad face has a convex transverse cross section. 5
8. The rocker arm according to any one of claims 1 through 7, wherein the upright wall section has a pair of inner walls each spaced apart from the periphery of the valve stem by a distance in the range from 0.1 mm to 1 mm. 10

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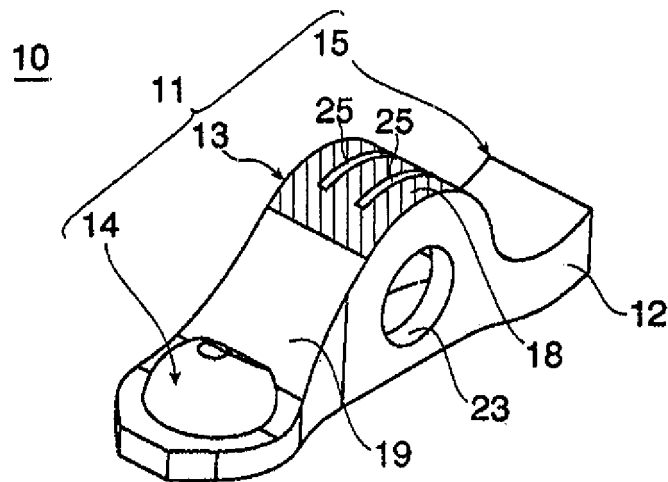
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Fig. 1

(a)



(b)

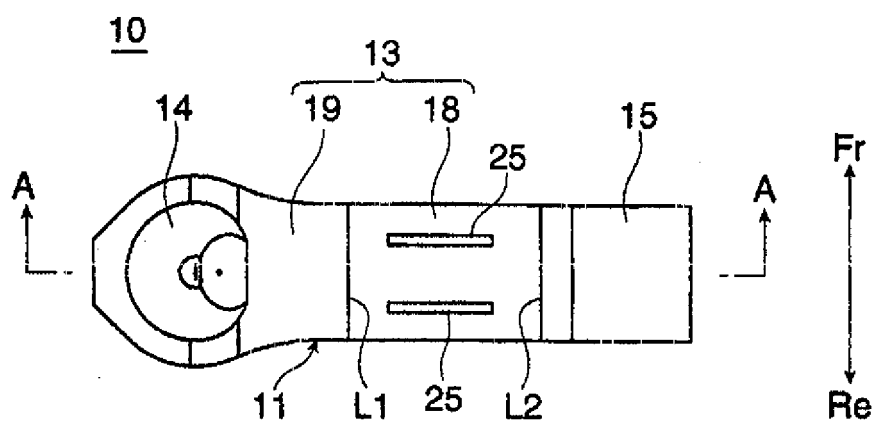


Fig. 2

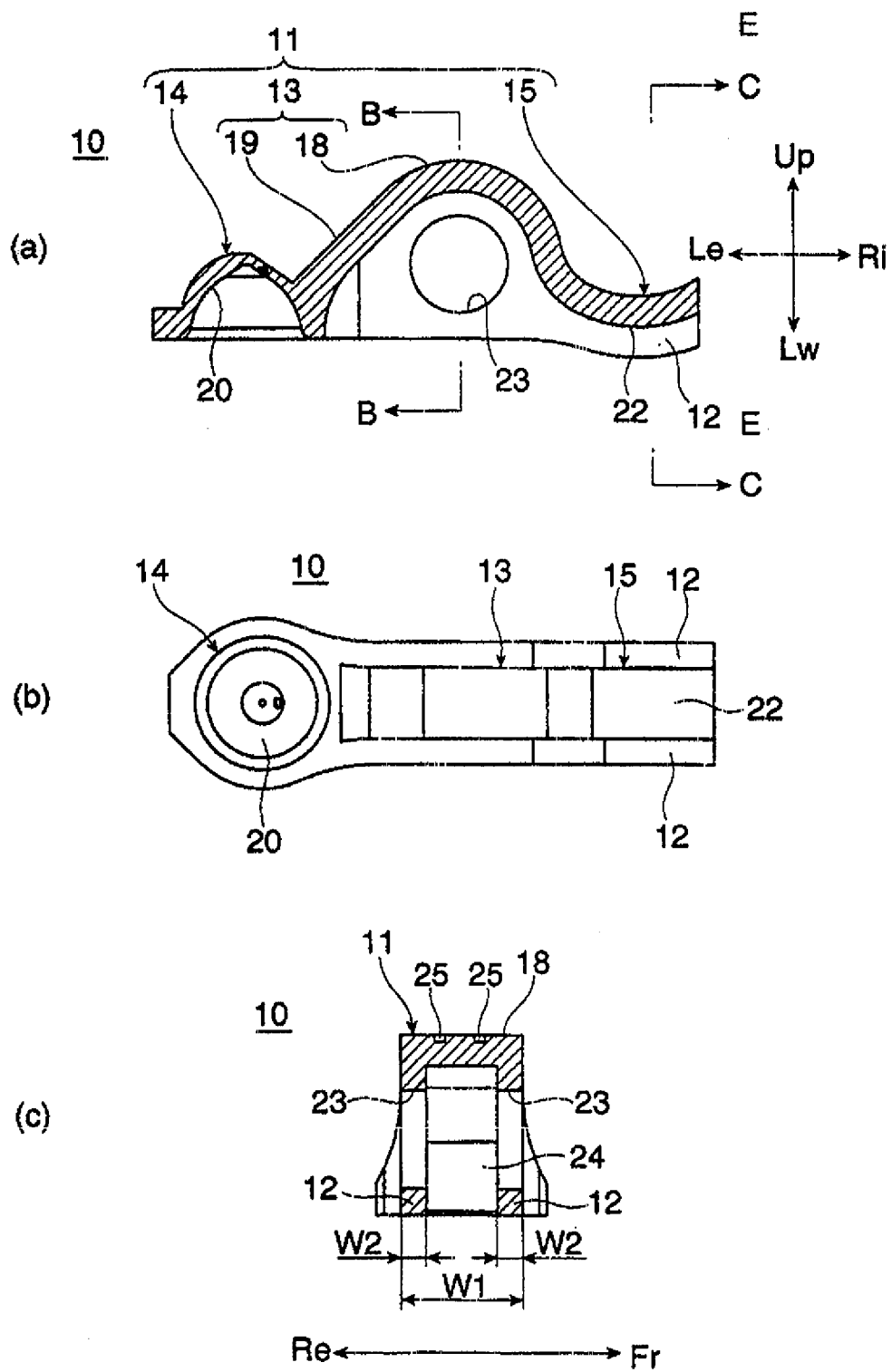


Fig. 2A

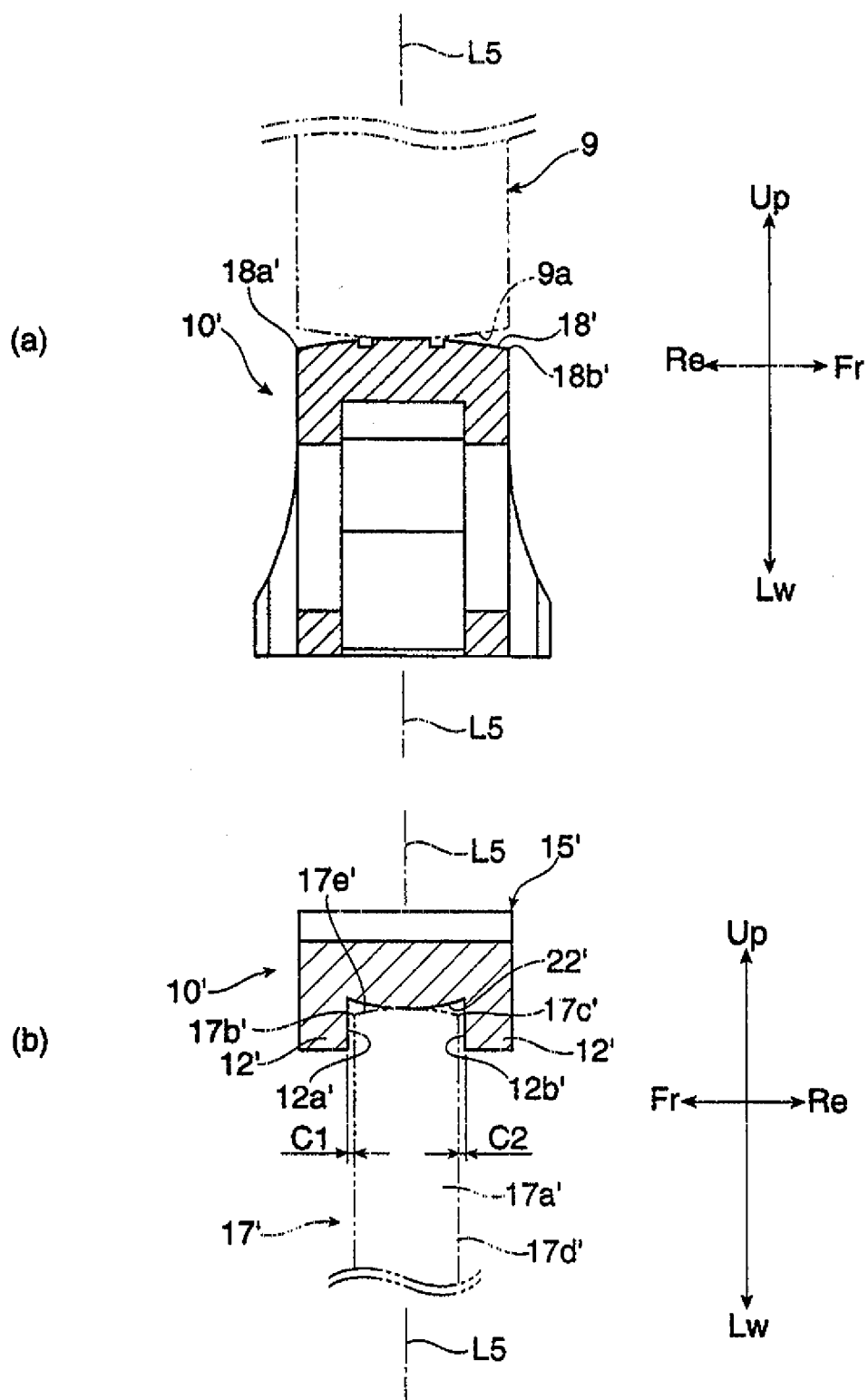


Fig. 3

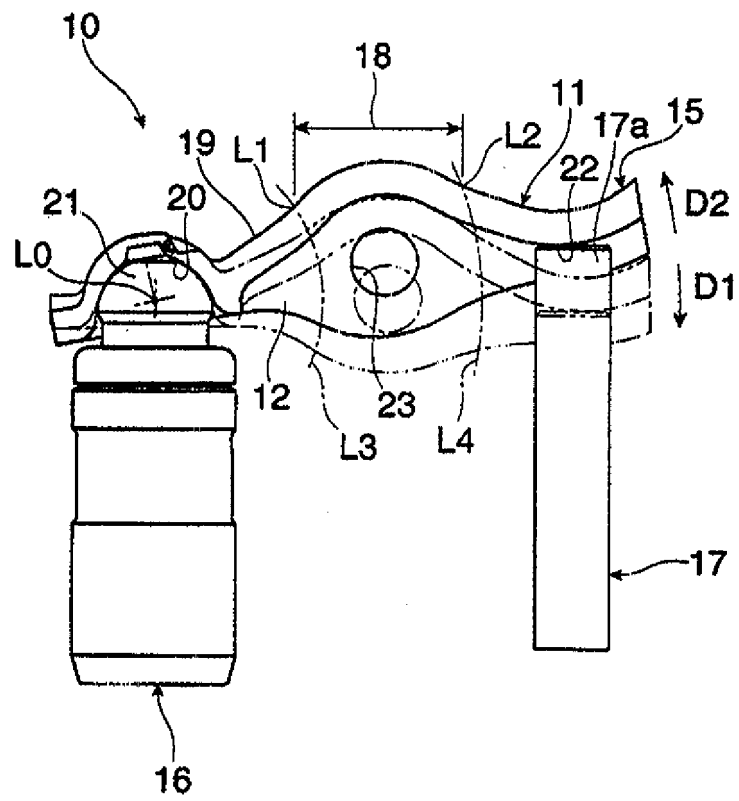


Fig. 4

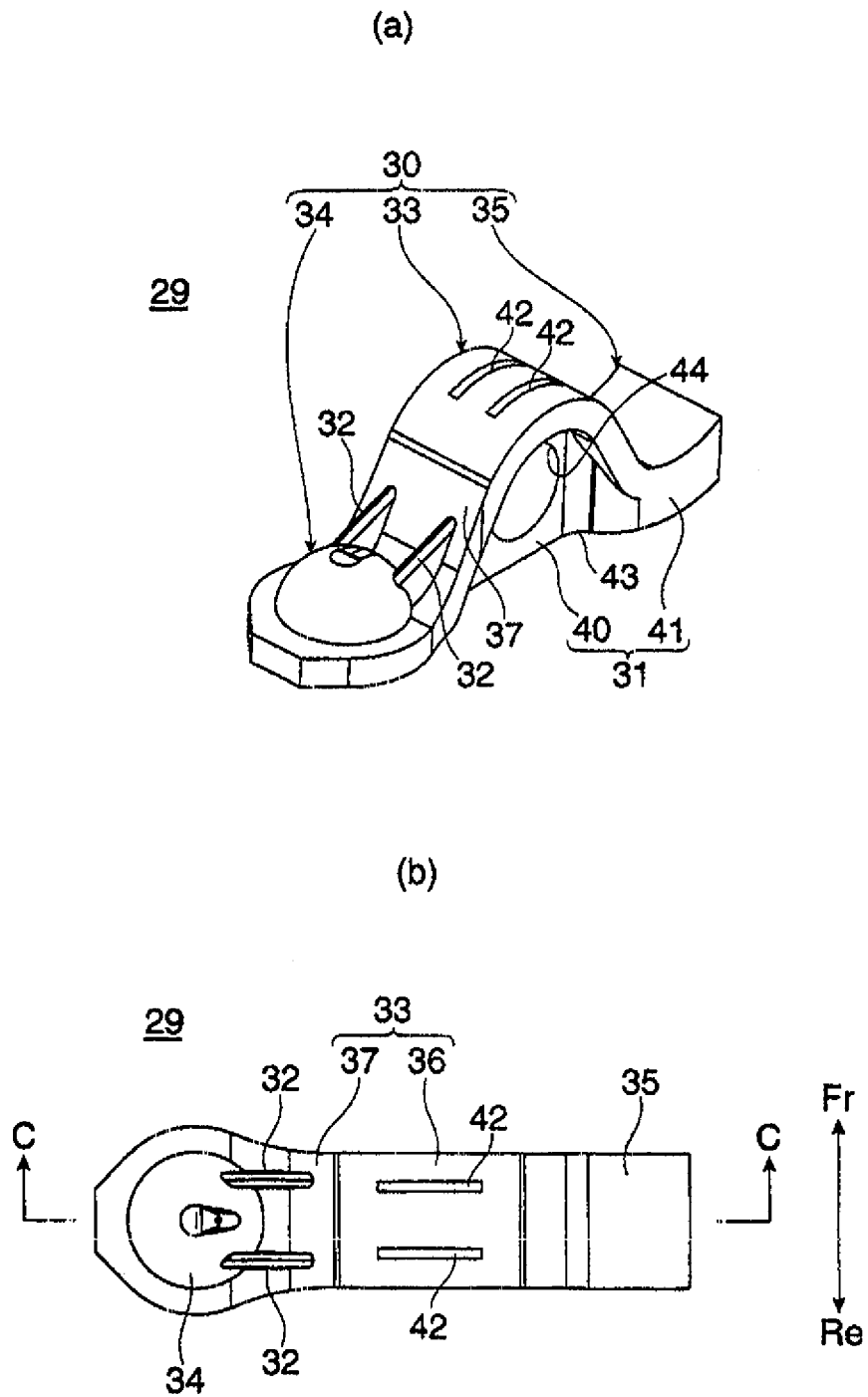


Fig. 5

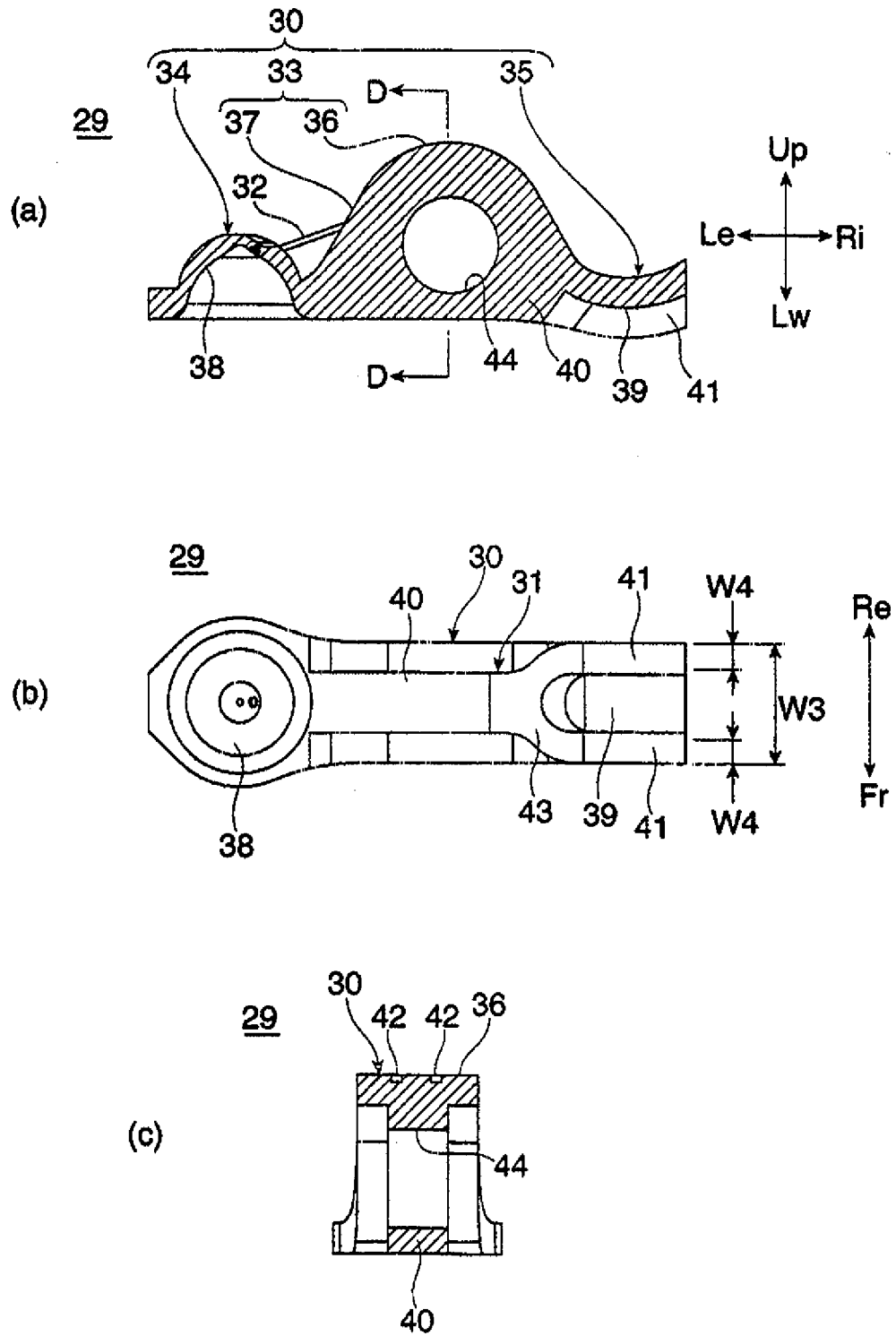
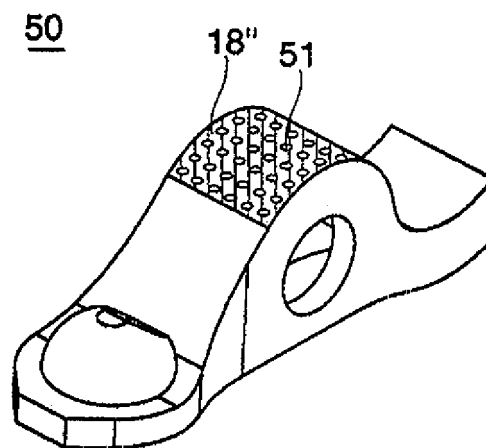


Fig. 6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/072867

A. CLASSIFICATION OF SUBJECT MATTER

F01L1/18 (2006.01) i

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)

F01L1/18

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 1996-2011

Kokai Jitsuyo Shinan Koho 1971-2011 Toroku Jitsuyo Shinan Koho 1994-2011

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.
A	JP 60-222513 A (Teikoku Piston Ring Co., Ltd.), 07 November 1985 (07.11.1985), entire text; all drawings (Family: none)	1-8
A	JP 2004-358530 A (NSK Ltd.), 24 December 2004 (24.12.2004), paragraphs [0020] to [0023]; fig. 1 to 4 (Family: none)	1-8

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

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Date of the actual completion of the international search
22 December, 2011 (22.12.11)Date of mailing of the international search report
10 January, 2012 (10.01.12)Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 70041/1985 (Laid-open No. 186707/1986) (Honda Motor Co., Ltd.), 21 November 1986 (21.11.1986), pages 9 to 13; all drawings (Family: none)	1-8
A	JP 57-20509 A (Toyota Motor Corp.), 03 February 1982 (03.02.1982), entire text; all drawings (Family: none)	1-8
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 15343/1984 (Laid-open No. 128907/1985) (Nippon Oil Seal Industry Co., Ltd.), 29 August 1985 (29.08.1985), pages 2 to 8; all drawings (Family: none)	1-8
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 73607/1987 (Laid-open No. 182204/1988) (Nissan Motor Co., Ltd.), 24 November 1988 (24.11.1988), pages 7 to 10; fig. 1 to 3 (Family: none)	1-8

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Patent documents cited in the description

- JP H1037719 A [0003]