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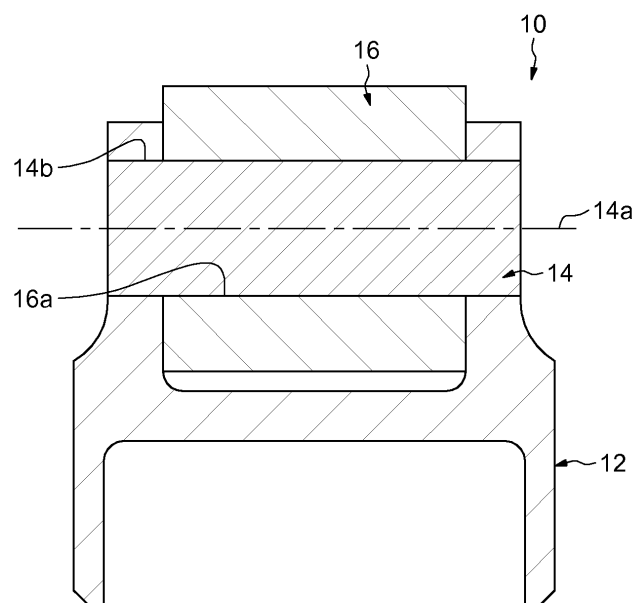
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(54) **Cam follower roller device, notably for a fuel injection pump**

(57) The cam follower roller device notably for fuel injection pump of an internal combustion engine, comprises a body 12, a shaft 14 mounted on the body and a

roller 16 rotatably mounted on said shaft. At least one of the shaft and the roller is coated with an antifriction and/or wear resistance coating.

FIG.1



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Description

[0001] The present invention relates to the field of mechanical cam follower roller devices for actuating a reciprocating movement used in automotive or industrial applications, such as fuel injection pumps, ICE valve timing systems, valvetrain cam followers or rocker arm bearings.

[0002] An advantageous application of the invention is the use of the device in a fuel injection pump intended for an internal combustion engine, notably of a motor vehicle.

[0003] Such a device generally comprises an outer sleeve or casing and a roller mounted on said casing and adapted to collaborate with a cam synchronized with the internal combustion engine camshaft so that the rotation of the camshaft leads to a periodic displacement of a piston of the pump which is in contact against the casing of the device. Patent application US2008/0190237 discloses such a conventional mechanical device.

[0004] With increasing demand on fuel efficiency, the pressure of the fuel pump has raised significantly last years. With a higher fuel pump pressure, the load applied on the cam follower roller device increases as well.

[0005] Otherwise, automotive engine manufactures are looking for an oil-free operation. This means that the use of the lubricating oil shall be limited or even avoided for the cam follower roller device. Besides, some time is necessary for the engine oil to reach the device. Accordingly, there will be a period of time without lubrication for the device.

[0006] Currently, the conventional mechanical cam follower roller devices are not adapted to meet these two major requirements: a higher contact pressure and an increased service life under conditions where lubrication is poor or absent.

[0007] One aim of the present invention is to overcome these drawbacks.

[0008] It is a particular object of the present invention to provide a cam follower roller device, notably for a fuel injection pump, which has an increased service life.

[0009] In one embodiment, the cam follower roller device, notably for fuel injection pump of an internal combustion engine, comprises a body, a shaft mounted on the body and a roller rotatably mounted on said shaft. At least one of the shaft and the roller is coated with an antifriction and/or wear resistance coating.

[0010] Each of the shaft and the roller may be coated with an antifriction and/or wear resistance coating. Advantageously, at least the outer surface of the shaft and the bore of the roller are coated with an antifriction and/or wear resistance coating.

[0011] In one embodiment, one of the shaft and the roller is coated with a diamond like carbon coating, the other being coated with a black oxide coating. Preferably, the shaft is coated with the diamond like carbon coating and the roller is coated with the black oxide coating.

[0012] In one embodiment, the thickness of the dia-

mond like carbon coating is from 1 to 4 μm . The thickness of the black oxide coating may be from 0.5 to 1.5 μm , and preferably from 0.8 to 1.2 μm .

[0013] In one embodiment, the device comprises a bushing radially interposed between the roller and the shaft. Advantageously, the outer surface of the bushing in contact with the roller and the bore of said bushing in contact with the shaft are each coated with an antifriction and/or wear resistance coating. One of the outer surface and the bore of the bushing may be coated with a diamond like carbon coating, the other being coated with a black oxide coating. Preferably, the outer surface of the bushing is coated with the diamond like carbon coating and the bore is coated with the black oxide coating.

[0014] The present invention and its advantages will be better understood by studying the detailed description of specific embodiments given by way of non-limiting examples and illustrated by the appended drawings on which:

- Figures 1 and 2 are sections of cam follower roller devices according to first and second examples of the invention, and
- Figure 3 is a side view of a cam follower roller device according to a third example of the invention.

[0015] A first embodiment of a cam follower roller device 10 is illustrated on Figure 1, said device may for example be used in a fuel injection pump intended for an internal combustion engine.

[0016] The device 10 comprises an outer body or casing 12, a pin or shaft 14 extending along an axis 14a and mounted on the casing, and a roller 16 supported on the shaft and adapted to press against a cam (not shown) synchronized with the internal combustion engine camshaft or directly against a cam of the said camshaft. The outer casing 12 has a tubular form and may be made of stamped metal sheet.

[0017] The ends of the shaft 14 are fixed for example by push-fitting in through-holes formed on the casing 12 and facing on another. Alternatively, the shaft 14 may be fixed to the casing by any other appropriate means.

[0018] The roller 16 is rotatably mounted on an outer cylindrical surface 14b of the shaft 14 and has a bore 16a of cylindrical shape which comes radially into direct contact with said outer surface. In order to obtain both low friction and high wear resistance, the outer surface 14b of the shaft 14 is coated with a diamond like carbon (DLC) coating. The diamond like carbon coating may be a metal-mixed diamond like carbon coating comprising alternating layers of predominantly diamond like carbon but containing some metal carbide, and layers of predominantly metal carbide but containing some diamond like carbon, each of the order of 1 to 50 nanometre thickness for instance. Alternatively, the metal carbide can be in the form of clusters disposed throughout a layer of diamond like carbon. Such layers consist of a matrix of predominantly diamond like carbon with a dispersion of particles of metal

carbide. Said particles can have clustered morphology regions of metal carbide up to 100 nm in extent. The clusters may be composed of carbides of one or more metals.

[0019] The metal mixed diamond like carbon coating may be formed on a metallic interlayer of Cr, W, Mo, or A1, which is pre-deposited onto the outer surface 14b of the shaft 14. The diamond like carbon coating, applied to the metallic interlayer, may also contain one or more metallic carbide forming elements such as W, Mo or Ti. For more detail on such diamond like carbon coating, it could be referred to EP-B1-1 015 780 (SKF) which is hereby incorporated by reference.

[0020] Alternatively, the diamond like carbon coating may be a doped diamond like carbon coating, such as a metal doped hydrogenated diamond-like carbon coating a-C:H:Me or metal doped diamond like carbon coating Me-DLC. For the coating a-C:H:Me, the hydrogen concentration may be from 10 to 40% of hydrogen, and preferably from 20 to 30 %. Said coating may be doped with elements such as W or Ti. For the coating Me-DLC, the concentration of the metal may be from 5 to 30%, preferably from 15 to 25%.

[0021] The doped diamond like carbon coating may have a multilayer structure with one layer rich in metal and another layer rich in carbon. The thickness of each layer may be from 2 to 10 nm, and preferably from 10 to 50 nm. The multilayer structure increases the toughness of the coating and gives rise to reduced residual stresses in the coating and therefore enhanced adhesion. In fact, a reduced residual stresses increase the resistance of the coating to indentation damage and reduce the risk of coating cracks and delamination. The total thickness of the doped diamond like carbon coating may be from 1 to 4 μm . The hardness of said coating may be from 8 to 25 GPa, and preferably from 10 to 15GPa. The doped diamond like carbon coating may be formed on a metallic interlayer of W or Ti which is pre-deposited onto the outer surface of the shaft 14. The thickness of the metallic interlayer may be from 0.05 to 0.5 μm . A bond layer of W may be provided between the metallic interlayer and the doped diamond-like carbon coating.

[0022] The bore 16a of the roller 16 in contact with the diamond like carbon coating of the shaft 14 is coated with a black oxide coating such as magnetite Fe_3O_4 . The thickness of the black oxide coating may be from 0.5 to 1.5 μm , and preferably from 0.8 to 1.2 μm . For the sake of the coating process, all the surfaces of the roller 16 may be coated with the black oxide coating. With the black oxide coating, the adhesive wear or seizure is limited during an oil-free operation even in highly loaded conditions. Such coating acts as a wear resistance coating. Light preservative oil can be applied on both the black oxide coating of the roller and the diamond like carbon coating of the shaft to improve the ability to work in the oil-free condition and the resistance to rust.

[0023] In the described embodiment, the diamond like carbon coating is provided on the shaft 14 and the black

oxide coating on the roller 16. Alternatively, it may be possible to have a device 10 with a diamond like carbon coating on the roller and a black oxide coating on the shaft.

[0024] The embodiment shown on Figure 2, in which identical parts are given identical references, differs from the previous embodiment in that the device 10 further comprises a sleeve or bushing 18 radially disposed between the outer surface 14b of the pin 14 and the bore 16a of the roller 16. An outer cylindrical surface 18a of the bushing comes radially into contact with the bore 16a of the roller and a bore 18b of said bushing comes radially into contact with the outer surface 14b of the shaft. Advantageously, the bushing 18 is coated with at least an antifriction and/or wear resistance coating. The bushing 18 may be coated with a diamond like carbon coating or a black oxide coating as previously described. Preferably, the outer surface 18a of the bushing 18 is coated with the diamond like carbon coating when the black oxide coating is provided on the bore 16a of the roller 16, and the bore 18b of said bushing is coated with the black oxide coating when the diamond like carbon coating is provided on the outer surface 14b of the shaft 14. Alternatively, for a device having the diamond like carbon coating on the roller and the black oxide coating on the shaft, the disposition on the bushing of the black oxide and diamond like carbon coatings is inverted.

[0025] A third embodiment of a cam follower roller device 10 is illustrated on Figure 3, said device being used to control a valve 22 of an internal combustion engine 24. The device 10 comprises a rocker body or arm 26, a pin 27 and a shaft 28 each extending along an axis 27a, 28a and being mounted on the arm, and a roller 30 supported on the shaft 28 and adapted to press against a cam 32 of the internal combustion engine camshaft so that rotation of the camshaft causes a periodic pivoting of the rocker arm in order to open and close the valve 22. The roller 30 is rotatably mounted on an outer cylindrical surface 28b of the shaft and has a bore 30a of cylindrical shape which comes radially into direct contact with said outer surface.

[0026] The rocker arm 26 comprises two identical and spaced walls 26a which are assembled together to support therebetween the pin 27 and the shaft 28. One end of each wall 26a presses against a plate 34 provided on the top of the control valve 22. A spring 35 is mounted between said plate and the combustion engine 24. The shaft 28 is mounted at the opposite end of each wall 26a. The rocker arm 26 may pivot around the axis 27a of the transversal pin 27 which is parallel to the axis 28a of the shaft. In this embodiment, the shaft 28 and the roller 30 are identical to those described in the first embodiment and comprise coatings as previously disclosed. Similarly, a bushing may radially be interposed between the roller 30 and the shaft 28 as disclosed in the second embodiment.

[0027] With the combination of two coatings applied separately on the shaft and the roller, and possibly on

the bushing, and coming into contact one another, the service life of the device is enhanced even under highly loaded conditions and conditions where lubrication is poor or absent.

[0028] Otherwise, in the case of a lubricated device, since it will take a few seconds for the lubricant to reach the contact zone, in addition to the coating(s), it is advantageous to apply some lubricant on the roller and/or pin, e.g. by dipping, either before or after assembly of the device. It is particularly advantageous to apply the lubricant on the component(s) with the black oxide coating because the latter is able to retain a quantity of lubricant higher than a non-coated surface or the diamond like carbon coating.

face of the bushing (18) in contact with the roller and the bore of said bushing in contact with the shaft are each coated with an antifriction and/or wear resistance coating.

10. Device according to claim 9, wherein one of the outer surface and the bore of the bushing (18) is coated with a diamond like carbon coating, the other being coated with a black oxide coating.
11. Device according to claim 10, wherein the outer surface of the bushing (18) is coated with the diamond like carbon coating and the bore is coated with the black oxide coating.

Claims

1. Cam follower roller device, notably for fuel injection pump of an internal combustion engine, comprising a body (12; 26), a shaft (14; 28) mounted on the body and a roller (16; 30) rotatably mounted on said shaft, **characterized in that** at least one of the shaft and the roller is coated with an antifriction and/or wear resistance coating.
2. Device according to claim 1, wherein each of the shaft and the roller is coated with an antifriction and/or wear resistance coating.
3. Device according to claim 2, wherein at least the outer surface (14b; 28b) of the shaft and the bore (16a; 30a) of the roller are coated with an antifriction and/or wear resistance coating.
4. Device according to claim 2 or 3, wherein one of the shaft and the roller is coated with a diamond like carbon coating, the other being coated with a black oxide coating.
5. Device according to claim 4, wherein the shaft is coated with the diamond like carbon coating and the roller is coated with the black oxide coating.
6. Device according to claim 4 or 5, wherein the thickness of the diamond like carbon coating is from 1 to 4 μm .
7. Device according to any of the preceding claims 4 to 6, wherein the thickness of the black oxide coating is from 0.5 to 1.5 μm , and preferably from 0.8 to 1.2 μm .
8. Device according to any of the preceding claims, further comprising a bushing (18) radially interposed between the roller (16; 30) and the shaft (14; 28).
9. Device according to claim 8, wherein the outer sur-

FIG.1

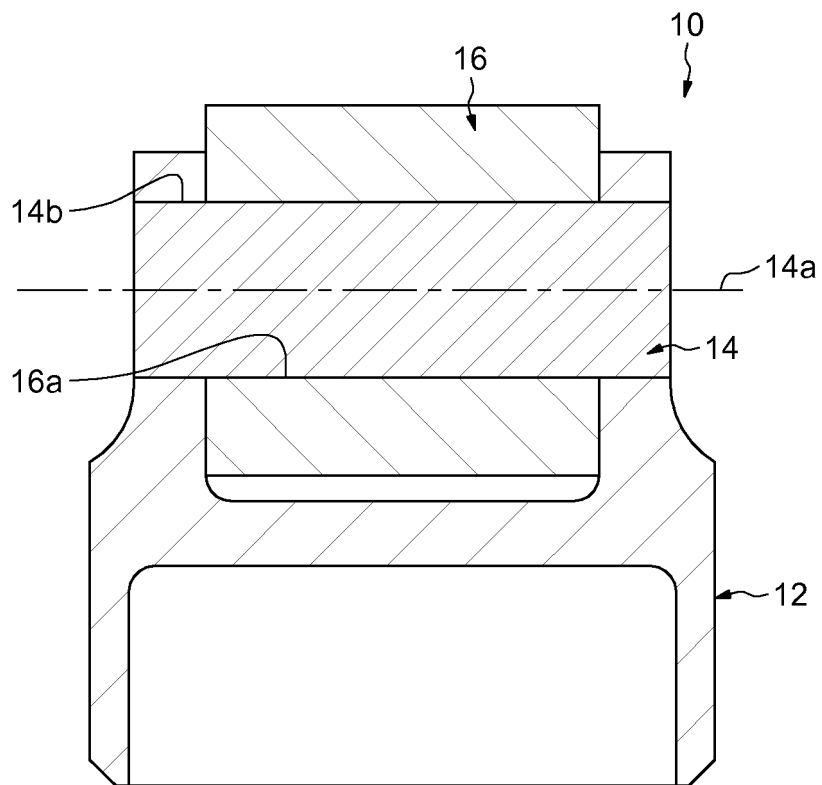


FIG.2

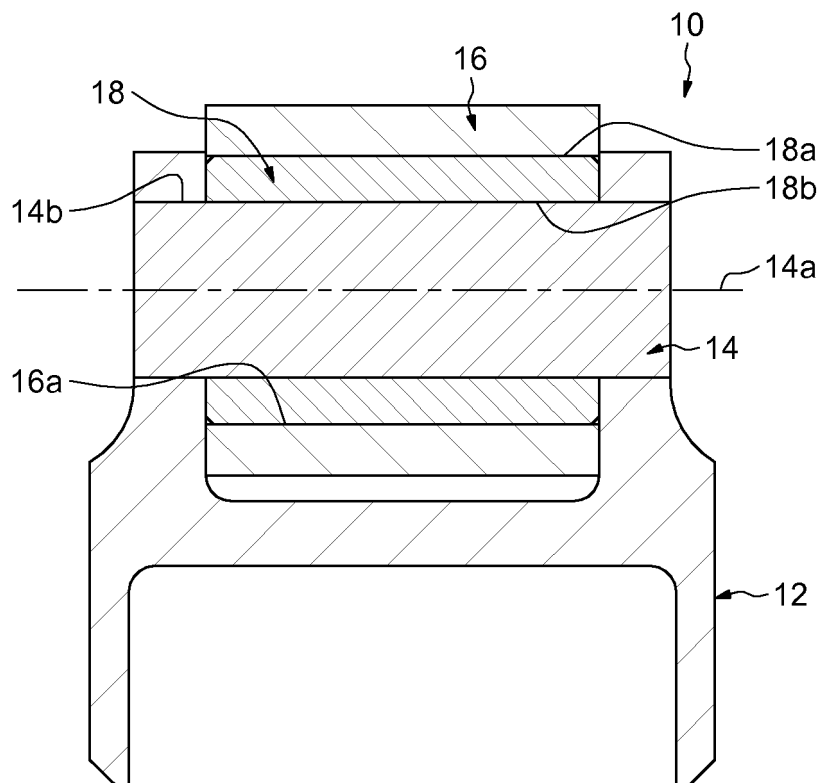
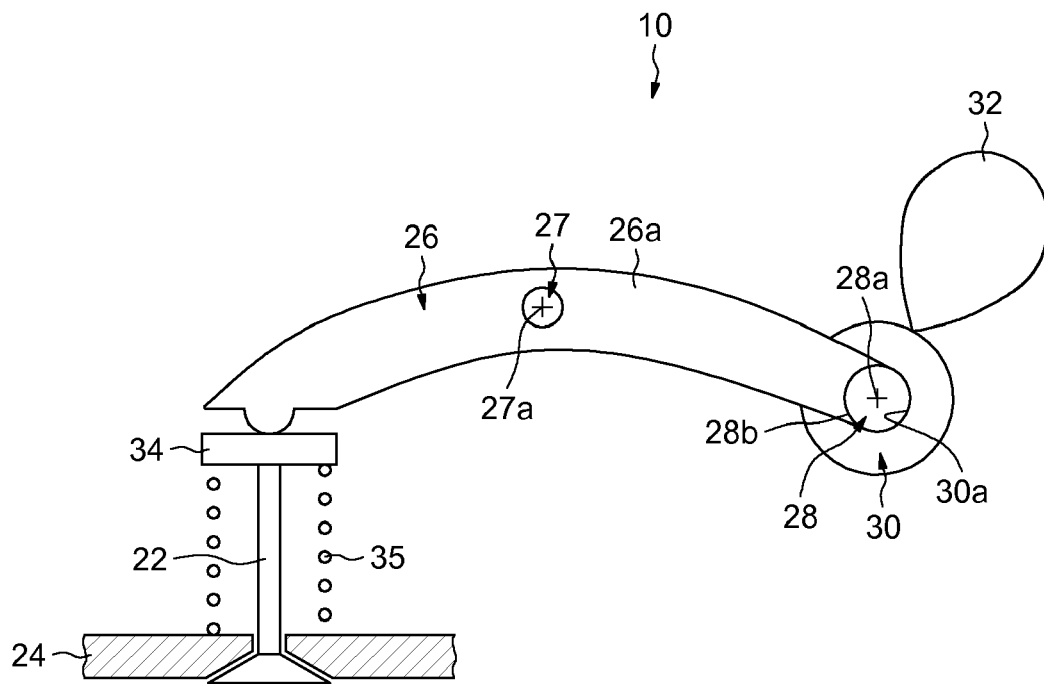


FIG.3





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Application Number
EP 12 30 5653

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Y	* column 2, line 24 - column 3, line 18 *	8,9	
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X	----- US 5 816 207 A (NSK, LTD. [JP]) 6 October 1998 (1998-10-06) * column 3, line 54 - column 9, line 53 * * claim 1 * * figures 4,5 *	1-3,6,7	
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Place of search Munich		Date of completion of the search 18 December 2012	Examiner Gnächtel, Frank
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EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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