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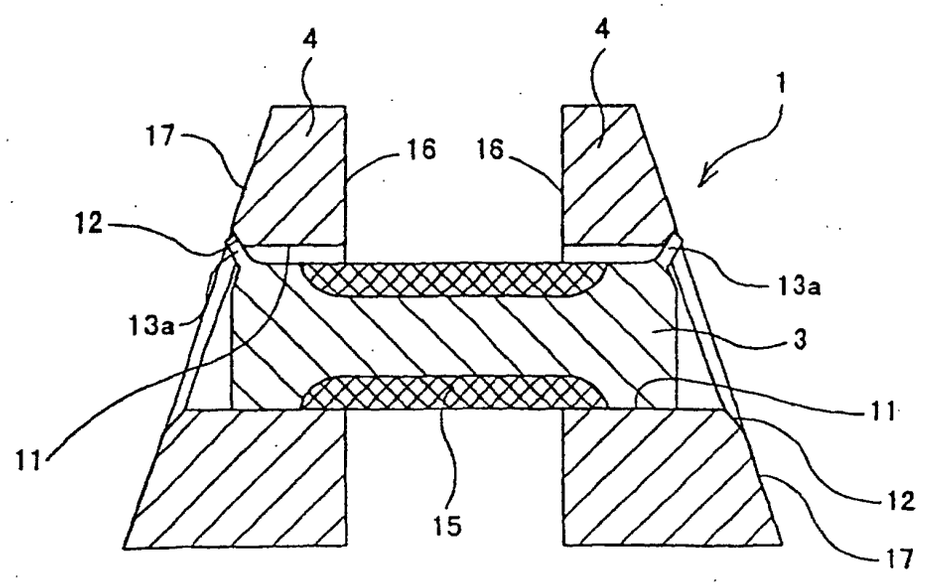
(54) **CAM FOLLOWER WITH SHEET METAL ROCKER ARM**

(57) The space between the outer side-surfaces 17 of a pair of side-wall sections 4 is not parallel to each other due to differences in expansion amount during plastical deformation. In use, a load is applied to the pivot 3 from the side where the space between the outer side surfaces 17 is narrow to the side where the space is broad. A crimped section 13a is formed on the outer periphery at the opposite end surfaces of the pivot 3, on the half on the side where the space between the outer side surfaces 17 is narrow. Therefore, the outer peripheral surface of the opposite ends of the pivot 3 comes into contact with the inner peripheral surface of the through hole 11 on the load support side. Consequently, the load is sufficiently supported by the contact surface, and even after being used for a long time of period, lost motion is prevented from occurring on the support section at the opposite ends of the pivot 3 with respect to the pair of side-wall section 4.

FIG. 3



EP 1 447 526 A1

Description

Technical Field of the Invention:

[0001] This invention relates to the improvement of a cam follower having a sheet-metal rocker arm that is manufactured by press working of metal plate.

Background Technology

[0002] In reciprocating engines (reciprocating piston engines), except for some 2-cycle engines, there are air-intake valves and exhaust valves that open and close in synchronization with the rotation of the crankshaft. Also, the rocker arm is used in a cam follower which is incorporated in the valve mechanism of the engine to convert the rotation of the camshaft to the reciprocating motion of the valve stem (air-intake valve and exhaust valve). In this kind of reciprocating engine, the camshaft rotates in synchronization with the rotation of the crankshaft (the rotating speed of the camshaft is 1/2 that of the crankshaft in the case of a 4-cycle engine), and the motion of the cam shaft is transmitted to the air-intake valve and exhaust valve by the rocker arm to move the value stem of the air-intake valve and exhaust valve in a reciprocating motion in the axial direction.

[0003] In order to secure the strength of the rocker arm inside the valve mechanism of the engine, while at the same time make it more lightweight, it has been proposed and put in practice to manufacture the rocker arm by press working metal plate such as steel plate. Of this kind of cam follower having a sheet-metal rocker arm developed under such a situation, Figs. 4 through 7 show a cam follower that is disclosed in US Patent No. 5,048,475. This cam follower comprises a sheet-metal rocker arm 1, roller 2 and pivot 3, where the roller 2 is supported by the pivot 3 such that it rotates freely with respect to the sheet-metal rocker arm 1.

[0004] The cam follower constitutes the cam 9 of the cam shaft and the lash adjuster as shown in Fig. 7, and associated with the plunger 8 which is the center of rocking movement of the sheet metal rocker arm 1, and with the valve stem 7 of the air-intake valve and exhaust valve. The sheet-metal rocker arm 1 of the cam follower is made from a metal plate such as a 2 mm to 4 mm thick steel plate by a punching process to remove any unnecessary parts, and plastic-working, such as drawing, for obtaining the desired shape; and it comprises a pair of side-wall sections 4 and first and second connecting sections 5, 6 that connect both of these side-wall sections 4 together, respectively. As shown in Fig. 7, the first connecting section 5 comes in contact against the base end face of the valve stem 7 and functions as a pressure portion for displacing the valve stem 7, and the second connecting section 6 functions as a fulcrum portion for coming in contact with the tip end face of the plunger 8. Therefore, in the example shown in the figures, a spherical concave section is formed on one end surface (lower surface in Fig. 6) of the second connecting section 6. Construction that differs from that of the example shown in the figure, in which a screw hole is formed in the section that corresponds to the second connecting section, so as to threadably receive an adjust screw with a spherical surface end for fixing, is also conventionally known.

[0005] On the other hand, the roller 2 is located in a space defined by the pair of connecting sections 5, 6, and the pair of side-wall sections 4 and supported by the pivot 3 such that it can rotate freely. In order to support the roller 2 by the pivot 3 in the pair of side-wall sections, both end sections of the pivot 3 is fitted into the through-holes that are formed at matching locations in the pair of side-wall sections 4. The outer peripheral edge of both end surfaces of this pivot 3 is crimped outward toward the peripheral edge of the respective through-holes (see Fig.10). With this construction, both end sections of the pivot 3 are attached to the pair of side-wall sections 4 such that the pivot 3 spans between both of these side-wall sections 4. The roller 2 fits around the middle section of the pivot 3 that spans between both of these side-wall sections 4 in this way, and is supported either directly or by way of a radial needle roller bearing such that it can rotate freely.

[0006] As shown in Fig. 7, when installed in the engine, the base end face of the valve stem 7 comes in contact with one surface of the first connecting section 5 (bottom surface in Fig. 7), and the tip end face of the plunger 8 comes in contact with the spherical concave section on one surface of the second connecting section 6, and the outer peripheral surface of the cam 9 securely fastened in the middle section of the cam shaft comes in contact with the outer peripheral surface of the roller 2. When the engine is running, as the cam 9 rotates, the sheet-metal rocker arm 1 moves in a rocking motion with the point of contact between the tip end surface of the plunger 8 and the spherical concave section as the center (fulcrum), and the pressure force from the first connecting section 5 and the elastic force of a return spring 10 moves the valve stem 7 in a reciprocating motion in the axial direction. Incidentally, a cam follower with a sheet-metal rocker arm having similar construction is also disclosed in Japanese Patent Publication No. Tokukou Hei 6-81892, which is not shown in the figures here.

[0007] Since the sheet-metal rocker arm 1 is made by plastic-working of sheet-metal, the thickness of the sheet-metal rocker arm 1 changes during the plastic-working process, so if the shape and construction of the other parts are not designed properly, it may not be possible to secure sufficient durability. This aspect is explained using Figs. 8 through 10 in addition to Figs. 4 through 7, mentioned above.

[0008] When a sheet-metal rocker arm 1 like that shown in Figs. 4 to 7 is manufactured by drawing of a metal plate such as a steel plate, with regard to both end sections in the width direction (top and bottom direction in Figs. 6 and 7) of the pair of side-wall sections 4, the

end sections on the side of the first and second connecting sections 5, 6 (top side in Figs. 6 and 7) stretch in the planar direction an amount more than the end sections on the other side (bottom side in Figs. 6 and 7), and thus the thickness of the side-wall sections 4 becomes thinner as going upward in Figs. 6 and 7. Accordingly, the cross-sectional shape in the width direction of both of the side-wall sections 4 is a wedge shape that is inclined in a direction such that it becomes thicker moving away from the connecting sections 5, 6 as shown in Figs. 8, 10. On the other hand, the inner side surfaces of these side-wall sections 4 must be parallel with each other. The reason for that is to prevent that only one of these side wall sections 4 comes into contact with the roller 2 located between these sidewall sections 4, so that the roller 2 can rotate smoothly between the side wall sections 4.

[0009] When the inner side surfaces of these side-wall section 4 having a wedge-shaped cross-sectional shape are arranged such that they are parallel with each other, the outer side surface of the side-wall sections 4 are not parallel with each other as shown in Figs. 8 and 10. That is, the space between the outer side surfaces of these sidewall sections 4 gradually becomes large as it goes away from the connecting sections 5, 6 (to the bottom in Figs. 8 and 10). The space between the outer side surfaces of the sidewall sections 4 in this way similarly gradually changes in the middle section in the width direction of these side-wall sections 4 where through holes 11 are formed for attaching both ends of the pivot 3. For example, in the results of the tests and measurement performed by the inventors, the thickness of the side-wall sections 4 was approximately 1 mm along the edge on the side of the connecting sections 5, 6 (top edge in Figs. 8 and 10), and was approximately 3 mm along the edge on the opposite side to the connecting sections 5, 6 (bottom edge in Fig. 8). In this case, the thickness of the peripheral edge of the through holes 11 was 2.3 mm on the side of the connecting sections 5, 6 and was 2.9 mm on the opposite side from the connecting sections 5, 6. The difference in this thickness is the degree that the outer side surfaces of the side-wall sections 4 are not parallel.

[0010] As mentioned above, the outer peripheral edge of the both end surfaces of the pivot 3 is crimped out and fixed to the beveled sections 12 formed around the peripheral edges of the openings of each through hole 11. However, in the state with the outer side surfaces of the sidewall sections 4 are not parallel with each other, it is not possible to uniformly crimp and fasten both end sections of the pivot 3 all the way around the beveled sections 12. In other words, since both end surfaces of the pivot 3 are at right angles with the center axis of the pivot 3, the positional relationship in the axial direction between both of these end surfaces and the beveled sections 12 is not uniform in the circumferential direction. In order to maintain sufficient crimping strength, it is necessary to have a proper positional relationship in the axial direction between both of the end surfaces and the beveled sections 12. However, as long as the outer side surfaces of the side-wall sections 4 are not parallel with each other, it is not possible to have a proper positional relationship all the way around the openings. Incidentally, it is unrealistic from the aspect of mass production to make both end surfaces in the axial direction of the pivot 3 such that they are not parallel with each other in alignment with the outer side surfaces.

[0011] Therefore, conventionally, the positional relationship in the axial direction between the beveled sections 12 formed around the peripheral edges of the through holes 11 and both end surfaces of the pivot 3 is made to be proper on the opposite side from the connecting sections 5, 6 (lower side in Fig. 8), as shown in Fig. 8. Also, as shown by the dot-dash line α in Fig. 9, a crimping tool (punch) is pressed on a portion of the end surfaces of the pivot 3 from the middle to the side opposite to the connecting sections 5, 6, so that the edge of the portion from the middle to the side opposite to the connecting sections 5, 6 is crimped outward in the radial direction. Therefore, as shown in Fig. 10, the outer peripheral surface around the end section of the pivot 3 comes in contact with the inner peripheral surfaces of the through holes 11 at a section on the side closer to the connecting sections 5, 6 (on the upper side in Fig. 10). On the sides where the crimped sections 13 are formed, or in other words, on the sides opposite from the connecting sections 5, 6 (on the lower side in Fig. 10), there is a clearance 14 between the outer peripheral surface around the both end sections of the pivot 3 and the inner peripheral surface of the through holes 11.

[0012] In the state where there is a clearance 14 between the outer peripheral surface around the both end sections of the pivot 3 and the inner peripheral surface of the through holes 11 on the opposite side from the first and second connecting section 5, 6 as shown in Fig. 10, the crimped sections 13 formed on the both ends of the pivot 3 support the load applied to the pivot 3 from the cam 9 shown in Fig. 7 by way of the roller 2 (further by way of the radial needle roller bearing). In other words, when the engine is running, a load is applied to pivot 3 from the top side toward the bottom side in Fig. 10 (in balance with the elastic force of the return spring 10). Since there is a clearance 14 between the outer peripheral surface around the both end sections of the pivot 3 and the inner peripheral surface of the through holes 11 in the direction where the load is applied, the crimped section 13 supports the load, and the load is not directly transmitted from the outer peripheral surface around the both end sections of the pivot 3 to the inner peripheral surface of the through holes 11.

[0013] However, the area of contact between the crimped sections 13 and the beveled sections 12 is small, and since the crimped sections 13 are formed just by plastically deforming the ends of the pivot 3, it is easy for them to become plastically deformed. Therefore, after a long period of use, the crimped sections 13 plasti-

cally deform inward in the radial direction, and there is a possibility that the contact pressure between the crimped sections 13 and the beveled sections 12 will decrease. When the contact pressure decreases in this way, the pivot 3 and the roller 2 that is supported around the middle section of the pivot 3 are lashed with respect to the sheet-metal rocker arm 1, and thus vibration and noise occur so largely while the engine is running, which is not desirable.

[0014] The cam follower of this invention was invented taking the aforementioned problems into consideration.

Disclosure of the Invention

[0015] The cam follower of this invention comprises a sheet-metal rocker arm, pivot and roller.

[0016] The sheet-metal rocker arm is manufactured by plastic-working of a metal plate such as steel plate, and comprises a pair of side-wall sections, and connecting sections that connect this pair of side-wall sections.

[0017] There is a pair of through holes formed at locations in alignment with each other in these sidewall sections. By crimping and opening up the outer peripheral edges around the opposite end surfaces of the pivot toward the inner peripheral surface of the pair of through holes, the pivot is attached to the pair of side-wall sections such that it extends between the pair of side-wall sections.

[0018] Also, the roller is rotatably supported around the middle section of the pivot directly, or through a rolling bearing such as radial needle roller bearing, or through a sliding bearing.

[0019] The thickness of the respective side-wall sections of the sheet-metal rocker arm gradually changes in the width direction, specifically from the thin portion located near the connecting sections to the thick portion located remote from the connecting sections.

[0020] The space between the outer side surfaces of the pair of the side-wall sections becomes large going away from the connecting sections.

[0021] During use, a load is applied to the pivot from the side of the connecting sections.

[0022] Particularly, in the cam follower provided with the sheet-metal rocker arm of the present invention, the outer peripheral edges around both end surfaces in the axial direction of the pivot are crimped around half of the peripheral edges of the through holes on the side near the connecting sections. In addition, the outer peripheral surfaces of both end sections of the pivot come in contact with the inner peripheral surfaces of the respective through holes on the side away from the connecting sections.

[0023] It is desirable that the portion of the middle section of the pivot on the radially inner side of the roller is quench hardened, while the portions at the both ends of the pivot to be crimped and opened are left as it is without being quench hardened.

[0024] It is desirable that of the openings at the both ends of the through holes, the peripheral edge of the opening on the outer side surface of the both side wall sections is beveled, and the outer peripheral edge at the axially opposite end surfaces of the pivot is crimped, such that the outer peripheral surface of the crimped portion comes into contact with the beveled portion around the opening.

[0025] In the case of the cam follower provided with the sheet-metal rocker arm constructed as mentioned above, the side where the load is supported, or in other words, in the load-support section, the outer peripheral surfaces around both ends of the pivot come in contact with the inner peripheral surfaces of the respective through holes over a large area. Moreover, in this load-support section, the outer peripheral surface sections around both ends of the pivot that come in contact with the inner peripheral surfaces of the respective through holes are not plastically deformed as are the crimped sections, so they are not easily plastically deformed even when large surface pressure is applied to them. Therefore, even when used for a long period of time, lost motion does not easily occur in the support sections on both ends of the pivot with respect to the side-wall sections of the sheet-metal rocker arm.

Brief Explanation of the Drawings

[0026]

Fig. 1 is a view, similar to the cross section taken along the line I-I in Fig. 6, to show one example of the embodiment of the present invention in the state before both ends of the pivot are crimped, where the thickness of the side-wall sections and the clearance between the outer peripheral surface of the both ends of the pivot and the inner peripheral surface of the through hole are exaggerated.

Fig. 2 is a view as seen from the direction II in Fig. 1, to show the position where the crimping tool is pressed in order to crimp the both ends of the pivot.

Fig. 3 is a view, similar to that of Fig. 1, to show the state after both ends of the pivot are crimped.

Fig. 4 is a perspective view showing an example of a cam follower having a sheet-metal rocker arm conventionally known in the art.

Fig. 5 is a top plan view as seen from above in Fig. 4.

Fig. 6 is a cross-sectional view taken along the line VI-VI in Fig. 5.

Fig. 7 is a cross-sectional view of part of the engine showing the state in which the cam follower is installed in the engine.

Fig. 8 is a view, similar to Fig. 1, to show a conventional structure.

Fig. 9 is a view as seen from the direction IX in Fig. 8 and shows the position where the crimping tool is pressed to crimp both ends of the pivot.

Fig. 10 is a view, similar to Fig. 1, to show the both

ends of the pivot which have been crimped.

Best Mode of the Invention for Working

[0027] A first example of the embodiment of the invention is shown in Figs. 1 to 3. The feature of this invention resides in the construction of a pair of side-wall sections 4 which have a wedge-shaped cross section such that the outer side surfaces of the side-wall sections 4 are not parallel to each other, and specifically of the part to support both ends of a pivot 3 with respect to the pair of side-wall sections 4. The overall construction and function of the cam follower with sheet-metal rocker arm is substantially the same as the conventionally well-known construction, including the construction disclosed in US Patent No. 5,048,475, and Japanese Patent Publication No. Tokukou Hei 6-81892, so drawings and explanations are either omitted or simplified, and this explanation will center only on the features of this invention. Throughout all of the drawings, the same reference numbers are used for like parts.

[0028] Similar to the prior art cam followers, the cam follower of this example comprises a sheet-metal rocker arm 1, roller 2 and pivot 3.

[0029] The sheet-metal rocker arm 1 is manufactured by plastic-working, specifically drawing of metal plate such as steel plate, and comprises: a pair of side-wall sections 4, and first and second connecting sections that connect the pair of side-wall sections 4 (for example, the first and second connecting sections 5, 6 as shown in Figs. 4 to 7). There are through holes 11 formed at locations in alignment with each other in the middle sections of each of the pair of side-wall sections 4, and both ends of the pivot 3 fit inside and are supported by these through holes 11 such that this pivot 3 extends between the sidewall sections 4. The outer peripheral surface of the middle portion of the pivot 3 is subjected to induction hardening to form a quench-hardened layer 15 generally in the circumference.

[0030] In the example illustrated, the axial length of the quench-hardened layer 15 is a little longer than the space between the inner side surfaces of the both side-wall section 4. Accordingly, the both ends of the quench-hardened layer 15 enter the both through holes 11. The outer peripheral surface of the middle portion of the pivot 3 functions as the inner raceway of the radial needle roller bearing for supporting the roller 2 (see Figs. 4 to 7). The both end sections of the pivot 3, however, are kept as it is without undergoing quench hardening, so that the both end sections of the pivot 3 may easily be processed to form the crimped portion 13a to fix the both end sections with respect to the respective through holes 11.

[0031] The both side-wall sections 4 have a wedge-shaped cross section in the width direction (up and down direction in Figs. 1 and 3), and the thickness of the side-wall sections 4 generally changes in the width direction such that it is thinner on the side closer to the connecting sections (upper side in Figs. 1 and 3) and thicker on the side remote from the connecting sections. The inner side surfaces 16 of the both side-wall sections 4 are parallel to each other at least in the width direction, while the space between the outer side surfaces 17 of the both side-wall sections 4 becomes larger going remote from the connecting sections. During use, a load is applied to the pivot 3 from the side of the connecting sections, specifically from the upper side to the lower side in Figs. 1 and 3.

[0032] Particularly, in the cam follower of the present invention, the outer peripheral edge of the both axial end surfaces of the pivot 3 are crimped onto the half on the side near the connecting sections (top half in Figs. 1 to 3) of the peripheral edge of the respective through holes 11. In order to do this, as shown in Fig. 2 with the dot-chain line β, a crimping tool is pressed to part in the circumferential direction of each end surface of the pivot 3 from the middle section to the side near the connecting sections to form a crimped section 13a. When performing this crimping, the outer peripheral surfaces around the both end portions of the pivot 3 come in contact with the inner peripheral surfaces of the through holes 11 on the side away from the connecting sections (lower side in Figs. 1 to 3). In this illustrated case, with the openings at the opposite ends of the respective through holes 11, a beveled section 21 is formed along the peripheral edge of the opening on the side of the outer side surface 17 of the respective side-wall sections 4, the outer peripheral surfaces around the crimped sections 13a formed along the outer peripheral edge of the axial opposite end surfaces of the pivot 3 come in contact with the beveled sections 21. Also, due to processing of these crimped sections 13a, the opposite ends of the pivot 3 are strongly pressed toward the side away from the connecting sections so that the outer peripheral surfaces around the opposite ends of the pivot 3 and the inner peripheral surfaces of the respective through holes 11 come in strong contact with each other on the side away from the connecting sections (lower side in Figs. 1 to 3).

[0033] As clearly shown in Figs. 1 and 3, in the present invention, the space between the outer side surfaces 17 of the both side-wall sections 4 at the portions to be abutted by the crimped portion 13a is smaller than the space between the outer side surfaces at the portions to be abutted by the crimped portion 13 in the conventional structure shown in Figs. 8 to 10. Accordingly, the axial length of the pivot 3 of the cam follower in the present invention is a little shorter than the axial length of the pivot 3 of the conventional structure.

[0034] In the case of the cam follower of this invention having the construction as mentioned above, on the side where the load is supported, or in other words, in the load-support section, the outer peripheral surfaces around the both end sections of the pivot 3 come in contact with the inner peripheral surfaces of the through holes 11 over a wide area. Also, in this load-support section, the portion of the outer peripheral surface of the

ends of the pivot 3 that come in contact with the inner peripheral surfaces of the through holes 11 did not undergo plastical deformation like the crimped sections 13a, so they do not easily deform plastically even when large pressure is applied. Particularly, in the example shown in the figures, there is a quench hardened layer 15 on part of the outer peripheral surfaces around the both end sections of the pivot 3 that come in contact with the inner peripheral surfaces of the through holes 11. This quench hardened layer 15 is hard and very difficult to deform. Therefore, even when used for a long period of time, it is difficult for lost motion to occur in the support sections of the both ends of the pivot 3 with respect to the side-wall sections 4 of the sheet-metal rocker arm 1.

Industrial Applicability

[0035] This invention is constructed and functions as described above and is capable of improving the durability of a cam follower having a lightweight and produced at low-cost.

Claims

1. A cam follower comprising a rocker arm, pivot and roller,

(1) the rocker arm is :

(1a) made from a metal plate through a drawing process, and comprises
(1b) a pair of side-wall sections,
(1c) connecting sections to connect the pair of side-wall sections,
(1d) provided that the connecting section side is on the upper side while the opposite side to the connecting section side is on the lower side, the thickness of the pair of side-wall sections is gradually changed in the width directions such that the thickness of the pair of side-wall sections is thin on the upper side and thick on the lower side,
(1e) the space between the outer side surfaces of the pair of the side wall sections becoming larger going to the lower side, and
(1f) through holes being formed at locations in the pair of side wall sections in alignment with each other,

(2) the pivot :

(2a) is fitted into the pair of through holes to extend between the pair of side-wall sections,
(2b) the outer peripheral edge of the axially opposite end surfaces of the pivot being crimped onto the upper side of the pair of the through holes, and

(3) the roller being supported rotatably around the middle portion of the pivot.

2. The cam follower of Claim 1,

(1) wherein with the openings at the both ends of the through holes, the peripheral edge of the opening on the outer side surface of the pair of the side-wall sections is beveled, and
(2) wherein each of the opposite end surfaces in the axial direction of the pivot exists between the axial position of the highest point in the inner peripheral circle of the beveled section and the axial position of the lowest point of the inner peripheral circle.

3. The cam follower of one of Claims 1 and 2, wherein a middle portion of the pivot, facing the inner periphery side of the roller, is quench-hardened, and wherein the portion at the axially opposite end surfaces of the pivot to be crimped is kept as it is and not subjected to quench-hardening.

4. The cam follower of Claim 2, wherein the outer peripheral surface of the crimped portion formed on the outer peripheral edge of the axially opposite end surfaces of the pivot comes into contact with the beveled portion.

FIG. 1

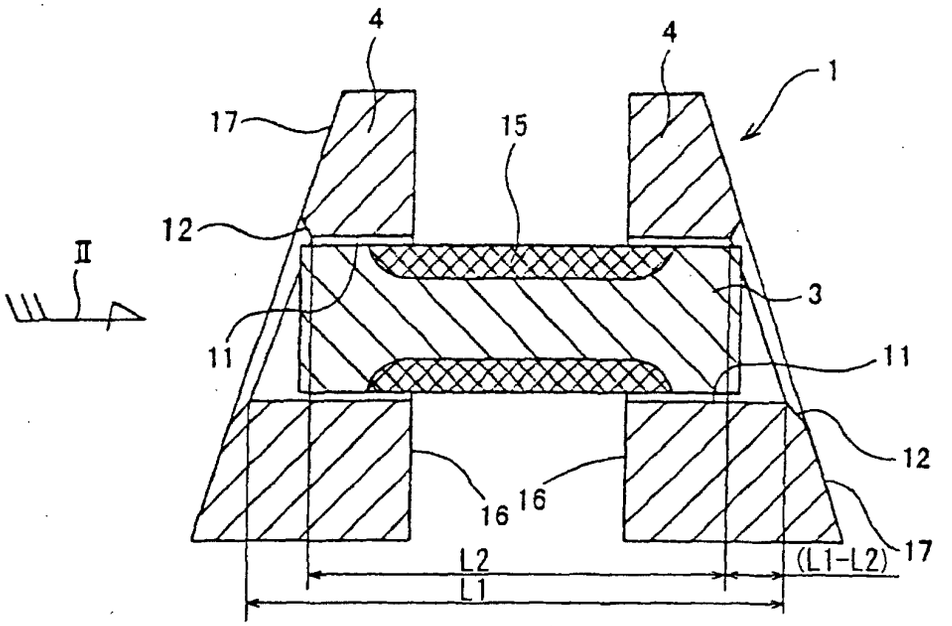


FIG. 2

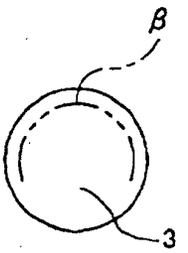


FIG. 3

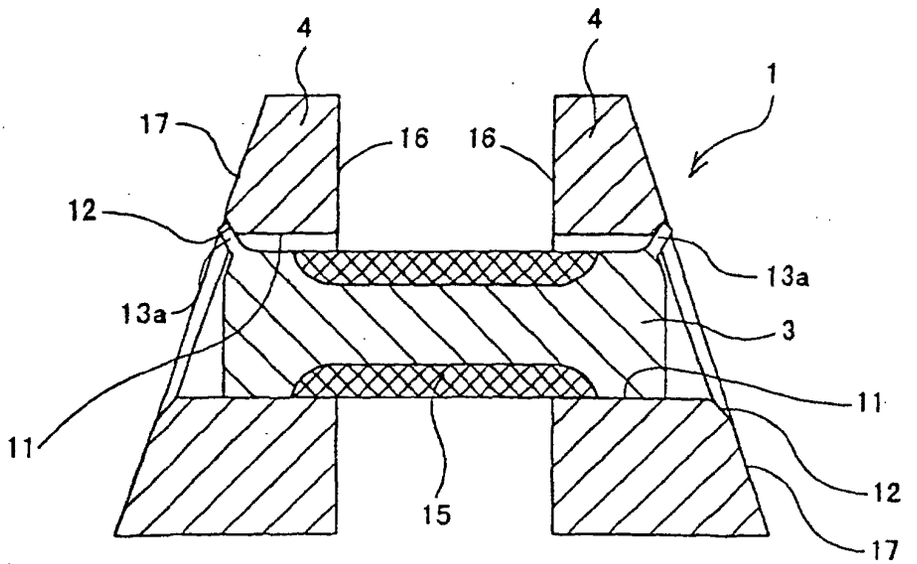


FIG. 4

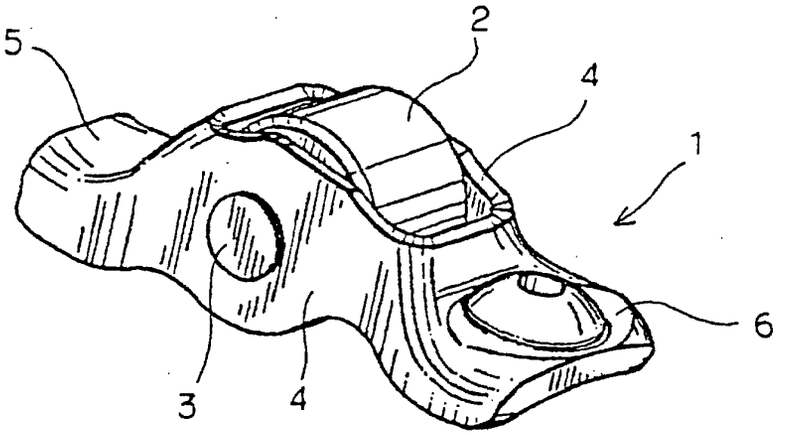


FIG. 5

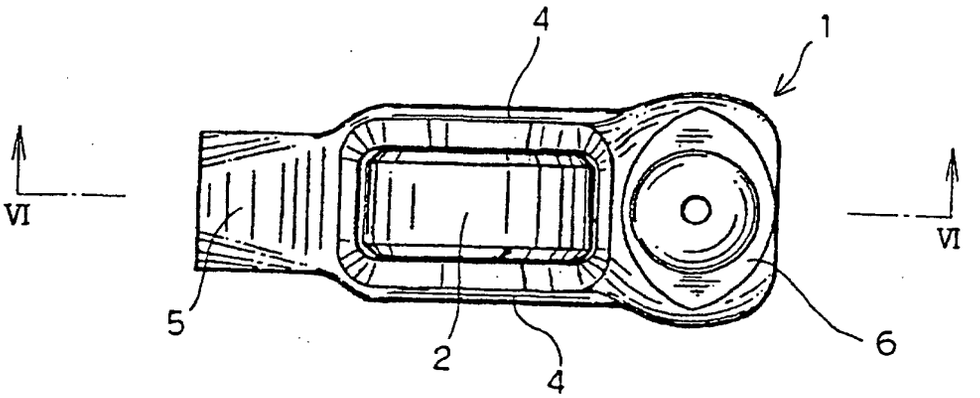


FIG. 6

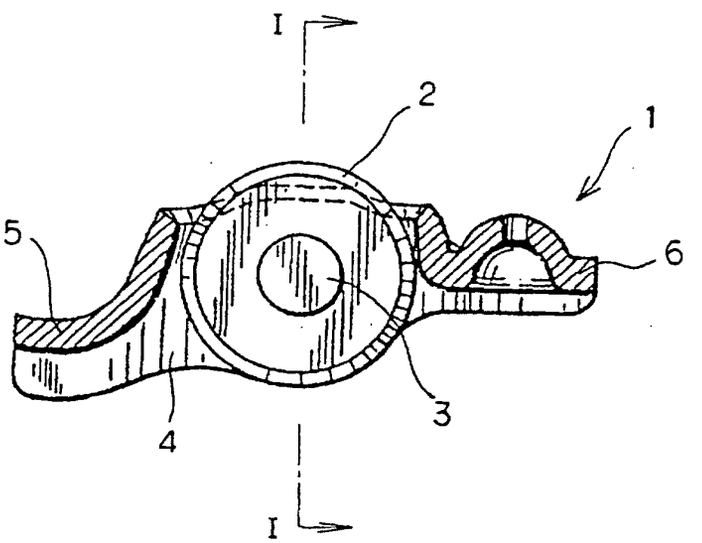


FIG. 7

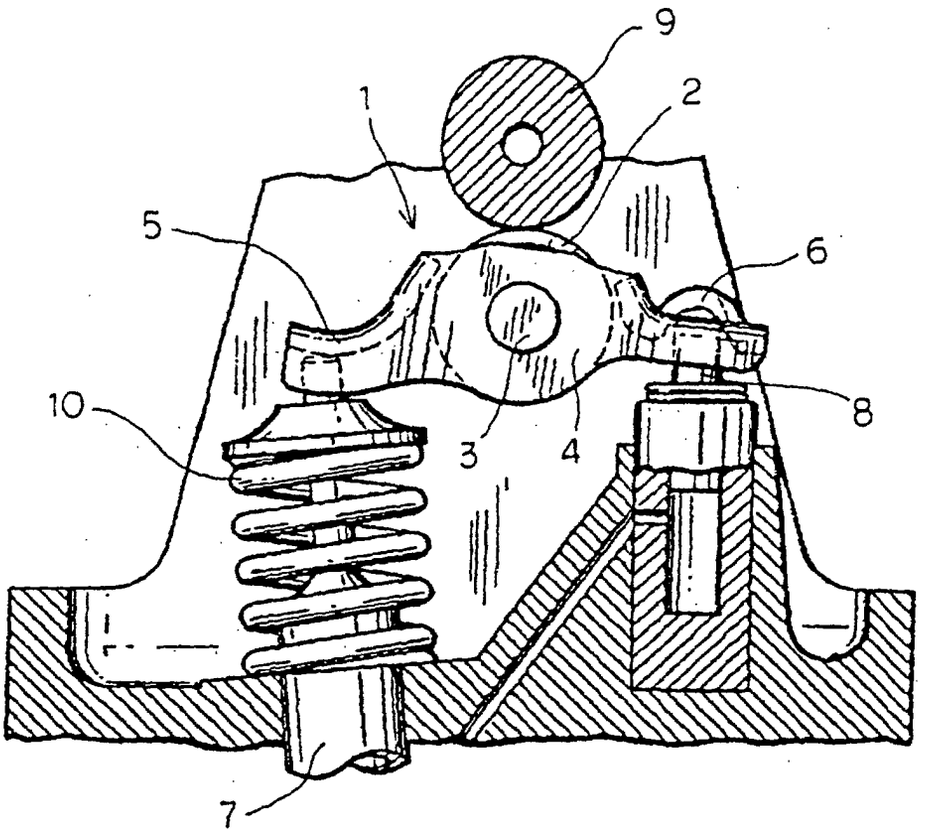


FIG. 8

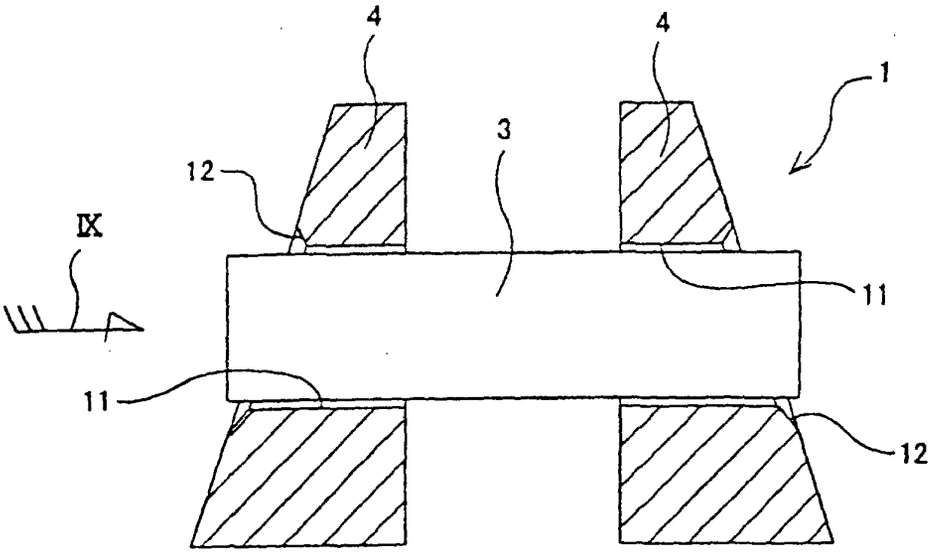


FIG. 9

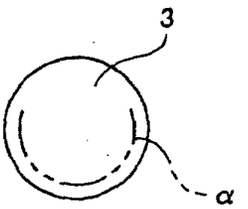
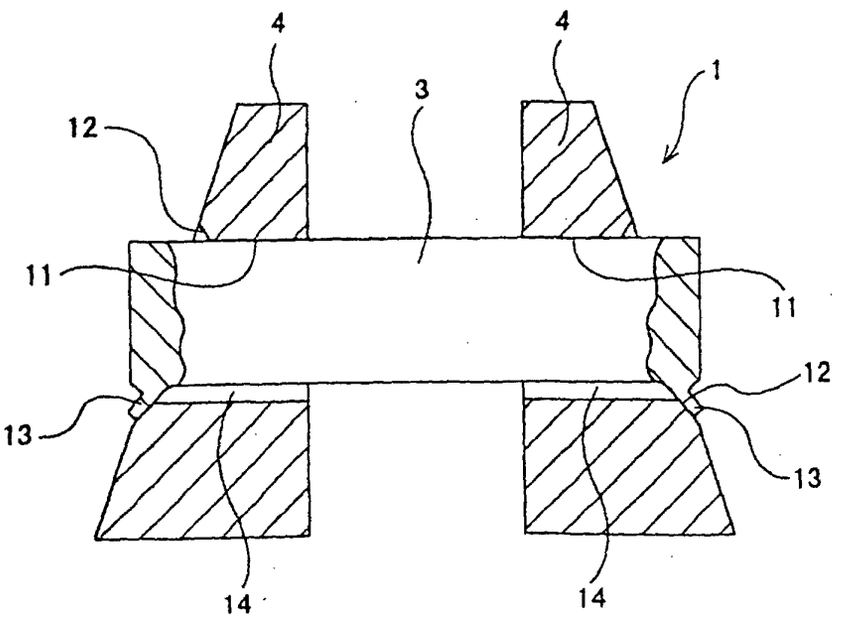


FIG. 10



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/12061

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] F01L1/18

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)
Int.Cl[7] F01L1/18

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1926-1996 Toroku Jitsuyo Shinan Koho 1994-2003
Kokai Jitsuyo Shinan Koho 1971-2003 Jitsuyo Shinan Toroku Koho 1996-2003

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.
Y	JP 6-74006 A (Koyo Seiko Co., Ltd.), 15 March, 1994 (15.03.94), Full text; all drawings (Family: none)	1-4
Y	US 5048475 A (Henley Manufacturing Holding Co., Inc.), 17 September, 1991 (17.09.91), Full text; all drawings (Family: none)	1-4
Y	JP 6-19763 Y (Mazda Motor Corp.), 25 May, 1994 (25.05.94), Column 4, line 49 to column 5, line 2; Fig. 7 (Family: none)	1-4

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

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
14 February, 2003 (14.02.03)	25 February, 2003 (25.02.03)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/12061

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 3-172506 A (Koyo Seiko Co., Ltd.), 25 July, 1991 (25.07.91), Claims; all drawings (Family: none)	1-4
Y	JP 62-7908 A (Honda Motor Co., Ltd.), 14 January, 1987 (14.01.87), Page 2, lower left column, line 12 to lower right column, line 1; Figs. 2, 3 (Family: none)	3
A	JP 4-44289 Y (Mitsubishi Motors Corp.), 19 October, 1992 (19.10.92), Claims; Figs. 1 to 3 (Family: none)	1
A	JP 3120068 B (Kuno Kinzoku Kogyo Kabushiki Kaisha), 19 October, 1992 (19.10.92), Par. No. [0029]; Figs. 33, 34 (Family: none)	1

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