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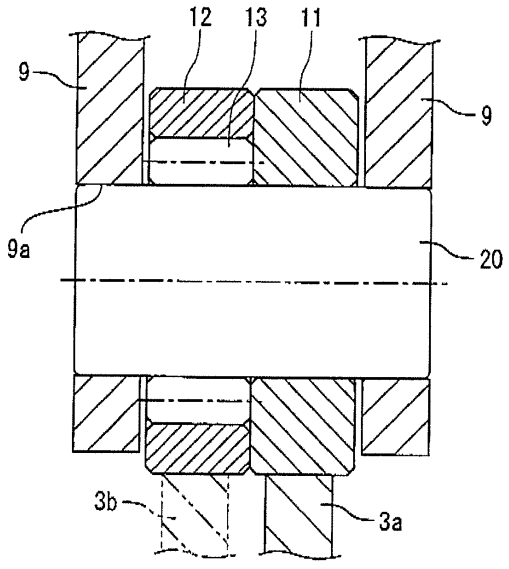
(54) **TAPPET ROLLER BEARING**

(57) A tappet roller bearing 10 includes a support shaft 20 to be supported on a locker arm 4, and first and second rollers 11 and 12 which can be respectively supported rotatably on the periphery of the support shaft 20 and are arranged together in the axial direction of the support shaft 20. The first roller 11 constitutes a plain bearing, and the second roller 12 constitutes a full type roller bearing or a plain bearing. Due to this, the tappet roller bearing 10 can extend its life, can enhance its assembling efficiency and can reduce its manufacturing cost.

FIG. 3



EP 2 546 480 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a tappet roller bearing and, specifically, the invention relates to a tappet roller bearing to be mounted into a cam follow apparatus which is used in the variable valve mechanism of an engine.

BACKGROUND ART

[0002] In recent years, there has been increasing an engine employing a variable valve mechanism which changes the opening and closing timing of one or both of a suction valve or an exhaust valve according to the changes of the rotation speed of the engine. Such variable valve mechanism is generally constituted of a cam follower apparatus including a locker arm for a high speed cam and a locker arm for a low speed cam. Also, in order to make compact the structure of an engine in the axial direction thereof and to reduce the number of parts of the engine to thereby reduce the cost of the engine, there is also proposed a cam follower apparatus which includes a lock arm for high speed and low speed cams and also which, in operation, slides these cams in the axial direction thereof to thereby switch the high speed and low speed cams over to each other.

[0003] The cam follower apparatus includes a locker arm which is disposed opposed to a cam fixed to a cam shaft rotatable in synchronization with the crankshaft of the engine and has a roller to receive the movement of the cam (see, for example, the patent reference 1 to 3). According to a cam follower apparatus disclosed in the patent reference 1, in the intermediate portion of a locker arm, there is provided a support shaft and, on this support shaft, there are rotatably supported multiple tappet rollers which can be contacted with the cam fixed to the cam shaft. According to a cam follower apparatus which is disclosed in the patent reference 2 and is mounted on the end portion of a locker arm, there are included: a shaft the two end portions of which are respectively supported on a pair of support plates and also which is used to constitute an inner race; three outer races respectively interposed between the pair of support plates; and, multiple rollers respectively interposed between the shaft and three outer races and each having a length extending over the whole of the three outer races. Also, according to a cam follower apparatus which is disclosed in the patent reference 3 and is mounted on the end portion of a locker arm, there are included: a shaft the two end portions of which are respectively supported on a pair of support plates and also which is used to constitute an inner race; two outer races respectively interposed between the pair of support plates; and, multiple rollers respectively interposed between the shaft and two outer races and each having a length extending over the whole of the two outer races.

[0004] Further, according to a roller bearing disclosed in the patent reference 4, there are included: a shaft the two end portions of which are respectively supported on a pair of support plates and also which is used to constitute an inner race; an outer race interposed between the pair of support plates through a washer; and, multiple rollers respectively interposed between the shaft and outer race and arranged in two lines in the axial direction of the roller bearing through a spacer.

RELATED ART REFERENCE

PATENT REFERENCE

[0005]

Patent Reference 1: USP No. 6532920 Specification
Patent Reference 2: German Patent Application No. 102006018512 Specification
Patent Reference 3: Japanese Patent Publication No. 2009-293392
Patent Reference 4: USP No. 3674325 Specification

SUMMARY OF THE INVENTION

PROBLEM THAT THE INVENTION IS TO SOLVE

[0006] Here, according to the cam follower apparatus disclosed in the patent reference 1, since the rollers are separated from each other by the side walls of the locker arm, there is raised a problem that the space of the locker arm in the axial direction thereof is large. Also, in the patent reference 2 or 3, since, for each of the rollers of the locker arm, there are disposed two or three outer races in such a manner that the they straddle over the roller, there is a possibility that an edge load can occur in the end portions of the respective outer races. Further, in the roller bearing disclosed in the patent reference 4, the washer is interposed between the outer race and the side wall of the locker arm, and the spacer is interposed between the two lines of rollers. This complicates the assembling operation of the roller bearing and also increases the space thereof in the axial direction.

[0007] The present invention aims at solving the problems found in the above prior art technology. Thus, it is an object of the invention to provide a tappet roller bearing which can extend its life, can enhance its assembling efficiency and can reduce its manufacturing cost. Also, it is another object of the invention to provide a tappet roller bearing which, for use in a cam follower apparatus for sliding high speed and low speed cams in the axial direction thereof to thereby switch them over to each other, can extend its life, can enhance its rotation performance and its assembling efficiency, and can reduce its manufacturing cost.

MEANS FOR SOLVING THE PROBLEM

[0008] The above objects of the invention can be attained by the following structures.

(1) A tappet roller bearing, including:

a support shaft to be fixed to a locker arm for receiving the movement of a cam to be supported on the cam shaft of an engine; and
first and second rollers respectively supported rotatably on the periphery of the support shaft and arranged in the axial direction of the support shaft, wherein:

the first roller constitutes a plain bearing; and
the second roller constitutes a full type roller bearing or a plain bearing.

(2) The tappet roller bearing according to article (1), wherein:

the cam includes a high speed cam and a low speed cam respectively disposed on the cam shaft slidably in the axial direction of the cam shaft;
the first roller constituting the plain bearing is contacted with the high speed cam; and
the second roller constituting the full type roller bearing is contacted with the low speed cam.

(3) The tappet roller bearing according to article (1) or (2), wherein:

the cam includes a high speed cam and a low speed cam respectively disposed on the cam shaft slidably in the axial direction of the cam shaft;
the outer peripheral surface of the first roller to be contacted with the high speed cam is formed by barrel working to be carried out after polish finishing; and
the outer peripheral surface of the second roller to be contacted with the low speed cam is formed by polish finishing without being barrel worked.

(4) The tappet roller bearing according to any one of articles (1) to (3), wherein
the outer peripheral surfaces of the first and second rollers are not crowning worked but have a uniform diameter in the axial direction thereof.
(5) The tappet roller bearing according to any one of articles (1) to (4), wherein
at least one of the first and second rollers is structured so that an axial direction end face has a convex shape.
(6) The tappet roller bearing according to article (5), wherein:

at least one of the first and second rollers, the axial direction end face of which is formed to have the convex shape, constitutes a double roller; and
the inner roller of the double roller is structured so that an axial direction end face has a convex shape.

(7) The tappet roller bearing according to article (5), wherein:

the second roller constitutes a full type roller bearing; and
the multiple rollers of the roller bearing, together with the second roller, are structured so that respective axial direction end faces have a convex shape.

(8) The tappet roller bearing according to any one of articles (1) to (7), wherein:

the support shaft is formed to have a staged shape including first and second shaft portions different from each other in the outside diameter dimension thereof;
the first roller is disposed on the periphery of the first shaft portion; and
the second roller is disposed on the periphery of the second shaft portion.

(9) The tappet roller bearing according to any one of articles (1) to (8), wherein
the first and second rollers are different from each other in the axial direction width thereof.
(10) The tappet roller bearing according to any one of articles (1) to (9), wherein
the first and second rollers are different from each other in the roller diameter thereof.
(11) The tappet roller bearing according to any one of articles (1) to (10), further comprising
a third roller rotatably supported on the periphery of the support shaft and arranged together with the first and second rollers in the axial direction of the support shaft.
(12) The tappet roller bearing according to any one of articles (1) to (10), further comprising
a third roller rotatably supported on the periphery of the support shaft and arranged together with the first and second rollers in the axial direction of the support shaft, wherein
in a case that the second roller constitutes a roller bearing, the third roller is situated on the opposite side to the second roller with respect to the first roller.
(13) The tappet roller bearing according to article (11) or (12), wherein
the outer peripheral surface of at least one of the first

to third rollers is crowning worked.

ADVANTAGE OF THE INVENTION

[0009] According to a tappet roller bearing of the invention, in the first and second rollers which are respectively supported rotatably on the periphery of the support shaft and are arranged together in the axial direction of the support shaft, the first roller constitutes a plain bearing, while the second roller 12 constitutes a full type roller bearing or a plain bearing. Thanks to this structure, the present tappet roller bearing can extend its life, can enhance its assembling efficiency, and can reduce its manufacturing cost.

[0010] Also, according to the invention, in the cam follower apparatus which slides the high speed and low speed cams in the axial direction thereof to thereby switch these cams over to each other, the first roller constituting the plain bearing can be contacted with the high speed cam, while the second roller constituting the full type roller bearing can be contacted with the low speed cam. Thanks to this structure, the present cam follower apparatus can extend its life, can enhance its rotation performance and its assembling efficiency, and can reduce its manufacturing cost.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Fig. 1 is a partially cut-away side view of a cam follower apparatus into which a tappet roller bearing according to a first embodiment of the invention is assembled.

Fig. 2 is a perspective view of the tappet roller bearing shown in Fig. 1.

Fig. 3 is a section view taken along the A-A arrow line shown in Fig. 1.

Fig. 4 is a perspective view of a tappet roller bearing according to a first modification of the first embodiment of the invention.

Fig. 5 is a section view of the tappet roller bearing according to the first modification of the first embodiment of the invention.

Figs. 6A to 6C are respectively section views of the tappet roller bearing according to a second modification of the first embodiment of the invention, showing the combinations of two lines of rollers included therein.

Figs. 7A to 7H are respectively section views of the tappet roller bearing according to a third modification of the first embodiment of the invention, showing the combinations of three lines of rollers included therein.

Figs. 8A to 8E are respectively section views of the tappet roller bearing according to a second embodiment of the invention, showing the combinations of two lines of rollers included therein.

Figs. 9A and 9B are respectively section views of the tappet roller bearing according to the second embodiment of the invention, showing the other combinations of the two lines of rollers included therein.

Figs. 10A and 10B are respectively section views of the tappet roller bearing according to a modification of the second embodiment of the invention, showing the other combinations of the two lines of rollers included therein.

Figs. 11A to 11H are respectively section views of the tappet roller bearing according to a second modification of the second embodiment of the invention, showing the combinations of three lines of rollers included therein.

Figs. 12A to 12C are respectively section views of the tappet roller bearing according to a third modification of the second embodiment of the invention, showing the combinations of three lines of rollers included therein.

Figs. 13A to 13D are respectively section views of the tappet roller bearing according to a fourth modification of the second embodiment of the invention, showing the combinations of three lines of rollers included therein.

Fig. 14 is a section view of a tappet roller bearing including two lines of rollers respectively arranged around shafts having different diameters according a third embodiment of the invention.

Figs. 15A to 15C are respectively explanatory views of the tappet roller bearing shown in Fig. 14, showing the assembling steps of the tappet roller bearing.

Fig. 16A is a section view of a modification of the tappet roller bearing of the third embodiment of the invention including two lines of rollers, and Fig. 16B is a section view of another modification of the tappet roller bearing of the third embodiment of the invention including three lines of rollers.

Fig. 17 is a section view of a tappet roller bearing including two lines of rollers having different roller diameters according to a fourth embodiment of the invention.

Fig. 18 is a section view of a tappet roller bearing including two lines of rollers having different roller diameters according to a modification of the fourth embodiment of the invention.

Fig. 19 is an explanatory side view of a modification of a locker arm.

MODE FOR IMPLEMENTING THE INVENTION

[0012] Now, description will be given below specifically of a tappet roller bearing according to the respective embodiments of the invention with reference to the drawings.

(First Embodiment)

[0013] Firstly, description will be given below of a cam

follower apparatus 1 with reference to Fig. 1. In this cam follower apparatus 1, on a cam shaft 2 which can be rotated synchronously with the crank shaft of an engine (not shown), there are respectively supported a high speed cam 3a and a low speed cam 3b in such a manner that they can be slid in the axial direction of the cam shaft 2 (in Fig. 1, in the front and back direction of the sheet of Fig. 1). Also, at the position that is disposed opposed to the high speed cam 3a or low speed cam 3b slidably in the axial direction thereof, there is arranged a locker arm 4 which is used to receive the movements of these cams 3a and 3b. The locker arm 4 has a shaft hole 4a formed in the longitudinal direction intermediate portion thereof (in Fig. 1, in the right and left direction), while the lock arm 4 can be rotatably supported on a cylinder head (not shown) through a locker shaft 5 inserted through the shaft hole 4a.

[0014] Also, with the base end portion (in Fig. 1, the left end portion) of the locker arm 4, there is threadedly engaged an adjust bolt 6, while the adjust bolt 6 can be fastened and fixed to such base end portion using a lock nut 6a. And, with the end portion of the adjust bolt 6 (in Fig. 1, the lower end portion thereof), there is contacted the end portion (in Fig. 1, the upper end portion) of an engine valve 7 serving as a suction valve or an exhaust valve supported on a cylinder head (not shown) in such a manner that it can be moved reciprocatingly. The engine valve 7 is always energized by a valve spring 8 in a valve closing direction (a direction where the engine valve 7 is contacted with the adjust bolt 6). Therefore, the locker arm 4 is always energized clockwise in Fig. 1.

[0015] On the other hand, in the leading end portion (in Fig. 1, in the right end portion) of the locker arm 4, there are provided a pair of support wall portions 9 which are spaced from each other. On the pair of support wall portions 9, there is mounted a tappet roller bearing 10 according to the present embodiment.

[0016] The tappet roller bearing 10 according to the present embodiment, as shown in Figs. 1 ~ 3, includes: a first roller 11 and a second roller 12 which are respectively interposed between the paired support wall portions 9, while the first roller 11 can be contacted with the high speed cam 3a and second roller 12 can be contacted with the low speed cam 3b; and, a support shaft 20 the two end portions of which are supported in the shaft holes 9a of the paired support wall portions 9 and also which supports the first and rollers 11 and 12 rotatably.

[0017] The support shaft 20 is constituted of a steel-made hollow or solid shaft member and, when the two end portions of the support shaft 20 are caulked into the shaft holes 9a formed in the paired support wall portions 9, the support shaft 20 can be fixed to the support wall portions 9.

[0018] Here, the first roller 11, with which the high speed cam 3a can be contacted, constitutes a single roller serving as a plain bearing which can be slidingly contacted with the outer peripheral surface of the support shaft 20. Also, the second roller 12, with which the low speed cam 3b can be contacted, constitutes the outer race of a roller bearing including multiple rollers 13 which are interposed in a full type roller manner between the roller bearing and support shaft 20.

[0019] The first and second rollers 11 and 12 are substantially equal to each other in the outside diameter dimension thereof. The first and second rollers 11 and 12 may be made of metal such as bearing steel or carbon steel, provided that the metal can secure necessary hardness through the heat treatment thereof. And, they may be constituted of the same material or may be constituted of different materials. For example, by using materials which are different in the carbon contents thereof, they may be prevented from biting into each other.

[0020] The respective outer peripheral surfaces of the first and second rollers 11 and 12 have been crowning worked, which can prevent an excessive surface pressure due to an edge load from acting on the rolling contact portions of the rollers with the cams 3a and 3b and also which makes it possible for the rollers to deal with the inclination of the cams 3a, 3b and tappet roller bearing 10. The crowning may include any of full crowning, partial crowning, logarithmic arc crowning and composite arc crowning. Also, the radius of curvature of the crowning may be different between the first and second rollers 11 and 12. Preferably, the radius of curvature of the first roller 11 to be contacted by the high speed cam 3a may be set smaller than the radius of curvature of the second roller 12 to be contacted by the low speed cam 3b, and large crowning may be carried out on the first roller 11 with which the high speed cam 3a can be contacted.

The allowable surface pressure of the respective cams 3a and 3b is up to 2GPa or so, while the allowable surface pressure of the tappet roller bearing 10 is set higher than the allowable surface pressure of the respective cams 3a and 3b. In the case that the surface pressure of these members 3a and 3b exceeds the allowable surface pressure, there occurs a peeling phenomenon in these members. Therefore, the crowning working is carried out on the outer peripheral surfaces of the cams 3a and 3b in order to prevent their respective contact surface pressures from exceeding their respective allowable surface pressures.

However, when there is little possibility that misalignment can occur, the crowning working can be omitted. In this case, the outer peripheral surfaces of the first and second rollers 11 and 12 respectively have a uniform diameter in the axial direction thereof.

[0021] Also, the second roller 12 to be contacted by the low speed cam 3b, after it is polish finished, may not receive additional surface working such as barrel working. On the other hand, on the first roller 11 to be contacted by the high speed cam 3a, there are carried out not only polish finishing but also additional surface working such as barrel working.

Here, in Fig. 2 and also in Figs. 4, 6, 7 and the like which will be described later, the illustration of the support wall portion 9 for supporting the support shaft 20 is omitted.

[0022] In the cam follower apparatus 1 structured in the above-mentioned manner, the outer peripheral surface of the first or second roller 11 or 12 is contacted with the outer peripheral surface of the high speed cam 3a or low speed cam 3b due to the energizing force of the valve spring 8. In this state, the rotation of the cam shaft 2 is converted to the reciprocating oscillatory motion of the locker arm 4 about the locker shaft 5, and the engine valve 7 is moved or reciprocated in the axial direction thereof against the energizing force of the valve spring 8 or due to the energizing force of the valve spring 8, while the lift amount of the engine valve 7 is variable. Thanks to this, a suction port or an exhaust port to be formed in a cylinder head (not shown) can be opened and closed.

[0023] Also, in the tappet roller bearing 10, since the first roller 11 is used as a plain bearing and the second roller 12 is used a roller bearing, there is eliminated the need to provide a washer, which is necessary when the two rollers are respectively constituted of roller bearings, for prevention of mutual interference between the two rollers in the axial direction thereof. Therefore, the tappet roller bearing 10 is enhanced in the assembling efficiency thereof and also can reduce the manufacturing cost thereof.

[0024] Further, a plain bearing has a problem that it has such sufficient durability as can neglect the need to consider the life of the bearing but it provides large frictional resistance in the low speed rotation area. However, in the high speed rotation area, the frictional resistance of the plain bearing is low and is substantially equal to that of a roller bearing.

Therefore, in the tappet roller bearing 10, the second roller 12 for contact with the low speed cam 3b is constituted of a roller bearing to thereby be able to reduce the frictional resistance in the low speed rotation time, while the first roller 11 for contact with the high speed cam 3a is constituted of a plain bearing to thereby be able to eliminate a possibility that a high load in the high speed rotation time can have an influence on the life of the bearing.

Accordingly, since the first and second rollers 11 and 12 are structured as in the present embodiment according to the high speed cam 3a and low speed cam 3b, the enhanced rotation performance (dynamic torque) due to the reduced frictional resistance and the increased life of the bearing can be attained at the same time.

[0025] Now, Figs. 4 and 5 respectively show a tappet roller bearing 10 according to a modification of the present embodiment. In this tappet roller bearing 10, a first roller 11a constitutes the outer roller of a double roller (plain bearing) including an inner roller 14 which is interposed between a support shaft 20 and first roller 11a. In the case that the first roller 11a functions as an outer roller and cooperates together with the inner roller 14 to constitute a double roller in this manner, when compared with the single roller 11 according to the first embodiment, the frictional resistance can be reduced.

[0026] Also, Figs. 6 and 7 respectively show another modification of the tappet roller bearing according to the first embodiment.

For example, as shown in Figs. 6A - 6C, in the case that the first and second rollers are both constituted of plain bearings, the tappet roller bearing can be structured with no provision of a washer. Specifically, as shown in Fig. 6A, the first and second rollers 11 and 12a may be respectively constituted of plain bearings formed as single rollers; as shown in Fig. 6B, the first roller 11a may be constituted of a double roller including an inner roller 14, and the second roller 12 may be constituted of a single roller; and, as shown in Fig. 6C, the first and second rollers 11a and 12b may be both constituted of double rollers respectively including inner rollers 14 and 15. In the case of such double roller as shown in Fig. 6C, the materials of the first and second rollers 11a, 12b and inner rollers 14, 15 may be changed respectively.

[0027] Also, the tappet roller bearing 10, as shown in Figs. 7A ~ 7H, may further include a third roller 16, 16a, 16b which is rotatably supported on the periphery of a support shaft 20 and is arranged in the axial direction of the support shaft 20 together with the first and second rollers 11, 12. In this case, preferably, the types of the rollers to be arranged on both sides in the axial direction of the support shaft 20 may be the same.

[0028] Specifically, as shown in Figs. 7A~7F, in the case that the third roller 16, 16a is constituted of a plain bearing, when the third roller 16, 16a and the first roller 11, 11a constituted of a plain bearing are arranged on both sides in the axial direction of the support shaft 20, the second roller 12, 12a, 12b may be constituted of a full type roller bearing or may be constituted of a plain bearing. In this case, it is unnecessary to consider interference between the rollers and unnecessary to dispose a washer.

[0029] On the other hand, as shown in Figs. 7G and 7H, in the case that the third roller 16b is constituted of a full type roller bearing and the second roller 12 is also constituted of a full type roller bearing, in order that interference between the rollers can be prevented without provision of a washer, the third roller 16b may be arranged such that it is situated on the opposite side to the second roller 12 with respect to the first roller 11, 11a, that is, the third roller 16b and second roller 12 may be arranged on both sides in the axial direction of the support shaft 20.

(Second Embodiment)

[0030] Next, description will be given below of a tappet roller bearing according to a second embodiment of the invention with reference to Figs. 8 ~ 13. Here, in the following description, in the case that a plain bearing is constituted of a single roller, the single roller itself may also be referred to as the composing element of the bearing; in the case that a plain bearing is constituted of a double roller, the outer roller and inner roller may also be referred

to as the composing elements of the bearing; and, in the case of a full type roller bearing, the roller constituting the outer race and multiple rollers may also be referred to as the composing elements of the bearing.

[0031] In a tappet roller bearing according to the present embodiment, the axial direction two end faces of at least first and second rollers 11, 11a and 12, 12a are formed to have a convex shape. Owing to this, bearings, which are respectively constituted of the first and second rollers 11, 11a, 12, 12a, can be prevented from moving together, thereby being able to reduce sliding torque which can be generated between the mutually opposing end faces of the rollers. Also, there can also be reduced sliding torque which can be generated between the first and second rollers 11, 11a, 12, 12a and a pair of support wall portions 9 of a locker arm respectively disposed opposed to the first and second rollers on the outside in the axial direction of the support shaft 20. Further, supply of a lubricant to the support shaft 20 can be facilitated and thus the support shaft 20 can be prevented against abrasion and seizure.

[0032] The above structure according to the present embodiment can be applied to an arbitrary tappet roller bearing 10 according to the first embodiment. That is, for example, similarly to Fig. 3, in a tappet roller 10 shown in Fig. 8A in which a first roller 11 constitutes a single roller and a second roller 12 constitutes a full type roller bearing, the axial direction two end faces of the second roller 12 and multiple rollers 13 are respectively formed to have a convex shape (a convex-shaped partially spherical surface).

[0033] Also, in a tappet roller bearing 10 as well which is shown in Fig. 8B and in which a first roller 11a constitutes the outer roller of a double roller and a second roller 12 constitutes a full type roller bearing, the axial direction two end faces of the second roller 12 and multiple rollers 13 are formed to have a convex shape (a convex-shaped partially spherical surfaces).

[0034] Further, Figs. 8C - 8E, similarly to Figs. 6A - 6C, respectively show a structure in which, in the case that first and second rollers 11, 11a, 12a, 12b are both constituted of a plain bearing, the axial direction end faces of one of the first and second rollers are respectively formed to have a convex shape. However, as shown in Fig. 8D, in the case that the tappet roller bearing 10 is constituted of a single roller and a double roller, in order to prevent the mutually opposing axial direction end faces of the rollers from surface contacting with each other, preferably, the axial direction two end faces of the inner and outer rollers of the double roller may be respectively formed to have a convex shape.

[0035] Also, although, in Figs. 8A - 8E, there is shown a structure in which the axial direction two end faces of one of the first and second rollers 11, 11a, 12a, 12b are respectively formed to have a convex shape, the axial direction two end faces of both the first and second rollers 11, 11a, 12a, 12b may also be respectively formed to have a convex shape. That is, as shown in Fig. 9A, in a tappet roller bearing having a similar structure to Fig. 8B, the axial direction two end faces of the first roller 11a (the outer roller of the double roller) and inner roller 14 as well as the axial direction two end faces of the second roller 12 and multiple rollers 13 are respectively formed to have a convex shape (a convex-shaped partially spherical surface). Also, as shown in Fig. 9B, in a tappet roller bearing having a similar structure to Fig. 8C, the axial direction two end faces of first and second rollers 11 and 12a respectively constituting a single roller are formed to have a convex shape.

[0036] However, as shown in Fig. 10A, in a tappet roller bearing having a similar structure to Fig. 8A, also in the case that the axial direction two end faces of the second roller 12 and multiple rollers 13 are respectively formed to have a convex shape, there is a possibility that the mutually opposing axial direction end faces of the rollers can be surface contacted with each other. Therefore, the axial direction end face of the first roller 11 must be formed to have such a two-stage convex shape as shown in Fig. 10B which is recessed in the diameter direction at the same diameter direction positions of the inside diameter of the second roller 12.

[0037] Also, the structure according to the present embodiment, similarly to Figs. 7A - 7H according to the first embodiment, can also be applied to a structure including a third roller 16, 16a constituted of a full type roller bearing or a plain bearing. That is, a second roller 12 and multiple rollers 13 respectively constituting a full type roller bearing, first or second roller 11 or 12a constituting a single roller, first or second roller 11a or 12b constituting the outer roller of a double roller and inner roller 14 or 15 of the double roller, which are respectively situated in the axial direction intermediate portion of the tappet roller bearing in Figs. 11A ~ 11H, are respectively formed such that the axial direction two end faces thereof respectively have a convex shape. Or, as shown in Figs. 12A - 12C, a convex shape may also be formed in the axial direction two end faces of two bearing composing elements respectively situated on both sides in the axial direction of the support shaft 20. Or, as shown in Figs. 13A ~ 13D, a convex shape may also be formed in the axial direction two end faces of three bearing composing elements. However, the second roller 12a shown in Fig. 11F and the first roller 11 shown in Fig. 11H respectively have a convex-shaped axial direction end faces which are similar to the Fig. 11B.

(Third Embodiment)

[0038] Next, description will be given below of a tappet roller bearing according to a third embodiment of the invention with reference to Figs. 14 ~16.

[0039] According to the present embodiment, there is provided a structure which can prevent a tappet roller bearing 10 against wrong assembly when it is assembled. In the previously described embodiments, it is difficult to judge from the outside which of the first and sec-

ond rollers 11, 11a, 12, 12a, 12b is a roller to be contacted with the high speed cam or low speed cam. Therefore, in the case that the first and second rollers are different from each other only in the crowning shape thereof, it is difficult to judge visually which one of the rollers is the roller to be contacted. Also, in the case that the first and second rollers 11, 11a, 12, 12a, 12b are different from each other in the surface treatment thereof, even when they respectively constitute the same bearing composing elements, it is necessary to judge whether they are to be contacted with the high speed or low speed cam, which makes it necessary to take measures against wrong assembly.

[0040] Therefore, in the case that a tappet roller bearing 10 shown in Fig. 14 is composed of a combination of a plain bearing including a first roller 11 constituted of a single roller and a full type roller bearing including a second roller 12 constituting the outer race of the roller bearing, a support shaft 20 is formed to have a staged shape including a first shaft portion 20a and a second shaft portion 20b respectively adjoining each other and having different outside diameter dimensions. The first roller 11 is disposed on the periphery of the first shaft portion 20a, while the second roller 12 is disposed on the periphery of the second shaft portion 20b.

[0041] Here, since a load to be applied to the second roller 12 from the low speed cam 3b is smaller than a load to be applied thereto from the high speed cam 3a, stress involved with the support shaft 20 is also low and an oil film may be formed small. In view of this, the second roller 12 to be contacted with the low speed cam 3b is disposed on the periphery of the second shaft portion 20b having a smaller diameter than the first shaft portion 20a.

[0042] Also, the outside diameter dimensions of the first and second rollers 11 and 12 are set equal to each other. Therefore, the sum of the diameter direction dimension (thickness) of the second roller 12 and the diameter direction dimension (roller diameter) of multiple rollers 13 can be set larger than the diameter direction dimension (thickness) of the first roller 11. Here, in this case, preferably, the thickness of the second roller 12 may be set larger than the roller diameter.

[0043] Specifically, the tappet roller bearing 10 shown in Fig. 14 is assembled to the locker arm 4 using a method shown in Fig. 15. Firstly, as shown in Fig. 15A, before assembled to the locker arm 4, the tappet roller bearing 10 is held by a staged stop plug 50 including a shaft portion having an outside diameter substantially equal to the axial direction width of the tappet roller bearing 10 and also substantially equal to the first and second shaft portions 20a, 20b of the support shaft 20. And, the tappet roller bearing 10, while it remains held by the stop plug 50, is interposed between the support wall portions 9 of the locker arm 4; and, the stop plug 50 is pushed out from the small diameter side thereof using a jig 51 having an outside diameter dimension substantially equal to the small diameter side outside diameter of the stop plug 50. And, after the stop plug 50 is removed from the locker arm 4, the support shaft 20 is inserted from the side where the stop plug 50 has been pushed out to thereby remove the jig 51, so that the tappet roller bearing 10 is assembled to the locker arm 4 without wrong assembly.

[0044] Also, according to a modification of the present embodiment, as shown in Figs. 1.6A and 16B, the first and second rollers 11 and 12 may be formed such that they are different from each other in the axial direction width thereof, thereby being able to visually prevent the wrong assembly of the tappet roller bearing 10. That is, as shown in Fig. 16A, the axial direction width a of the first roller 11 receiving a large load from the high speed cam 3a may be formed set larger than the axial direction width b of the second roller 12.

[0045] Also, as shown in Fig. 16B, in the case that the tappet roller bearing 10 is constituted of a combination of a plain bearing including the first roller 11 constituting a single roller and a full type roller bearing including the second and third rollers 12 and 16b constituting the outer race of the roller bearing, the axial direction width a of the first roller 11 may also be set larger than the axial direction width b of the second and third rollers 12 and 16b.

[0046] Further, according to a further modification of the present embodiment, the tappet roller bearing may also be structured such that the first and second rollers 11 and 12 are formed different from each other in the roller diameter thereof, whereby the wrong assembly of the tappet roller bearing can be prevented visually. For example, as shown in Fig. 17, in the case that the surface pressure of the first roller 11 is high, the roller diameter of the first roller 11 is set larger than that of the second roller 12 to thereby reduce the surface pressure. On the other hand, in the case that the surface pressure of the second roller 12, the roller diameter of the second roller 12 may be increased.

[0047] Also, as shown in Fig. 18, the tappet roller bearing may also be structured by combining together the two structures respectively shown in Figs. 14 and 17. That is, the support shaft 20 is formed to have a staged shape which includes first and second shaft portions 20a and 20b respectively having mutually different outside diameter dimensions, the first roller 11 is disposed on the periphery of the first shaft portion 20a, while the second roller 12 is disposed on the periphery of the second shaft portion 20b. Also, the first and second rollers 11 and 12 are structured such that their respective roller diameters (outside diameters) are different from each other.

[0048] Also, according to the present embodiment, there can also be employed a structure in which both bearings are constituted of plain bearings and, there can also be employed in a structure which includes such first to third rollers as shown in Fig. 7. That is, to any of the above-mentioned embodiments, there can also be applied the following structures: for example, a structure in which rollers are respectively disposed in the shaft portions of the support shaft 20 having different axial diam-

eters; and, a structure in which rollers are formed such that their respective axial direction widths are different from each other. Also, a structure in which the axial direction widths of the respective rollers are different from each other can be applied to any of the above embodiments. Or, at least one of the rollers may also be formed to have a roller diameter which is different from the roller diameters of the remaining rollers.

[0049] Here, the invention is not limited to the above-mentioned embodiments but it can be changed properly without departing from the subject matter of the invention.

[0050] In the above embodiments, there is illustrated an example in which the tappet roller bearing 10 is mounted on the leading end portion of the locker arm 4. However, as shown in Fig. 19, the tappet roller bearing 10 may also be mounted onto the intermediate portion of a locker arm 40. In this case, the locker arm 40 includes a shaft hole 41 which is formed in the intermediate portion of the locker arm 40 and to the inner surface of which the two end portions of the support shaft 20 of the tappet roller bearing 10 can be fitted and fixed. Also, on one end portion (in Fig. 19, the right end portion) of the locker arm 40 in the longitudinal direction thereof, there is provided a substantially semi-cylindrical projecting portion 42 against which the end portion of the engine valve 7 (see Fig. 1) can be butted, whereas, in the other end portion of the locker arm 40, there is formed a spherical recessed portion against which the end portion of a rush adjuster (not shown) can be butted against.

[0051] Here, the invention is based on the Japanese Patent Application (Patent Application No. 2010-055650) filed on March 12, 2010 and the Japanese Patent Application (Patent Application No. 2011-006244) filed on Jan. 14, 2011 and thus the contents thereof are incorporated herein for reference.

MODE FOR IMPLEMENTING THE INVENTION

[0052]

1:	Cam follower apparatus
2:	Cam shaft
3a, 3b:	Cam
4, 40:	Locker arm
9:	Support wall portion
10:	Tappet roller bearing
11:	First roller (plain bearing)
11a:	First roller (plain bearing, outer roller)
12:	Second roller (outer race of roller bearing)
12a:	Second roller (plain bearing)
12b:	Second roller (plain bearing, outer roller)
16:	Third roller (plain bearing)
16a:	Third roller (plain bearing, outer roller)
16b:	Third roller (outer race of roller bearing)
20:	Support shaft

Claims

1. A tappet roller bearing, comprising:

a support shaft to be fixed to a locker arm for receiving the movement of a cam to be supported on the cam shaft of an engine; and
first and second rollers respectively supported rotatably on the periphery of the support shaft and arranged in the axial direction of the support shaft, wherein:

the first roller constitutes a plain bearing; and
the second roller constitutes a full type roller bearing or a plain bearing.

2. The tappet roller bearing according to Claim 1, wherein:

the cam includes a high speed cam and a low speed cam respectively disposed on the cam shaft slidably in the axial direction of the cam shaft;
the first roller constituting the plain bearing is contacted with the high speed cam; and
the second roller constituting the full type roller bearing is contacted with the low speed cam.

3. The tappet roller bearing according to Claim 1 or 2, wherein:

the cam includes a high speed cam and a low speed cam respectively disposed on the cam shaft slidably in the axial direction of the cam shaft;
the outer peripheral surface of the first roller to be contacted with the high speed cam is formed by barrel working to be carried out after polish finishing; and
the outer peripheral surface of the second roller to be contacted with the low speed cam is formed by polish finishing without being barrel worked.

4. The tappet roller bearing according to any one of Claims 1 to 3, wherein
the outer peripheral surfaces of the first and second rollers are not crowning worked but have a uniform diameter in the axial direction thereof.

5. The tappet roller bearing according to any one of Claims 1 to 4, wherein
at least one of the first and second rollers is structured so that an axial direction end face has a convex shape.

6. The tappet roller bearing according to Claim 5, wherein:

at least one of the first and second rollers, the axial direction end face of which is formed to have the convex shape, constitutes a double roller; and
the inner roller of the double roller is structured so that an axial direction end face has a convex shape.

7. The tappet roller bearing according to Claim 5, wherein:

the second roller constitutes a full type roller bearing; and
the multiple rollers of the roller bearing, together with the second roller, are structured so that respective axial direction end faces have a convex shape.

8. The tappet roller bearing according to any one of Claims 1 to 7, wherein:

the support shaft is formed to have a staged shape including first and second shaft portions different from each other in the outside diameter dimension thereof;
the first roller is disposed on the periphery of the first shaft portion; and
the second roller is disposed on the periphery of the second shaft portion.

9. The tappet roller bearing according to any one of Claims 1 to 8, wherein
the first and second rollers are different from each other in the axial direction width thereof.

10. The tappet roller bearing according to any one of Claims 1 to 9, wherein
the first and second rollers are different from each other in the roller diameter thereof.

11. The tappet roller bearing according to any one of Claims 1 to 10, further comprising
a third roller rotatably supported on the periphery of the support shaft and arranged together with the first and second rollers in the axial direction of the support shaft.

12. The tappet roller bearing according to any one of Claims 1 to 10, further comprising
a third roller rotatably supported on the periphery of the support shaft and arranged together with the first and second rollers in the axial direction of the support shaft, wherein
in a case that the second roller constitutes a roller bearing, the third roller is situated on the opposite side to the second roller with respect to the first roller.

13. The tappet roller bearing according to Claim 11 or 12, wherein
the outer peripheral surface of at least one of the first to third rollers is crowning worked.

FIG. 1

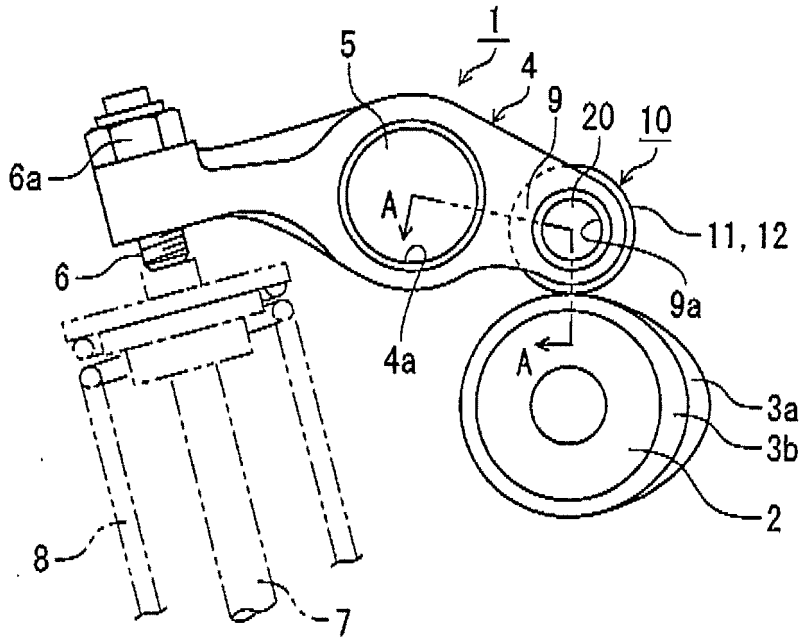


FIG. 2

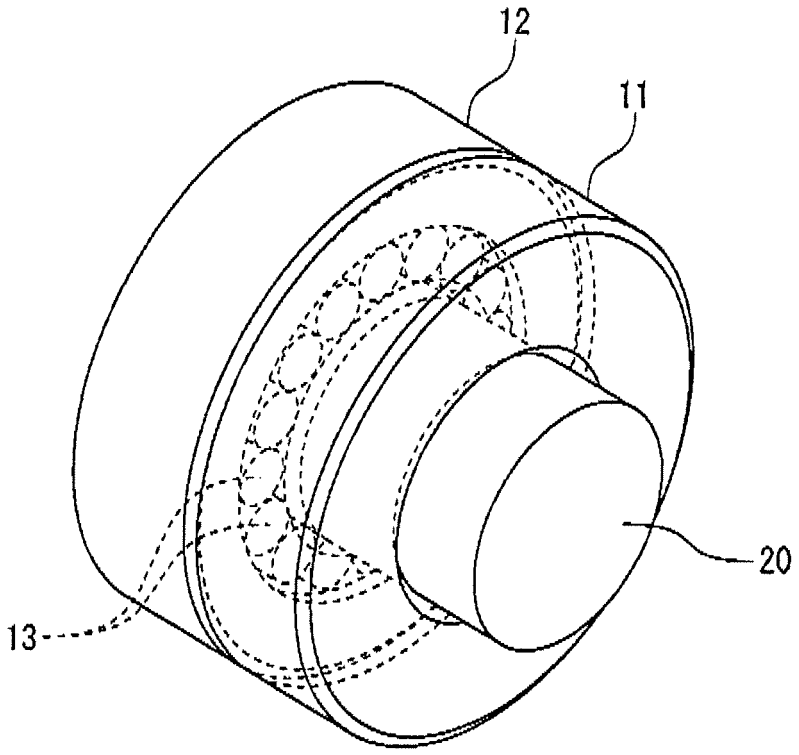


FIG. 3

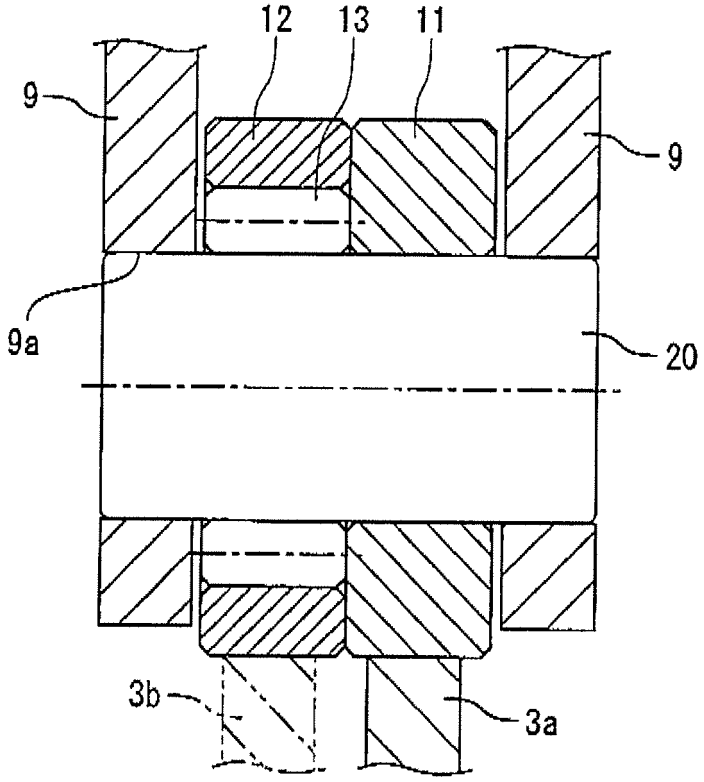


FIG. 4

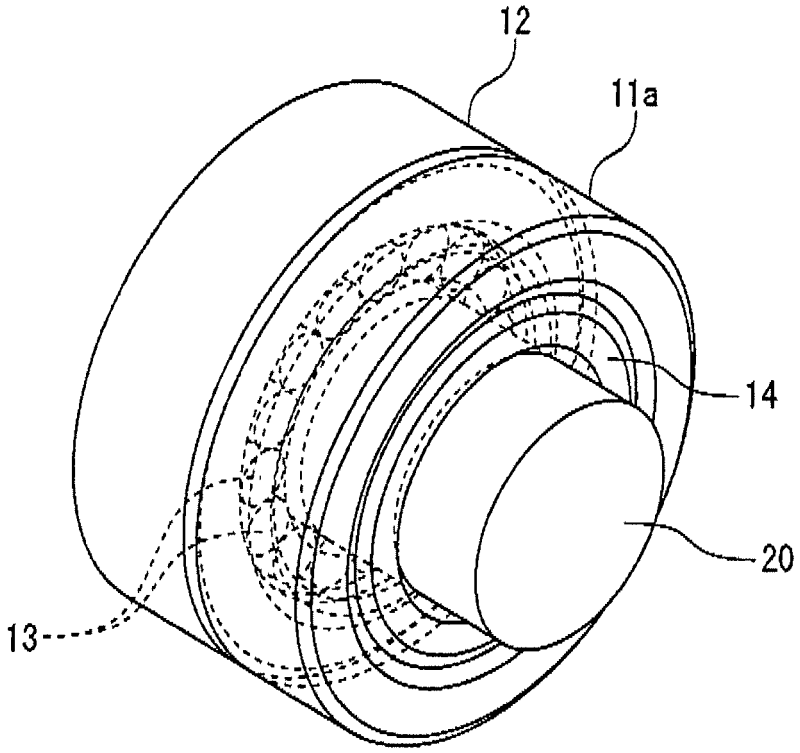


FIG. 5

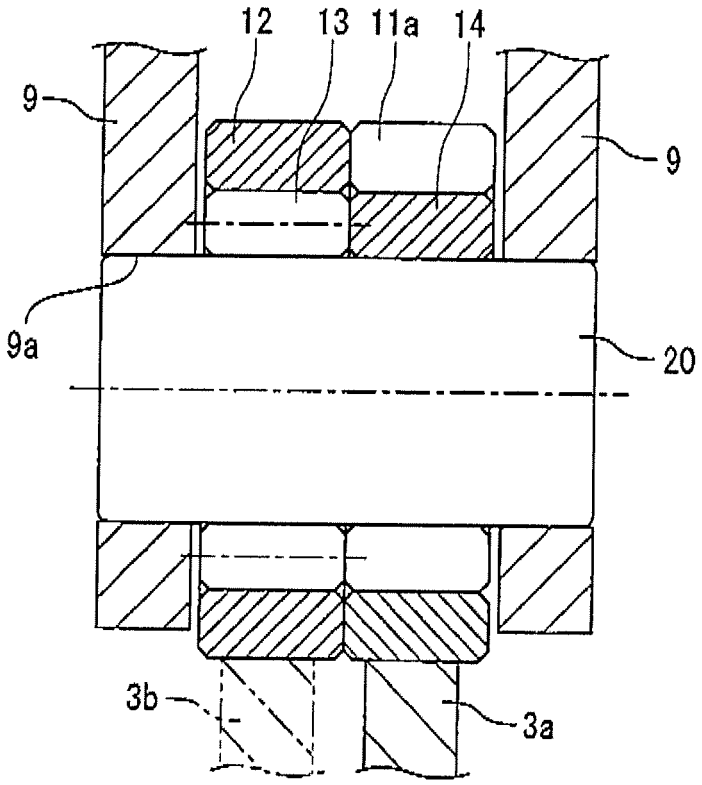
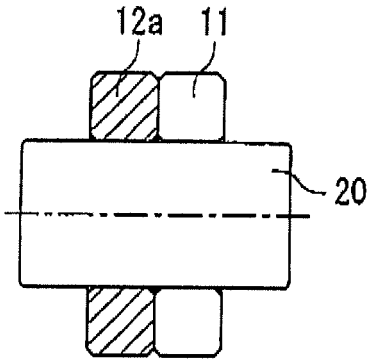
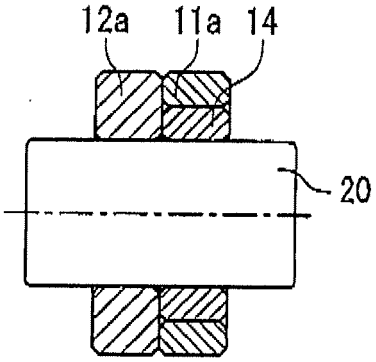


FIG. 6A



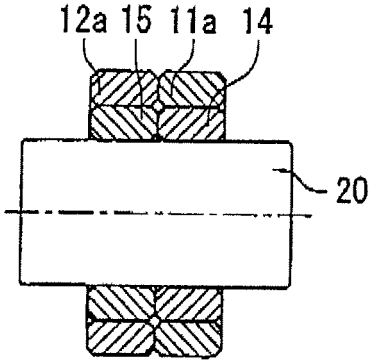
SINGLE ROLLER+SINGLE ROLLER

FIG. 6B



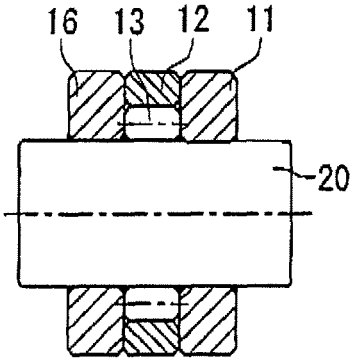
SINGLE ROLLER+DOUBLE ROLLER

FIG. 6C



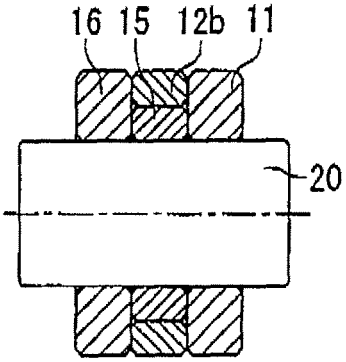
DOUBLE ROLLER+DOUBLE ROLLER

FIG. 7A



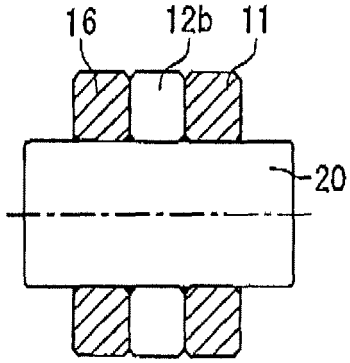
SINGLE+FULL+SINGLE

FIG. 7B



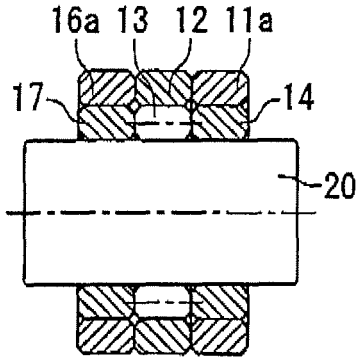
SINGLE+DOUBLE+SINGLE

FIG. 7C



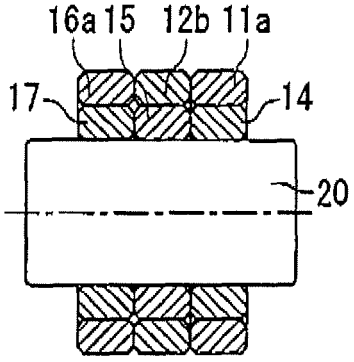
SINGLE+SINGLE+SINGLE

FIG. 7D



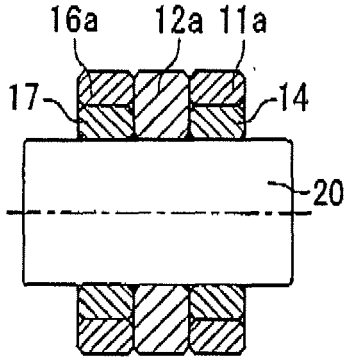
DOUBLE+FULL+DOUBLE

FIG. 7E



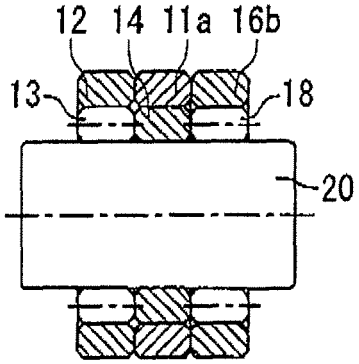
DOUBLE+DOUBLE+DOUBLE

FIG. 7F



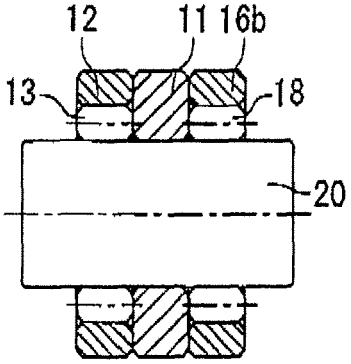
DOUBLE+SINGLE+DOUBLE

FIG. 7G



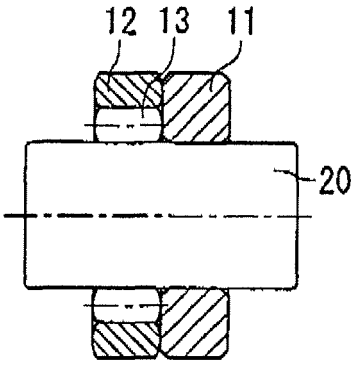
FULL+DOUBLE+FULL

FIG. 7H



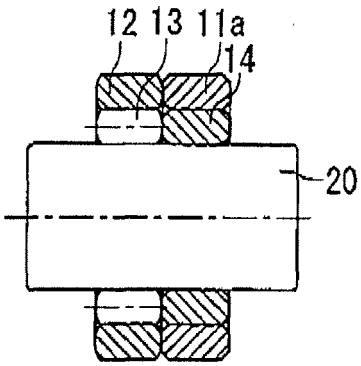
FULL+SINGLE+FULL

FIG. 8A



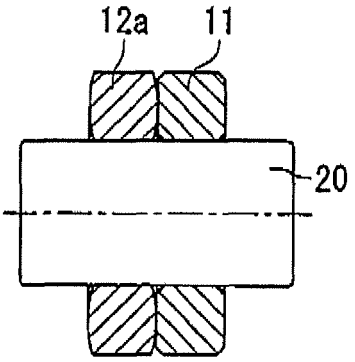
FULL (CONVEX-SHAPED END FACE) +SINGLE ROLLER

FIG. 8B



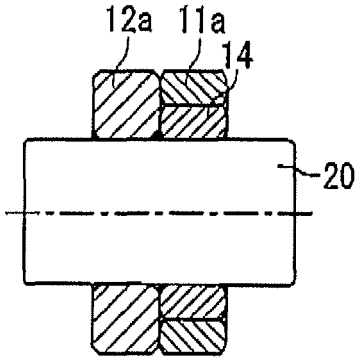
FULL (CONVEX-SHAPED END FACE) +DOUBLE ROLLER

FIG. 8C



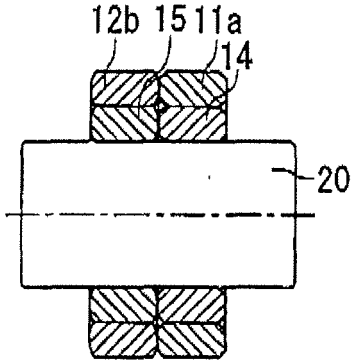
SINGLE ROLLER (CONVEX-SHAPED END FACE) +SINGLE ROLLER

FIG. 8D



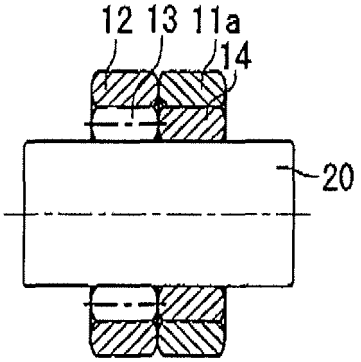
SINGLE ROLLER+DOUBLE ROLLER (CONVEX-SHAPED END FACE)

FIG. 8E



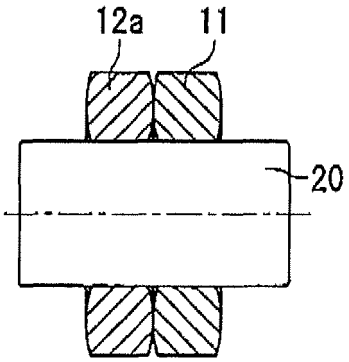
DOUBLE ROLLER (CONVEX-SHAPED END FACE) +DOUBLE ROLLER

FIG. 9A



FULL (CONVEX-SHAPED END FACE) +
DOUBLE ROLLER (CONVEX-SHAPED END FACE)

FIG. 9B



SINGLE ROLLER (CONVEX-SHAPED END FACE) +
SINGLE ROLLER (CONVEX-SHAPED END FACE)

FIG. 10A

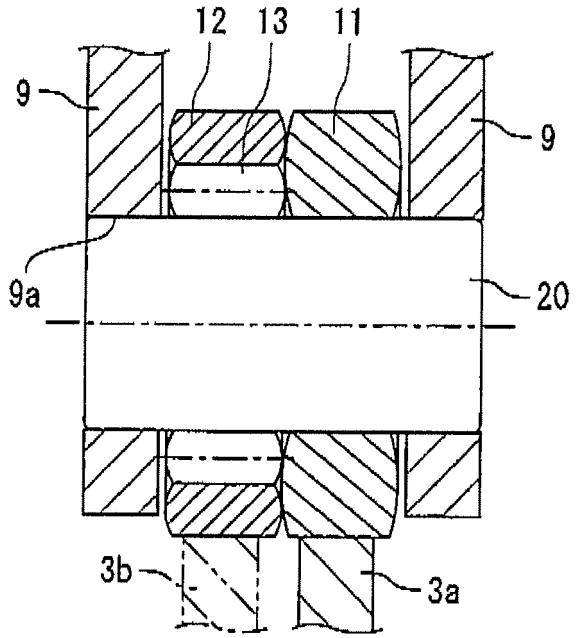


FIG. 10B

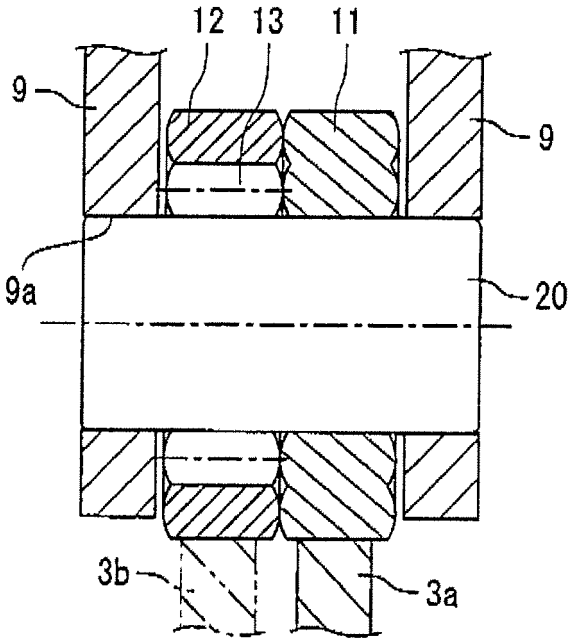
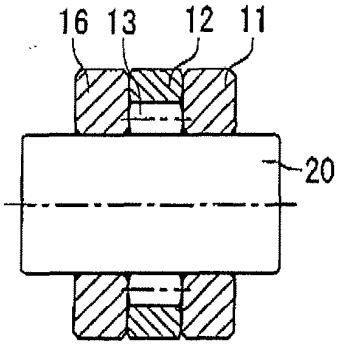
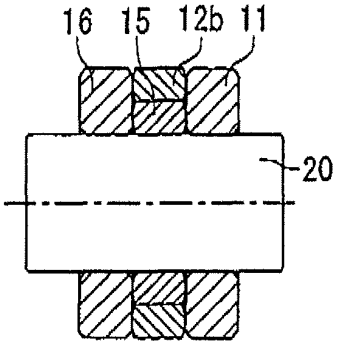


FIG. 11A



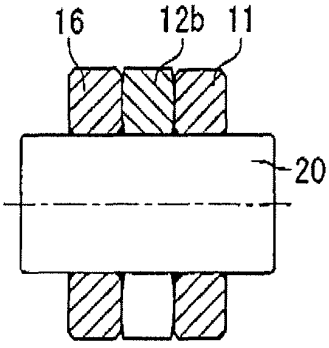
SINGLE+FULL+SINGLE

FIG. 11B



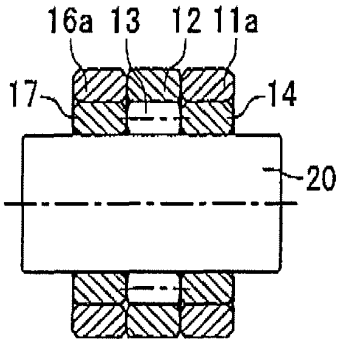
SINGLE+DOUBLE+SINGLE

FIG. 11C



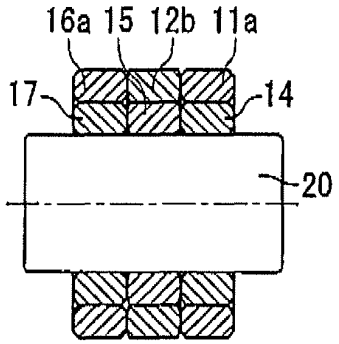
SINGLE+SINGLE+SINGLE

FIG. 11D



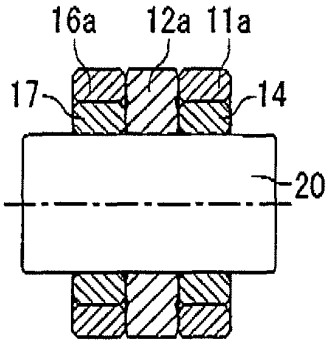
DOUBLE+FULL+DOUBLE

FIG. 11E



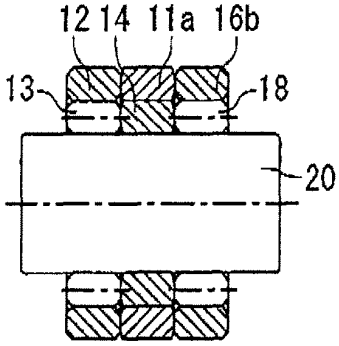
DOUBLE+DOUBLE+DOUBLE

FIG. 11F



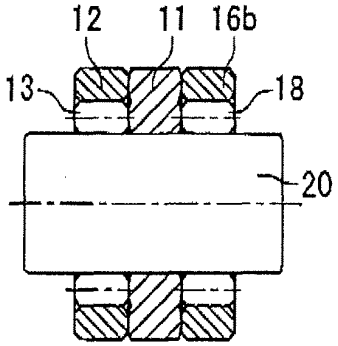
DOUBLE+SINGLE+DOUBLE

FIG. 11G



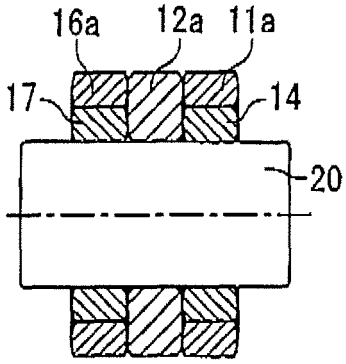
FULL+DOUBLE+FULL

FIG. 11H



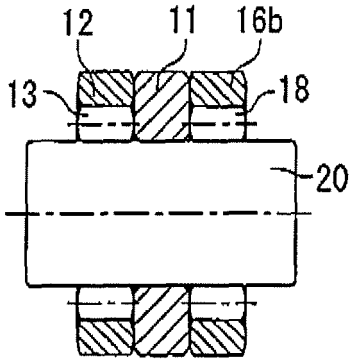
FULL+SINGLE+FULL

FIG. 12A



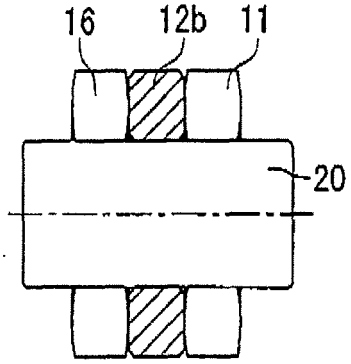
DOUBLE ROLLER (CONVEX-SHAPED END FACE) +SINGLE ROLLER+DOUBLE ROLLER (CONVEX-SHAPED END FACE)

FIG. 12B



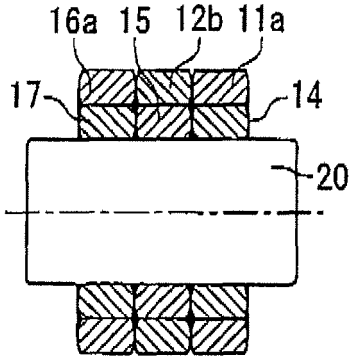
FULL (CONVEX-SHAPED END FACE) +SINGLE ROLLER+FULL (CONVEX-SHAPED END FACE)

FIG. 12C



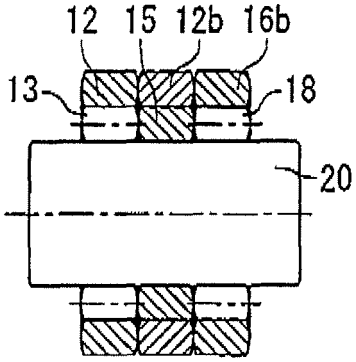
SINGLE ROLLER (CONVEX-SHAPED END FACE) +SINGLE ROLLER+SINGLE ROLLER (CONVEX-SHAPED END FACE)

FIG. 13A



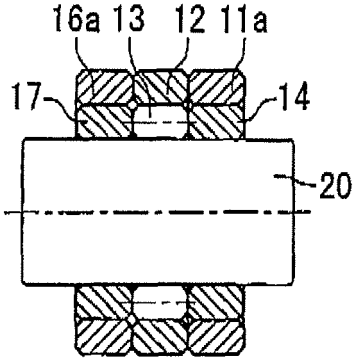
DOUBLE ROLLER (CONVEX-SHAPED END FACE) +DOUBLE ROLLER (CONVEX-SHAPED END FACE) +DOUBLE ROLLER (CONVEX-SHAPED END FACE)

FIG. 13B



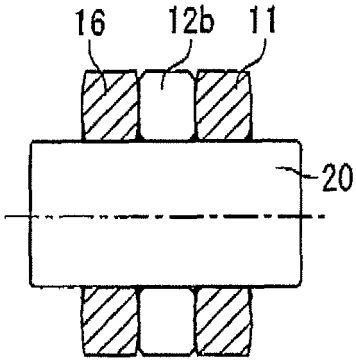
FULL (CONVEX-SHAPED END FACE) +DOUBLE ROLLER (CONVEX-SHAPED END FACE) +FULL (CONVEX-SHAPED END FACE)

FIG. 13C



DOUBLE ROLLER (CONVEX-SHAPED END FACE) +FULL (CONVEX-SHAPED END FACE) +DOUBLE ROLLER (CONVEX-SHAPED END FACE)

FIG. 13D



SINGLE ROLLER (CONVEX-SHAPED END FACE) +SINGLE ROLLER (CONVEX-SHAPED END FACE) +SINGLE ROLLER (CONVEX-SHAPED END FACE)

FIG. 14

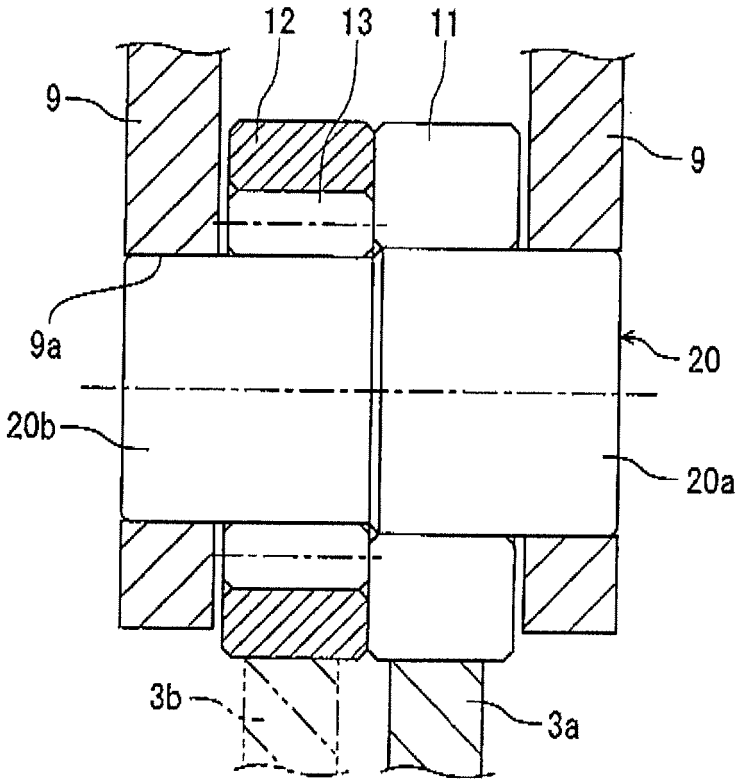


FIG. 15A

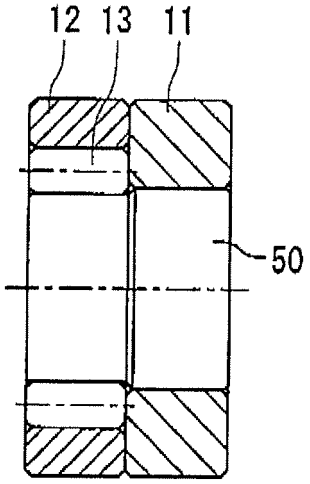


FIG. 15B

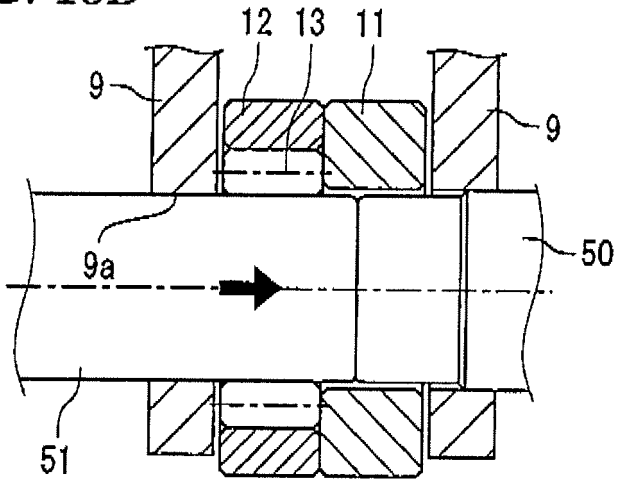


FIG. 15C

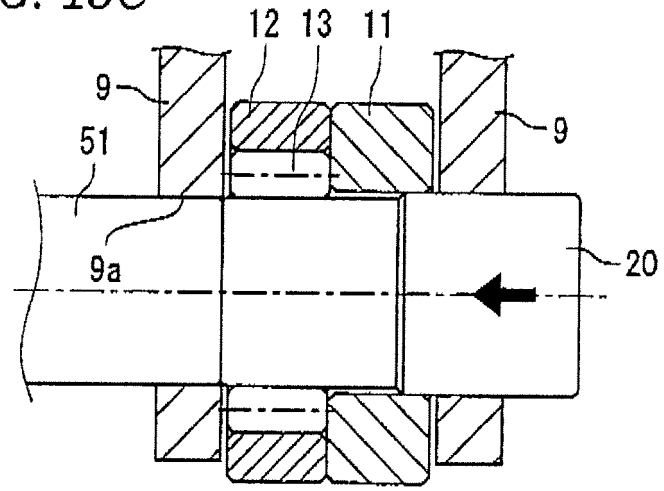


FIG. 16A

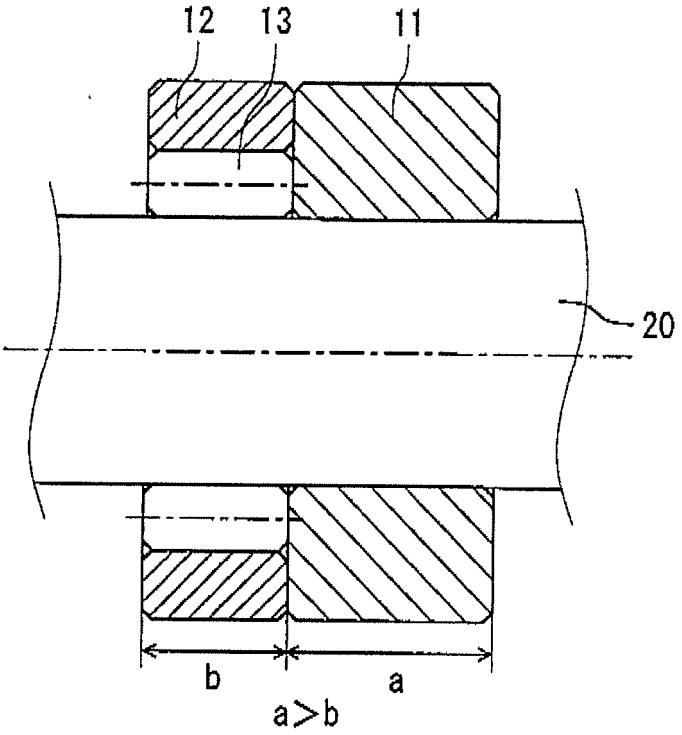


FIG. 16B

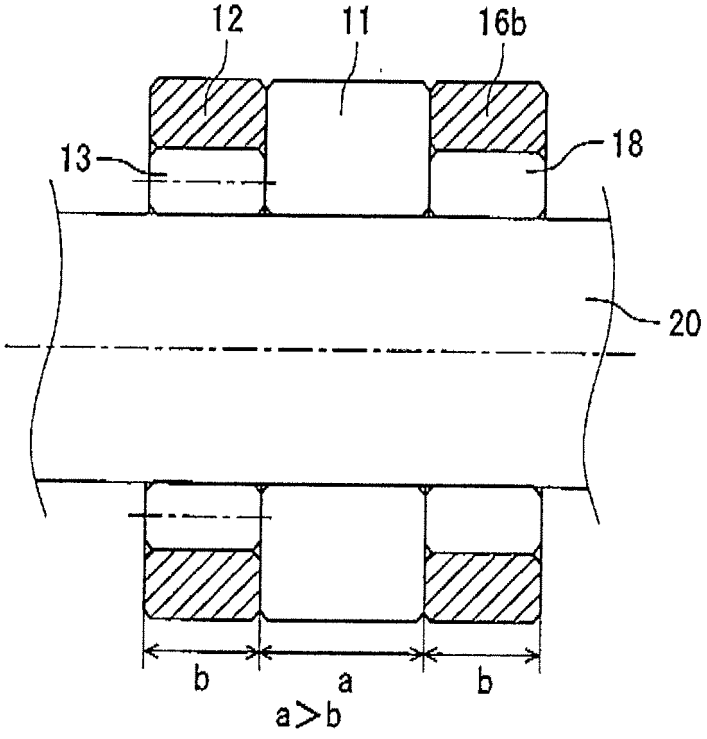


FIG. 17

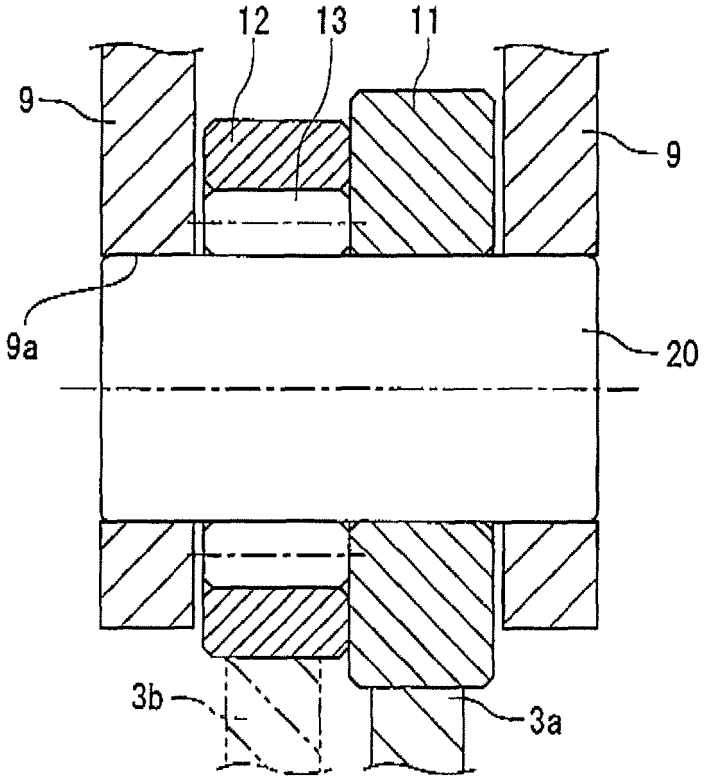


FIG. 18

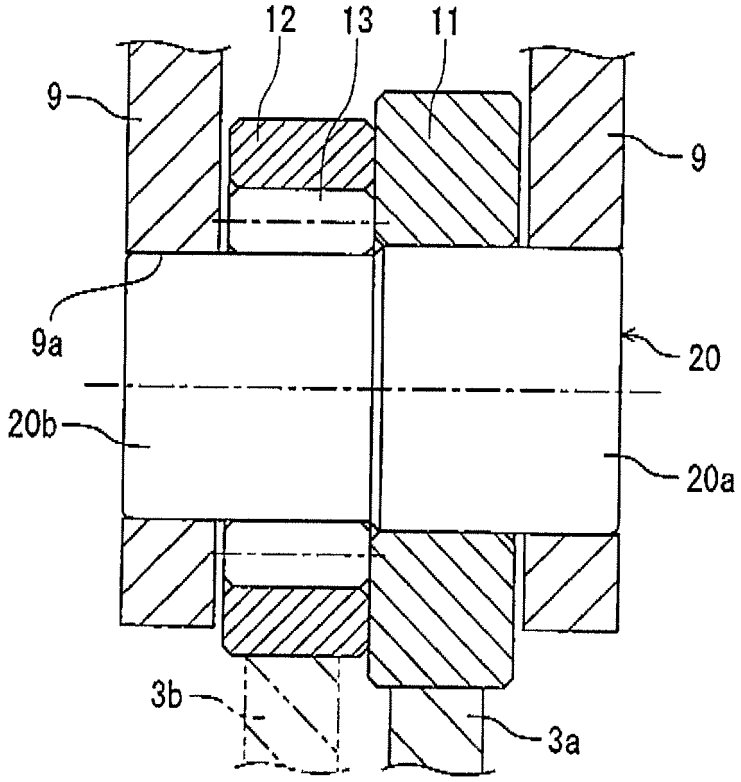
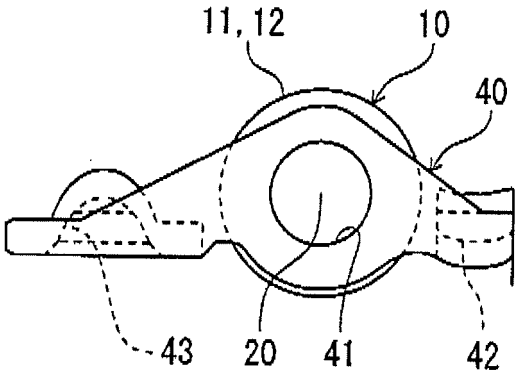


FIG. 19



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/050763

A. CLASSIFICATION OF SUBJECT MATTER
F01L1/18(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01L1/18

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2011
Kokai Jitsuyo Shinan Koho 1971-2011 Toroku Jitsuyo Shinan Koho 1994-2011

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2004-100539 A (NTN Corp.), 02 April 2004 (02.04.2004), paragraph [0014]; fig. 3 & US 2004/0045518 A1 & US 2006/0107916 A1 & DE 10341885 A	1-13
Y	JP 2009-293392 A (NTN Corp.), 17 December 2009 (17.12.2009), paragraphs [0020], [0026], [0060]; fig. 1, 4, 8 (Family: none)	1-13
Y	JP 50-35976 B2 (The Torrington Co.), 20 November 1975 (20.11.1975), fig. 2 & DE 2158345 A1 & US 3674325 A & GB 1344687 A & CA 942366 A1	1-13

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

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Date of the actual completion of the international search	Date of mailing of the international search report
08 April, 2011 (08.04.11)	19 April, 2011 (19.04.11)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/050763

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 113070/1983(Laid-open No. 21505/1985) (Toyota Motor Corp.), 14 February 1985 (14.02.1985), fig. 3 to 4 (Family: none)	2-3
Y	JP 2005-299551 A (Honda Motor Co., Ltd.), 27 October 2005 (27.10.2005), paragraph [0028] (Family: none)	8
A	JP 6-331003 A (Koyo Seiko Co., Ltd.), 29 November 1994 (29.11.1994), paragraphs [0018] to [0019], [0024] (Family: none)	1-13
A	JP 2000-45737 A (Honda Motor Co., Ltd.), 15 February 2000 (15.02.2000), paragraph [0021]; fig. 1 to 2 (Family: none)	1-13

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 6532920 B **[0005]**
- DE 102006018512 **[0005]**
- JP 2009293392 A **[0005]**
- US 3674325 A **[0005]**
- JP 2010055650 A **[0051]**
- JP 2011006244 A **[0051]**