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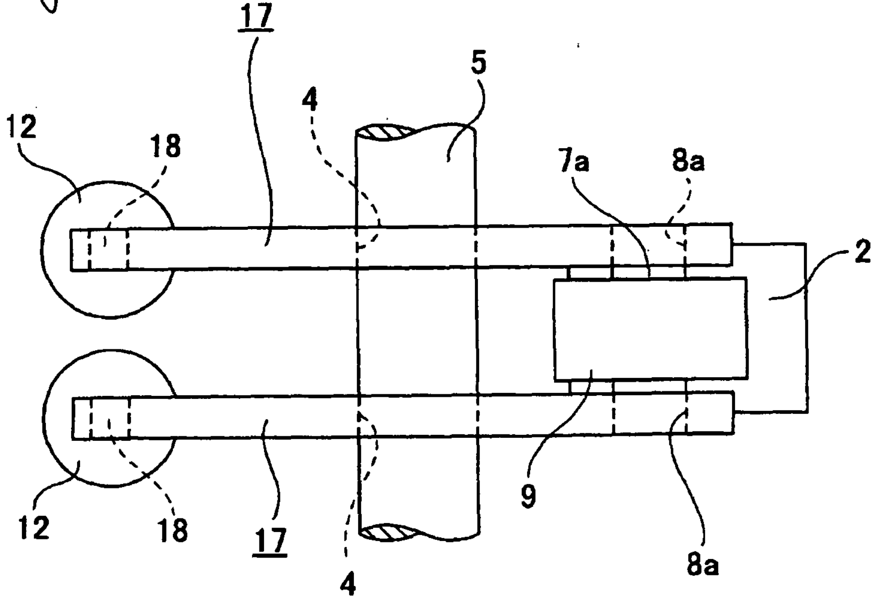
(54) CAM FOLLOWER DEVICE

(57) A cam follower device includes a pair of plate-shaped rocker arms 17 parallel mutually, a support shaft 7a fixed in support holes 8a, 8a at one end portions of the rocker arms 17 at both end portions and a tappet roller 9 supported rotatably around a circumference of an intermediate portion of the support shaft 7a. When the cam follower device is built in a valve train, rotary motion of a cam 2 provided on a camshaft is transmitted to valve elements 12 constituting two inlet (or exhaust) valves by the tappet roller 9 and the pair of rocker arms 17 so as to reciprocate the two valve elements 12 axially. By this configuration, the number of components in a valve train of an engine, in which a number of at least one of inlet and exhaust valves per cylinder is two or more, can be reduced.

Fig.2



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Description

Technical Field

[0001] A cam follower device according to the present invention is built in a valve train of an engine such as, for example, a three-valve engine, four-valve engine or five-valve engine in which the number of at least either of inlet valves and exhaust valves which are provided for one cylinder is two or more for converting rotation of a camshaft into a reciprocating motion of the two inlet valves or two exhaust valves.

Background Art

[0002] Excluding part of two-cycle engines, an inlet valve and an exhaust valve which are adapted to open and close in synchronism with rotation of a crankshaft are provided in reciprocating engines (reciprocating piston engines). In reciprocating engines like these, the movement of the camshafts which rotate in synchronism with rotation of the crankshaft (at one half crankshaft speed in the case of a four-cycle engine) is transmitted to the inlet valve and the exhaust valve by rocker arms, so as to cause the inlet valve and the exhaust valve to reciprocated in an axial direction. In addition, it is general practice to build in a tappet roller between the camshaft and the rocker arm with a view to realizing a reduction in friction within an interior of the engine so as to reduce the fuel consumption rate.

[0003] Figs. 30 to 31 show a conventional cam follower device which is described in Patent Document No. 1 as a first example of a conventional construction of a cam follower device which includes the rocker arm and the tappet roller described above. A rocker arm 3 constituting the cam follower device is provided at a portion which confronts a cam 2 fixedly provided on a camshaft 1 which rotates in synchronism with a crankshaft of an engine. A rocker arm shaft 5, which is a stationary shaft provided parallel to the camshaft 1, is inserted into a through hole 4 formed in an intermediate portion of the rocker arm 3. This configuration enables a swinging displacement of the rocker arm 3 about the rocker arm shaft 5.

In addition, a pair of support wall portions 6, 6 which are parallel to each other is provided at one end portion (a right end portion in Fig. 30) of the rocker arm 3 as shown in detail in Fig. 31. A support shaft 7 is fixed to the one end portion so as to extend between the end portions. For this purpose, both end portions of the support shaft 7 are fixedly fitted, respectively, in a pair of support holes 8, 8 formed in both the support wall portions 6, 6 in positions which are aligned with each other.

In addition, a tappet roller 9 is supported rotatably on the periphery of an intermediate portion of the support shaft 7 via a radial needle bearing 10. Then, an outer circumferential surface of this tappet roller 9 is brought into an outer circumferential surface of the cam 2.

Additionally, a screw hole, not shown, is provided at the other end portion (a left end portion in Fig. 30) of the rocker arm 3, and an adjustment screw 11 is fixedly screwed into this screw hole. Then, a distal end portion (a pressing portion) of the adjustment screw 11 is caused to strike a proximal end face of a valve element 12 which is an inlet valve or an exhaust valve.

[0004] When the engine is running, the rocker arm 3 is displaced in a swinging fashion about a center (a fulcrum) of the rocker arm shaft 5 in accordance with rotation of the cam 2. Then, the rocker arm 3 reciprocates the valve element 12 in an axial direction by pressing force of the adjustment screw 11 and spring force of a return spring 13. As this time, the tappet roller 9 can reduce frictional force acting between the cam 2 and the rocker arm 3, and therefore, a reduction in fuel consumption rate when the engine is running can be realized.

[0005] Next, Figs. 32 to 34 show a cam follower device which is also described in Patent Document No. 1 as a second example of a conventional construction of a cam follower device including the rocker arm and the tappet roller. A rocker arm 3a in the cam follower device of the second example of conventional construction is formed by applying to a sheet metal, such as sheet steel, stamping process for removing unnecessary portions and plastic process such as drawing process for obtaining a desired shape. Thus formed rocker arm 3a includes a pair of support wall portions 6a, 6a which are parallel to each other, a first connecting portion 14 which connects one end portions (right end portions in Figs. 32 to 34) of these support wall portions 6a, 6a to each other, and a second connecting portion 15 which connects the other end portions (left end portions in Figs. 32 to 34) thereof to each other.

In addition, a tappet roller 9 is disposed between the support wall portions 6a, 6a and between the first and second connecting portions 14, 15. This tappet roller 9 is supported rotatably around the periphery of an intermediate portion of a support shaft 7 which is fixed directly or via radial needle bearing to the support wall portions 6a, 6a so as to extend therebetween. In addition, both end portions of the support shaft 7 are fittingly fixed, respectively, in a pair of support holes 8 formed in both the support wall portions 6a, 6a in positions aligned with each other for fixing the support shaft 7 at both the support wall portions 6a, 6a.

[0006] In an assembling state of the cam follower device to the valve train of an engine, as shown in Fig. 34, a distal end face of a plunger 16 constituting a lash adjuster is caused to strike a spherically recessed portion (a receiving portion) provided on one side (a lower side in Fig. 34) of the first connecting portion 14 and a proximal end portion of the valve element 12 which is the inlet valve or the exhaust valve is caused to strike one side (a lower side in Fig. 34) of the second connecting portion 15 (the pressing portion). In addition, an outer circumferential surface of a cam 2 fixedly provided at an intermediate portion of a camshaft 1 is brought into abutment with an outer circumferential surface of the tappet roller 9.

When the engine is running, in accordance with rotation of the cam 2, the rocker arm 3a is displaced in a swinging fashion about an abutment portion between the distal end face of the plunger 16 and the spherically recessed portion as a center (a fulcrum) between states indicated by solid and chain lines in Fig. 34, so as to reciprocate the valve element 12 in the axial direction by the pressing force of the second connecting portion 15 and the spring force of a return spring 13. As this time, the tappet roller 9 can reduce frictional force acting between the cam 2 and the rocker arm 3a, and therefore, a reduction in fuel consumption rate when the engine is running can be realized.

[0007] In addition, in either case of the conventional constructions that have been described above, as a method of fittingly fixing both the end portions of the support shaft 7 in the support holes 8, 8 which are formed in the pair of support wall portions 6, 6 (6a, 6a), it is considered to adopt a method of press fitting both the end portions of the support shaft 7 in both the support holes 8, 8, respectively. In either case of the conventional constructions, however, both the support wall portions 6, 6 (6a, 6a) are formed integrally on the rocker arm 3 (3a), and a space between both the support wall portions 6, 6 (6a, 6a) cannot be expanded. Therefore, when press fitting both the end portions of the support shaft 7 in both the support holes 8, 8, respectively, in a press fitting process, an intermediate portion of the support shaft 7 needs to be passed through an inside of either of the support holes 8 while being press fitted in either of the support holes 8. As a result, there is a fear that an outer circumferential surface of the intermediate portion of the support shaft 7 is damaged. However, since the outer circumferential surface of the intermediate portion of this support shaft 7 has a function as an inner ring raceway of the radial needle bearing 10 (or an internal sliding surface of a slide bearing) which supports rotatably the tappet roller 9, the damage described above is not preferred.

Thus, with a view to preventing the occurrence of such a drawback, a following fixing method has conventionally been adopted.

The conventional method is, after hardening only the outer circumferential surface of the intermediate portion of the support shaft 7 by induction hardening,

while inwardly fitting both the end portions of the support shaft 7 are fitted, respectively, in insides of both the support holes 8, 8 without looseness and interference therebetween, outer circumferential edge portions of both end faces of the support shaft 7 are compressed to be expanded towards circumferential edge portions of openings of both the support holes 8, 8. However, the fixing method of this type needs a number of steps and causes an increase in production costs.

[0008] Incidentally, in configuration of the valve train of the engine, when only conventional cam follower devices like one that has been described above are used as cam follower devices that are to be built in the valve train, the same numbers of cams 2 and tappet rollers 9 as valve elements 12 are necessary. However, in association with the recent trend of multi-valve engines, the numbers of inlet valves and exhaust valves to be provided per cylinder are gradually increased such as two or three. Therefore, in configuring the valve train of such a multi-valve engine, when only conventional cam follower devices like one that has been described above are used, the number of components of the valve train becomes too many, and this easily calls for drawbacks of the valve train being made enlarged in size, heavy in weight, highly frictional and highly expensive in cost.

[0009] Patent Document No. 1: Japanese Patent Unexamined Publication JP-A-2004-100499

Disclosure of the Invention

Problem that the Invention is to Solve

[0010] A cam follower device of the invention has been made in view of the situations described above and an object thereof is to realize a construction which can reduce the numbers of cams and tappet rollers which are used when configuring a valve train of a multi-valve engine.

Means for Solving the Problem

[0011] The invention is attained by the following configurations.

(1) A cam follower device that is built in a valve train of an engine in which a number of at least one of inlet valves and exhaust valves which are to be provided per cylinder is two or more, including:

a pair of rocker arms which are disposed parallel to each other with a predetermined interval provided therebetween and have a pair of support holes which are concentric with each other at one end portions or intermediate portions thereof in positions which are aligned with each other;
a support shaft which is fixed to both the rocker arms so as to be extended between the rocker arms by fitting both end portions in the support holes, respectively;
a tappet roller which is supported rotatably around a periphery of an intermediate portion of the support shaft, an outer circumferential surface of the tappet roller being capable of abutting with an outer circumferential surface of a cam which is fixed on a camshaft when the cam follower device is built in the valve train; and
a pair of pressing portions which are provided directly or via a separate member at the other end portions of both the rocker arms, the pair of pressing portions being capable of striking individually proximal end faces of two inlet valves or two exhaust valves when the cam follower

device is built in the valve train.

(2) The cam follower device as set forth in (1), wherein the pair of rocker arms is formed separately.

(3) The cam follower device as set forth in (2), wherein
the pair of support holes are formed at the one end portions of the pair of rocker arms, and
a pair of through holes, into which a rocker arm shaft provided in parallel with the camshaft is capable of being inserted when the cam follower device is built in the valve train, are formed at the intermediate portions of the rocker arms in positions which are aligned with each other, so as to enable a swinging displacement of both the rocker arms.

(4) The cam follower device as set forth in (3), wherein
an interval between inner surfaces of both the rocker arms which confront each other are made relatively narrow at the one end portions and relatively wide at the other end portions of both the rocker arms by making thickness of both the rocker arms relatively large at the one end portions and relatively small at the other end portions of both the rocker arms.

(5) The cam follower device as set forth in (3), wherein
an interval between inner surfaces of both the rocker arms which confront each other are made relatively narrow at the one end portions and relatively wide at the other end portions of both the rocker arms by providing non-parallel plate portions which are not parallel to the intermediate portions of both the rocker arms at portions between the one end portions and the intermediate portions or between the intermediate portions and the other end portions of both the rocker arms.

(6) The cam follower device as set forth in (3), wherein
both end portions of a cylindrical sleeve are inwardly fitted and fixed, respectively, in the pair of through holes and
the rocker arm shaft is inserted into an inside of the sleeve.

(7) The cam follower device as set forth in (2), wherein
the pair of support holes are formed at the intermediate portions of the pair of rocker arms, and
the one end portions of both the rocker arms have a pair of receiving portions which are provided thereon directly or via separate members and with which distal end faces of a pair of plungers is capable of being brought into abutment when the cam follower device is built in the valve train, so as to enable a swinging displacement of both the rocker arms about abutment portions between the receiving portions and the distal end faces of the pair of plungers as fulcrums.

(8) The cam follower device as set forth in (7), wherein
an interval between inner surfaces of both the rocker arms which confront each other are made relatively narrow at the one end portions and relatively wide at the other end portions of both the rocker arms by making thickness of both the rocker arms relatively large at the one end portions and relatively small at the other end portions of both the rocker arms.

(9) The cam follower device as set forth in (7), wherein an interval between inner surfaces of both the rocker arms which confront each other are made relatively narrow at the one end portions and relatively wide at the other end portions of both the rocker arms by providing non-parallel plate portions which are not parallel to the intermediate portions of both the rocker arms at portions between the one end portions and the intermediate portions or between the intermediate portions and the other end portions of both the rocker arms.

(10) The cam follower device as set forth in (1), wherein
an axial displacement amount allowed to the tappet roller is controlled to a desired magnitude by disposing spacers which are fitted on the support shaft, respectively, between inner surfaces of both the rocker arms and both axial end faces of the tappet roller.

(11) The cam follower device as set forth in (1), wherein
thickness of portions of both the rocker arms which need to have a higher strength than that of peripheral areas thereof are larger than thickness of the peripheral areas.

(12) The cam follower device as set forth in (2), wherein
the pair of rocker arms is each formed by applying stamping process to a single sheet metal.

(13) The cam follower device as set forth in (1), wherein
the pair of rocker arms is connected together by a connecting portion provided in at least one location so as to prohibit a relative displacement.

(14) The cam follower device as set forth in (13), wherein
the pair of support holes are formed at the one end portions of the pair of rocker arms, and
a pair of through holes into which a rocker arm shaft provided in parallel with the camshaft is capable of being inserted when the cam follower device is built in the valve train, are formed at the intermediate portions of the rocker arms in positions which are aligned with each other, so as to enable a swinging displacement of both the rocker arms.

(15) The cam follower device as set forth in (13), wherein
the pair of rocker arms which are connected together by the connecting portion provided in at least the one location so as to prohibit a relative displacement are

made by applying stamping process and bending process to a single sheet metal. Advantage of the Invention

[0012] When the valve train of the engine in which the number of at least one of the inlet valves and the exhaust valves which are to be provided per cylinder is two or more is configured using the cam follower device of the invention, the two inlet valves or the two exhaust valves can be opened and closed simultaneously only by providing the single cam and the single tappet roller. Thus, as the cam follower device that is to be built in the valve train, the cam follower device can realize a reduction in the number of components of the valve train, when compared with the above described conventional cam follower device. Consequently, the valve train can be made smaller in size (space saving) and lighter in weight and can realize reductions in friction and production costs.

[0013] In addition, in the cam follower device of the invention, as the method of fittingly fixing both the end portions of the support shaft in the support holes, the method of press fitting both the end portions of the support shaft in both the support holes can be adopted.
In addition, when this method is adopted, the outer circumferential surface of the support shaft {the inner ring raceway of the radial needle bearing (or the inner sliding surface of the slide bearing) for supporting the tappet roller rotatably} can be prevented from being damaged. This is because when the invention which has the pair rocker arms which are disposed parallel to each other with the predetermined interval (at the same pitch as the pitch of the two valve elements which are to be opened and closed simultaneously) and which have the pair of support holes, both the end portions of the support shaft can be press fitted, respectively, in the insides of both the support holes through the openings of the support holes which lie on sides thereof opposing to each other. In other words, in the invention which is different from the above described respective conventional constructions, in the step of press fitting both the end portions of the support shaft, respectively, in the pair of support holes, it is not necessary to cause the support shaft to pass through the inside of either of the support holes while the intermediate portion of the support shaft is press fitted (fitted through interference fit) in either of the support holes.

[0014] In addition, when assembling the cam follower device of the invention, when the above described method of press fitting (fitting through interference fit) both the end portions of the support shaft in the pair of support holes is adopted, since the necessity is obviated of compressing to expand both ends of the support shaft, it is not necessary to keep both the ends of the support shaft in a raw state (a state in which no hardening treatment has been applied). Consequently, a so-called immersion quenching in which the whole of the support shaft is heated and is then immersing the heated support shaft in hardening oil can be applied as the hardening of the support shaft. Since the hardening treatment using immersion quenching is lower in cost than the hardening treatment using induction hardening, the production costs can be lowered due to the immersion quenching.

[0015] The pair of rocker arms of the invention which can prevent the damage to the outer circumferential surface of the intermediate portion of the support shaft may be parts which are separate from each other.
Further, the pair of rocker arms of the invention may be constructed such that although the pair of rocker arms are connected together by a connecting portion in at least one location so that the rocker arms are disabled from a relative displacement, a distance between the portions where the support holes are formed and the connecting portion is made relatively large so that the interval between the rocker arms can be expanded.

[0016] In addition, when both the rocker arms are connected together by a connecting portion in at least one location so that the rocker arms are disabled from a relative displacement, the phase aligning operation becomes unnecessary which has conventionally been performed when the cam follower device is assembled onto the engine.

[0017] Additionally, when the cam follower device set forth under (3) is carried out, in the event that the configurations set forth under (4), (5) are adopted, even if the interval between the proximal end faces of the two inlet valves or two exhaust valves which are to be pressed by the pair of pressing portions is made remarkably large compared with the axial dimension of the tappet roller, the pair of pressing portions which can press both the proximal end faces accurately can be provided and the intervals between both the axial end faces of the tappet roller and the inner surfaces of the pair of rocker arms can be made small sufficiently (the axial displacement permitted to the tappet roller can be controlled to the desired magnitude). In other words, it becomes unnecessary to increase the axial dimension of the tappet roller so as to match the interval between both the proximal end faces.

[0018] In addition, when the cam follower device set forth under (3) to (5) is carried out, if adapting the configuration set forth under (6), since both the end portions are fittingly fixed, respectively, in both the through holes provided in the intermediate portions of the pair of rocker arms, displacement of the positional relationship between both the rocker arms can effectively be prevented from a proper positional relationship.
Consequently, the occurrence of a drawback associated with such a displacement can be prevented effectively. (As the drawback associated with the displacement, followings can be exemplified. A drawback occurring when the cam follower device is assembled such as the difficulty in insertion of the rocker arm shaft into both the through holes, a drawback of displacement in phases of the two inlet valves or exhaust valves which are to be pressed by the cam follower device deviate from each other when using and a drawback of occurrence of partial

contact in which the outer circumferential surface of the tappet roller and the outer circumferential surface of the cam do not contact in parallel due to the inclination of the center axis of the tappet roller.)

Additionally, not inner circumferential surfaces of both the through holes whose axial dimension is small but an inner circumferential surface of the sleeve whose axial dimension is sufficiently large is brought into slide contact with the outer circumferential surface of the rocker arm shaft. Thus, a sliding area relative to the outer circumferential surface of the rocker arm shaft can be secured sufficiently, whereby wear amount of the outer circumferential surface of the rocker arm shaft can be made sufficiently small. Accordingly, duration life of the rocker arm shaft can be increased. In addition, since the inner circumferential surfaces of both the through holes do not have to be brought into slide contact with the outer circumferential surface of the rocker arm shaft, the thickness of both the rocker arms can be made thinner by such an amount.

[0019] In addition, when the cam follower device set forth under (7) is carried out and the configurations set forth under (8), (9) are adopted, even if the interval between the proximal end faces of the two inlet or exhaust valves to be pressed by the pair of pressing portions and the interval between the distal end faces of the pair of plungers to be made to strike the pair of receiving portions become remarkably large compared with the axial dimension of the tappet roller, the pair of pressing portions which can press both the proximal end faces accurately and the pair of receiving portions having both the distal end faces made to strike accurately can be provided and also the intervals between both the axial end faces of the tappet roller and the inner surfaces of the pair of rocker arms can be made small sufficiently (the axial displacement permitted to the tappet roller can be controlled to the desired magnitude). In other words, it becomes unnecessary to increase the axial dimension of the tappet roller so as to match the interval between both the proximal end faces and the interval between both the distal end faces.

[0020] Additionally, when the cam follower device set forth under (1) is carried out and the configuration set forth under (10) is adopted, even if the interval between the inner surfaces of the pair of rocker arms becomes remarkably large compared with the axial dimension of the tappet roller, the axial displacement that is permitted to the tappet roller can be controlled to the desired magnitude. Consequently, if the configuration described under (10) is adopted, a common tappet roller (and a radial rolling bearing such as the radial needle bearing provided radially inside the tappet roller) can be used for pairs of rocker arms having various shapes. In addition, the shape of a pair of rocker arms can be determined so as to match the layout of an engine.

[0021] Furthermore, when the cam follower device set under (1) is carried out and the configuration set forth under (11) is adopted, compared with a construction in which the thickness dimension of a pair of rocker arms is increased overall, the strength at part of both the rocker arms can be increased accurately without calling for a wasteful and meaningless increase in weight.

Brief Description of the Drawings

[0022]

[Fig. 1] Fig. 1 is a side view showing a state in which a first embodiment of the invention is built in a valve train of an engine.

[Fig. 2] Fig. 2 is a view as viewed from the top of Fig. 1.

[Fig. 3] Fig. 3 is a sectional view taken along the line III-III in Fig. 1.

[Fig. 4] Fig. 4 is an enlarged view of a portion denoted as IV in Fig. 1.

[Fig. 5] Fig. 5 is a similar diagram to Fig. 4, which shows a first example of a rocker arm of a different construction.

[Fig. 6] Fig. 6 (a) is a view as viewed in the same direction as Fig. 2, which shows a second example of a rocker arm of a different construction in a partially sectioned state, and Fig. 6(b) is an end view of the second example.

[Fig. 7] Fig. 7 (a) is a view as viewed in the same direction as Fig. 2, which shows a third example of a rocker arm of a different construction in a partially sectioned state, and Fig. 7(b) is an end view of the second example.

[Fig. 8] Fig. 8 is a view as viewed in the same direction as Fig. 2, which shows a fourth example of a rocker arm of a different construction in a partially sectioned state.

[Fig. 9] Fig. 9 is a view as viewed in the same direction as Fig. 2, which shows a fifth example of a rocker arm of a different construction in a partially sectioned state.

[Fig. 10] Fig. 10 is a diagram similar to Fig. 2, which shows a second embodiment of the invention.

[Fig. 11] Fig. 11 is a diagram of a left end portion of an upper rocker arm in Fig. 10 as viewed from an internal surface side of the left end portion.

[Fig. 12] Fig. 12 is a view as viewed in the same direction as Fig. 2, which shows a third embodiment of the invention.

[Fig. 13] Fig. 13 is a diagram similar to Fig. 2, which shows a fourth embodiment of the invention in a partially sectioned state.

[Fig. 14] Fig. 14 is a perspective view showing a construction which is not preferred when compared with the construction of the fourth embodiment.

[Fig. 15] Fig. 15 is a diagram similar to Fig. 2, which shows a fifth embodiment of the invention in a partially sectioned state.

[Fig. 16] Fig. 16 is a diagram similar to Fig. 2, which shows a sixth embodiment of the invention.

[Fig. 17] Fig. 17 is a diagram similar to Fig. 1, which shows a seventh embodiment of the invention.

[Fig. 18] Fig. 18 is a diagram as viewed from the top of Fig. 17, which shows the same embodiment in a partially sectioned state.

[Fig. 19] Fig. 19 is a diagram corresponding to a central portion of Fig. 18, which shows an eighth embodiment of the invention.

[Fig. 20] Fig. 20 is a side view showing a ninth embodiment of the invention in such a state that it is built in the valve train of the engine.

[Fig. 21] Fig. 21 is a view as viewed from the top of Fig. 20 with part thereof omitted.

[Fig. 22] A sectional view taken along the line XXII-XXII in Fig. 20.

[Fig. 23] Fig. 23 is a diagram similar to Fig. 2, which shows a tenth embodiment of the invention.

[Fig. 24] Fig. 24A is a diagram similar to Fig. 2, which shows a modified example to the tenth embodiment of the invention, and Fig. 24B is a diagram similar to Fig. 2, which shows another modified example to the tenth embodiment of the invention. [Fig. 25] Fig. 25 is a side view showing a state in which an eleventh embodiment of the invention is built in the valve train of the engine.

[Fig. 26] Fig. 26 is a view as viewed from the top of Fig. 25.

[Fig. 27] Fig. 27A is a diagram illustrating a first step in which stamping process is applied to a sheet metal for forming rocker arms, and Fig. 27B is a diagram illustrating a second step in which bending process is applied to the stamped sheet metal for forming rocker arms.

[Fig. 28] Fig. 28 is a view resulting when rocker arms are viewed from thereabove which are constructed such that cylindrical portions are formed at through holes.

[Fig. 29] Fig. 29 is a perspective view of rocker arms which are constructed such that cylindrical portions are formed at through holes.

[Fig. 30] Fig. 30 is a partial side view of a valve train of an engine in which a first example of a conventional cam follower device is built.

[Fig. 31] Fig. 31 is an enlarged sectional view taken along the line XXXI-XXXI in Fig. 30.

[Fig. 32] Fig. 32 is a perspective view showing a second example of a conventional cam follower device.

[Fig. 33] Fig. 33 is a sectional view taken along the line XXXIII-XXXIII in Fig. 32.

[Fig. 34] Fig. 34 is a partially sectional view of a valve train of an engine in which a second example of a conventional cam follower device is built.

Description of Reference Numerals

[0023] 1 camshaft; 2 cam; 3, 3a rocker arm; 4, 4a through hole; 5 rocker arm shaft; 6, 6a support wall portion; 7, 7a support shaft; 8, 8a support hole; 9 tappet roller; 10 radial needle bearing; 11 adjustment screw; 12 valve element; 13 return spring; 14 first connecting portion; 15 second connecting portion; 16 plunger; 17, 17a-17r rocker arm; 18 projecting portion; 19 holding piece; 20 recessed portion; 21 pressing plate portion; 22 flat plate portion; 23 cylindrical portion; 24 through hole (or screw hole); 25 cylindrical portion; 26 cylindrical portion; 27 cylindrical member; 28 sleeve; 29 sleeve; 30 spherically recessed portion; 31, 31a thick portion; 32 ring spacer; 33 cylindrical spacer; 34 thick portion; 35, 35a, 35b inclined plate portion; 36 radial needle bearing; 37 ring plate; 38 connecting portion; 39 cylindrical portion. Best Mode for Carrying out the Invention

[First Embodiment]

[0024] Figs. 1 to 4 show a first embodiment of the invention. A cam follower device of this embodiment is built, for use, in a valve train of an engine (of an OHC or DOHC type) such as, for example, a three-valve engine, a four-valve engine or a fifth-valve engine in which the number of at least one of inlet valves and exhaust valves provided per cylinder is made to be two or more. The cam follower device of the embodiment that is so designed includes a pair of plate-shaped rocker arms 17, 17 which are identical in shape and size to each other, a support shaft 7a and a tappet roller 9.

[0025] In these constituent parts, the pair of plate-shaped rocker arms 17, 17 is formed separately into a shape like a boomerang by applying stamping process to a sheet metal such as a sheet steel. The two so formed rocker arms 17, 17 are disposed parallel to each other with a predetermined interval defined therebetween. In addition, the support shaft 7a is fixed to one end portions (right end portions in Figs. 1 to 2) of both the rocker arms 17, 17 so as to be extended therebetween. For this purpose, a pair of support holes 8a, 8a is formed concentric with each other in positions which are aligned with each other at the one end portions of both the rocker arms 17, 17. Then, after a hardening treatment by immersion quenching is applied to a whole surface of the support shaft 7a, both end portions of the support shaft 7a are press fitted, respectively, in insides of both the support holes 8a, 8a through openings of the support holes 8a, 8a which lie on sides thereof opposing to each other.

[0026] In addition, in this embodiment, in a state of the support shaft 7a being press fitted, by bringing male serrations (not shown) formed on outer circumferential surfaces of both the end portions of the support shaft 7a and female serrations (not shown) formed on inner circumferential surfaces of both the support holes 8a, 8a into engagement with each other (or causing ridge portions of the male serrations to bite into the inner circumferential surfaces of the support holes), relative rotation at the press fitted portions is prevented effectively. In other words, both the rocker arms 17, 17 prevent the relative swing between the rocker arms about the support shaft 7a effectively.

In addition, in press fitting the end portions of the support shaft 7a, respectively, in the pair of support holes 8a, 8a, and serrations may be provided on at least either of the outer circumferential surfaces of the end portions of the support shaft 7a and the inner circumferential surfaces of the support holes 8a, 8a.

[0027] In addition, the tappet roller 9 is supported rotatably on an outer circumferential surface of an intermediate portion of the support shaft 7a via a radial needle bearing 10. Additionally, a pair of through holes 4, 4 which is concentric with each other is formed at intermediate portions of both the rocker arms 17, 17 in positions aligned with each other. In addition, a pair of projecting portions 18, 18 (pressing portions) is provided on lower sides of the other end portions (left end portions in Figs. 1 to 2) of both the rocker arms 17, 17. Distal end faces of both the projecting portions 18, 18 are each made into a partially cylindrical surface. In addition, it is adaptable to support the tappet roller 9 rotatably on the circumference of the intermediate portion of the support shaft 7a via the radial rolling bearing such as the radial needle bearing 10, it is also adaptable to support the tappet roller 9 rotatably on the support shaft 7a directly or via a slide bearing.

By using the radial rolling bearing as in this embodiment, swing resistance of the pair of rocker arms 17, 17 about the rocker arm shaft 5 can be reduced and also the fuel consumption rate at the running of the engine can be reduced.

[0028] As shown in Figs. 1 to 2, in a state of assembling the cam follower device to the valve train of the engine, the rocker arm shaft 5 as a stationary shaft is inserted into the respective through holes 4, 4 without looseness and no interference therebetween so as to enable the swinging displacement of both the rocker arms 17, 17 about the rocker arm shaft 5. In conjunction with this, an outer circumference of the tappet roller 9 is brought into abutment with an outer circumferential surface of a cam 2 which is fixedly provided on a camshaft 1, and the distal end faces of both the projecting portions 18, 18 are caused to strike individually proximal end faces of two valve elements 12, 12 (two inlet valves or two exhaust valves which are provided for the same cylinder). When the engine is running, both the rocker arms 17, 17 are swung about the rocker arm shaft 5 as the cam 2 rotates, so as to reciprocate the two valve elements 12, 12 in an axial direction by pressing force exerted by both the projecting portions 18, 18 and spring force by the return spring 13 (which is omitted in Figs. 1 to 4. Refer to Figs. 30, 34).

[0029] As has been described, when the cam follower device of the embodiment is used, only by providing the single cam 2 and the single tappet roller 9, the two valve elements 12, 12 can be reciprocated simultaneously. Thus, when compared with the case where only the aforesaid conventional cam follower device is used as the cam follower device to be built in the valve train (the independent cam follower device is built in for each valve element), the number of parts in the valve train can be reduced. Consequently, the resulting valve train can be made smaller in size (space saving) and lighter in weight and can realize reductions in friction and production costs. In addition, according to this embodiment, both the end portions of the support shaft 7a can be press fitted in the pair o support holes 8a, 8a without damaging the outer circumferential surface of the intermediate portion of the support shaft 7a. Thus, as a hardening treatment applied to the surface of the support shaft 7a, an immersion quenching which is more inexpensive than induction hardening can be adopted. Consequently, the production costs can be suppressed.

[0030] In addition, as has been described above, it is only required for both the rocker arms 17, 17 to be formed in the same shape and size, then, the positional relationship between both the rocker arms 17, 17 can be made proper, whereby the occurrence of a difference in contact state with their mating parts such as the valves can be prevented effectively.

[0031] Note that when carrying out the cam follower device of the embodiment, rocker arms 17a to 17e which are shown in Figs. 5 to 9 can also be used as the pair of rocker arms. These rocker arms 17a to 17e differ from the rocker arm 17 that has been described heretofore in shape of at least the other end portions (left end portions in Figs. 5 to 9) thereof.

In these rocker arms, firstly, in the rocker arm 17a shown in Fig. 5, a pair of holding pieces 19, 19 is projectingly provided on both front and rear sides (left- and right-hand sides in Fig. 5) of a projecting portion 18 provided on a lower surface of the other end portion thereof.

In the rocker arm 17b shown in Fig. 6, a pressing plate portion 21 having U-shaped cross section provided with a recessed portion 20 on a lower surface thereof is provided at the other end thereof, and a bottom surface of the recessed portion 20 is made into a pressing portion caused to strike a proximal end face of the valve element.

In the rocker arm 17c shown in Fig. 7, a flat plate portion 22 which is perpendicular to one end portion (a right end portion in Fig. 7) to an intermediate portion is provided at the other end portion, hole opening work is applied to a central portion of this flat plate portion 22 and then, burring process is applied to the portion to which the hole opening work is applied so as to form a cylindrical portion 23. Then, an inside of this cylindrical portion 23 is made into a through hole (or a screw hole) 24. When using this rocker arm 17c, a distal end portion of an adjustment pin (or an adjustment screw), not shown, which is fittingly fixed in the through hole (or the screw hole) 24 is made into a pressing portion caused to strike the proximal end face of the valve element.

[0032] In the rocker arm 17d shown in Fig. 8, a cylindrical portion 25 is formed integrally at the other end portion by bending process. An inside of the cylindrical portion 25 is made into a through hole (or a screw hole) 24 in which the aforesaid adjustment pin (or the adjustment screw), not shown, is fittingly fixed (or screw fixed). Additionally, in order to secure an insertion length of the rocker arm shaft 5 (refer to Fig. 2) relative to a through hole 4 provided in an intermediate portion of the rocker arm 17d, burring process is applied to a peripheral portion of the through hole 4 so as to form a cylindrical portion 26. In addition, in the rocker arm 17e shown in Fig. 9, a cylindrical member 27 is fixedly joined to the other end portion through welding, electric welding or the like. Then, an inside of the cylindrical member 27 is made into a through hole (or a screw hole) 24 in which the aforesaid adjustment pin (or the adjustment screw), not shown, is fittingly fixed (or screw fixed). Additionally, in order to secure an insertion length of the rocker arm shaft 5 (refer to Fig. 2) relative to a through hole 4 provided in an intermediate portion of the rocker arm 17e, a sleeve 28 is fittingly fixed in an inside of the through hole 4, so that the rocker arm shaft 5 is made to be inserted into an inside of the sleeve 28.

[Second Embodiment]

[0033] Next, Figs. 10 to 11 show a second embodiment of the invention. In this embodiment, in order to increase the strength at the other end portions (left end portions in Fig. 10) of a pair of rocker arms 17h, 17h where projecting portions 18, 18 are provided, both the end portions are made into thick portions 31, 31. In order to form both the thick portions 31, 31, in this embodiment, internal surfaces of the other end portions of both the rocker arms 17h, 17h are caused to swell. Thus, a thickness dimension T of the other end portions (the thick portions 31, 31) of both the rocker arms 17h, 17h is made larger than a thickness dimension t of one end portions and intermediate portions thereof (T>t). In this embodiment which is configured in the way described above, compared to a construction in which a thickness dimension of both the rocker arms 17h, 17h is increased along the full length thereof, the strength at both the end portions can be increased accurately without calling for a wasteful and meaningless increase in weight. The other configuration and function of this embodiment are similar to those of the first embodiment described before.

[Third Embodiment]

[0034] Next, Fig. 12 shows a third embodiment of the invention. In this embodiment, too, in order to increase the strength at the other end portions (left end portions in Fig. 12) of a pair of rocker arms 17i, 17i where projecting portions 18, 18 are provided, both the other end portions are made into thick portions 31a, 31a. However, in the case of this embodiment, in order to form both the thick portions 31a, 31a, both side surfaces of the other end portions of both the rocker arms 17i, 17i are caused to swell. The other configuration and function of this embodiment are similar to those of the second embodiment described above.

[Fourth Embodiment]

[0035] Next, Fig. 13 shows a fourth embodiment of the invention. In this embodiment, compared to the above described respective embodiments, an interval between a pair of valve elements 12, 12 which are to be pressed becomes remarkably large. Due to this, in this embodiment, an interval between a pair of rocker arms 17i, 17i is made remarkably large compared to the aforementioned respective embodiments so as to match the interval between both the valve elements 12, 12. In contrast to this, in this embodiment, as a tappet roller 9 disposed between one end portions (right end portions in Fig. 13) of both the rocker arms 17i, 17i, a tappet roller 9 is used which has the same axial dimension as those of the respective embodiments. Thus, in this embodiment, widths of gaps which reside between internal surfaces of the one end portions of both the rocker arms 17i, 17i and both axial end faces of the tappet roller 9 are both made far larger than a permissible axial displacement of the tappet roller 9.

[0036] Here, as shown in Fig. 14, if a construction is adopted, in which no member is disposed in portions defined between the internal surfaces of the one end portions (right end portions in Fig. 14) of both the rocker arms 17i, 17i and both the axial end faces of the tappet roller 9, the tappet roller 9 would be allowed to be displaced in axial directions by a distance equal to the widths of the gaps residing in the portions. As a result, when the engine is running, the tappet roller 9 is displaced largely in the axial direction, whereby there emerges a possibility that a drawback is caused, such as a radial needle bearing 10 disposed radially inwards of the tappet roller 9 being dislocated outwards of the tappet roller 9 or the tappet roller 9 being disengaged from the cam 2, and hence, the construction is not preferred. In order to avoid such a situation, although it is considered that the axial dimension of the tappet roller 9 is increased so as to match the interval between the internal surfaces of both the rocker arms 17i, 17i. However, since a drawback of increasing of the weight of the tappet roller 9 will be caused and it makes difficult for the engine to revolve at higher speeds or the fuel consumption rate at the time of running of the engine is increased, thus, such a construction is not preferred.

[0037] Then, with a view to preventing the occurrence of the drawbacks described above, in this embodiment shown in Fig. 13, a ring spacer 32 and a cylindrical spacer 33 which are both fitted on a support shaft 7a are disposed in each of the gaps between the internal surfaces of the one end portions of both the rocker arms 17i, 17i and both the axial end faces of the tappet roller 9 in this order from the tappet roller 9 side while eliminating large looseness in the axial direction. Then, the axial displacement permitted to the tappet roller 9 (and the radial needle bearing 10) is controlled to a desired magnitude (a minute amount) by the respective ring spacers 32, 32 and the respective cylindrical spacers 33, 33. The other configuration and function of this embodiment are similar to those of the third embodiment that has been described above.

[Fifth Embodiment]

[0038] Next, Fig. 15 shows a fifth embodiment of the invention. In this embodiment, in place of omitting the pair of cylindrical spacers 33, 33 (refer to Fig. 13), internal surfaces of one end portions (right end portions in Fig. 15) of a pair of rocker arms 17k, 17k are caused to swell into thick portions 34, 34. By this configuration, an interval between the internal surfaces of the one end portions of both the rocker arms 17, 17 is narrowed, so that an axial displacement permitted to a tappet roller 9 is controlled to a desired magnitude (a minute amount). The other configuration and function of this embodiment are similar to those of the fourth embodiment that has been described above except for the fact that no thick portion is provided at the other end portions (left end portions in Fig. 15) of both the rocker arms 17k, 17k.

[Sixth Embodiment]

[0039] Next, Fig. 16 shows a sixth embodiment of the invention. In this embodiment, in place of omitting the pairs of ring spacers 32, 32 and cylindrical spacers 33, 33 (refer to Fig. 13), inclined plate portions 35, 35 (non-parallel plate portions) are formed between one end portions (right end portions in Fig. 16) to intermediate portions and the other end portions (left end portions in Fig. 16) of a pair of rocker arms 17m, 17m so as to be inclined in directions in which the inclined plate portions 35, 35 approach each other as they extend towards the one end portions. By this configuration, an interval between internal surfaces of the one end portions of both the rocker arms 17m, 17m is narrowed, so as to control an axial displacement permitted to a tappet roller 9 to a desired magnitude (a minute amount). The other configuration and function are similar to those of the aforesaid fourth embodiment shown in Fig. 13 except for the fact that no thick portion is provided at the other end portions (left end portions in Fig. 15) of both the rocker arms 17m, 17m.

[Seventh Embodiment]

[0040] Next, Figs. 17 to 18 show a seventh embodiment of the invention. In this embodiment, by press fitting both end portions of a cylindrical sleeve 29, respectively, in insides of through holes 4a, 4a formed, respectively, at intermediate portions of a pair of rocker arms 17f, 17f, the sleeve 29 is fixed to both the rocker arms 17h, 17f so as to be extended therebetween.
In addition, by bringing male serrations (not shown) formed on outer circumferential surfaces of both end portions of the sleeve 29 into engagement with female serrations (not shown) formed on inner circumferential surfaces of both the through holes 4a, 4a, relative rotation at the press fitted portions is prevented effectively. Then, a rocker arm shaft 5 is inserted into an inside of thus formed sleeve 29.

[0041] In the cam follower device of this embodiment, since the pair of rocker arms 17f, 17f are coupled together by the above sleep 29, a drawback of displacement of the both the rocker arms 17f, 17f relative to each other can be prevented more effectively. Namely, the displacement of a positional relationship between both the rocker arms 17f, 17f from a proper positional relationship can be prevented effectively. Consequently, drawbacks associated with such a displacement can be prevented effectively. (As the drawback associated with the displacement, followings can be exemplified. A drawback occurring when the cam follower device is assembled such as the difficulty in insertion of the rocker arm shaft 5 into both the through holes 4a, 4a, a drawback of displacement in phases of the two valves 12, 12 which are to be pressed when using and a drawback of occurrence of partial contact in which the outer circumferential surface of the tappet roller 9 and the outer circumferential surface of the cam 2 do not contact in parallel due to the inclination of the center axis of the tappet roller 9.)
Additionally, the inner circumferential surfaces of both the through holes 4a, 4a whose axial dimension is small but an inner circumferential surface of the sleeve 29 whose axial dimension is sufficiently large is brought into slide contact with an outer circumferential surface of the rocker arm shaft 5. Thus, a sliding area relative to the outer circumferential surface of the rocker arm shaft 5 can be secured sufficiently, whereby wear amount at the outer circumferential surface of the rocker arm shaft 5 can be made sufficiently small. As a result, the duration of life of the rocker arm shaft 5 can be increased.
In addition, since it is not necessary to bring the inner circumferential surfaces of both the through holes 4a, 4a into slide contact with the outer circumferential surface of the rocker arm shaft 5, the thickness of both the rocker arms 17f, 17f can be made thinner.

[0042] Further, lubricant is supplied between the inner circumferential surface of the sleeve 29 and the outer circumferential rocker arm shaft 5 from openings at the end portions of the sleeve 29 during the running of the engine, whereby frictional force acting between both the circumferential surfaces is reduced sufficiently. Further, when carrying out this embodiment, if forming oil communication holes on at least one portion of an intermediate portion of the sleeve 29, which penetrate the portions in radial direction, the lubricant can be supplied to both the circumferential surface by this oil communication hole. Additionally, in this embodiment, too, the aforesaid shapes of the other end portions of the rocker arms 17a to 17e, 17h, 17i which are shown in Figs. 5 to 12 can be adopted as the shape of the other end portions of the pair of rocker arms. The other configuration and function are similar to those of the aforesaid first embodiment which is shown in Figs. 1 to 4.

[Eighth Embodiment]

[0043] Next, Fig. 19 shows an eighth embodiment of the invention. In this embodiment, a radial needle bearing 36 is provided between an inner circumferential surface of a cylindrical sleeve 29 and an outer circumferential surface of a rocker arm shaft 5. In conjunction with this, a pair of circular ring plates 37, 37 are fixedly joined to external surfaces of a pair of rocker arms 17f, 17f at peripheral portions of through holes 4a, 4a so that inner circumferential edges thereof are made to closely confront the outer circumferential surface of the rocker arm shaft 5. Thus, the radial needle bearing 36 is prevented from being dislocated to an outside of the sleeve 29 through openings at both ends thereof by inner circumferential edge portions of both the circular ring plates 37, 37. According to the cam follower device of this embodiment, since the swing resistance of the pair of rocker arms 17f, 17f about the rocker arm shaft 5 can be reduced by the radial needle bearing 36, the fuel consumption rate at the running of the engine can be reduced. The other configuration and function of this embodiment are similar to those of the aforesaid seventh embodiment.

[Ninth Embodiment]

[0044] Next, Figs. 20 to 22 show a ninth embodiment of the invention. In this embodiment which is different from the heretofore described first to eighth embodiments, a tappet roller 9 is supported rotatably around a circumference of a support shaft 7a via a radial needle bearing 10 and is disposed in an interval portion defined between intermediate portions of a pair of plate-shaped rocker arms 17g, 17g. Therefore, in this embodiment, a pair of support holes 8a, 8a in which both end portions of the support shaft 7a are press fitted (brought into serrated engagement with) are formed concentric with each other at the intermediate portions of the pair of plate-shaped rocker arms 17g, 17g in positions aligned with each other. In addition, spherically recessed portions 30, 30 (receiving portions) are provided on lower surfaces of one end portions (right end portions in Figs. 20 to 21) of both the rocker arms 17g, 17g. In contrast to this, projecting portions 18, 18 which are similar to those in the aforesaid first to second embodiments are provided on lower surfaces of the other end portions (left end portions in Figs. 20 to 21) of both the rocker arms 17g, 17g.

[0045] In an assembling state of the cam follower device of this embodiment to the valve train of the engine, as shown in Figs. 20 to 21, distal end faces of a pair of plungers 16, 16 which make up lash adjusters are caused to strike the spherically recessed portions 30, 30, respectively, and proximal end faces of two valve elements 12, 12 (two inlet valves or two exhaust valves which are provided for the same cylinder) are caused to strike distal end faces of both the projecting portions 18, 18, respectively. In association with this, an outer circumferential surface of a cam 2 fixed at an intermediate portion of a camshaft 1 is brought into abutment with an outer circumferential surface of the tappet roller 9. When the engine is running, in accordance with the rotation of the cam 2, both the rocker arms 17g, 17g are displaced in a swinging fashion about the abutment portion between the distal end faces of both the plungers 16, 16 and both the spherically recessed portions 30, 30 as centers (fulcrums) of their swing, so as to reciprocate the two valve elements 12, 12 in an axial direction by pressing force exerted by both the projecting portions 18, 18 and spring force by a return spring 13 (which is omitted in Figs. 20 to 22. Refer to Figs. 30, 34.).

[0046] As has been described above, also when making up a valve train by the use of the cam follower device of this embodiment, only by providing the single cam 2 and the single tappet roller 9, the two valve elements 12, 12 can be made to reciprocate simultaneously. Thus, compared with the case where only the conventional cam follower devices are built in the valve train, the use of the cam follower device of this embodiment as a cam follower device to be built in the valve train can reduce the number of components involved in the valve train. Consequently, the resulting valve train can be made smaller in size (space saving) and lighter in weight and can realize reductions in friction and production costs.

In addition, in this embodiment, too, similar to the cases of the aforesaid first to eighth embodiments, both the end portions of the support shaft 7a can press fitted in the support holes 8a, 8a without damaging an outer circumferential surface of an intermediate portion of the support shaft 7a. Therefore, as a hardening treatment applied to the surface of the support shaft 7a, an immersion quenching which is more inexpensive than induction hardening can be adopted. Consequently, the production costs can be suppressed.

In addition, in this embodiment, too, the aforesaid shapes of the other end portions of the rocker arms 17a to 17e, 17h, and 17i shown in Figs. 5 to 12 can be adopted as the shape of the other end portions of the pair of rocker arms. In addition, as to the receiving portions, various constructions can be adopted including a construction in which they are formed directly or via separate members at the one end portions of both the rocker arms. For example, a construction can also be adopted in which screw holes are provided at the one end portions of both the rocker arms and adjustment screws whose distal end portions are made into receiving portions are fixedly screwed into the screw holes, respectively.

[Tenth Embodiment]

[0047] Next, Fig. 23 shows a tenth embodiment of the invention. In this embodiment, an interval between distal end faces of a pair of plungers 16, 16 which constitute fulcrums and an interval between proximal end faces of a pair of valve elements 12, 12 which are to be pressed become far larger than those of the ninth embodiment. In contrast to this, in the case of this embodiment, as a tappet roller 9 which is disposed between intermediate portions of a pair of rocker arms 17n, 17n, a tappet roller 9 is used which has the same axial dimension as that of the tappet roller of the ninth embodiment. Therefore, in this embodiment, inclined plate portions 35a, 35b (non-parallel plate portions) are formed, respectively, between one end portions (right end portions in Fig. 23) and intermediate portions of both the rocker arms 17n, 17n and between the other end portions (left end portions in Fig. 23) and the intermediate portions of both the rocker arms 17n, 17n so as to be inclined in directions in which the inclined plate portions come nearer to each other as they extend towards the intermediate portions.

By this configuration, an interval between the one end portions of both the rocker arms 17n, 17n is expanded so as to match the interval between the distal end faces of both the plungers 16, 16, and an interval between the other end portions of both the rocker arms 17n, 17n is expanded so as to match the interval between both the valve elements 12, 12. In contrast, an interval between internal surfaces of the intermediate portions of both the rocker arms 17n, 17n is narrowed, so as to control an axial displacement permitted to the tappet roller 9 to a desired magnitude (a minute amount).

In this embodiment, too, there is provided an advantage that the axial dimension of the tappet roller 9 is not necessary to be increased so as to match the interval between the distal end faces of both the plungers 16, 16 and the interval between the proximal end faces of both the valve elements 12, 12. The other configuration and function are similar to those of the ninth embodiment.

[0048] The aforesaid advantage that the axial dimension of the tappet roller 9 is not necessary to be increased so as to match the interval between the distal end faces of both the plungers 16, 16 and the interval between the proximal end faces of both the valve elements 12, 12 can be obtained by other constructions.

As such constructions, for example, a construction as shown in Fig. 24A is considered in which thickness of a pair of rocker arms 17o, 17o are both made relatively large at intermediate portions of both the rocker arms 17o, 17o and are made relatively small at one end portions and the other end portions thereof, so that an interval between internal surfaces of both the rocker arms 17o, 17o which oppose to each other is made relatively narrow at the intermediate portions and is made relatively wide at the one end portions and the other end portions of both the rocker arms 17o, 17o. Alternatively, as shown in Fig. 24B, a construction can also be adopted in which spacers 32, 33 which are both fitted on a support shaft 7a are disposed in each of intervals defined between internal surfaces of a pair of rocker arms 17p, 17p and both axial end faces of the tappet roller 9.

[Eleventh Embodiment]

[0049] Figs. 25 to 27 show an eleventh embodiment of the invention. A cam follower device of this embodiment is built in a valve train of an engine (of an OHC or DOHC type) such as, for example, a three-valve engine, a four-valve engine or a fifth-valve engine in which the number of at least one of inlet valves and exhaust valves provided per cylinder is made to be two or more. The thus designed cam follower device of the embodiment includes a pair of plate-shaped rocker arms 17q, 17q which are identical to each other in shape and size, a single support shaft 7a and a single tappet roller 9.

[0050] Of these components, the pair of plate-shaped rocker arms 17q, 17q are disposed parallel to each other with a predetermined interval (the same pitch as a pitch at which a pair of valve elements 12, 12 are disposed) and are joined together so as to prohibit a relative displacement therebetween by a connecting portion 38 provided in at least one location. In addition, the support shaft 7a is fixed to one end portions (right end portions in Figs. 25 to 26) of both the rocker arms 17q, 17q so as to be extended therebetween. Because of this, a pair of support holes 8a, 8a is formed concentric with each other at the one end portions of both the rocker arms 17q, 17q in positions aligned with each other. In addition, after a hardening treatment by immersion quenching is applied to the whole surface of the support shaft 7a, by expanding the interval between the rocker arms 17q, 17q, both end portions of the support shaft 7a are press fitted, respectively, in insides of both the support holes 8a, 8a through openings lying on sides thereof which oppose to each other. In addition, in order to expand the interval between the rocker arms 17q, 17q, angles at connecting portions between the rocker arms 17q, 17q and the connecting portion 38 are increased (to a magnitude which exceeds 90 degrees).

Further, in this embodiment, the relative swing of both the rocker arms 17q, 17q about the support shaft 7a is prevented by the connecting portion 38. The tappet roller 9 is supported rotatably on an outer circumferential surface of an intermediate portion of the support shaft 7a via a radial needle bearing 10 (refer to Fig. 3). A pair of through holes 4, 4 is formed concentric with each other at intermediate portions of the rocker arms 17q, 17q in positions aligned with each other. A pair of projecting portions 18, 18 (pressing portions) is provided on lower surfaces of the other end portions (left end portions in Figs. 25 to 26) of the rocker arms 17q, 17q. Distal end faces of these projecting portions 18, 18 are each made into a partially cylindrical surface.

[0051] The above mentioned rocker arms 17q, 17q are fabricated in the following manner. Firstly, as shown in Fig. 27A, by applying stamping process to a single sheet metal, a pair of plate-shaped rocker arms 17q, 17q which are identical to each other in shape and size are formed so that the pair of plate-shaped rocker arms 17q, 17q are made integral by a connecting portion 38 provided in at least one location. Thereafter, as shown in Fig. 27B, both end portions of the connecting portion 38 are each bent through 90 degrees until the pair of rocker arms become parallel to each other, whereby the pair of plate-shaped rocker arms 17q, 17q are formed which are disposed parallel to each other with a predetermined interval provided therebetween and are connected together by the connecting portion 38 which is provided in at least one location so that relative displacement between the rocker arms 17q, 17q are disabled. Note that in the process of the bending process, both the end portions of the support shaft 7a having the tappet roller 9 provided around the circumference of the intermediate portion thereof can also be fitted in the support holes 8a, 8a, respectively.

[0052] As shown in Figs. 25 to 26, in an assembling state of the above rocker arms 17q, 17q to the valve train of the engine, a rocker shaft 5 as a stationary shaft is inserted in the respective through holes 4, 4 without looseness and interference therebetween, whereby the swing displacement of the rocker arms 17q, 17q about the rocker arm shaft 5 is enabled. In conjunction with this, an outer circumferential surface of the tappet roller 9 is brought into abutment with an outer circumferential surface of a cam 2 which is fixedly provided on a camshaft 1, and the distal end faces of the projecting portions 18, 18 are caused to strike individually proximal end faces of the two valve elements 12, 12 (the two inlet valves or the two exhaust valves provided for the same cylinder). When the engine is running, the rocker arms 17q, 17q are displaced in a swinging fashion about the rocker arm shaft 5 in synchronism with each other as the cam 2 rotates, so as to reciprocate the two valve elements 12, 12 in an axial direction by pressing force exerted by both the projecting portions 18, 18 and spring force produced by a return spring 13 (not shown. Refer to Fig. 30, 34.).

[0053] As has been described above, when using the cam follower device of this embodiment, only by providing the single cam 2 and the single tappet roller 9, the two valve elements 12, 12 can be reciprocated simultaneously. Therefore, compared with the case where only the conventional cam follower devices are built in the valve train (the independent cam follower device is built in each valve element), the number of components in the valve train can be reduced. Consequently, the resulting valve train can be made smaller in size (space saving) and lighter in weight and can realize reductions in friction and production costs.

In addition, in this embodiment, since the construction is adopted in which the interval between the rocker arms 17q, 17q can be expanded by increasing the angles at the bending portions from the connecting portion 38, the end portions of the support shaft 7a can be press fitted, respectively, in the pair of support holes 8a, 8a without damaging the outer circumferential surface of the intermediate portion of the support shaft 7a. Thus, an immersion quenching, which can be implemented inexpensive relative to induction hardening, can be adopted as a hardening treatment applied to the surface of the support shaft 7a. Consequently, the production costs can be suppressed.

In addition, by forming the support shaft 7a into a circular tubular shape and providing an oil supply hole at an axially intermediate portion thereof, it also becomes possible to supply oil to the radial needle bearing 10. Similarly, by forming the rocker arm shaft 5 into a circular tubular shape and providing oil holes at an axially intermediate portion of the rocker arm shaft 5 in positions lying in insides of the through holes 4, 4, a slide contact portion between inner circumferential surfaces of the through holes 4, 4 and the outer circumferential surface of the rocker arm shaft 5 can be lubricated.

[Twelfth Embodiment]

[0054] Figs. 28 to 29 show a twelfth embodiment of the invention. In this embodiment, cylindrical portions 39, 39 are formed by burring process which is applied to peripheral portions of through holes 4b, 4b provided at intermediate portions of a pair of rocker arms 17r, 17r, which are disposed parallel to each other with a predetermined interval and are connected by a connecting portion 38 in at least one location so as to disable relative displacement. These cylindrical portions 39, 39 secure an insertion length of a rocker arm shaft 5 (refer to Fig. 26) into the respective through holes 4b, 4b and suppress wear at the swing support portions. Since the configuration and function of other portions are like to those of the cam follower device illustrated in the eleventh embodiment, the description of like portions will be omitted herein.

[0055] Note that, in the invention, the connecting portion which connects integrally the pair of rocker arms to each other can be formed on the edges of the rocker arms in positions which cause no problem when being built in the cam follower device, when the cam follower device is assembled on to the engine and when the cam follower device is incorporated in the engine. However, in consideration of enhancement in performance of the engine (follow-up properties when the engine is running at high revolution speeds) to which the rocker arms are incorporated, the position where the connecting portion is formed is desirably as close to the through hole into which the rocker arm shaft is inserted as possible. This is because the inertia moment around the rocker arm shaft can be suppressed to a smaller level as the connecting portion forming position comes closer to the through hole.

[0056] Note that in the respective embodiments that have been described heretofore, the construction (the single-roller type) is adopted in which the single tappet roller is disposed round the support shaft. However, when carrying out the invention, a construction (a double-roller type) can also be adopted in which two outside diameter side and inside diameter side tappet rollers which are combined concentrically and relatively rotatably are disposed around the circumference of the support shaft.

In addition, although not shown, the construction of the invention can also be applied to a screw type adjuster system, an HLA system in which the cam follower device of the invention is combined with lash adjusters and the like.

[0057] This patent application is based on Japanese Patent Application (No. 2006-96399) filed on March 31, 2006, Japanese PatentApplication (No. 2006-238741) filed on September 4, 2006 and Japanese Patent Application (No. 2006-282123) filed on October 17, 2006, and the contents thereof are incorporated herein in their entireties by reference.

Claims

1. A cam follower device that is built in a valve train of an engine in which a number of at least one of inlet valves and exhaust valves which are to be provided per cylinder is two or more, comprising:

a pair of rocker arms which are disposed parallel to each other with a predetermined interval provided therebetween and have a pair of support holes which are concentric with each other at one end portions or intermediate portions thereof in positions which are aligned with each other;
a support shaft which is fixed to both the rocker arms so as to be extended between the rocker arms by fitting both end portions in the support holes, respectively;
a tappet roller which is supported rotatably around a periphery of an intermediate portion of the support shaft, an outer circumferential surface of the tappet roller being capable of abutting with an outer circumferential surface of a cam which is fixed on a camshaft when the cam follower device is built in the valve train; and
a pair of pressing portions which are provided directly or via a separate member at the other end portions of both the rocker arms, the pair of pressing portions being capable of striking individually proximal end faces of two inlet valves or two exhaust valves when the cam follower device is built in the valve train.

2. The cam follower device as set forth in Claim 1, wherein the pair of rocker arms is formed separately.

3. The cam follower device as set forth in Claim 2, wherein
the pair of support holes are formed at the one end portions of the pair of rocker arms, and
a pair of through holes, into which a rocker arm shaft provided in parallel with the camshaft is capable of being inserted when the cam follower device is built in the valve train, are formed at the intermediate portions of the rocker arms in positions which are aligned with each other, so as to enable a swinging displacement of both the rocker arms.

4. The cam follower device as set forth in Claim 3, wherein
an interval between inner surfaces of both the rocker arms which confront each other are made relatively narrow at the one end portions and relatively wide at the other end portions of both the rocker arms by making thickness of both the rocker arms relatively large at the one end portions and relatively small at the other end portions of both the rocker arms.

5. The cam follower device as set forth in Claim 3, wherein
an interval between inner surfaces of both the rocker arms which confront each other are made relatively narrow at the one end portions and relatively wide at the other end portions of both the rocker arms by providing non-parallel plate portions which are not parallel to the intermediate portions of both the rocker arms at portions between the one end portions and the intermediate portions or between the intermediate portions and the other end portions of both the rocker arms.

6. The cam follower device as set forth in Claim 3, wherein
both end portions of a cylindrical sleeve are inwardly fitted and fixed, respectively, in the pair of through holes and
the rocker arm shaft is inserted into an inside of the sleeve.

7. The cam follower device as set forth in Claim 2, wherein
the pair of support holes are formed at the intermediate portions of the pair of rocker arms, and
the one end portions of both the rocker arms have a pair of receiving portions which are provided thereon directly or via separate members and with which distal end faces of a pair of plungers is capable of being brought into abutment when the cam follower device is built in the valve train, so as to enable a swinging displacement of both the rocker arms about abutment portions between the receiving portions and the distal end faces of the pair of plungers as fulcrums.

8. The cam follower device as set forth in Claim 7, wherein
an interval between inner surfaces of both the rocker arms which confront each other are made relatively narrow at the one end portions and relatively wide at the other end portions of both the rocker arms by making thickness of both the rocker arms relatively large at the one end portions and relatively small at the other end portions of both the rocker arms.

9. The cam follower device as set forth in Claim 7, wherein
an interval between inner surfaces of both the rocker

arms which confront each other are made relatively narrow at the one end portions and relatively wide at the other end portions of both the rocker arms by providing non-parallel plate portions which are not parallel to the intermediate portions of both the rocker arms at portions between the one end portions and the intermediate portions or between the intermediate portions and the other end portions of both the rocker arms.

10. The cam follower device as set forth in Claim 1, wherein
an axial displacement amount allowed to the tappet roller is controlled to a desired magnitude by disposing spacers which are fitted on the support shaft, respectively, between inner surfaces of both the rocker arms and both axial end faces of the tappet roller.

11. The cam follower device as set forth in Claim 1, wherein
thickness of portions of both the rocker arms which need to have a higher strength than that of peripheral areas thereof are larger than thickness of the peripheral areas.

12. The cam follower device as set forth in Claim 2, wherein
the pair of rocker arms is each formed by applying stamping process to a single sheet metal.

13. The cam follower device as set forth in Claim 1, wherein
the pair of rocker arms is connected together by a connecting portion provided in at least one location so as to prohibit a relative displacement.

14. The cam follower device as set forth in Claim 13, wherein
the pair of support holes are formed at the one end portions of the pair of rocker arms, and
a pair of through holes into which a rocker arm shaft provided in parallel with the camshaft is capable of being inserted when the cam follower device is built in the valve train, are formed at the intermediate portions of the rocker arms in positions which are aligned with each other, so as to enable a swinging displacement of both the rocker arms.

15. The cam follower device as set forth in Claim 13, wherein
the pair of rocker arms which are connected together by the connecting portion provided in at least the one location so as to prohibit a relative displacement are made by applying stamping process and bending process to a single sheet metal.

Fig. 1

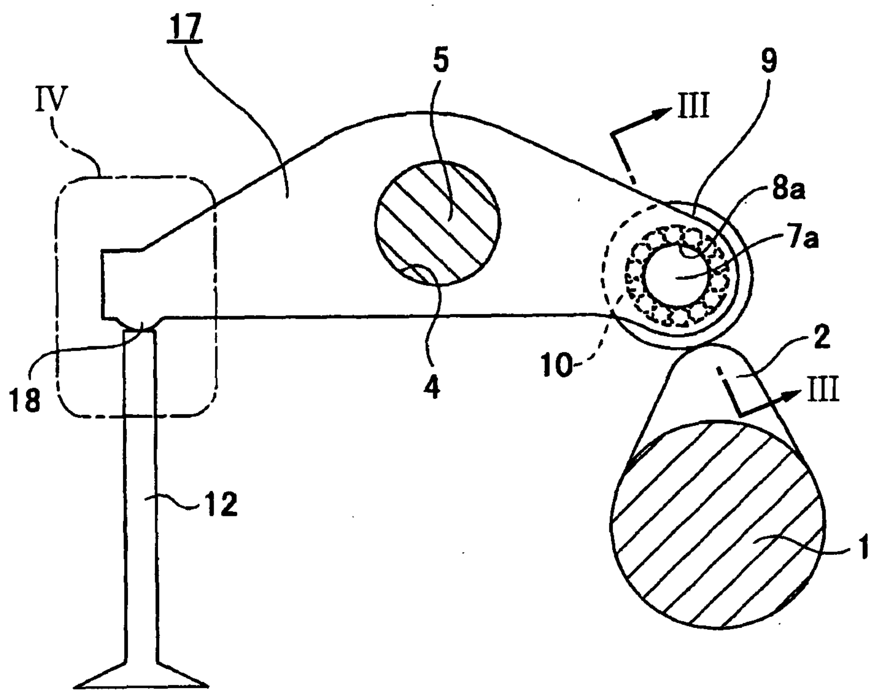


Fig. 2

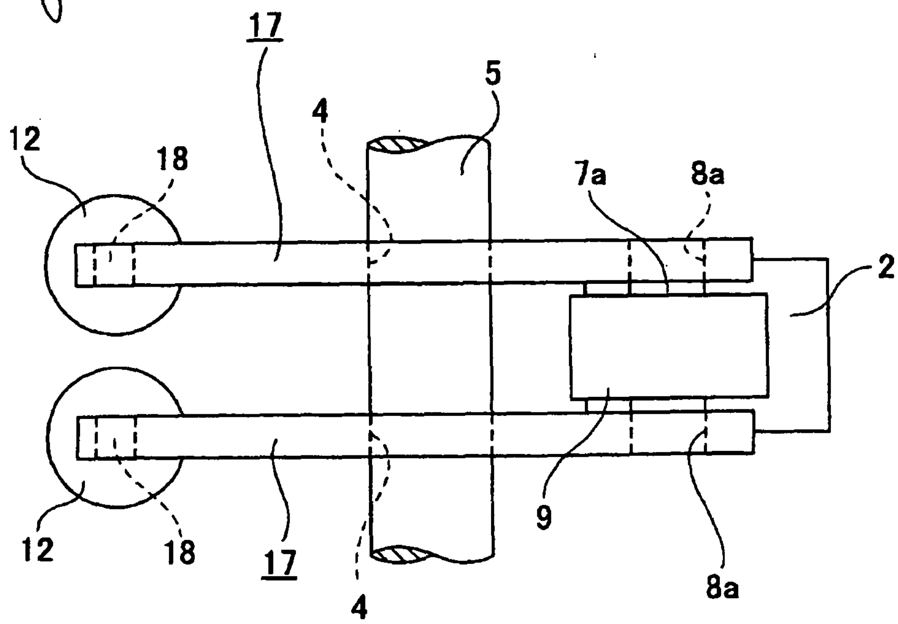


Fig. 3

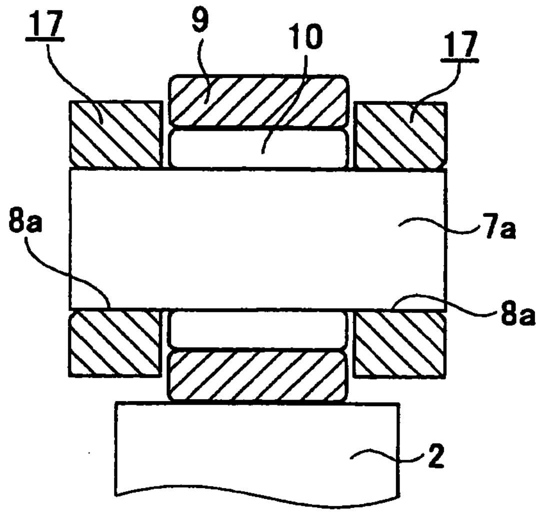


Fig. 4

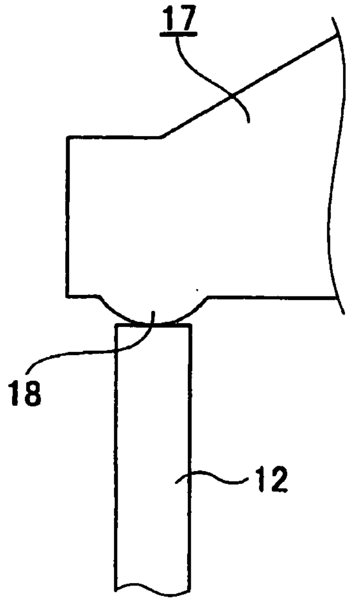


Fig. 5

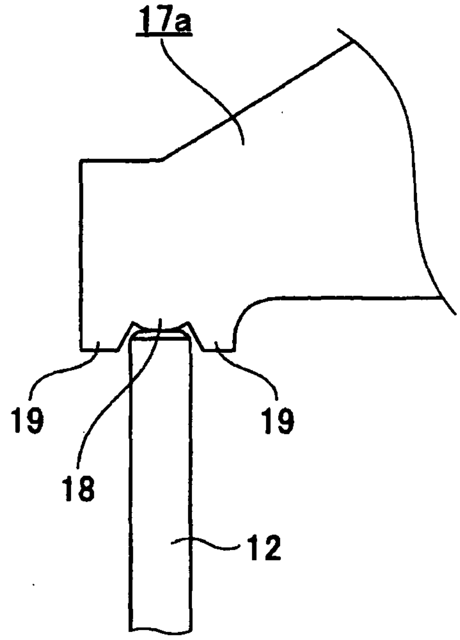


Fig. 6

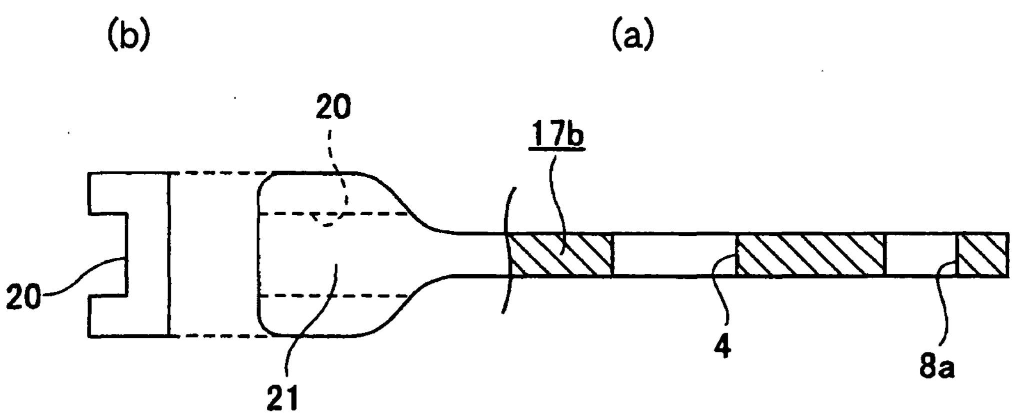


Fig. 7

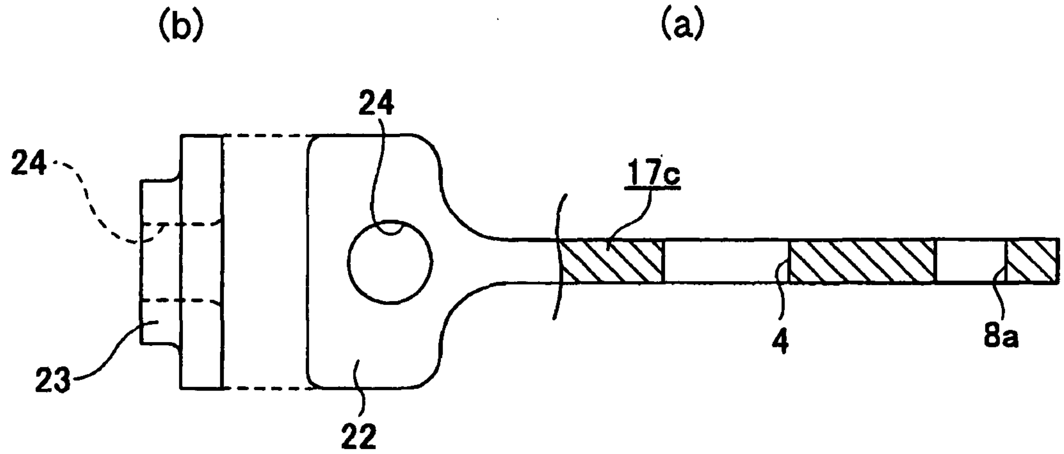


Fig. 8

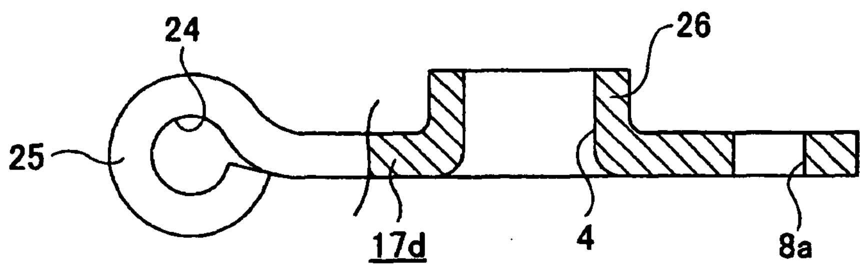


Fig. 9

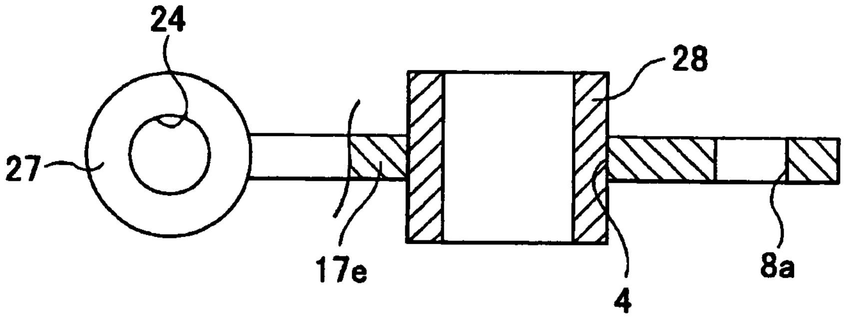


Fig. 10

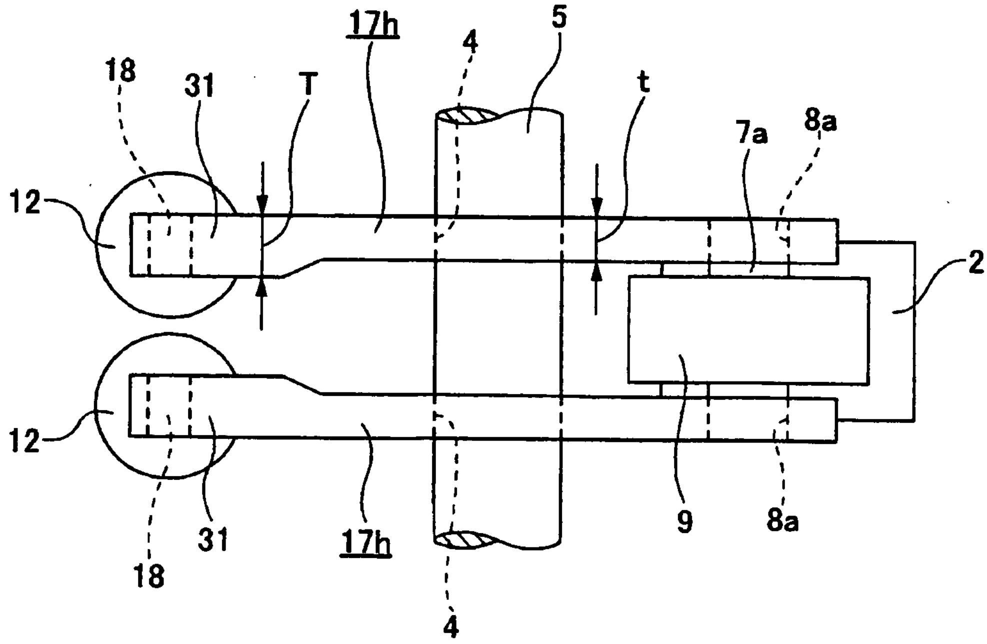


Fig. 11

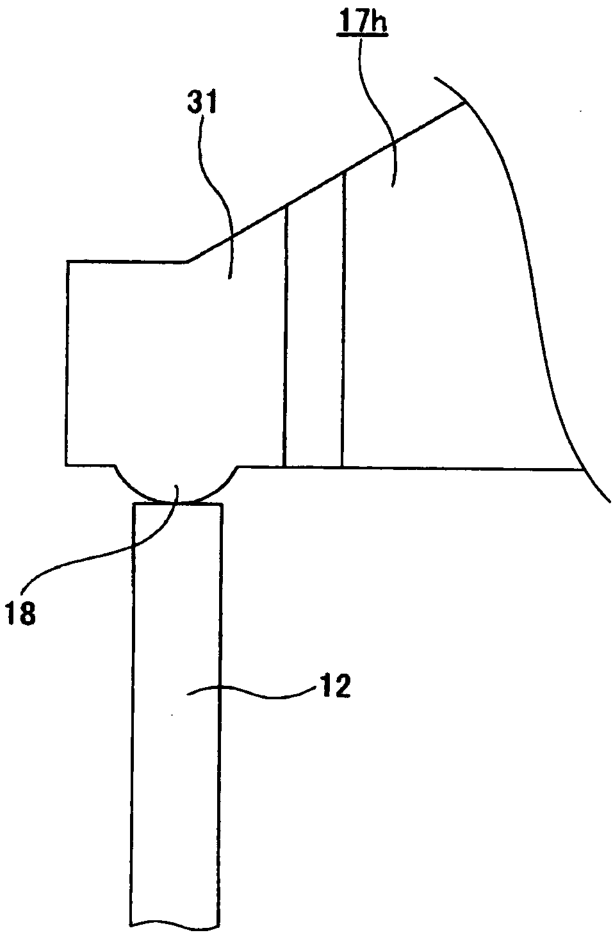


Fig. 12

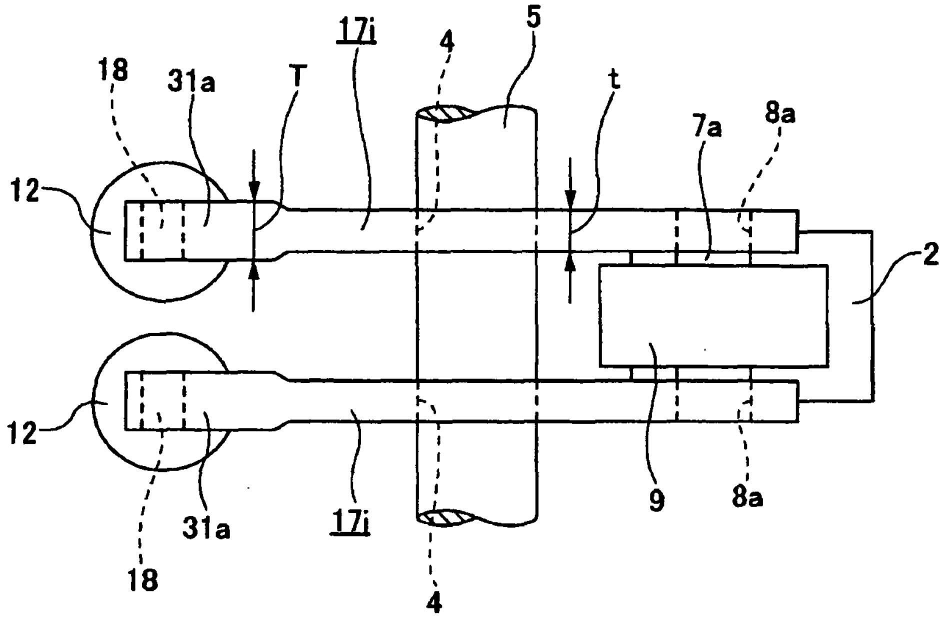
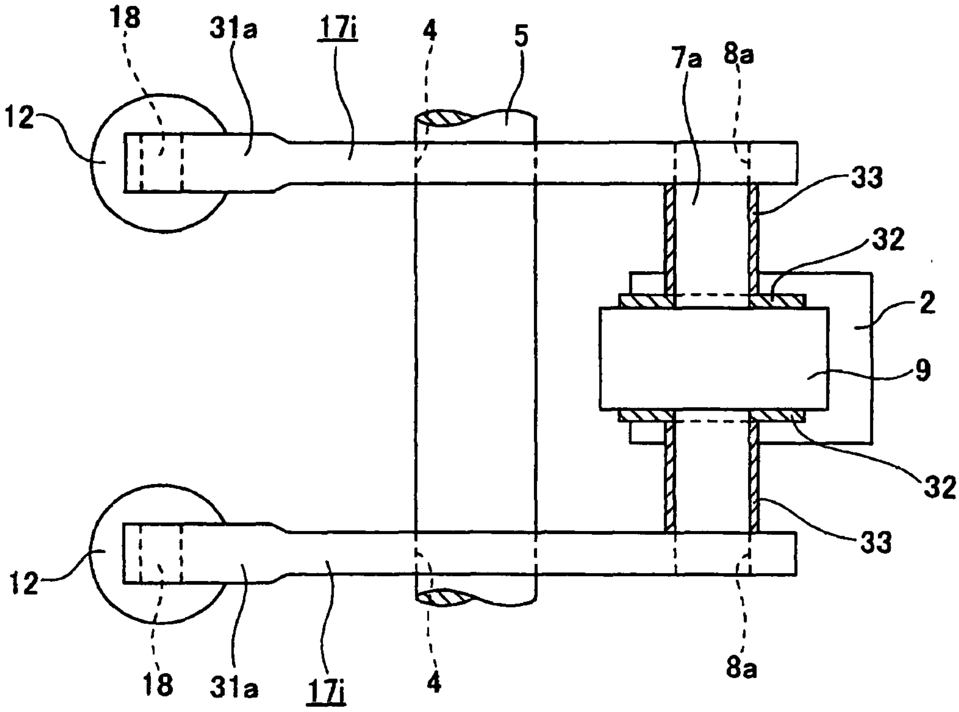

17i
5
4
18
31a
T
t
8a
7a
12
2
12
9
8a
31a
17i
18
4

Fig. 13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31a
17i
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8a
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31a
17i
4

Fig. 14

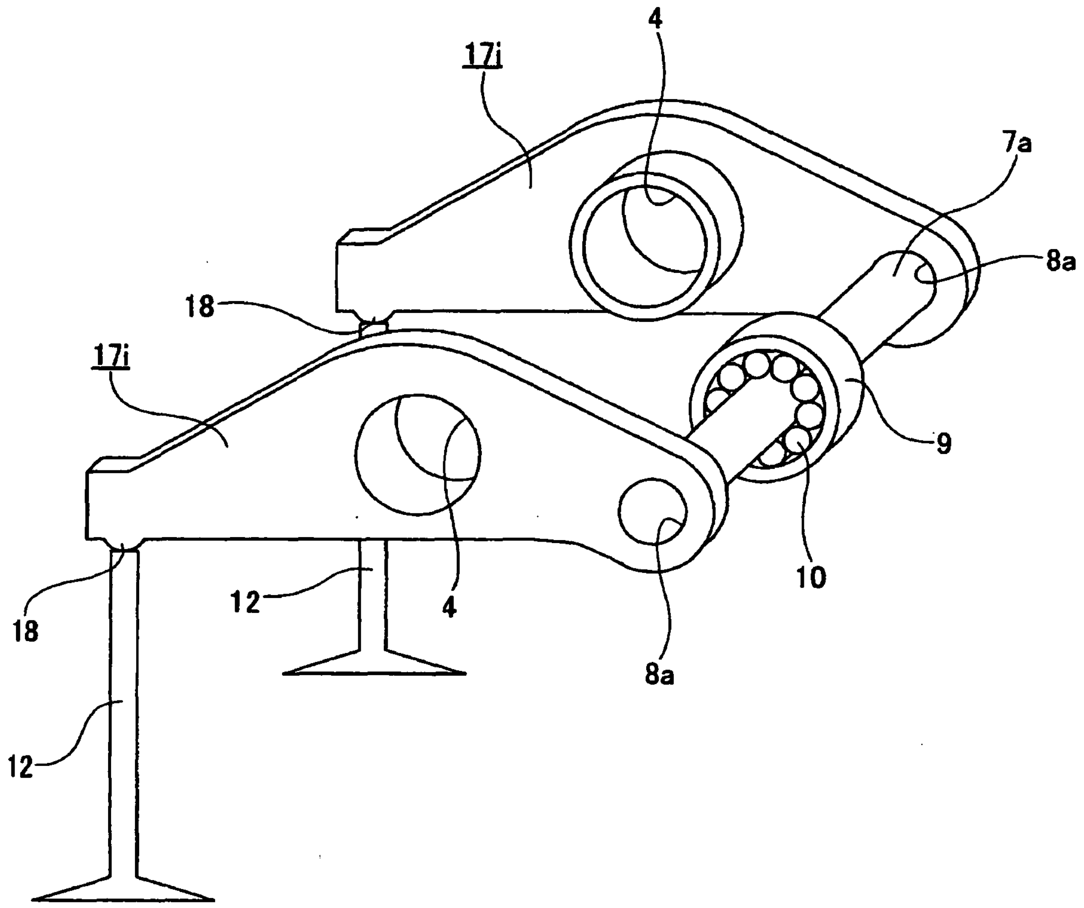
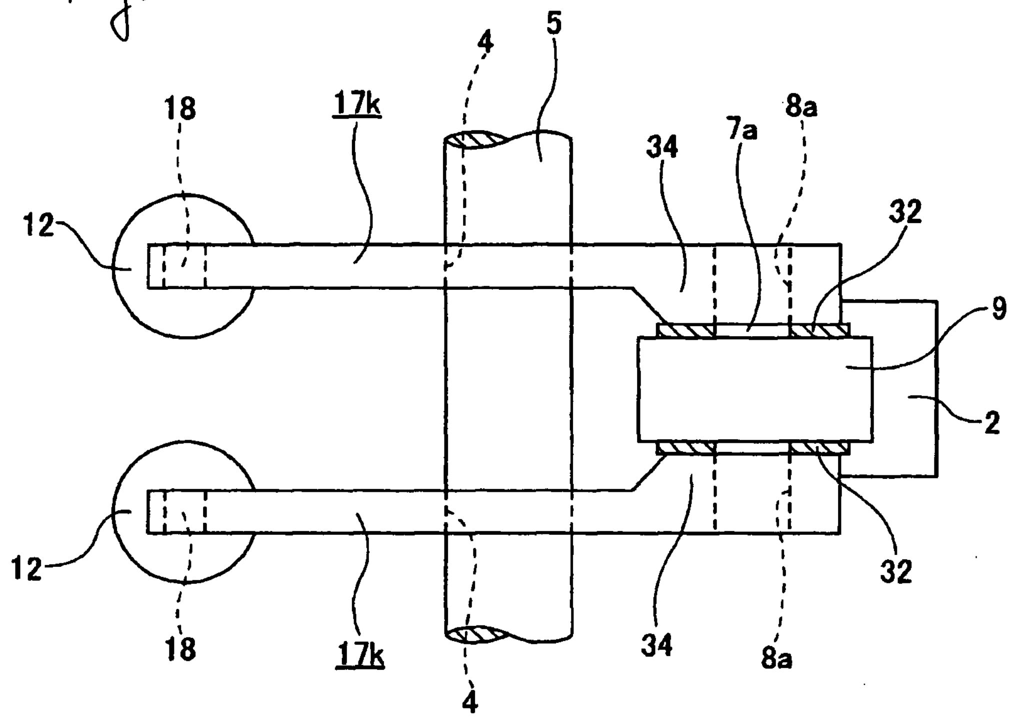


Fig. 15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7a
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32
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9
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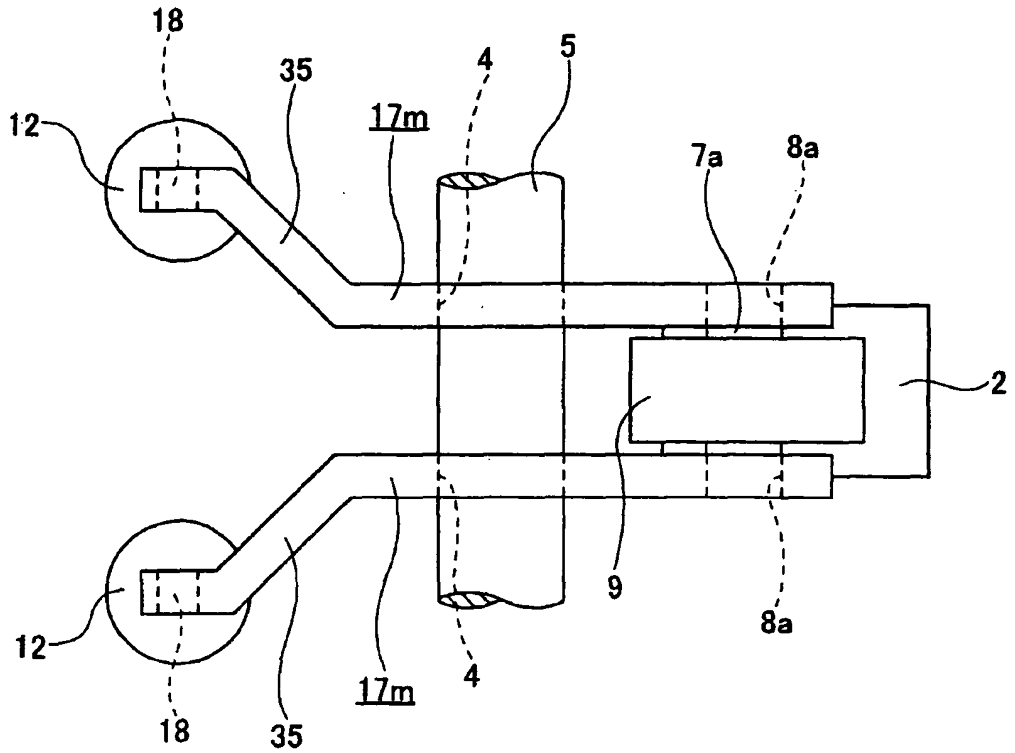
8a
4

Fig. 16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17m
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18
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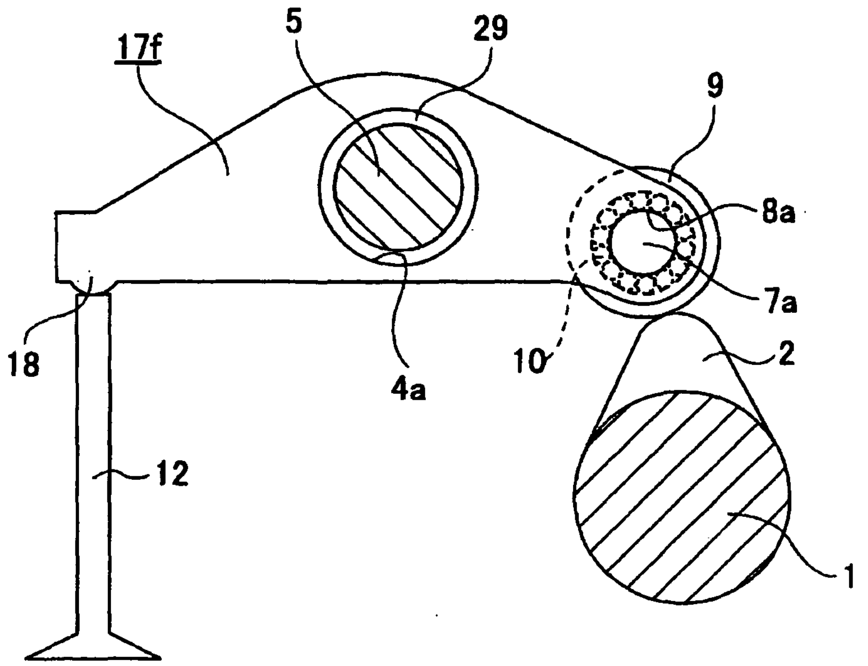
Fig. 17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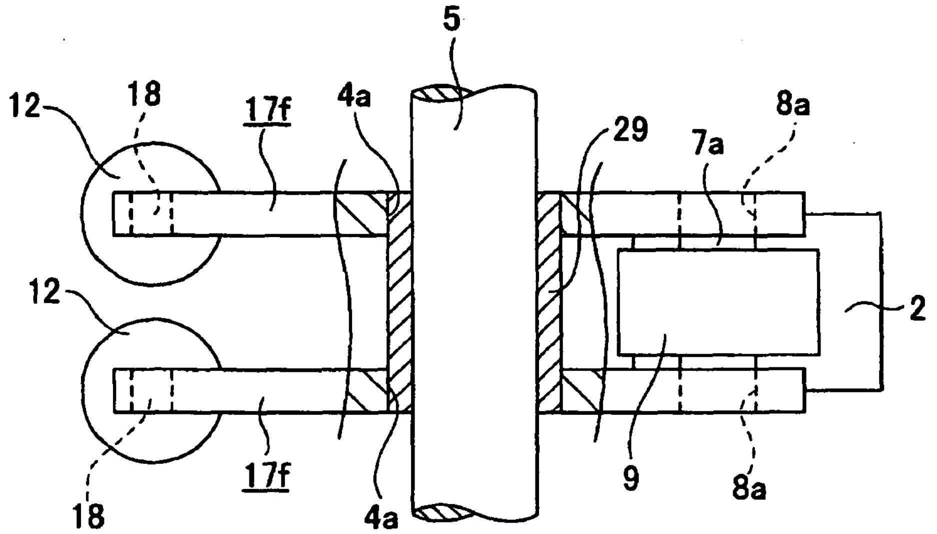
12
1

Fig. 18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29
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8a
18
4a

Fig. 19

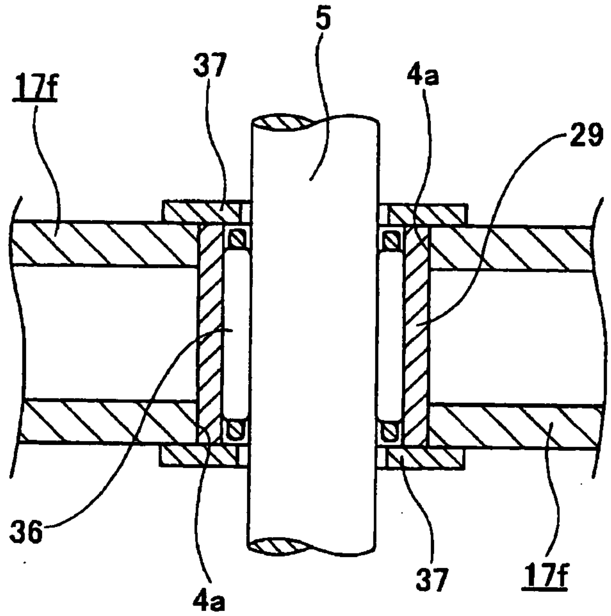


Fig 20

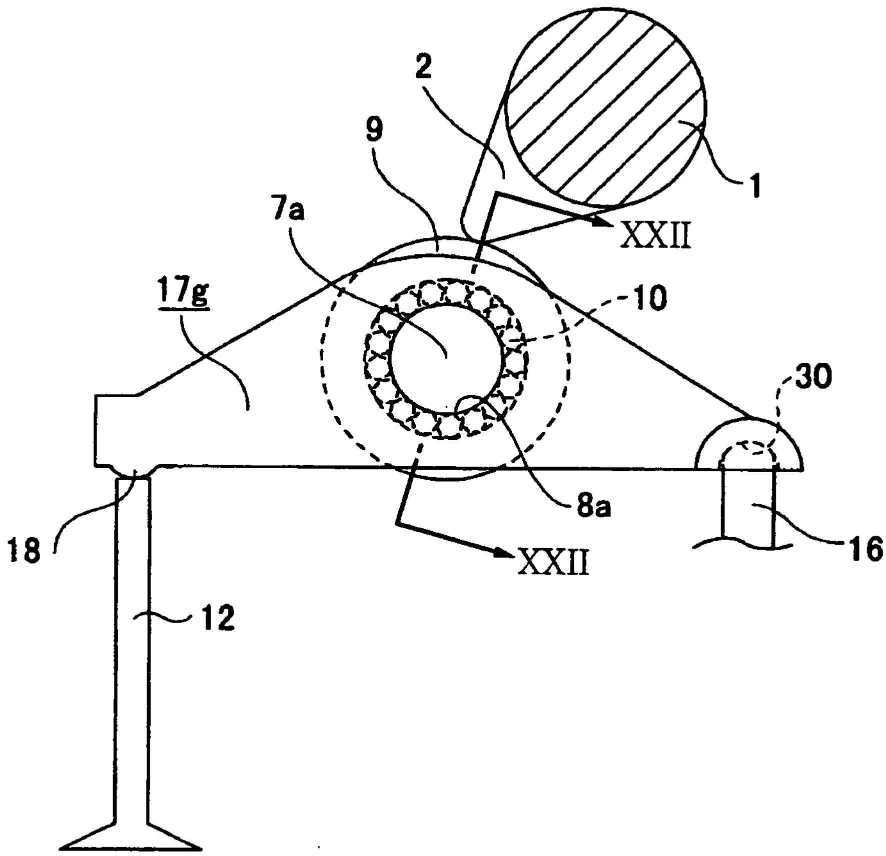


Fig. 21

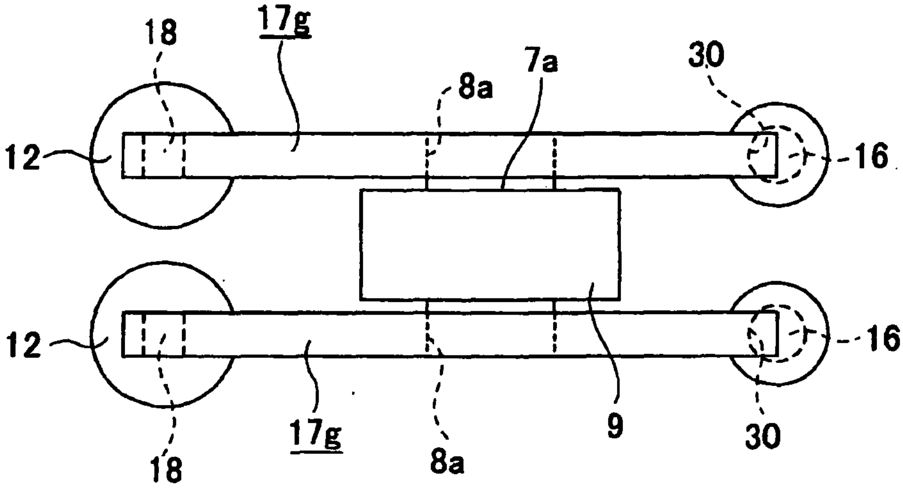


Fig. 22

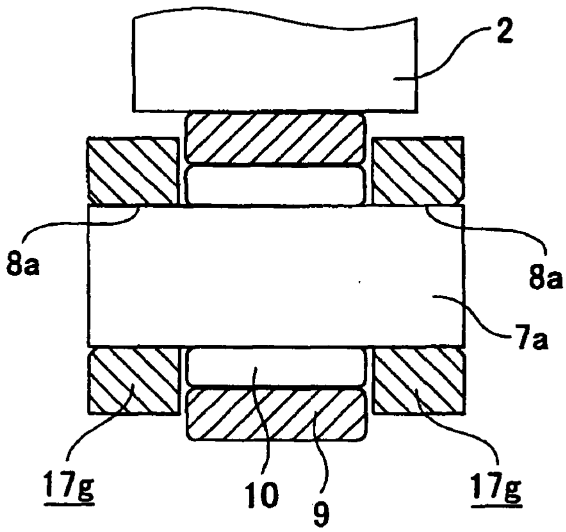


Fig. 23

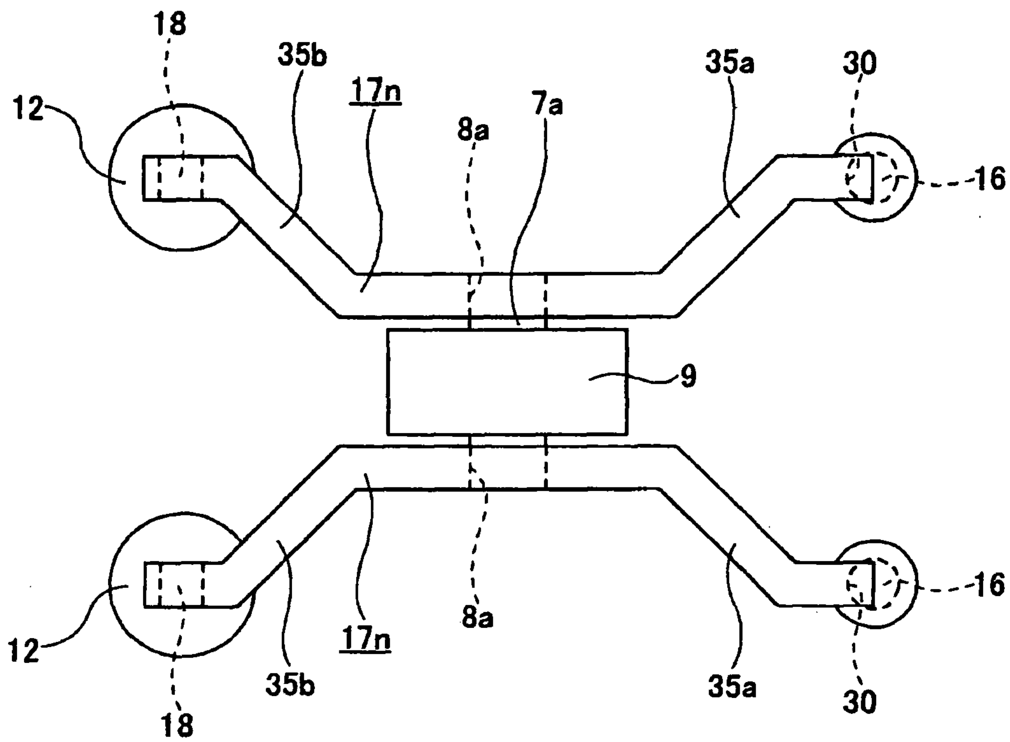


Fig. 24A

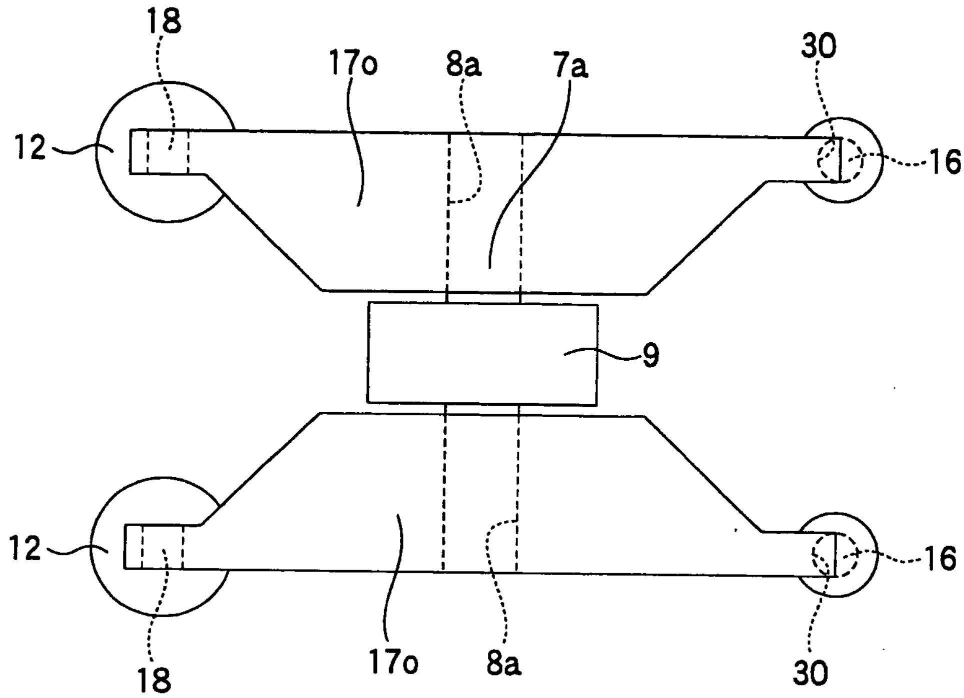


Fig. 24B

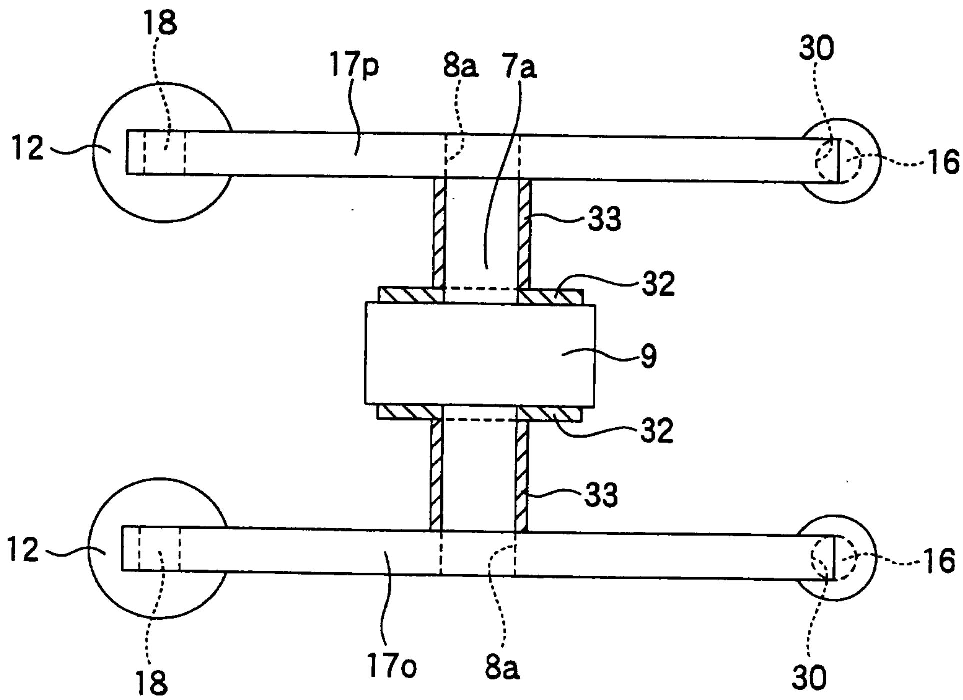


Fig.25

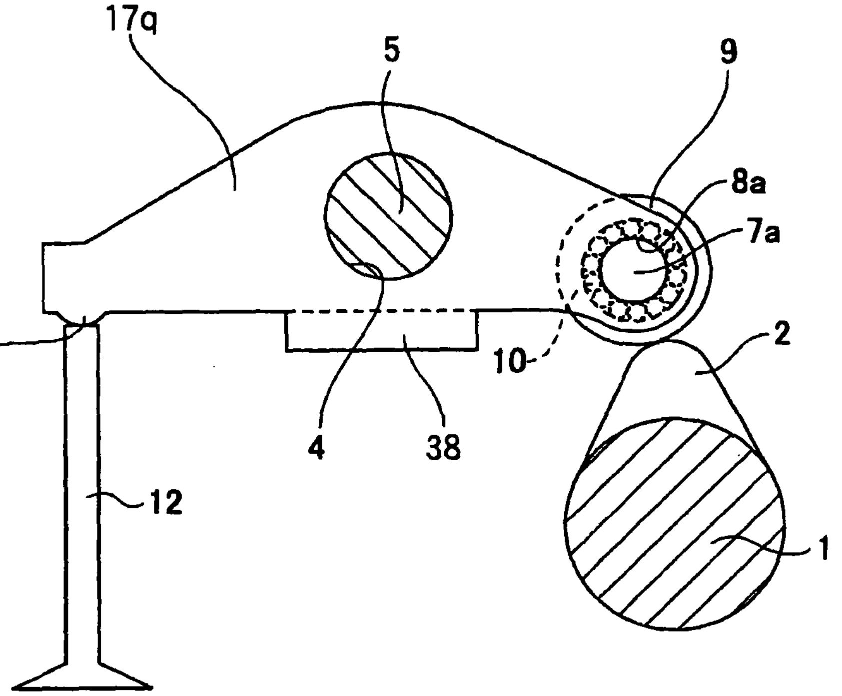


Fig.26

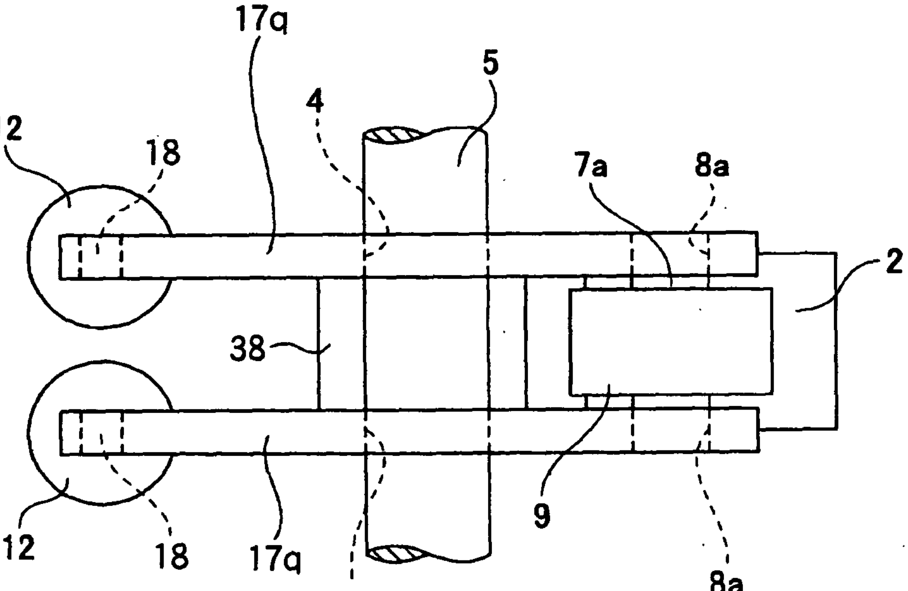


Fig. 27A

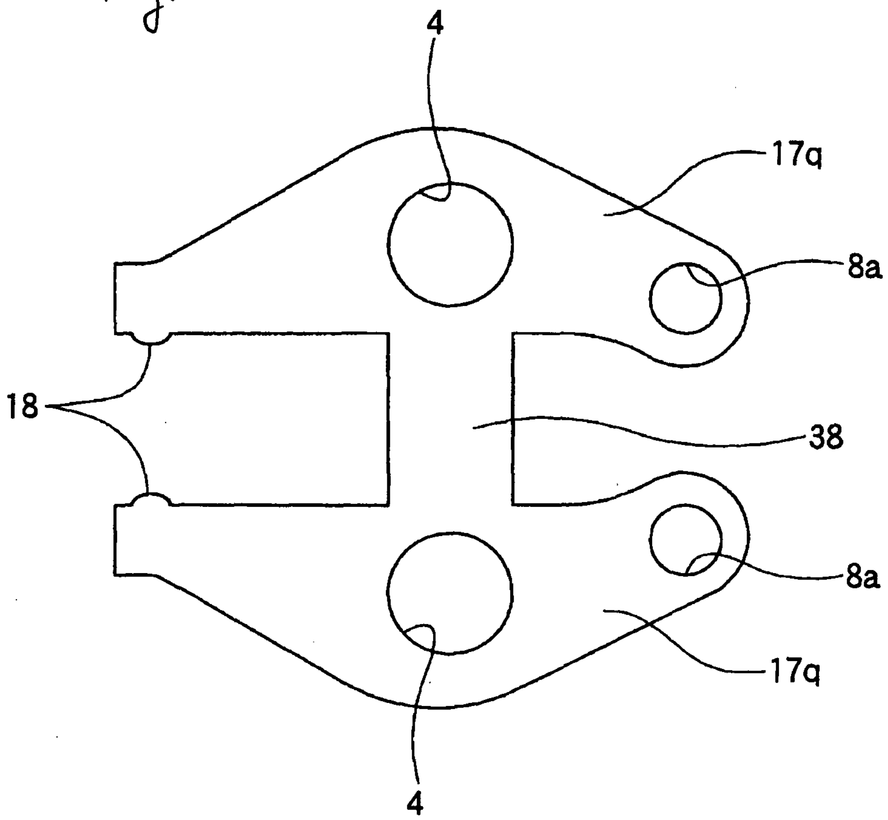


Fig. 27B

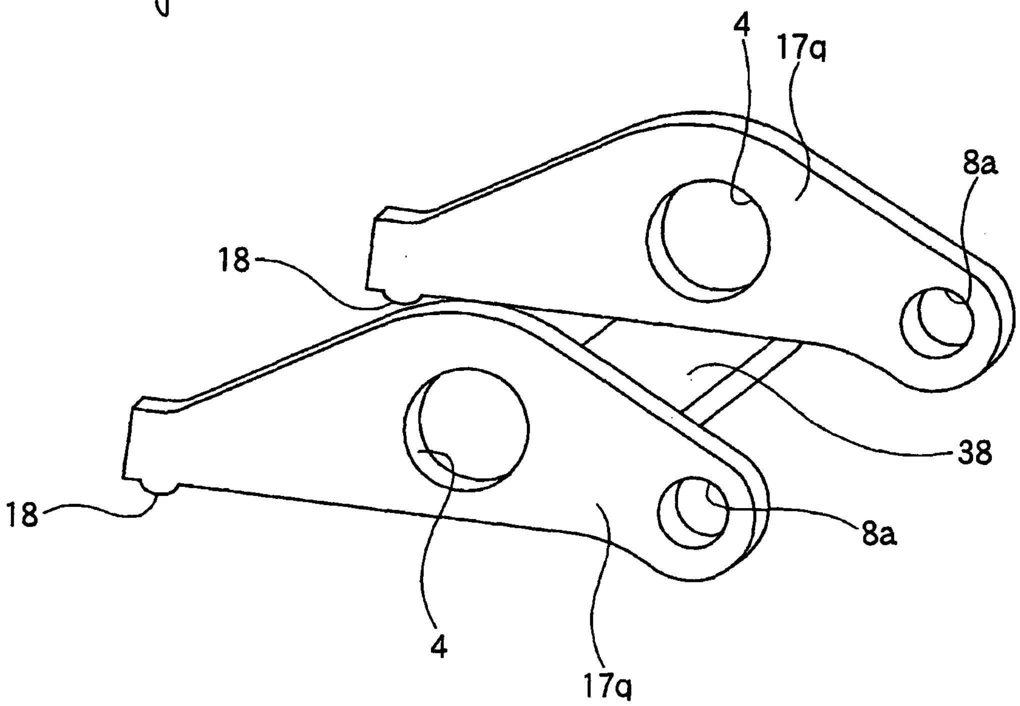


Fig. 28

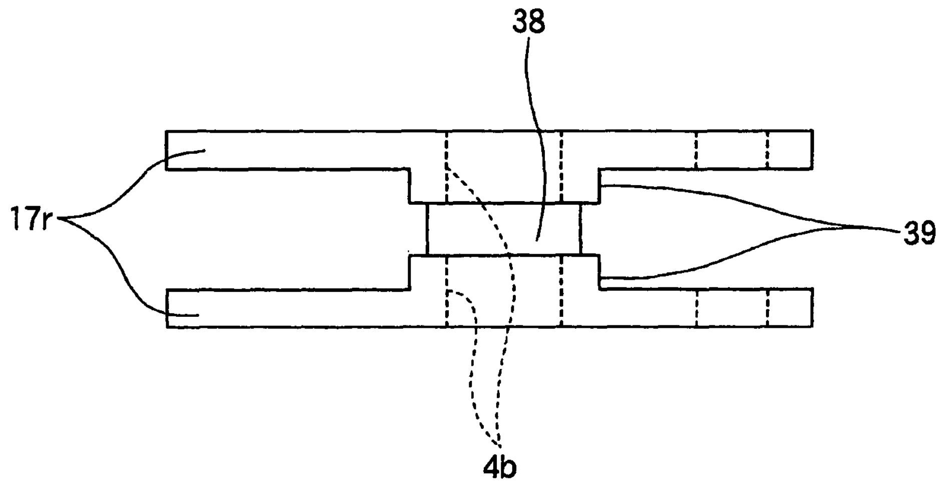


Fig. 29

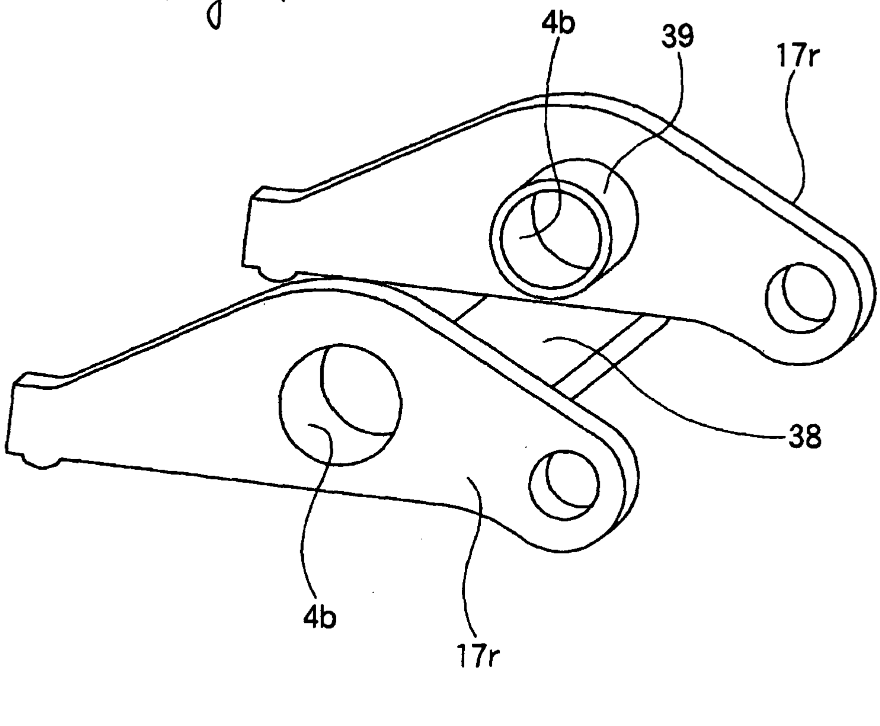


Fig. 30

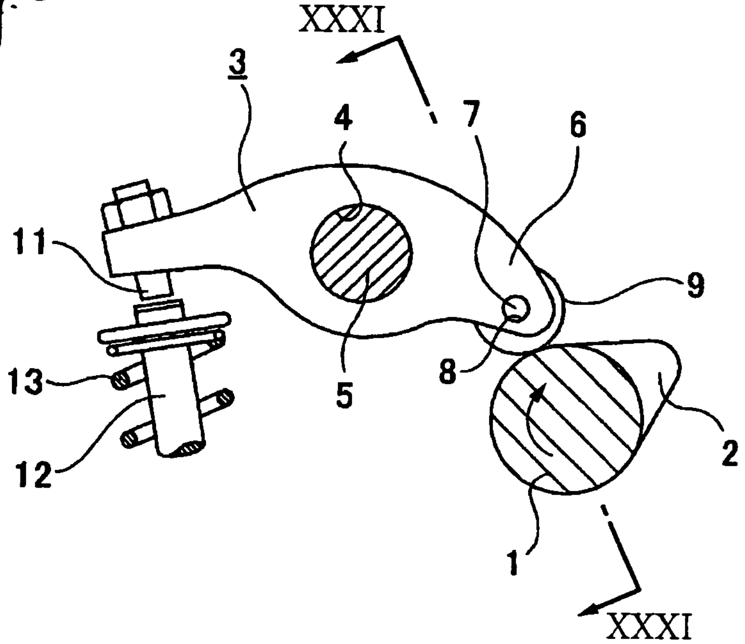


Fig. 31

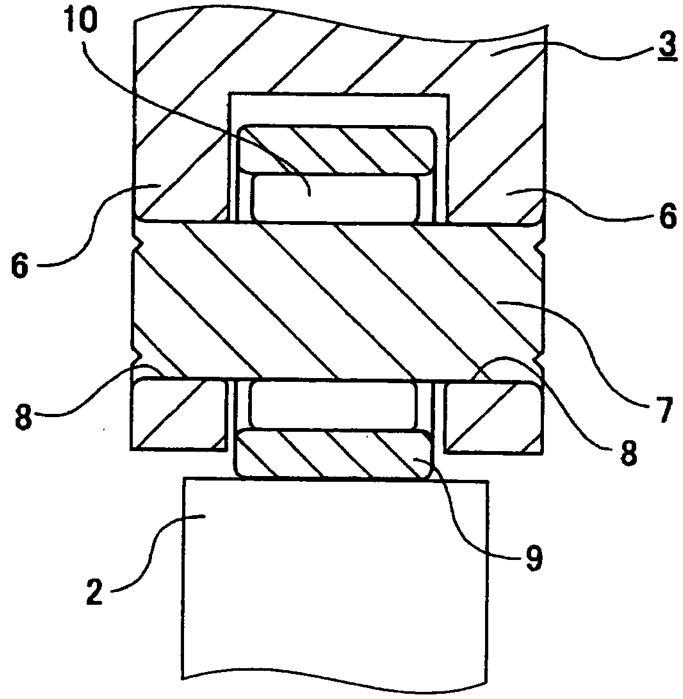


Fig. 32

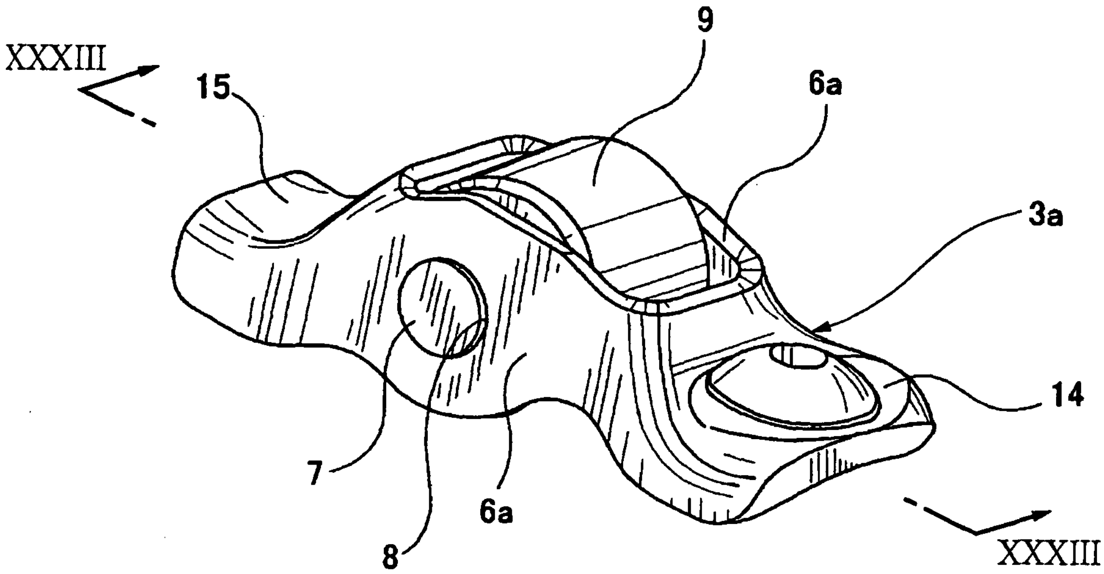
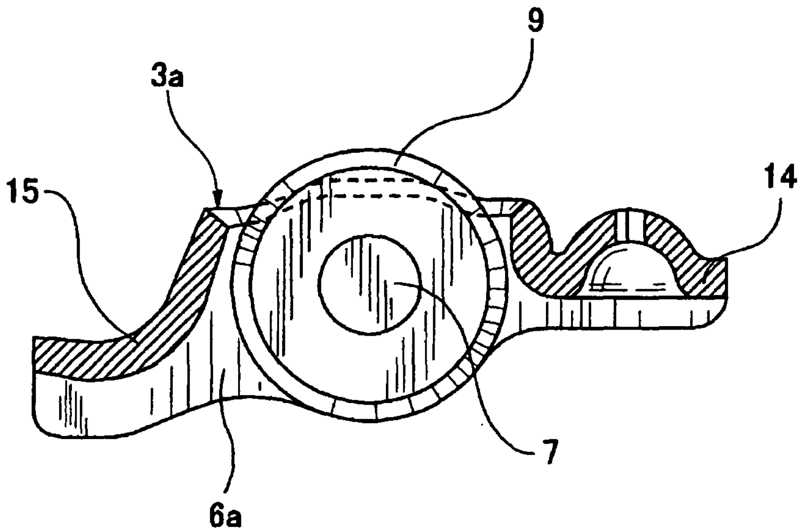


Fig. 33



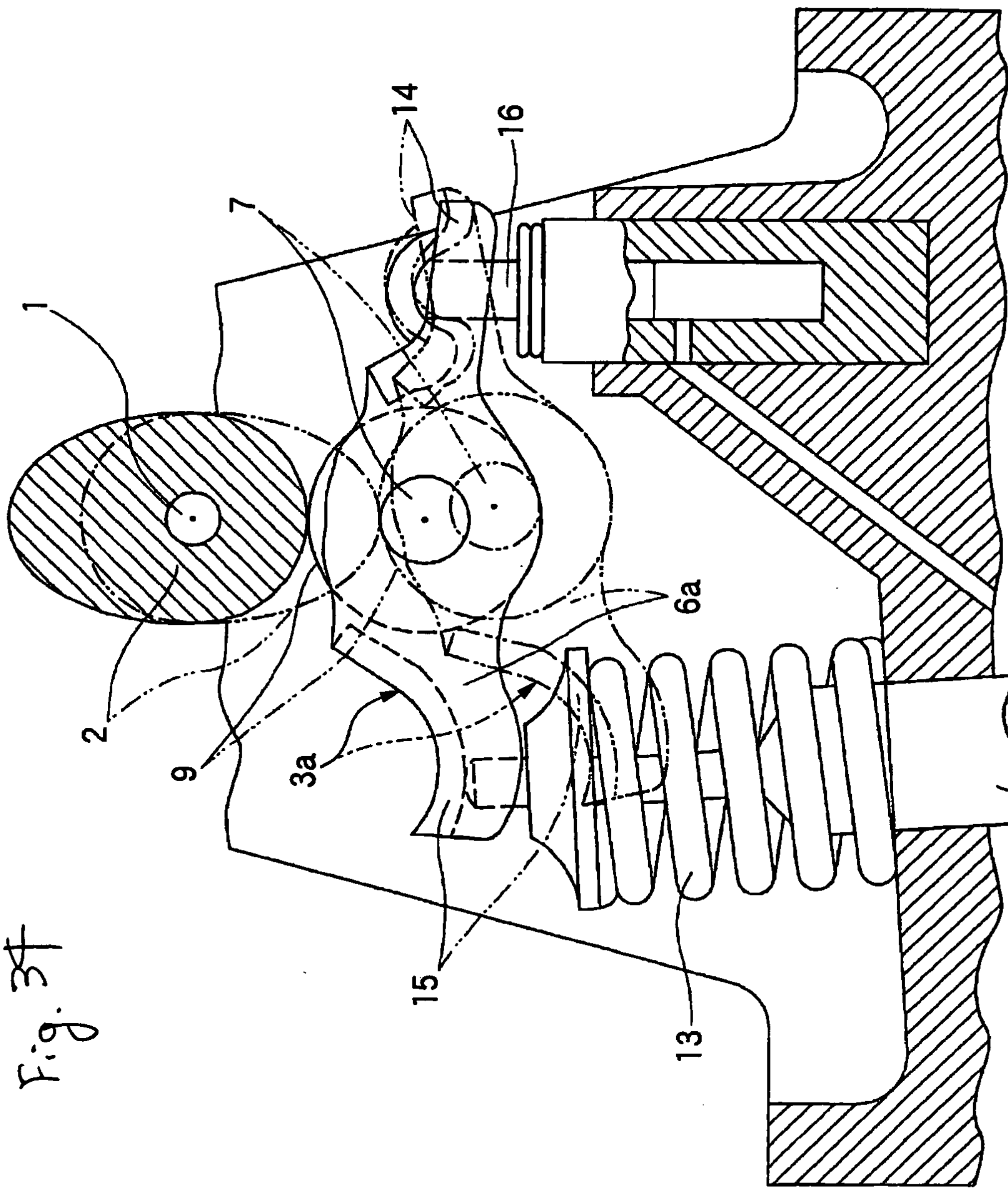


Fig. 37

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2004100499 A **[0009]**
- JP 2006096399 A **[0057]**
- JP 2006238741 A **[0057]**
- JP 2006282123 A **[0057]**