



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication:
27.06.2007 Bulletin 2007/26

(51) Int Cl.:
F01L 1/18 (2006.01) C22C 38/00 (2006.01)

(21) Application number: **05738624.5**

(86) International application number:
PCT/JP2005/008671

(22) Date of filing: **12.05.2005**

(87) International publication number:
WO 2006/013663 (09.02.2006 Gazette 2006/06)

(84) Designated Contracting States:
DE

(30) Priority: **04.08.2004 JP 2004228038**

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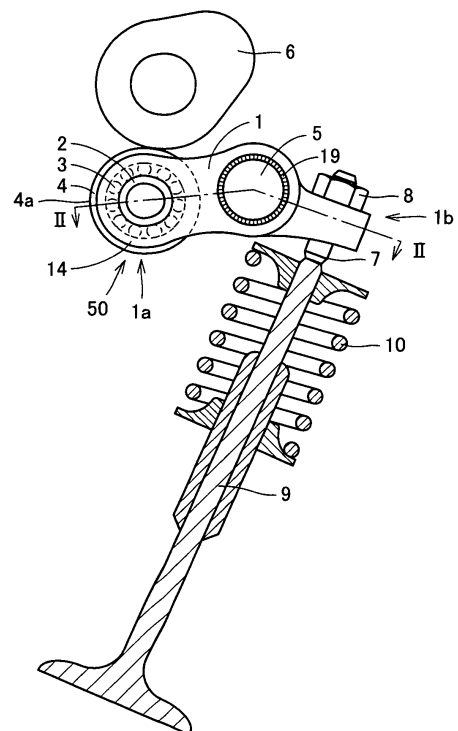
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(54) **BEARING FOR LOCKER ARM**

(57) A bearing (50) for a rocker arm includes a shaft (2) corresponding to an inner race fixed to a rocker arm (1) interposed between an engine valve (9) and a cam (6) to adjust intake and exhaust, an outer race (4) in contact with the cam (6), located outer to the inner race (2), and a plurality of needle rollers (3) located between the outer race (4) and the inner race (2). The outer race (4) includes a nitrogen-enriched layer. The grain size number of austenite crystal grains in the nitrogen-enriched layer is in a range exceeding No. 10. The outer race outside cylindrical surface (4a) has random small concave pits.

FIG.1



Description

Technical Field

5 [0001] The present invention relates to a bearing used in a rocker arm employed for opening/closing an intake valve or exhaust valve of a motor engine. More specifically, the present invention relates to a rocker arm bearing having a long lifetime with respect to peeling.

Background Art

10 [0002] The approach of improving mileage is known by incorporating a rolling bearing in a rocker arm and forming contact between the outside cylindrical perimeter of the outer race and the cam of the engine to reduce the friction generated at the valve gear system. The full complement type roller bearing is used for recent rocker arm bearings when it is employed for opening/closing the engine intake valve and exhaust valve. The full complement type roller bearing is now often used in high speed and high load applications. Particularly, in such full complement type roller bearings absent of cages, interference occurs between rollers, and/or positioning of the rollers cannot be controlled smoothly, resulting in the generation of roller skew. Furthermore, the lubricant may not be supplied smoothly into the bearing, causing an event of poor lubrication. This will induce sliding heat generation, local rise in contact pressure, insufficient lubrication, and the like. Although the bearing has a great load capacity as well as sufficient lifetime with respect to the required lifetime from the numerical calculation perspective, surface damage (peeling, smearing, surface origin type flaking) and/or internal origin type flaking occurs in a short period of time of usage, whereby the bearing cannot function appropriately any longer.

15 [0003] In applications where the outer race forms rolling contact with a cam such as a rocker arm bearing employed in opening/closing engine intake valves and exhaust valves, attention was conventionally focused on the outer circumferential portion of the outer race, and development was conducted directed to improving the outer circumferential portion. For example, it is known to sequentially provide, from the surface to the interior, a layer with compressive residual stress by shot peening and the like, a layer containing retained austenite, and a quench-hardened layer (Japanese Patent Laying-Open No. 2-168022 (Patent Document 1)).

20 [0004] Patent Document 1: Japanese Patent Laying-Open No. 2-168022

Disclosure of the Invention

Problems to be Solved by the Invention

35 [0005] The cam component has a poor lubrication condition among the engine components. By variation in the rotating speed of the bearing outer race as well as abrupt change in the active load due to the cam configuration, absolute rolling movement is not possible, and contact with sliding is effected. Furthermore, the demand for higher speed, smaller size, and higher stress places a further severe usage environment. Thus, there is a problem that the outside cylindrical surface of the rocker arm bearing exhibits peeling damage even when subjected to the measures set forth above. An object of the present invention is to provide a rocker arm bearing including an outer race that can have peeling damage suppressed more reliably under such severe circumstances of the usage condition.

Means for Solving the Problem

45 [0006] A rocker arm bearing of the present invention includes a shaft corresponding to an inner race fixed to the rocker arm that is interposed between an engine valve and a cam to adjust intake and exhaust, an outer race located outer to said inner race and in contact with said cam, and a plurality of rolling elements located between said outer race and inner race. The outer race includes a nitrogen-enriched layer. The grain size number of the austenite crystal grains in the nitrogen-enriched layer is in a range exceeding No. 10. Small concave pits are formed randomly at the surface of the outside cylindrical perimeter of the outer race.

50 [0007] According to another aspect of the present invention, a rocker arm bearing of the present invention includes a shaft corresponding to an inner race fixed to the rocker arm that is interposed between an engine valve and a cam to adjust intake and exhaust, and an outer race located outer to the inner race and in contact with the cam. In this rocker arm bearing, the outer race includes a nitrogen-enriched layer. The grain size number of austenite crystal grains in the nitrogen-enriched layer is in a range exceeding No. 10. Small concave pits are formed randomly at the surface of the outside cylindrical perimeter of the outer race. The rocker arm bearing is of the type absent of a rolling element, and with the inner race and outer race forming sliding contact directly.

55 [0008] The small concave pits formed randomly on the surface of the outside cylindrical perimeter of the outer race

is set such that, when the surface roughness is represented by the parameter value of R_{qni} (ISO International Standard), the ratio of the axial surface roughness $R_{qni}(L)$ to the circumferential surface roughness $R_{qni}(C)$, i.e. $R_{qni}(L)/R_{qni}(C)$, is at most 1.0, and the surface roughness parameter value of Sk is at most -1.6.

[0009] By the structure set forth above, occurrence of peeling can be suppressed to allow a longer lifetime. As used herein, R_{qni} represents the roughness corresponding to the root mean square roughness R_q of the JIS (former RMS). The peak Z is measured across a reference length l_r in the x direction, and the surface roughness is obtained by $R_q = [(1/l_r) \int Z^2(x) dx]^{1/2}$. Integration $\int$ is conducted from the reference position of zero up to l_r . $R_{qni}(L)$ takes the aforementioned reference length in the axial direction. $R_{qni}(C)$ takes the reference length in the direction of the circumference, i.e. the circumferential direction of the outside cylindrical surface of the outer race. The ratio $R_{qni}(L)/R_{qni}(C)$ of 1.0 and below implies that there are large depressions and projections along the circumferential direction of the outside cylindrical perimeter. For example, it implies that a groove is formed along the axial direction. The axial small groove serves as an oil dam, facilitating formation of an oil film at the outside cylindrical surface of the outer race.

[0010] The surface roughness parameter Sk refers to the skewness of the distribution curve of the surface depressions and projections. The Sk value of a symmetric distribution such as a Gaussian distribution is 0. The Sk value corresponds to skewness Rsk (skew Sk) of the roughness curve based on the JIS, and is defined by the following equation:

$$Rsk = (l / R_q^3) \times \{ (l / l_r) \int Z^3(x) dx \}$$

[0011] Integration $\int$ is conducted from the reference zero position up to l_r . When the surface roughness parameter Sk takes a negative value, the surface configuration corresponds to the case where a projection has a flat top with rounded corners, and a plurality of such inversed U-shaped projections are provided continuously with an acute valley between the projections. (For the sake of reference, when the Sk value is positive, the surface configuration corresponds to the case where steep projections are located, spaced apart from each other, with an U-shaped valley between the steep projections). By setting the parameter Sk value to the average of -1.6 at most in both the circumferential and axial directions, the configuration and distribution of the surface depression will become advantageous to form an oil film through the processing conditions.

Effect of the Invention

[0012] As apparent from the description set forth above, a rocker arm bearing including an outer race that can have peeling damage suppressed is provided by the rocker arm bearing of the present invention.

Brief Description of the Drawings

[0013]

Fig. 1 shows a rocker arm including a rolling bearing according to an embodiment of the present invention.

Fig. 2 is a sectional view taken along line II-II of Fig. 1.

Fig. 3 shows another type of a rocker arm including a rolling bearing according to an embodiment of the present invention.

Fig. 4 shows a further type of a rocker arm including a rolling bearing according to an embodiment of the present invention.

Fig. 5 is an enlarged view of the portion of the rolling bearing of Fig. 4.

Fig. 6 represents a heat treatment pattern applied to at least one of an inner race, outer race, and rolling element of the rolling bearing of the present invention.

Fig. 7 represents a heat treatment pattern of a modification of Fig. 6, applied to at least one of an inner race, outer race, and rolling element of the rolling bearing of the present invention.

Fig. 8A represents austenite grains (microstructure) of the rolling bearing component of the present invention.

Fig. 8B represents austenite grains (microstructure) of a conventional rolling bearing component.

Fig. 9A represents the austenite grain boundary based on a diagrammatic form of Fig. 8A.

Fig. 9B represents the austenite grain boundary based on a diagrammatic form of Fig. 8B.

Fig. 10 represents the distribution of the Sk value and R_{qni} distribution at the surface of the outer race of a bearing of the present invention and a bearing of a conventional example.

Fig. 11 represents an example of the depression and projection pattern in the circumferential direction at the surface of the outer race in the example of the present invention.

Fig. 12 represents the oil film formation rate of the outer race of the present invention.

Fig. 13 represents the oil film formation rate of a conventional outer race.

Description of the Reference Characters

[0014] 1 rocker arm, 2 inner race (roller shaft), 3 needle roller (rolling element), 4 outer race (roller), 4a surface of outside cylindrical perimeter of outer race, 5 rocker arm shaft (rotation shaft), 6 cam, 7 adjust screw, 8 lock nut, 9 valve, 10 spring, 14 inner race support, 19 bearing metal, 21 drive roll, 22 guide roll, 23 (3/4) "ball, 31 rolling fatigue life test sample, 50 rocker arm bearing, 52 inner race incorporated into rolling fatigue life testing machine, 53 needle roller, 54 outer race incorporated into rolling fatigue lifetime testing machine, 55, 56 weight load member of rolling fatigue life testing machine, T1 carbonitriding temperature, T2 quenching heat temperature.

Best Modes for Carrying Out the Invention

[0015] Embodiments of the present invention will be described hereinafter with reference to the drawings. Referring to Figs. 1 and 2, a rocker arm 1 identified as a swinging member is supported rotatably to a rocker arm shaft (rotation shaft) 5 at the center region via a bearing metal 19 or the like. At the other end 1b of rocker arm 1, an adjust screw 7 is screwed on. Adjust screw 7 is fixed by a lock nut 8. The lower end of adjust screw 7 abuts against the upper end of a valve 9 that is an intake valve or exhaust valve of an internal combustion engine. Valve 9 is energized by the resilience of spring 10.

[0016] Rocker arm 1 has a rolling bearing 50 provided at one end 1a. A shaft 2 corresponding to the inner race of rolling bearing 50 is supported by an inner race support 14 formed to have a bifurcated configuration. Respective ends of shaft 2 corresponding to the inner race are pressed-fitted, double-end caulked, or fixed by snap rings to the bifurcated inner race support 14. Roller 4 constituting the outer race is supported rotatably to the center portion of the outer circumferential plane of inner race 2 via a needle roller 3. Needle roller 3 constitutes the bearing located between inner race 2 and outer race 4. In other words, a rolling element (needle roller) 3 is interposed between inner race 2 and outer race 4. The direction of the axis of needle roller 3 is arranged parallel to the axis of the inner race. Outer race 4 has its outer circumferential place abut against the surface of cam 6 provided at the cam shaft through the urge of spring 10.

[0017] Inner race 2, rolling elements of needle rollers 3, and outer race 4 constituting the rolling bearing is employed as the full complement type roller bearing for a rocker arm. In general, a roller bearing without a cage is referred to as a full complement type roller bearing. Since the rocker arm full complement type roller bearing set forth above rolls while forming contact with cam 6, the urging force and impulsive force of cam 6 act on outer race 4. The engine rocker arm according to the embodiment of the present invention is a member including the foregoing rocker arm full complement type roller bearing. Inner race 2 is not limited to a hollow shaft, and may be a solid shaft.

[0018] Furthermore, a sliding bearing absent of a needle roller may be employed instead of the aforementioned configuration including a rolling element, i.e. a needle roller. In other words, the type in which the inner race forms sliding contact with the outer race by the direct contact between the shaft corresponding to the inner race and the outer race, absent of a needle roller, may be employed. In this case, the rocker arm bearing can be made compact and reduction in weight can be effected economically since there are fewer components.

[0019] Outer race 4 includes a nitrogen-enriched layer. The structure of the nitrogen-enriched layer is rendered microscopic to a degree where the grain size number of the austenite crystal grains therein exceeds No. 10. Furthermore, a surface 4a of the outside cylindrical perimeter of outer race 4 has small concave pits formed at random. The surface is treated such that, when the surface roughness is represented by the surface roughness parameter of R_{qni} (ISO International Standard), the ratio of the axial surface roughness $R_{qni}(L)$ to the circumferential surface roughness $R_{qni}(C)$, i.e. $R_{qni}(L)/R_{qni}(C)$, becomes 1.0 at most, and the surface roughness parameter Sk becomes -1.6 at most.

[0020] The measurement method and condition of parameters Sk and R_{qni} can be exemplified as set forth below. When the superficial aspects represented by these parameters are to be measured based on the constituent elements of the rolling element and races of the rolling bearing, measurements from two sites opposite to each other in the direction of the diameter, for example, may be acquired, although the measurement of one site can be taken as a reliable representative value.

[0021] Parameter calculation standard: JIS B 0601:1994 (SURFCOM, JIS 1994)

Cut off type: Gaussian

Measurement length: 5λ

Cut off wavelength: 0.25 mm

Measurement magnification: $\times 10000$

Measurement speed: 0.30 mm/s

Site of measurement: center region of roller

Number of measurements: 2

Measurement device: surface roughness measurement device SURFCOM 1400A (TOKYO SEIMITSU CO., LTD.)

[0022] An engine rocker arm bearing according to another embodiment of the present invention will be described with reference to Fig. 3. A rocker arm rolling bearing 50 includes a shaft 2 corresponding to an inner race fixed to an inner race bore (not shown) across two sidewalls, formed open between one end 1b and the other end 1a of rocker arm 1. An end of engine valve 9 abuts against one end 1b. A pivot not shown is fitted to the other end 1a. Rocker arm 1 with a pivot hole 15 is urged by spring 10 in a predetermined direction around the pivot, and receives the driving force transmitted from cam 6 at roller 4 constituting the outer race to move valve 9 against the urging force of said spring.

[0023] An engine rocker arm according to a further embodiment of the present invention will be described with reference to Figs. 4 and 5. Referring to Fig. 4, a rotation shaft 5 is disposed at the central region of rocker arm 1 such that rocker arm 1 turns about rotation shaft 5. Rocker arm 1 has one end 1b abut against an end of engine valve 9 and the other end 1a abut against an end of an interlock rod 16. Adjust screw 7 functions to adjust the position of abutment between the other end 1a of the rocker arm and interlock rod 16.

[0024] A rocker arm rolling bearing (rocker arm full complement type roller bearing) 50 is attached by an attachment member 17 to a hollow bearing attachment 16a located at the lower end of interlock rod 16. Cam 6 abuts against outer race 4 of the full complement type roller bearing to transmit the driving force to the interlock rod.

[0025] Outer race 4 of the rocker arm bearing shown in Figs. 3, 4 and 5 has the nitrogen-enriched layer, austenite crystal grains, and the surface roughness set similar to those of the embodiment of Figs. 1 and 2. In order to render the structure of the nitrogen-enriched layer of outer race 4 microscopic such that the grain size number of the austenite grain size exceeds No. 10, a heat treatment of a low temperature secondary quenching that will be described hereinafter is applied. Furthermore, small concave pits are formed at random on the surface 4a of the outside cylindrical perimeter of outer race 4. The surface is treated such that, when the surface roughness is represented by the parameter value of R_{qni} (ISO International Standard), the ratio of the axial direction surface roughness $R_{qni}(L)$ to the circumferential surface roughness $R_{qni}(C)$, i.e. $R_{qni}(L)/R_{qni}(C)$, becomes 1.0 at most, and the surface roughness parameter value of Sk becomes -1.6 at most.

[0026] A heat treatment including carbonitriding applied on the outer race (roller) of the rocker arm bearing set forth above will be described hereinafter. Fig. 6 represents the heat treatment pattern based on the method of conducting primary quenching and secondary quenching. Fig. 7 represents the heat treatment pattern based on the method of cooling the material during quenching treatment to less than the transformation point of A1, and then heating again to eventually conduct quenching. Both are embodiments of the present invention. In these drawings, carbon and nitrogen are diffused into the base material of steel, and carbon is sufficiently dissolved, followed by cooling to a transformation point below A1 in treatment T1. Then, at treatment T2, heating is applied again at a temperature lower than that of treatment T1, followed by oil-quenching.

[0027] According to the heat treatment set forth above, the crack resistance is improved and the secular dimensional distortion rate is reduced, although the surface layer of the outer race of the rocker arm bearing is carbonitrided, instead of ordinary quenching, i.e. instead of conducting quenching once directly after carbonitriding. According to the heat treatment method set forth above, a microstructure can be obtained in which the grain size of the austenite crystal grains is reduced to at least 1/2 the conventional size. The outer race subjected to the heat treatment set forth above can exhibit a longer life with respect to the rolling fatigue property, improved crack resistance, and lower secular dimensional distortion rate.

[0028] The microstructure of the outer race of the bearing, particularly the austenite grains, will be described hereinafter with reference to Figs. 8A, 8B, 9A, and 9B. According to these structures indicating the austenite crystal grains, the austenite grain size of the conventional example is No. 10 at most, based on the grain size number of the JIS. By applying the heat treatment method of the present invention, small grains corresponding to the grain size number of 12 can be achieved. The average grain size of Fig. 9A was 5.6 μm as a result of measuring based on an intercept method.

[0029] A method of forming the small concave pits set forth above will be described hereinafter. Small concave pits are formed by barrel-polishing. The desired superficial aspect can be achieved by appropriately selecting the rotating speed of the polishing machine, the processing time, the number of products inserted, chip type, size, and the like. Shot blasting and the like may also be employed.

[0030] The axial and circumferential R_{qni} of the outside cylindrical surface of the outer race of the bearing and the surface roughness parameter value of Sk according to an example of the present invention, formed by the method set forth above, will be described hereinafter with reference to Fig. 10. For the sake of comparison, Fig. 10 also shows measurement data corresponding to a conventional example. One feature is that the absolute value of Sk taking a negative value is larger in the example of the present invention than in the conventional example. Another feature is that the distribution of R_{qni} has a peak at a position considerably greater than zero, representing intentional small depressions and projections formed. As shown in Fig. 11, the pattern of depressions and projections along the circumferential direction of the outside cylindrical surface of the outer race of the bearing according to an example of the present invention, formed by the method set forth above, includes rounded projections with a deep acute groove between the

projections, corresponding to the Sk value of at most - 1.6.

[0031] The formation rate of an oil film at the outside cylindrical surface of the outer race when the test bearing according to the example of the present invention including the outer race set forth above is incorporated into an actual engine for testing will be described with reference to Figs. 12 and 13. As apparent from comparison therebetween, the oil film formation rate is improved by approximately 20% at the start-up operation in the example of the present invention than in the comparative example.

<Example 1>

[0032] An example of the present invention will be described here. A peeling test piece was produced using SUJ2 of the JIS. The test piece had the dimension of outer diameter $\phi 40$ mm $\times$ width L12. Each test bearing was fabricated as set forth below.

[0033] Test piece No. 1 (Example of present invention): carbonitriding temperature 850°C, holding time 150 minutes. An atmosphere of mixture gas of RX gas and ammonia gas was employed. Primary quenching was conducted starting from the carbonitriding temperature of 850°C. Then, heating was applied for 20 minutes at the temperature of 800°C that is lower than the carbonitriding temperature for secondary quenching, followed by tempering at 180°C for 90 minutes. Then, the desired finishing surface was obtained through specialized barrel-polishing for surface treatment.

[0034] Test piece NO.2 (Comparative Example 1): ordinary heat treatment was conducted (heating at the heating temperature of 840°C for the holding time of 20 minutes in an RX gas atmosphere, followed by quenching. Then, tempering was conducted for 90 minutes at 180°C).

[0035] Test piece No. 3 (Comparative Example 2): carbonitriding was conducted (in a mixture gas atmosphere of RX gas and ammonia gas, heated at the heating temperature of 850 °C for the holding time of 150 minutes, followed by quenching from 850°C. Then, tempering was conducted for 90 minutes at 180°C).

[0036] Results of material inspection and peeling test on the test pieces produced by the foregoing fabrication method are shown in Tables 1 and 2.

Table 1

Test Piece No.	Austenite Crystal Retained Grain Size (JIS)	Austenite (Vol. %)	Content (Wt. %)	Nitrogen Peeling strength ratio	Note
1	12	21	0.30	7.2	Example 1 of Invention
2	9	7	0	1	Comparative Example 1
3	8	29	0.31	1.4	Comparative Example 2

Table 2

Test Piece No.	Surface Treatment on Outer Race Outside Cylindrical Surface (barrel-polishing)	R _{qni} (μm)		R _{qni} (L)/R _{qni} (C) (Average Value)	Sk Value	Note
		L	C			
1	yes	0.09 ~ 0.16	0.10 ~ 0.16	0.7~1.0	-1.6~ -2.3	Example 1 of Invention
2	no	0.04 ~ 0.06	0.03 ~ 0.05	1.0~1.5	-0.8~ -1.2	Comparative Example 1
3	no	0.04 ~ 0.06	0.03 ~ 0.05	1.0~1.5	-0.8~ -1.2	Comparative Example 2

[0037] The peeling test method will be described hereinafter. The peeling test conditions are as set forth in Table 3.

Table 3

Peeling Test Condition	
Test Machine	2-Cylinder Test Machine
Test Piece	φ 40 straight
Counterpart Test Piece	φ 40 × R60 Surface Roughness(Rt) 3.0 μm (produced by SUJ2)
Contact Pressure	Pmax 2.3GPa
Lubricant	Turbine Oil VG46
Rotating Speed of Counterpart Test Piece	2000 rpm (test piece rolled by follower)
Overall Load Count	4.8×10^5 times

[0038] An ordinary heat-treated product of SUJ2 by the JIS having coarse surface roughness was employed as the counterpart test piece. Each of the foregoing test pieces was brought into rolling contact with the counterpart test piece, and the area ratio of peeling occurring on the test piece (aggregation of fine flakes) was measured. This area ratio was taken as the peeling strength. The peeling strength ratio was represented by the reciprocal of the ratio of the result of each test piece with test piece No. 2 subjected to ordinary heat treatment as 1 (reference value). Test piece No. 1 of the example of the present invention exhibited a peeling strength at least 7 times that of test piece No. 2 that was subjected to ordinary heat treatment, and a peeling strength of at least 5 times that of test piece No. 3 corresponding to the carbonitriding product. Such a significant improvement in lifetime is attributed to the fine austenite grain size set forth above and the improved oil film formation based on accurate control of the surface configuration of depressions and projections.

[0039] Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of the present invention being limited only by the terms of the appended claims.

Industrial Applicability

[0040] By using the rocker arm bearing of the present invention, the peeling resistance of the outer race that is brought into contact with the cam under severe conditions can be greatly improved. Since such an outer race of the rocker arm bearing can be obtained by applying secondary quenching at low temperature and barrel-polishing, the potential for wide applications to rocker arms and the like of the motor engine that is subjected to increasingly severe usage conditions is expected.

Claims

1. A rocker arm bearing (50) including a shaft (2) corresponding to an inner race fixed to a rocker arm (1) interposed between an engine valve (9) and a cam (6) to adjust intake and exhaust, an outer race (4) located outer to said inner race (2) and in contact with said cam (6), and a plurality of rolling elements (3) located between said outer race (4) and inner race (2),
wherein said outer race (4) includes a nitrogen-enriched layer, a grain size number of austenite crystal grains in the nitrogen-enriched layer being in a range exceeding No. 10, and including small concave pits randomly on a surface (4a) of an outside cylindrical perimeter of the outer race.
2. The rocker arm bearing (50) according to claim 1, wherein the surface (4a) of said outside cylindrical perimeter of the outer race having said small concave pits randomly formed has, when a surface roughness is represented by a parameter value of R_{qni} (ISO International Standard), a ratio of $R_{qni}(L)/R_{qni}(C)$, identified as the ratio of an axial surface roughness $R_{qni}(L)$ to circumferential surface roughness $R_{qni}(C)$, that is at most 1.0, and a surface roughness parameter value of Sk that is at most -1.6.
3. The rocker arm bearing (50) according to claim 1, wherein said rocker arm (1) is supported rotatably on a rotation shaft (5) located between one end (1a) and another end (1b) of the rocker arm, said one end (1a) including a bifurcated inner race support (14) to which said inner race (2) is fixed, and said another end (1b) abutting against

an end of said engine valve (9).

4. The rocker arm bearing (50) according to claim 1, wherein said rocker arm (1) has one end (1b) abut against an end of said engine valve (9), and a pivot is fitted to said another end (1a), and said inner race (2) is fixed through an inner race bore at two opposite sidewalls between one end (1b) and another end (1a) of said rocker arm (1).
5. The rocker arm bearing (50) according to claim 1, wherein the rocker arm (1) is supported rotatably on a rotation shaft (5) located between one end (1b) and another end (1a) of the rocker arm, an end of said engine valve (9) abutting against the one end (1b), and one end of an interlock rod (16) transmitting stress from said cam (6) abutting against said another end (1a), the inner race (2) of said rocker arm rolling bearing (50) being fixed to the other end of said interlock rod (16), and the outer race (4) forming contact with said cam (6).
6. The rocker arm bearing (50) according to claim 1, wherein said rocker arm bearing (50) is a full complement type needle bearing.
7. A rocker arm bearing (50) including a shaft (2) corresponding to an inner race fixed to a rocker arm (1) interposed between an engine valve (9) and a cam (6) to adjust intake and exhaust, and an outer race (4) located outer to said inner race (2) and in contact with said cam (6), wherein said outer race (4) includes a nitrogen-enriched layer, a grain size number of austenite crystal grains in the nitrogen-enriched layer being in a range exceeding No. 10, and including small concave pits randomly on a surface (4a) of an outside cylindrical perimeter of the outer race.
8. The rocker arm bearing (50) according to claim 7, wherein the surface (4a) of said outside cylindrical perimeter of the outer race having said small concave pits randomly formed has, when a surface roughness is represented by a parameter value of R_{qni} (ISO International Standard), a ratio of $R_{qni}(L)/R_{qni}(C)$, identified as the ratio of an axial surface roughness $R_{qni}(L)$ to circumferential surface roughness $R_{qni}(C)$, that is at most 1.0, and a surface roughness parameter value of Sk that is at most -1.6.
9. The rocker arm bearing (50) according to claim 7, wherein said rocker arm (1) is supported rotatably on a rotation shaft (5) located between one end (1a) and another end (1b) of the rocker arm, said one end (1a) including a bifurcated inner race support (14) to which said inner race (2) is fixed, and said another end (1b) abutting against an end of said engine valve (9).
10. The rocker arm bearing (50) according to claim 7, wherein said rocker arm (1) has one end (1b) abut against an end of said engine valve (9), and a pivot is fitted to said another end (1a), and said inner race (2) is fixed through an inner race bore at two opposite sidewalls between one end (1b) and another end (1a) of said rocker arm (1).
11. The rocker arm bearing (50) according to claim 7, wherein the rocker arm (1) is supported rotatably on a rotation shaft (5) located between one end (1b) and another end (1a) of the rocker arm, an end of said engine valve (9) abutting against the one end (1b), and one end of an interlock rod (16) transmitting stress from said cam (6) abutting against said another end (1a), the inner race (2) of said rocker arm rolling bearing (50) being fixed to the other end of said interlock rod (16), and the outer race (4) forming contact with said cam (6).

FIG.1

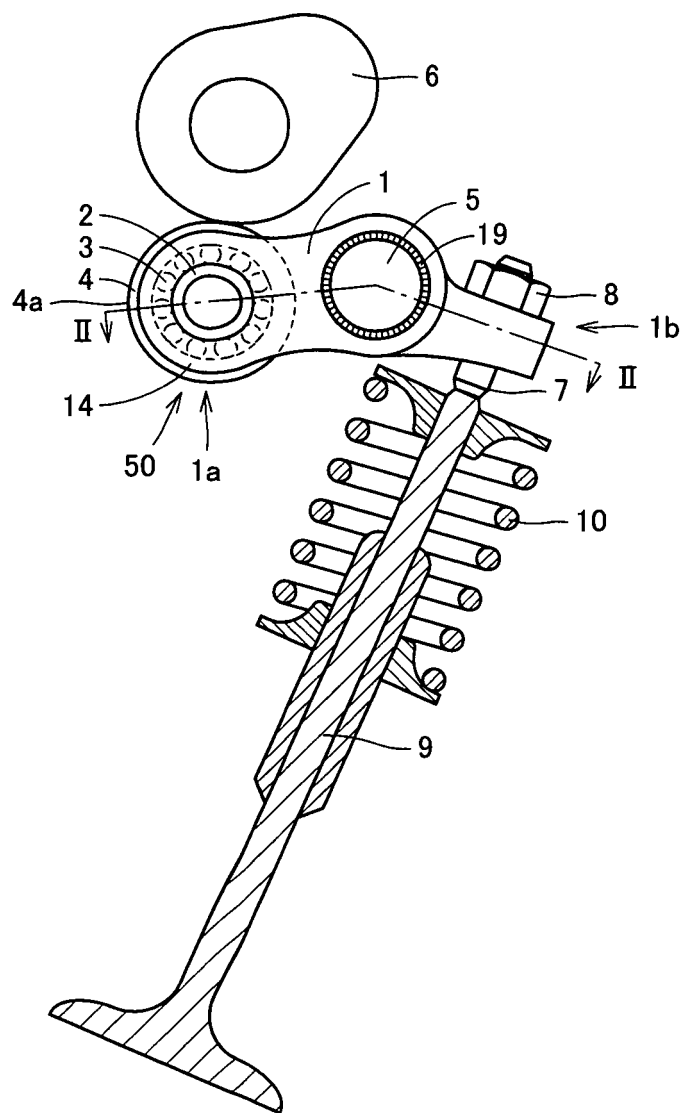


FIG.2

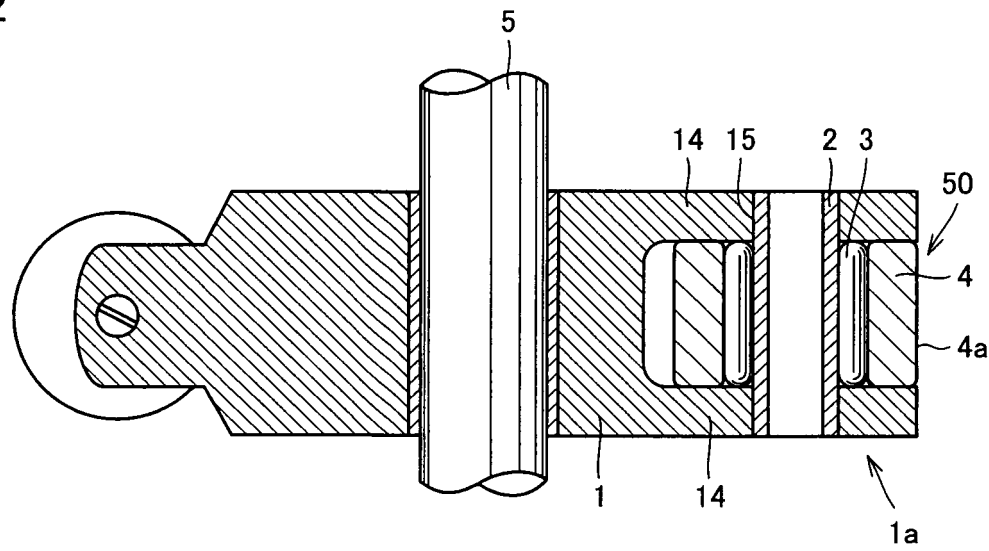


FIG.3

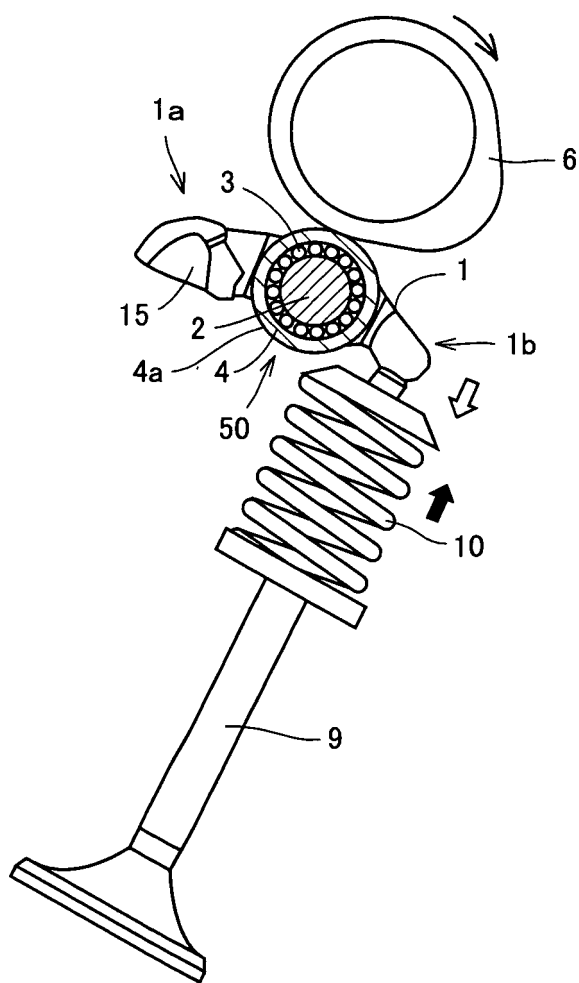


FIG.4

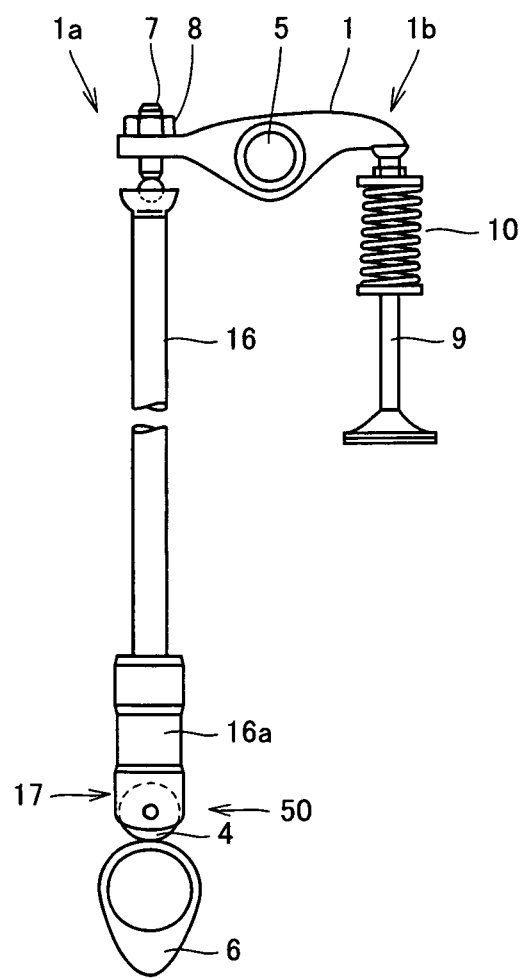


FIG.5

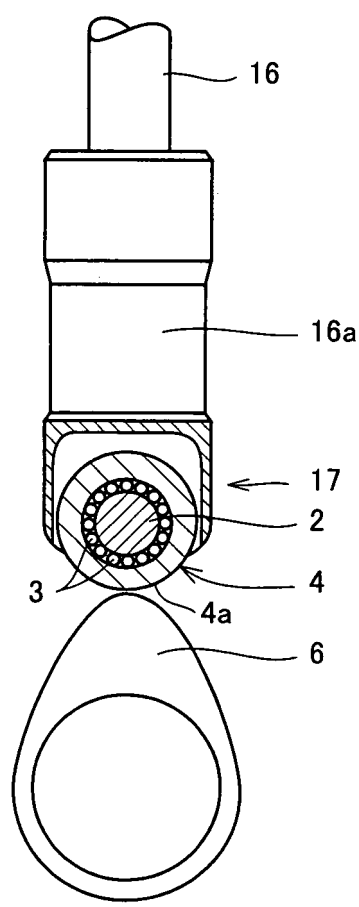


FIG.6

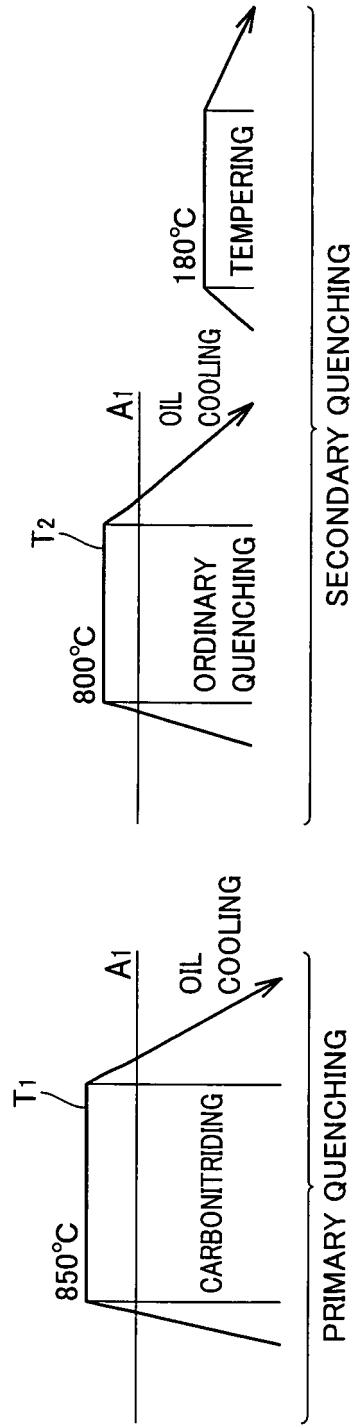


FIG. 7

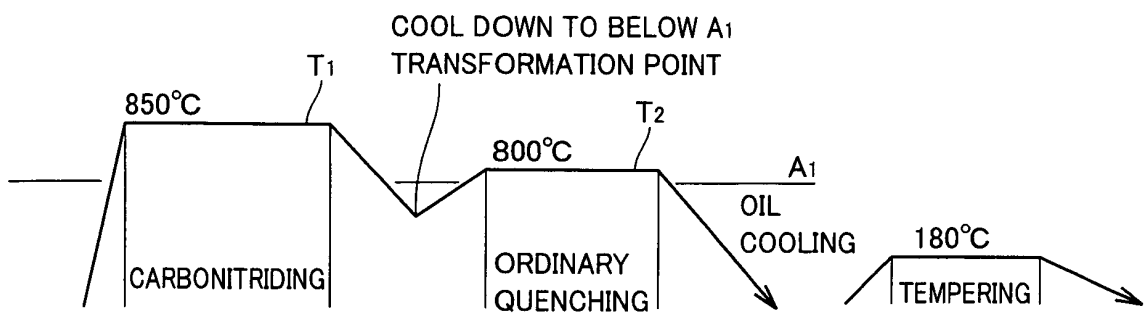


FIG.8A

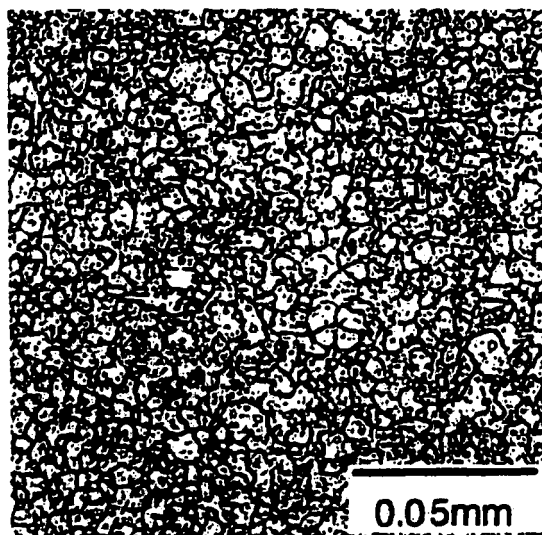


FIG.8B

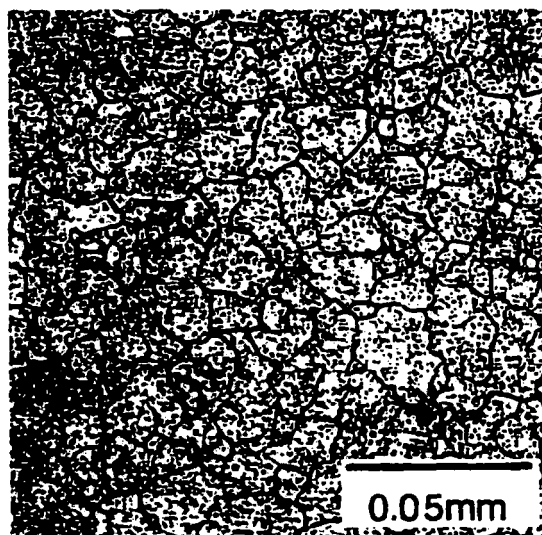


FIG.9A

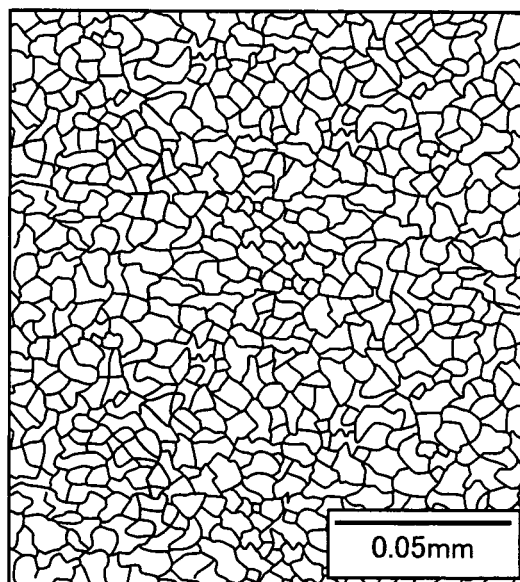


FIG.9B

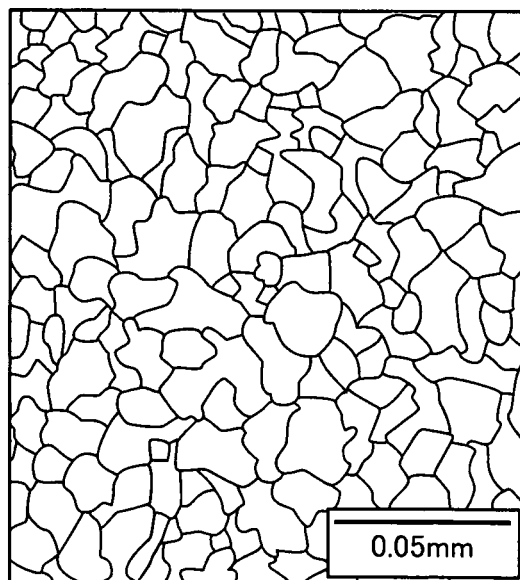


FIG.10

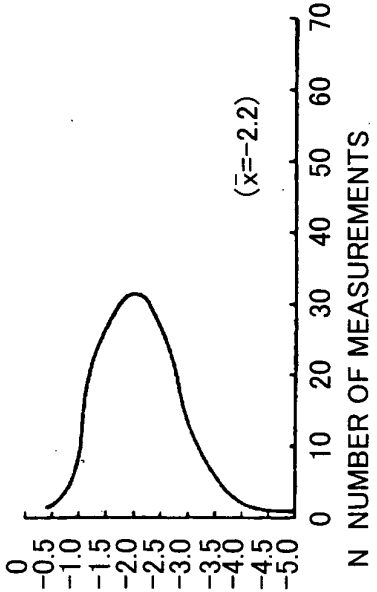
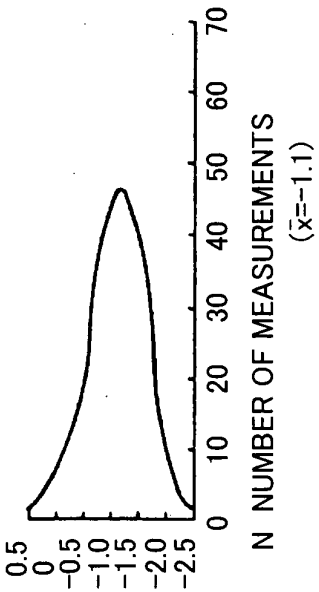
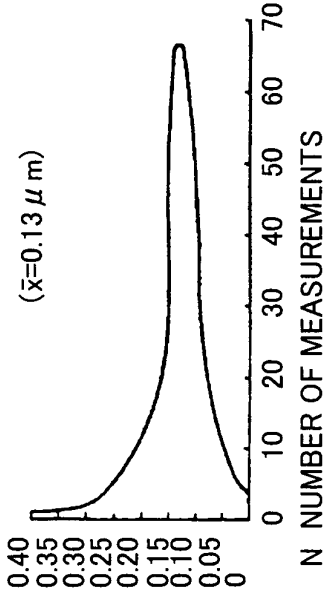
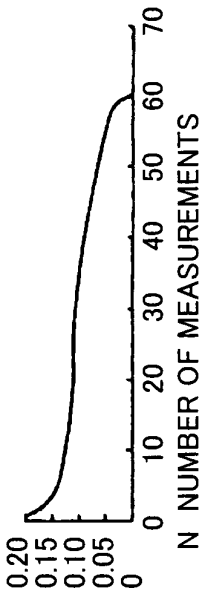
	EXAMPLE OF PRESENT INVENTION	CONVENTIONAL EXAMPLE
SK VALUE	 ($\bar{x}=-2.2$)	 ($\bar{x}=-1.1$)
Rqni (μ m) L,C PLOTTED IN BOTH DIRECTIONS	 ($\bar{x}=0.13 \mu \text{ m}$)	 ($\bar{x}=0.055 \mu \text{ m}$)

FIG.11

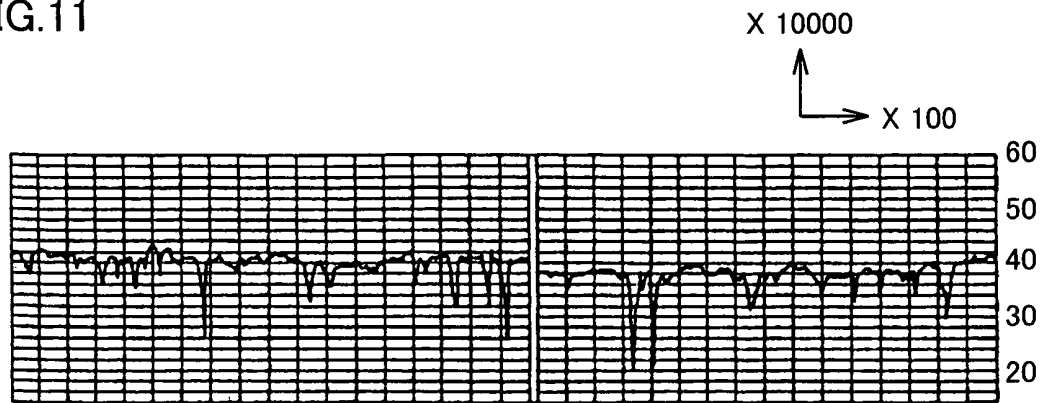


FIG.12

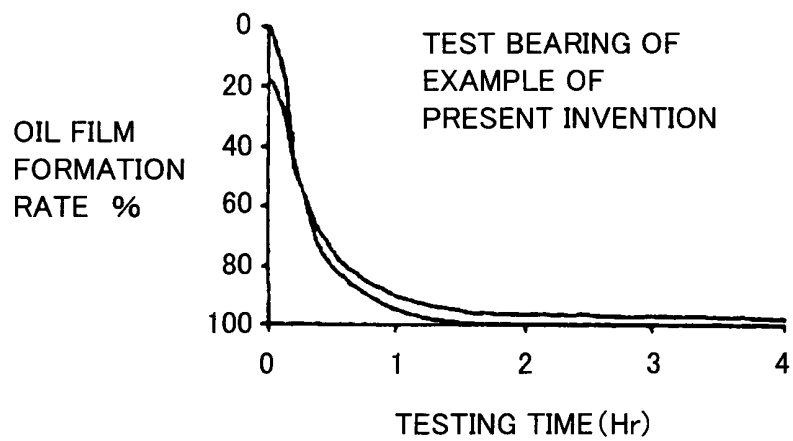
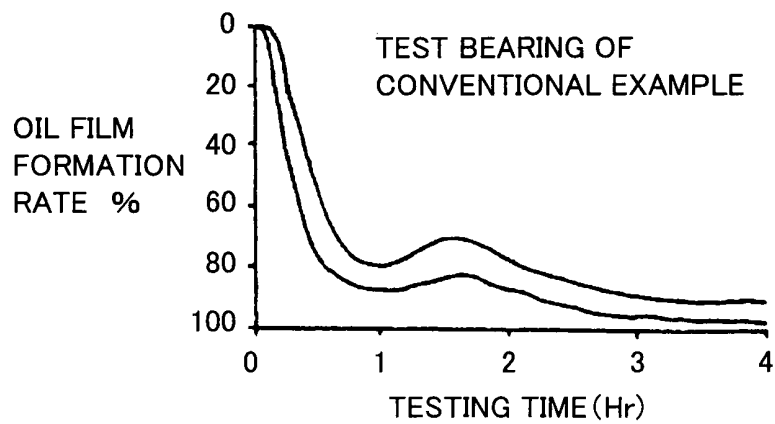


FIG.13



EP 1 801 365 A1

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/008671

A. CLASSIFICATION OF SUBJECT MATTER Int.Cl. ⁷ F01L1/18, C22C38/00		
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, C22C38/00		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2005 Kokai Jitsuyo Shinan Koho 1971-2005 Toroku Jitsuyo Shinan Koho 1994-2005		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 8-233070 A (Koyo Seiko Co., Ltd.), 10 September, 1996 (10.09.96), Par. No. [0011]; Fig. 2 (Family: none)	1-11
Y	JP 2004-115903 A (NTN Corp.), 15 April, 2004 (15.04.04), Par. Nos. [0020], [0052], [0053] (Family: none)	1-11
Y	JP 2004-137605 A (NTN Corp.), 13 May, 2004 (13.05.04), Par. No. [0024] & US 2003/123769 A1 & DE 10254635 A1 & FR 2841907 A1 & CN 1421541 A	1-11
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 28 July, 2005 (28.07.05)		Date of mailing of the international search report 16 August, 2005 (16.08.05)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/008671

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 2-130205 A (NTN Corp.), 18 May, 1990 (18.05.90), Page 2, upper left column, line 19 to lower left column, line 3; Figs. 1, 2 (Family: none)	2, 5, 8, 11
Y	JP 4-350310 A (NTN Corp.), 04 December, 1992 (04.12.92), Par. Nos. [0016] to [0018]; Fig. 4 & US 5159852 A & GB 2253255 A & DE 4114513 A1 & FR 2673444 A1 & KR 9505825 B	2, 5, 8, 11
Y	JP 2548811 B2 (NTN Corp.), 08 August, 1996 (08.08.96), Page 2, left column, lines 24 to 40 & US 5064298 A & GB 2238584 A & DE 4037734 A1 & FR 2655100 A1 & KR 9511949 B	2, 8
Y	JP 2003-56315 A (NTN Corp.), 26 February, 2003 (26.02.03), Figs. 1, 2 & US 2003/0037635 A1 & DE 10238252 A1 & CN 1407211 A	3, 9
Y	JP 2001-271910 A (Koyo Seiko Co., Ltd.), 05 October, 2001 (05.10.01), Fig. 4 (Family: none)	5, 11
Y	JP 2004-211686 A (Mitsubishi Motors Corp.), 29 July, 2004 (29.07.04), Par. Nos. [0031], [0033] (Family: none)	6
Y	JP 2004-183589 A (NSK Ltd.), 02 July, 2004 (02.07.04), Par. No. [0010]; Fig. 2 (Family: none)	6

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2168022 A [0003] [0004]