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(54) Method of mounting camshaft

(57) The present invention relates to a method for mounting a camshaft onto a cylinder head of an internal combustion engine, said camshaft being supported by several sets of cam carrier and cam cap, each set being independently disposed at every journal section of the camshaft, wherein at least the cam carriers are mounted onto said cylinder head using a shaft-like jig, wherein an outer diameter of a portion of the jig, which corresponds to the journal section of the camshaft, is set larger than an outer diameter of the journal section of the camshaft:

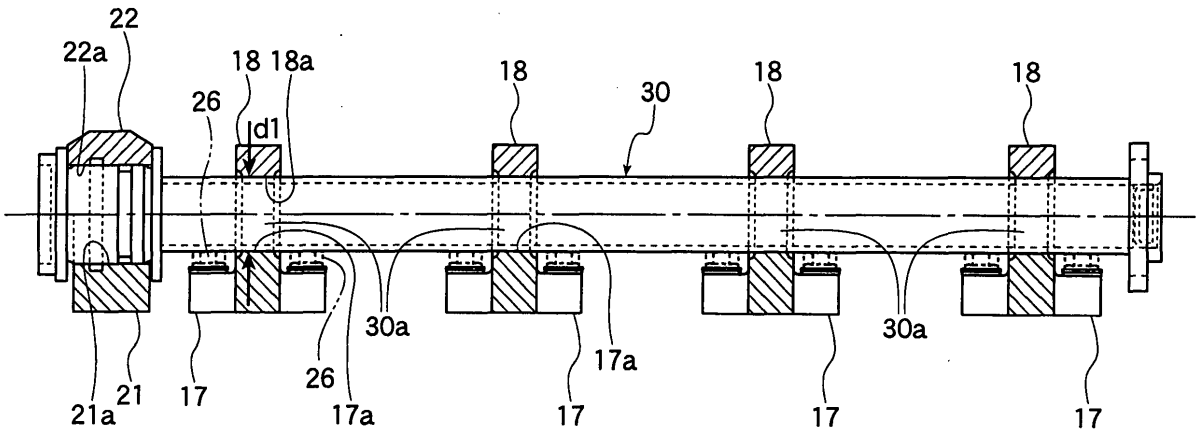

FIG. 1

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Description

[0001] The present invention relates to a method for mounting a camshaft, and in particular to a method for mounting a camshaft onto an internal combustion engine, and also relates to the engine on which the camshaft is mounted by means of the method.

[0002] Conventionally, this kind of methods includes a method described in JP-A-2000-170506, for example. JP-A-2000-170506 discloses a structure including a lower cam holder (cam carrier) provided for both an intake camshaft and an exhaust camshaft, and two upper cam holders (cam caps) independently provided for the intake camshaft and the exhaust camshaft. Both ends of the lower cam holder is coupled with a cylinder head by a first coupling member, while the respective upper cam holders are coupled with the lower cam holder by a set of second coupling members having a diameter smaller than a diameter of the first coupling member at a location more inside than the first coupling member. It is described that, because of the structure, the cylinder head can be compact and the first coupling member can function as a stopper for stopping a rotation of the rocker arm shaft.

[0003] However, in such a conventional structure, a clearance is made between a journal section of the camshaft and bearing portions of the cam carrier and the cam cap. Because of the clearance, if the camshaft is attached to the cylinder head using multiple sets of cam carrier and cam cap having bearing portions previously formed, accuracy of mounting positions of the cam carriers and the cam caps can be inferior. As a result, the respective journal sections can have uneasy contact with the camshaft and can cause much friction also with the camshaft.

[0004] In order to solve the problem, i.e., to improve the accuracy of the positioning of the multiple cam carriers and cam caps, the camshaft can be mounted after the cam carriers and the cam caps are attached to the cylinder head and the whole of them are machined throughout. However, a large scaled machining facility is required for the throughout-machining.

[0005] Also, in the throughout-machining of the cam carriers and the cam caps, even if only one cam carrier (or cam cap) has some inconvenience, the cam carriers and the cam caps of one camshaft need to be wholly exchanged for new ones. Because of the number of such exchange parts, the camshafts produced in this manner can be expensive.

[0006] Thus, the present invention aims to provide a mounting method for a camshaft onto an internal combustion engine that can improve accuracy of mounting positions of support portions of journal sections without having any large scaled machining facilities required for avoiding the uneasy contact of the journal sections with the camshaft and the increase of the friction of the journal sections with the camshaft and can reduces exchange parts to the minimum even if some inconvenience occurs with some of the cam carriers or the cam caps.

[0007] This objective is solved in an inventive manner by a method for mounting a camshaft onto a cylinder head of an internal combustion engine, said camshaft being supported by several sets of cam carrier and cam cap, each set being independently disposed at every journal section of the camshaft, wherein at least the cam carriers are mounted onto said cylinder head using a shaft-like jig, wherein an outer diameter of a portion of the jig, which corresponds to the journal section of the camshaft, is set larger than an outer diameter of the journal section of the camshaft.

[0008] Preferably, the method comprises the steps of providing the shaft-like jig, the portion of which corresponding to the journal section of said camshaft to be actually mounted having the outer diameter larger than the outer diameter of the journal section of said camshaft, mounting said shaft-like jig onto said cylinder head using said cam carriers to position said cam carriers at predetermined places, then, replacing said shaft-like jig with said camshaft to be actually used, under a condition that said cam carriers are coupled with said cylinder head, and afterwards, coupling said cam caps with the corresponding cam carriers.

[0009] Further, preferably the method comprises the steps of providing the shaft-like jig, the portion of which corresponding to the journal section of said camshaft to be actually mounted having the outer diameter larger than the outer diameter of the journal section of said camshaft, mounting said shaft-like jig onto said cylinder head using said sets of the cam carrier and the cam cap to position said multiple cam carriers at predetermined places, then, removing said cam caps to replace said shaft-like jig with said camshaft to be actually used, under a condition that said cam carriers are coupled with said cylinder head, and afterwards, coupling said cam caps with said cam carriers.

[0010] Still further, preferably said shaft-like jig has positioning portions, and said cam carriers are positioned in an axial direction of said shaft-like jig using said positioning portions.

[0011] Yet further, preferably said shaft-like jig has circular sections at positions corresponding to cam sections of said camshaft, and a diameter of each circular section is the same as a diameter of a base circle of each cam section.

[0012] The objective is further solved in an inventive manner by a method for mounting a camshaft onto a cylinder head of an internal combustion engine, said camshaft being supported by a set of a cam carrier and a cam cap, said camshaft having a journal section held by a bearing portion of said set of the cam carrier and the cam cap, the method comprising providing a mounting jig having a fitting section fitting in a space between an outer circumferential surface of said camshaft and an inner circumferential surface of a receiving section positioned adjacent to said bearing portion of said set of the cam carrier and the cam cap, wherein a sum of a first clearance made between an inner circumferential surface of said fitting section and the outer circumferential

surface of said camshaft and of a second clearance made between an outer surface of said fitting section and the inner circumferential surface of said receiving section of said set of the cam carrier and the cam cap is set smaller than a clearance made between an outer surface of said journal section and an inner surface of said bearing portion, placing said fitting section of said mounting jig between said camshaft and said set of the cam carrier and the cam cap, and removing said mounting jig after attaching said set of the cam carrier and the cam cap to said cylinder head.

[0013] The objective is yet further solved in an inventive manner by a method for mounting a camshaft onto a cylinder head of an internal combustion engine, said camshaft being supported by sets of cam carrier and cam cap, each set being independently disposed at every journal section, wherein every journal section is held at a bearing portion of a respective set of cam carrier and cam cap and having a fitting section neighboring the journal section, wherein each set of cam carrier and cam cap has a receiving section neighboring each bearing portion to receive the respective fitting section, and wherein a clearance between an outer surface of said each fitting section and an inner surface of said each receiving section is set smaller than a clearance between an outer surface of said each journal section and an inner surface of said each bearing portion, the method comprising fitting said fitting section of said camshaft into said receiving section of said set of cam carrier and cam cap to mount said camshaft onto said cylinder head using said sets of cam carrier and cam cap, and afterwards, sliding said camshaft in an axial direction to separate said fitting sections from said receiving sections, and attaching a slide restricting member under this condition to restrict a slide of said camshaft.

[0014] Preferably, a part of each bearing portion functions as said receiving section, and an outer diameter of each fitting section is set larger than an outer diameter of the respective journal section.

[0015] Further, preferably an outer diameter of each fitting section is set larger than an outer diameter of the respective journal section, and an inner diameter of each receiving section is set larger than an inner diameter of the respective bearing portion.

[0016] Yet further, preferably said slide restricting member is a housing cap positioned at an end of said camshaft.

[0017] With all the above, it is likewise preferred if a plurality of said cam carriers are disposed along said camshaft, each cam carrier has a rocker arm shaft provided independently from the other cam carriers, and each rocker arm shaft has a rocker arm for swing movement.

[0018] The above further provides an internal combustion engine, wherein said camshaft is mounted onto said cylinder head using said cam carrier and said cam cap by means of the camshaft mounting method recited in one of the above methods.

[0019] In the following, the present invention is explained in greater detail with respect to several embodiments thereof in conjunction with the accompanying drawings, wherein:

FIG. 1 is a cross sectional view, showing a shaft-like jig, cam carriers, cam caps and so forth according to a first embodiment,

FIG. 2 is an exploded perspective view, showing a cylinder head, a camshaft, the cam carriers, the cam caps and so forth according to the first embodiment,

FIG. 3 is a cross sectional view, showing a shaft-like jig, cam carriers, cam caps and so forth according to a second embodiment,

FIG.4 is an enlarged view of a part of FIG. 3 according to the second embodiment,

FIG. 5 is a cross sectional view, showing a circular section of the shaft-like jig according to the second embodiment,

FIG. 6 includes two cross sectional views of a shaft-like jig, cam carriers, cam caps and so forth, FIG. 6(a) showing a midway condition under which a camshaft is halfway mounted, and FIG. 6(b) showing a complete condition under which the camshaft is completely mounted,

FIG. 7 includes enlarged views of respective parts of FIG. 6 according to the third embodiment, FIG. 7(a) showing the midway condition under which the camshaft is halfway mounted, and FIG. 7(b) showing the complete condition under which the camshaft is completely mounted,

FIG. 8 includes illustrations, showing actions according to the third embodiment, FIG. 8(a) showing the midway condition under which the camshaft is halfway mounted, and FIG. 8 (b) showing the complete condition under which the camshaft is completely mounted,

FIG. 9 includes two cross sectional views of a camshaft, cam carriers, cam caps and so forth according to a fourth embodiment, FIG. 9(a) showing a midway condition under which a camshaft is halfway mounted, and FIG. 9(b) showing a complete condition under which the camshaft is completely mounted,

FIG. 10 includes enlarged views of respective parts of FIG. 9 according to the fourth embodiment, FIG. 10(a) showing the midway condition under which the camshaft is halfway mounted,

and FIG. 10(b) showing the complete condition under which the camshaft is completely mounted,

FIG. 11 is a cross sectional view of a camshaft, cam carriers, cam caps and so forth according to a fifth embodiment,

FIG. 12 is an enlarged view of a part of FIG. 11 according to the fifth embodiment, and

FIG. 13 is a front elevational view of a mounting jig according to the fifth embodiment.

Description of Reference Numerals

[0020]

11: engine (internal combustion engine)
12: cylinder head
13: intake camshaft
14: exhaust camshaft
13a: intake cam section
14a: exhaust cam section
13b, 14b: journal section
13f: fitting section
15, 16: bearing portion
15a: receiving section
17: cam carrier
17a: bearing portion
18: cam cap
18a: bearing portion
21: cam housing
22: housing cap
24: rocker arm shaft
25: rocker arm
30, 40: shaft-like jig
33: mounting jig
34: separable member
34a: fitting section
34b: grip section
40a: positioning section
40b: circular section
d1: outer diameter of the shaft-like jig
d2: outer diameter of the fitting section
d3: outer diameter of the journal section
d4: inner diameter of the receiving section
d5: inner diameter of the bearing portion
c1: clearance
c2: clearance

[0021] Embodiments will be described below.

First Embodiment

[0022] FIGs. 1 and 2 show a first embodiment.

[0023] In describing a structure first, reference numeral 11 of FIG. 2 indicates an engine as the "internal combustion engine." The engine 11 has an intake camshaft 13 and an exhaust camshaft 14 both disposed above a cylinder head 12 and each supported by multiple sets of a cam carrier 17 and a cam cap 18, and a set of a cam housing 21 and housing caps 22 for rotation.

[0024] The intake camshaft 13 has a plurality of intake cam sections 13a and journal sections 13b positioned between the neighboring intake cam sections 13a, while the exhaust camshaft 14 has a plurality of exhaust cam sections 14a and journal sections 14b positioned between the neighboring exhaust cam sections 14a. One end portion 13c, 14c of each camshaft 13, 14 is a power transmitting section, and has an outer diameter which is larger than the respective other end portion. The set of the cam housing 21 and the housing caps 22 holds the one end portion 13c, 14c for rotation. Flanges 13d, 13e are formed on both sides of the end portion 13c, while flanges 14d, 14e are formed on both sides of the end portion 14c. In addition, each other end has a cam sensor rotor 13g, 14g for a WT control.

[0025] Cam carriers 17 for each camshaft 13, 14 have a bearing recess 17a forming a lower half surface of respective bearing portions 15, 16 for supporting the respective journal sections 13b, 14b of the camshaft 13, 14.

[0026] Each cam carrier 17 has a rocker arm shaft 24 provided independently from the other cam carriers 17. Each rocker arm shaft 24 supports a rocker arm 25 for swing movement. In addition, each cam carrier 17 has bolt holes 17c through each one of which a bolt 26 extends for mounting the cam carrier 17 onto the cylinder head 12, and also has other bolt holes 17d through each one of which a bolt 27 extends for mounting the cam carrier 17 and the associated cam cap 18 onto the cylinder head 12.

[0027] Each cam cap 18 has another bearing recess 18a forming an upper half surface of the respective bearing portions 15, 16, and also has bolt holes 18b through each one of which a bolt 27 extends.

[0028] The cam housing 21 and the housing caps 22 individually have bearing recesses 21a, 22a for supporting both of the camshafts 13, 14.

[0029] A top surface of the cylinder head 12 has a plurality of knock pins 12a which can be fitted into holes of the cam carriers 17 and the cam housing 21.

[0030] A shaft-like jig 30 shown in FIG. 1 is used for mounting the camshaft 13, 14 and other components onto the cylinder head 12.

[0031] An outer diameter d of a portion 30a of the shaft-like jig 30 corresponding to the journal section 13b, 14b of the camshaft 13, 14 which is actually mounted is larger than an outer diameter of the journal section 13b, 14b by a certain length. The certain length is decided in such a manner that a clearance between an outer surface of the journal section 13b, 14b of the camshaft 13, 14 and an inner surface of the bearing portions 15, 16 can be sufficient even if the respective portions have some tolerances.

[0032] Next, a method for mounting the camshaft 13,

14 using the shaft-like jig 30 will be described.

[0033] First, the multiple cam carriers 17 are slackly (i.e., under a movable condition more or less) coupled with the cylinder head 12 by the bolts 26.

[0034] Next, the shaft-like jig 30 is mounted on the cam carriers 17. The cam caps 18 are placed on the shaft-like jig 30, and the bolts 26, 27 are tightly fixed.

[0035] Under the condition, it is checked that the shaft-like jig 30 is smoothly rotatable by a hand or a jig.

[0036] Then, the bolts 27 are loosen and the cam caps 18 are removed. The shaft-like jig 30 is removed to be replaced by the camshaft 13, 14. Again, the cam caps 18 are placed on the camshaft 13, 14.

[0037] By using the shaft-like jig 30 as thus discussed, the clearance made between each outer surface of the respective portions 30a of the shaft-like jig 30 and each inner surface of the respective bearing portions 15, 16 is smaller than a clearance made by using the actual camshaft 13, 14. Thus, differently from the conventional method, the cam carriers 17 and the cam caps 18 can be attached to the shaft-like jig 30 with almost easy contact.

[0038] Thus, by tightly fixing the cam carriers 17 and the other components under this condition, the multiple cam carriers 17 can be accurately attached to the cylinder head 12.

[0039] As a result, the uneasy contact of the journal sections 13b, 14b with respective camshafts 13, 14 and the increase of the friction of the journal sections 13b, 14b with the camshaft can be avoided.

[0040] Accordingly, the accuracy of the positioning of the support portions of the journal sections 13b, 14b can be ensured without having large scaled machining facilities.

[0041] Even if some of the cam carriers 17 or other components have inconvenience, the throughout-machining, which is conventionally required, is not necessary. Only the cam carrier 17 or the other component which have the inconvenience can be simply exchanged for new one and can be attached using the shaft-like jig 30. Exchange parts thus can be reduced to the minimum.

[0042] Because the rocker arm shafts 24 are provided to the respective cam carriers 17 independently from each other, no throughout-machining for improving the accuracy of the positioning is necessary after the multiple cam carriers 17 are mounted onto the cylinder head 12.

[0043] The cam caps 18 are fixed to the cylinder head 12 in this first embodiment. Alternatively, the cam caps 18 may be fixed to the cam carriers 17.

[0044] The cam caps 18 are attached when the shaft-like jig 30 is placed in the position in this first embodiment. Alternatively, only the cam carriers 17 may be fixed to the cylinder head 12 with the bolts 26 to align the components by the shaft-like jig 30.

[0045] In this alternative, the cam caps 18 are not attached when the components are aligned. After the cam carriers 17 are aligned using the shaft-like jig 30, the shaft-like jig 30 is removed to be replaced by the camshaft 13, 14, and then the cam caps 18 are attached.

[0046] Because, by employing the alternative manner, the cam caps 18 do not need to be attached or detached when the shaft-like jig 30 is placed in the position (i.e., in the alignment process), workability can be more preferable.

Second Embodiment

[0047] FIGs. 3-5 show a second embodiment.

[0048] This second embodiment differs from the first embodiment in a point that a shaft-like jig 40 has positioning sections 40a and circular sections 40b.

[0049] That is, an outer diameter d of a portion 40c of the shaft-like jig 40 corresponding to the journal section 13b, 14b of the camshaft 13, 14 which is to be actually mounted is larger than an outer diameter of the journal section 13b, 14b by a certain length. The certain length is decided in such a manner that a clearance between an outer surface of the journal section 13b, 14b of the camshaft 13, 14 and an inner surface of the respective bearing portions 15, 16 can be sufficient even if the respective portions have some tolerances.

[0050] The positioning sections 40a having a step-like configuration are formed neighboring the respective portions 40c. Each positioning section 40a fits in a receiving section 17e of the respective cam carrier 17 and in a receiving section 18c of the respective cam cap 18.

[0051] Each circular section 40b of the shaft-like jig 40 is formed at a location corresponding to the respective cam section 13a, 14a of the camshaft 13, 14. An outer diameter of each circular section 40b is the same as an outer diameter of a base circle of the respective cam section 13a, 14a.

[0052] In this embodiment such that the shaft-like jig 40 has the positioning sections 40a, positioning of the cam carriers 17 in the axial direction of the shaft-like jig 40 can be made by the positioning sections 40a. Thus, the shaft-like jig 40 can improve the alignment of the cam carriers 17 and the accuracy of the centering and positioning of the cam carriers 17 in the axial direction. Accordingly, widths of the cam sections and the journal sections can be shorter to make the camshaft lighter in weight.

[0053] Because the shaft-like jig 40 has the circular sections 40b at the locations corresponding to the cam sections 13a, 14a of the camshaft 13, 14, and the diameter of each circular section 40b is the same as the diameter of the base circle of each cam section 13a, 14a, a clearance between each rocker arm 25 positioned on the cam carrier 17 and the base circle of the respective cam section 13a, 14a can be adjusted using each circular section 40 without rotating the camshaft 13, 14.

[0054] The other constructions and actions thereof are the same as the first embodiment, and further descriptions are therefore not repeated.

[0055] The cam caps 18 are attached when the shaft-like jig 40 is placed in the position also in this second

embodiment. Alternatively, only the cam carriers 17 may be fixed to the cylinder head 12 by the bolts 26 to align and center the components using the shaft-like jig 40.

Third Embodiment

[0056] FIGs. 6 to 8 show a third embodiment.

[0057] This third embodiment differs from the first embodiment in a point that the shaft-like jig 30 of the first embodiment is not used. A mounting method of the intake camshaft 13 will be illustrated and described below. Although a description about a mounting method of the exhaust camshaft 14 is omitted, it is the same as the mounting method of the intake camshaft 13.

[0058] That is, the intake camshaft 13 has a fitting section 13f neighboring each journal section 13b, while each of the cam carriers 17 and the cam caps 18 has a receiving section 15a neighboring the respective bearing portion 15 to receive the fitting section 13f. In this embodiment, a part of each bearing portion 15, 16 functions as the receiving section 15a. As shown in FIGs. 7 and 8, an outer diameter d2 of each fitting section 13f is larger than an outer diameter d3 of each journal section 13b.

[0059] Because of such sizes, a clearance c1 made between an outer surface of each fitting section 13f and an inner surface of each receiving section 15a is smaller than a clearance c2 made between an outer surface of each journal section 13b and an inner surface of the respective bearing portion 15.

[0060] Next, a mounting method of the camshaft 13 will be described.

[0061] First, the respective fitting sections 13f of the camshaft 13 fit in the receiving sections 15a of the associated cam carriers 17 and cam caps 18. The camshaft 13 is mounted onto the cylinder head 12 using the cam carriers 17 and the cam caps 18 (FIGs. 7(a) and 8(a)).

[0062] Afterwards, the camshaft 13 is sled by a certain distance in the axial direction (i.e., leftward in FIGs. 6-8) so that the respective fitting sections 13f separate from the respective receiving sections 15a.

[0063] Under this condition, the housing cap 22, which is a "slide restricting member," is attached to the cam housing 21. Thereby, the housing cap 22 fits in a space between a pair of flange sections 13d. The camshaft 13 thus is restricted in this position.

[0064] In such a construction, because the camshaft 13 is only required to be restricted in the position by the housing cap 22 after being sled, the shaft-like jig 30, which is used in the first embodiment, is not necessary, and the same effect as the first embodiment can be obtained. Thus, workability or the like can be improved.

[0065] The other constructions and actions thereof are the same as the first embodiment, and further descriptions are omitted.

Fourth Embodiment

[0066] FIGs. 9 and 10 show a fourth embodiment.

[0067] A configuration of the fitting section 13f of the camshaft 13 and a configuration of the receiving section 15a of the camshaft 13 in this fourth embodiment are different from the counterparts employed in the third embodiment.

[0068] That is, the outer diameter d2 of each fitting section 13f is larger than the outer diameter d3 of each journal section 13b, and an inner diameter d4 of each receiving section 15a is larger than an inner diameter d5 of each bearing portion 15.

[0069] In such a construction, by sliding the camshaft 13 so that the respective fitting sections 13f fit in or separate from the associated receiving sections 15a, the accuracy of the mounting positions of the cam carriers 17 and other components can be improved, similarly to the third embodiment.

[0070] The other constructions and actions thereof are the same as the third embodiment, and further descriptions are omitted.

Fifth Embodiment

[0071] FIGs. 11-13 show a fifth embodiment.

[0072] This fifth embodiment differs from the second embodiment in a point that multiple mounting jigs 33 are used.

[0073] As shown in FIG. 13, each mounting jig 33 includes a pair of separable members 34,34. Each separable member 34 has a fitting section 34a and a grip section 34b.

[0074] The pair of fitting sections 34a fits in a space between an outer circumferential surface of the camshaft 13 and an inner circumferential surface of each receiving section 15a positioned adjacent to the bearing portions 15 of each pair of the cam carrier 17 and the cam cap 18.

[0075] Next, a mounting method of the camshaft 13 will be described.

[0076] The respective cam carriers 17 are temporarily fixed to the cylinder head 12 with the bolts 26. Afterwards, the multiple mounting jigs 33 are attached to the camshaft 13. The camshaft 13 is mounted on the cam carriers 17. Then, cam caps 18 are attached.

[0077] Under this condition, the fitting section 34a of each mounting jig 33 fits in a space between the outer circumferential surface of the camshaft 13 and an inner circumferential surface of the receiving section 15a of the respective bearing portion 15.

[0078] There are a first clearance made between the inner circumferential surface of the fitting section 34a of the mounting jig 33 and the outer circumferential surface of the camshaft 13 and a second clearance made between an outer circumferential surface of the fitting section 34a of the mounting jig 33 and an inner circumferential surface of the receiving section 15a of the cam carrier 17 and the cam cap 18. The sum of the first clearance and the second clearance is smaller than a clearance made between the outer surface of the journal section 13b and the inner surface of the bearing portion 15.

[0079] Afterwards, the respective mounting jigs 33 are sled leftward in FIGs. 11 and 12 to separate the fitting sections 34a of the mounting jigs 33 from the receiving sections 15a of the bearing portions 15, and then the separable members 34 are separated from each other to be removed from the camshaft 13.

[0080] In such a construction, only by attaching and removing the mounting jigs 33, the camshaft 13, the cam carriers 17 and other components can be easily and accurately mounted.

[0081] The other constructions and actions thereof are the same as the first embodiment, and further descriptions are omitted.

[0082] The description above discloses (amongst others) in order to solve the problem discussed above, in accordance with an embodiment according to a first aspect, a method for mounting a camshaft onto a cylinder head of an internal combustion engine using multiple sets of a cam carrier and a cam cap, and each set being independently disposed at every journal section, the method includes providing a shaft-like jig, a portion of the jig corresponding to the journal section of the camshaft to be actually mounted having an outer diameter larger than an outer diameter of the journal section of the camshaft; mounting the shaft-like jig onto the cylinder head using the multiple sets of the cam carrier and the cam cap to position the multiple cam carriers at predetermined places; then, removing the multiple cam caps to replace the shaft-like jig with the camshaft to be actually used, under a condition that the multiple cam carriers are coupled with the cylinder head; and, afterwards, coupling the multiple cam caps with the cam carriers.

[0083] In accordance with another embodiment according to a second aspect, there is disclosed a method for mounting a camshaft onto a cylinder head of an internal combustion engine using multiple sets of a cam carrier and a cam cap, and each set being independently disposed at every journal section, the method includes: providing a shaft-like jig, a portion of the jig corresponding to the journal section of the camshaft to be actually mounted having an outer diameter larger than an outer diameter of the journal section of the camshaft; mounting the shaft-like jig onto the cylinder head using the multiple cam carriers to position the multiple cam carriers at predetermined places; then, replacing the shaft-like jig with the camshaft to be actually used, under a condition that the multiple cam carriers are coupled with the cylinder head, and; afterwards, coupling the multiple cam caps with the cam carriers.

[0084] In accordance with a further embodiment according to a third aspect, there is disclosed that in the method according to first or second aspect, the shaft-like jig has positioning portions, and the multiple cam carriers are positioned in an axial direction of the shaft-like jig using the positioning portions.

[0085] In accordance with a further embodiment according to a fourth aspect, there is disclosed that in the method according to one of the first to third aspects, the shaft-like jig has circular sections at positions corresponding to cam sections of the camshaft, and a diameter of each circular section is the same as a diameter of a base circle of each cam section.

[0086] In accordance with a further embodiment according to a fifth aspect, there is disclosed a method for mounting a camshaft onto a cylinder head of an internal combustion engine using multiple sets of a cam carrier and a cam cap, each set being independently disposed at every journal section, the camshaft having the every journal section held at a bearing portion of each cam carrier and each cam cap and having a fitting section neighboring each journal section, each set of the cam carrier and the cam cap having a receiving section neighboring each bearing portion to receive the respective fitting section, and a clearance between an outer surface of the each fitting section and an inner surface of the each receiving section is smaller than a clearance between an outer surface of the each journal section and an inner surface of the each bearing portion, the method includes: fitting the fitting section of the camshaft into the receiving section of the set of the cam carrier and the cam cap to mount the camshaft onto the cylinder head using the sets of the cam carrier and the cam cap; and afterwards, sliding the camshaft in an axial direction to separate the fitting sections from the receiving sections; and attaching a slide restricting member under this condition to restrict a slide of the camshaft.

[0087] In accordance with a further embodiment according to a sixth aspect, there is disclosed that in the method according to the fifth aspect, a part of each bearing portion functions as the receiving section, and an outer diameter of the each fitting section is larger than an outer diameter of the each journal section.

[0088] In accordance with a further embodiment according to a seventh aspect, there is disclosed that in the method according to the fifth aspect, an outer diameter of the each fitting section is larger than an outer diameter of the each journal section, and an inner diameter of the each receiving section is larger than an inner diameter of the each bearing portion.

[0089] In accordance with a further embodiment according to an eight aspect, there is disclosed that in a method according to the fifth aspect, the slide restricting member is a housing cap positioned at an end of the camshaft.

[0090] In accordance with a further embodiment according to a ninth aspect, there is disclosed a method for mounting a camshaft onto a cylinder head of an internal combustion engine using a set of a cam carrier and a cam cap, and the camshaft having a journal section held by a bearing portion of the set of the cam carrier and the cam cap, the method includes: providing a mounting jig having a fitting section fitting in a space between an outer circumferential surface of the camshaft and an inner circumferential surface of a receiving section positioned adjacent to the bearing portion of the set of the cam carrier and the cam cap; the sum of a first clearance made be-

tween an inner circumferential surface of the fitting section and the outer circumferential surface of the camshaft and a second clearance made between an outer surface of the fitting section and the inner circumferential surface of the receiving section of the set of the cam carrier and the cam cap being smaller than a clearance made between an outer surface of the journal section and an inner surface of the bearing portion; placing the fitting section of the mounting jig between the camshaft and the set of the cam carrier and the cam cap; and removing the mounting jig after attaching the set of the cam carrier and the cam cap to the cylinder head.

[0091] In accordance with a further embodiment according to a tenth aspect, there is disclosed that in the method according to one of the first to ninth aspects, a plurality of the cam carriers are disposed along the camshaft, each cam carrier has a rocker arm shaft provided independently from the other cam carriers, and each rocker arm shaft has a rocker arm for swing movement.

[0092] In accordance with a further embodiment according to an eleventh aspect, there is disclosed an internal combustion engine, wherein the camshaft is mounted onto the cylinder head using the cam carrier and the cam cap by means of the camshaft mounting method recited in one of the first to tenth aspects.

[0093] According to the first aspect, the method includes: providing the shaft-like jig, the portion of the jig corresponding to the journal section of the camshaft to be actually mounted having the outer diameter larger than the outer diameter of the journal section of the camshaft; mounting the shaft-like jig onto the cylinder head using the multiple sets of the cam carrier and the cam cap to position the multiple cam carriers at predetermined places; then, removing the multiple cam caps to replace the shaft-like jig with the camshaft to be actually used, under the condition that the multiple cam carriers are coupled with the cylinder head; and, afterwards, coupling the multiple cam caps with the cam carriers. Thus, the accuracy of the positioning of the support portions of the journal sections can be improved without having any large scaled machining facilities required for avoiding for the uneasy contact of the journal sections with the camshaft and the increase of the friction of the journal sections with the camshaft and the exchange parts can be reduced to the minimum even if some inconvenience occurs with some of the cam carriers or the cam caps.

[0094] According to the second aspect, preferable workability can be obtained because there is no need for detaching the cam caps when the shaft-like jig is placed in the position (i.e., in an alignment process).

[0095] According to the third aspect, because the shaft-like jig has the positioning portions, and the multiple cam carriers are positioned in the axial direction of the shaft-like jig using the positioning portions, the shaft-like jig can improve the alignment of the cam carriers and the accuracy of the positions in the axial direction. Accordingly, the widths of the cam sections and the journal sections can be shorter to make the camshaft lighter in weight.

[0096] According to the fourth aspect, because the shaft-like jig has the circular sections at the locations corresponding to the cam sections of the camshaft, and the diameter of each circular section is the same as the diameter of the base circle of each cam section, the clearance between each rocker arm positioned on the cam carrier and the base circle of the respective cam section can be adjusted using each circular section without rotating the camshaft.

[0097] According to the fifth to eight aspects, the shaft-like jig is not necessary because the same effect as the aspect of the present invention recited in the first aspect can be obtained only by sliding the camshaft. Thus, workability or the like can be improved.

[0098] According to the ninth aspect, the same effect discussed above can be obtained only by attaching or removing the mounting jig.

[0099] According to the tenth aspect, because each cam carrier has the rocker arm shaft provided independently from the other cam carriers, the throughout-machining is not required to place the respective rocker arm shafts. No large scale machining facilities are required, accordingly.

[0100] According to the eleventh aspect, the internal combustion engine in which the camshaft is mounted onto the cylinder head using the cam carrier and the cam cap by means of the camshaft mounting method recited in one of the first to tenth aspects is provided. Thus, the accuracy of the positioning of the support portions of the journal sections can be improved, and the exchange parts can be reduced to the minimum even if some inconvenience occurs with some of the cam carriers or the cam caps.

[0101] The description above discloses as a particularly preferred embodiment, a method which includes providing a shaft-like jig 30, a portion 30a of the jig 30 corresponding to a journal section of the camshaft to be actually mounted having an outer diameter d1 larger than an outer diameter of the journal section of the camshaft; mounting the shaft-like jig 30 onto the cylinder head using the multiple sets of a cam carrier 17 and a cam cap 18 to position the multiple cam carriers 17 at predetermined places; then, removing the multiple cam caps 18 to replace the shaft-like jig 30 with the camshaft to be actually used, under a condition that the multiple cam carriers 17 are coupled with the cylinder head; and, afterwards, coupling the multiple cam caps 18 with the cam carriers 17. In particular, this embodiment provides a mounting method for a camshaft onto an internal combustion engine that can improve accuracy of mounting positions of support portions of journal sections without having large scaled machining facilities required for avoiding the uneasy contact of the journal sections with the camshaft and the increase of the friction of the journal sections with the camshaft and can reduces exchange parts to the minimum even if some inconvenience occurs with some of the cam carriers or the cam caps.

[0102] In line with the above, according to the first aspect, there is disclosed a method for mounting a camshaft onto a cylinder head of an internal combustion engine using multiple sets of a cam carrier and a cam cap, each set being independently disposed at every journal section, the method comprising: providing a shaft-like jig, a portion of the jig corresponding to the journal section of said camshaft to be actually mounted having an outer diameter larger than an outer diameter of the journal section of said camshaft; mounting said shaft-like jig onto said cylinder head using said multiple sets of the cam carrier and the cam cap to position said multiple cam carriers at predetermined places; then, removing said multiple cam caps to replace said shaft-like jig with said camshaft to be actually used, under a condition that said multiple cam carriers are coupled with said cylinder head; and afterwards, coupling said multiple cam caps with said cam carriers.

[0103] Further, as the second aspect, there is disclosed a method for mounting a camshaft onto a cylinder head of an internal combustion engine using multiple sets of a cam carrier and a cam cap, each set being independently disposed at every journal section, the method comprising: providing a shaft-like jig, a portion of the jig corresponding to the journal section of said camshaft to be actually mounted having an outer diameter larger than an outer diameter of the journal section of said camshaft; mounting said shaft-like jig onto said cylinder head using said multiple cam carriers to position said multiple cam carriers at predetermined places; then, replacing said shaft-like jig with said camshaft to be actually used, under a condition that said multiple cam carriers are coupled with said cylinder head; and afterwards, coupling said multiple cam caps with said cam carriers.

[0104] Further, as the third aspect, there is disclosed that said shaft-like jig has positioning portions, and said multiple cam carriers are positioned in an axial direction of said shaft-like jig using said positioning portions.

[0105] Further, according to the fourth aspect, there is disclosed that said shaft-like jig has circular sections at positions corresponding to cam sections of said camshaft, and a diameter of each circular section is the same as a diameter of a base circle of each cam section.

[0106] Further, according to the fifth aspect, there is disclosed a method for mounting a camshaft onto a cylinder head of an internal combustion engine using multiple sets of a cam carrier and a cam cap, each set being independently disposed at every journal section, said camshaft having the every journal section held at a bearing portion of each cam carrier and each cam cap and having a fitting section neighboring each journal section, each set of the cam carrier and the cam cap having a receiving section neighboring each bearing portion to receive the respective fitting section, and a clearance between an outer surface of said each fitting section and an inner surface of said each receiving section is smaller than a clearance between an outer surface of said each journal section and an inner surface of said each bearing portion, the method comprising: fitting said fitting section of said camshaft into said receiving section of said set of the cam carrier and the cam cap to mount said camshaft onto said cylinder head using said sets of the cam carrier and the cam cap; and afterwards, sliding said camshaft in an axial direction to separate said fitting sections from said receiving sections, and attaching a slide restricting member under this condition to restrict a slide of said camshaft.

[0107] Further, as the sixth aspect, there is disclosed that a part of each bearing portion functions as said receiving section, and an outer diameter of said each fitting section is larger than an outer diameter of said each journal section.

[0108] Further, as a seventh aspect, there is disclosed that an outer diameter of said each fitting section is larger than an outer diameter of said each journal section, and an inner diameter of said each receiving section is larger than an inner diameter of said each bearing portion.

[0109] Further, as an eight aspect, it is disclosed that said slide restricting member is a housing cap positioned at an end of said camshaft.

[0110] Further, according to a ninth aspect, there is disclosed a method for mounting a camshaft onto a cylinder head of an internal combustion engine using a set of a cam carrier and a cam cap, said camshaft having a journal section held by a bearing portion of said set of the cam carrier and the cam cap, the method comprising: providing a mounting jig having a fitting section fitting in a space between an outer circumferential surface of said camshaft and an inner circumferential surface of a receiving section positioned adjacent to said bearing portion of said set of the cam carrier and the cam cap, the sum of a first clearance made between an inner circumferential surface of said fitting section and the outer circumferential surface of said camshaft and a second clearance made between an outer surface of said fitting section and the inner circumferential surface of said receiving section of said set of the cam carrier and the cam cap being smaller than a clearance made between an outer surface of said journal section and an inner surface of said bearing portion; placing said fitting section of said mounting jig between said camshaft and said set of the cam carrier and the cam cap; and removing said mounting jig after attaching said set of the cam carrier and the cam cap to said cylinder head.

[0111] Further, as a tenth aspect, it is disclosed that a plurality of said cam carriers are disposed along said camshaft, each cam carrier has a rocker arm shaft provided independently from the other cam carriers, and each rocker arm shaft has a rocker arm for swing movement.

[0112] Further, as an eleventh aspect, there is disclosed an internal combustion engine, wherein said camshaft is mounted onto said cylinder head using said cam carrier and said cam cap by means of the camshaft mounting method recited in one of the first to tenth aspects.

Claims

1. Method for mounting a camshaft onto a cylinder head of an internal combustion engine, said camshaft being supported by several sets of cam carrier and cam cap, each set being independently disposed at every journal section of the camshaft, wherein at least the cam carriers are mounted onto said cylinder head using a shaft-like jig, wherein an outer diameter of a portion of the jig, which corresponds to the journal section of the camshaft, is set larger than an outer diameter of the journal section of the camshaft.

2. Method according to claim 1, comprising the steps of:

   providing the shaft-like jig, the portion of which corresponding to the journal section of said camshaft to be actually mounted having the outer diameter larger than the outer diameter of the journal section of said camshaft;
   mounting said shaft-like jig onto said cylinder head using said cam carriers to position said cam carriers at predetermined places;
   then, replacing said shaft-like jig with said camshaft to be actually used, under a condition that said cam carriers are coupled with said cylinder head; and
   afterwards, coupling said cam caps with the corresponding cam carriers.

3. Method according to claim 1 or 2, comprising the steps of:

   providing the shaft-like jig, the portion of which corresponding to the journal section of said camshaft to be actually mounted having the outer diameter larger than the outer diameter of the journal section of said camshaft;
   mounting said shaft-like jig onto said cylinder head using said sets of the cam carrier and the cam cap to position said multiple cam carriers at predetermined places;
   then, removing said cam caps to replace said shaft-like jig with said camshaft to be actually used, under a condition that said cam carriers are coupled with said cylinder head; and
   afterwards, coupling said cam caps with said cam carriers.

4. Method according to one of the claims 1 to 3, wherein said shaft-like jig has positioning portions, and said cam carriers are positioned in an axial direction of said shaft-like jig using said positioning portions.

5. Method according to one of the claims 1 to 4, wherein said shaft-like jig has circular sections at positions corresponding to cam sections of said camshaft, and a diameter of each circular section is the same as a diameter of a base circle of each cam section.

6. Method for mounting a camshaft onto a cylinder head of an internal combustion engine, said camshaft being supported by a set of a cam carrier and a cam cap, said camshaft having a journal section held by a bearing portion of said set of the cam carrier and the cam cap, the method comprising:

   providing a mounting jig having a fitting section fitting in a space between an outer circumferential surface of said camshaft and an inner circumferential surface of a receiving section positioned adjacent to said bearing portion of said set of the cam carrier and the cam cap,

   wherein a sum of a first clearance made between an inner circumferential surface of said fitting section and the outer circumferential surface of said camshaft and of a second clearance made between an outer surface of said fitting section and the inner circumferential surface of said receiving section of said set of the cam carrier and the cam cap is set smaller than a clearance made between an outer surface of said journal section and an inner surface of said bearing portion;
   placing said fitting section of said mounting jig between said camshaft and said set of the cam carrier and the cam cap; and
   removing said mounting jig after attaching said set of the cam carrier and the cam cap to said cylinder head.

7. Method for mounting a camshaft onto a cylinder head of an internal combustion engine, said camshaft being supported by sets of cam carrier and cam cap, each set being independently disposed at every journal section, wherein every journal section is held at a bearing portion of a respective set of cam carrier and cam cap and having a fitting section neighboring the journal section, wherein each set of cam carrier and cam cap has a receiving section neighboring each bearing portion to receive the respective fitting section, and wherein a clearance between an outer surface of said each fitting section and an inner surface of said each receiving section is set smaller than a clearance between an outer surface of said each journal section and an inner surface of said each bearing portion, the method comprising:

   fitting said fitting section of said camshaft into said receiving section of said set of cam carrier and cam cap to mount said camshaft onto said cylinder head using said sets of cam carrier and cam cap; and
   afterwards, sliding said camshaft in an axial direction to separate said fitting sections from said receiving sections, and attaching a slide restrict-

ing member under this condition to restrict a slide of said camshaft.

8. Method according to claim 7, wherein a part of each bearing portion functions as said receiving section, and an outer diameter of each fitting section is set larger than an outer diameter of the respective journal section.

9. Method according to claim 7, wherein an outer diameter of each fitting section is set larger than an outer diameter of the respective journal section, and an inner diameter of each receiving section is set larger than an inner diameter of the respective bearing portion.

10. Method according to one of the claims 7 to 9, wherein said slide restricting member is a housing cap positioned at an end of said camshaft.

11. Method according to one of the claims 1 to 10, wherein a plurality of said cam carriers are disposed along said camshaft, each cam carrier has a rocker arm shaft provided independently from the other cam carriers, and each rocker arm shaft has a rocker arm for swing movement.

12. Internal combustion engine, wherein said camshaft is mounted onto said cylinder head using said cam carrier and said cam cap by means of the camshaft mounting method recited in one of the claims 1 to 11.

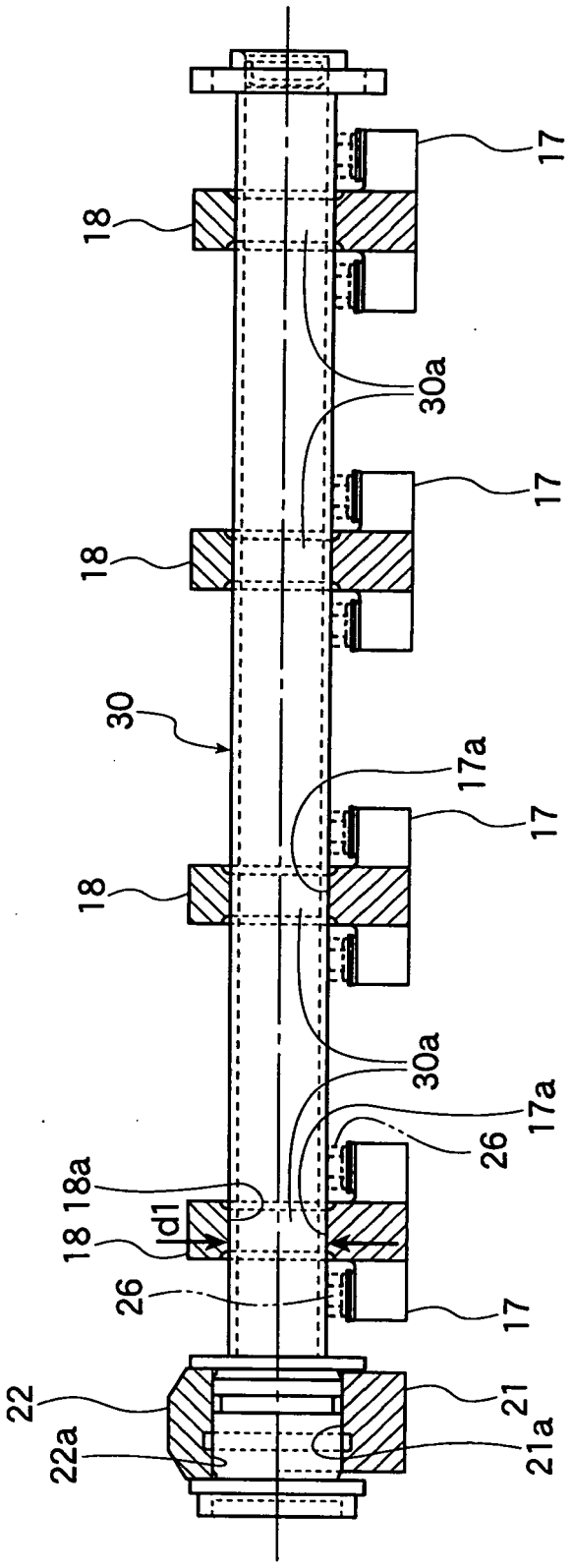
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FIG. 1

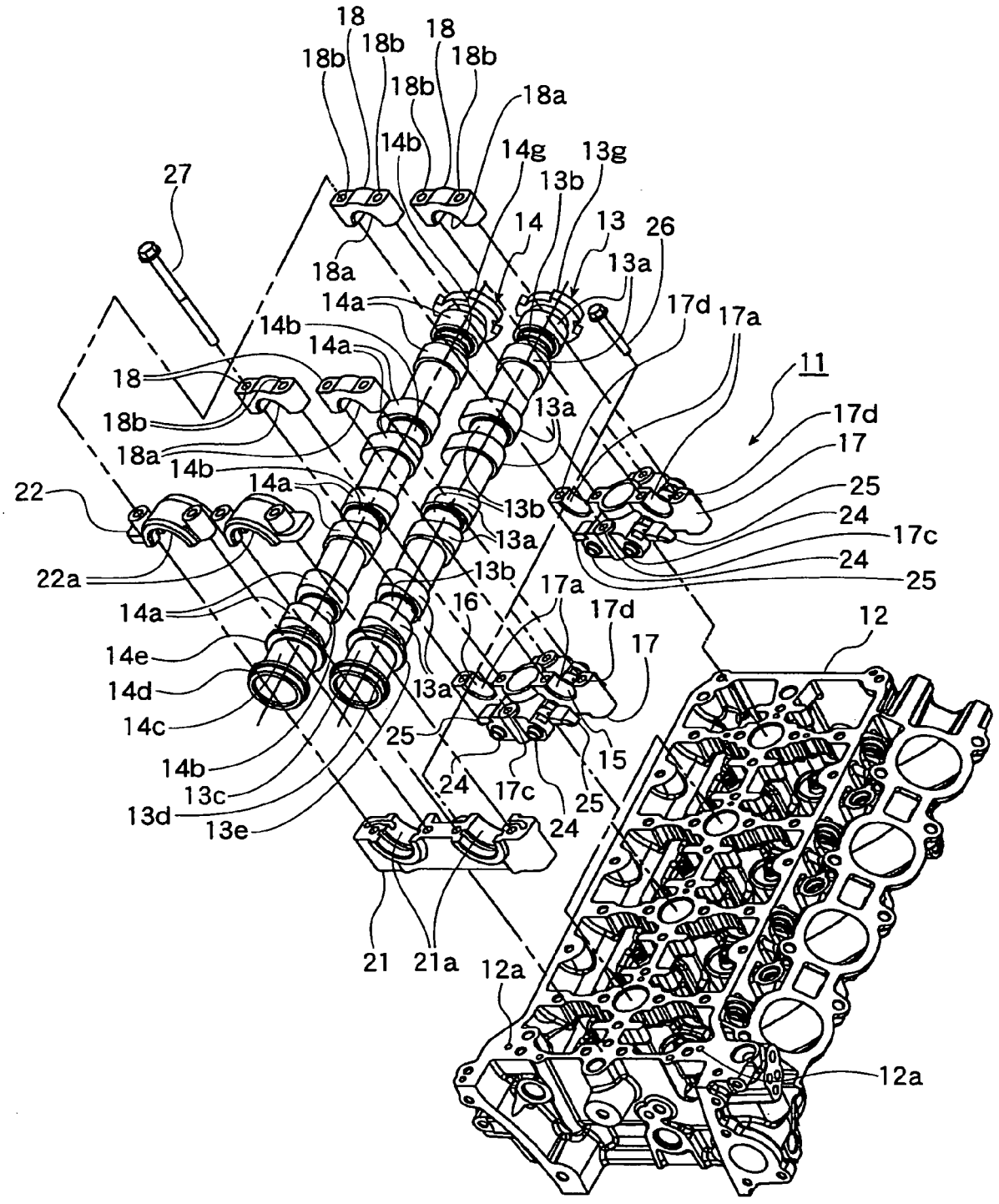
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FIG. 2

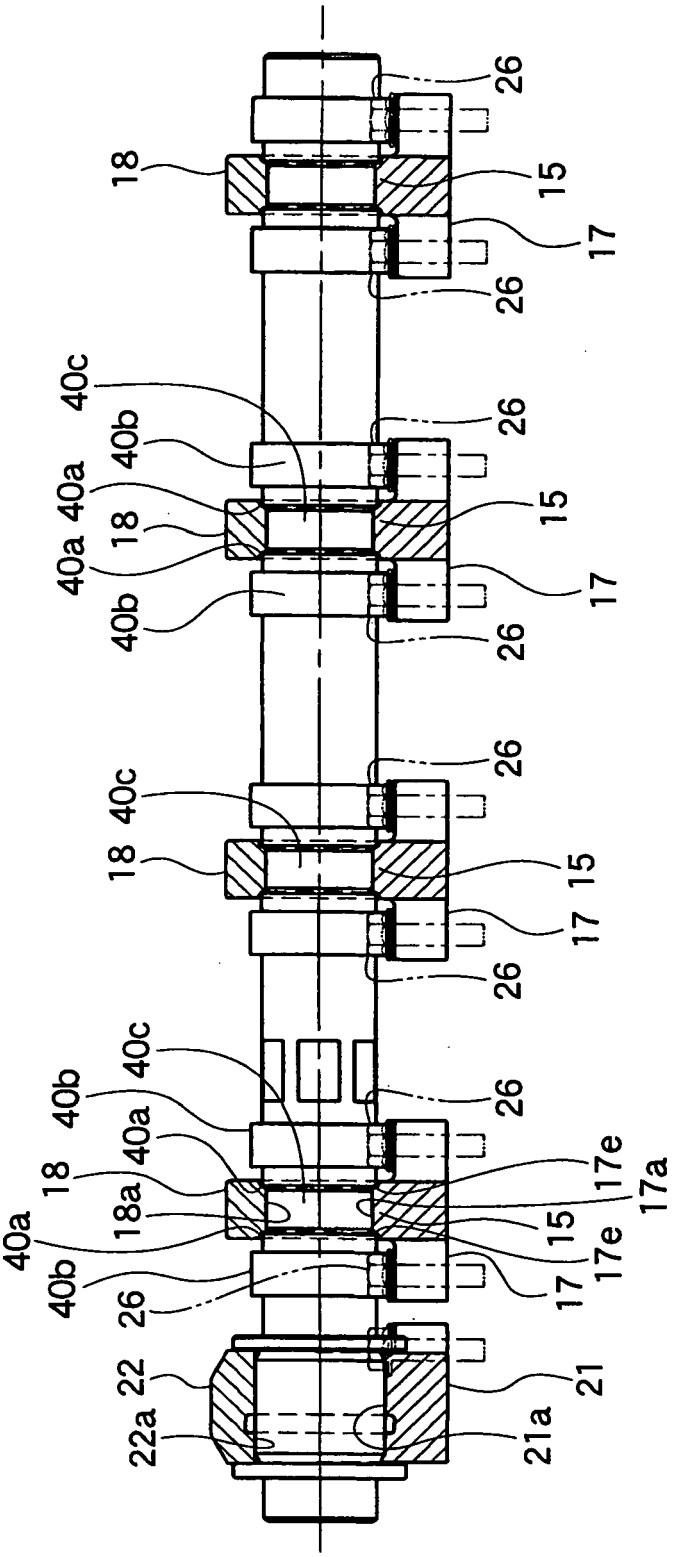
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FIG. 3

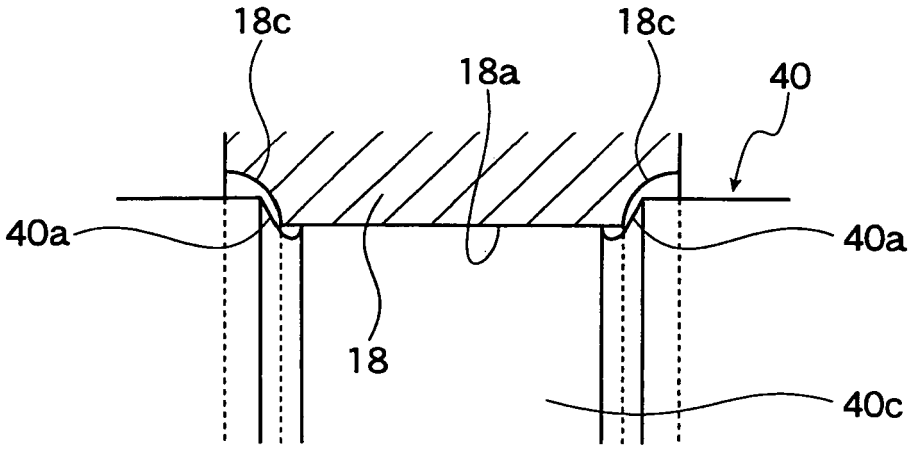

FIG. 4

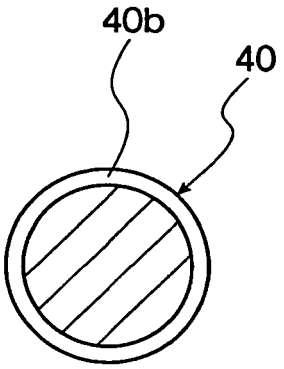

FIG. 5

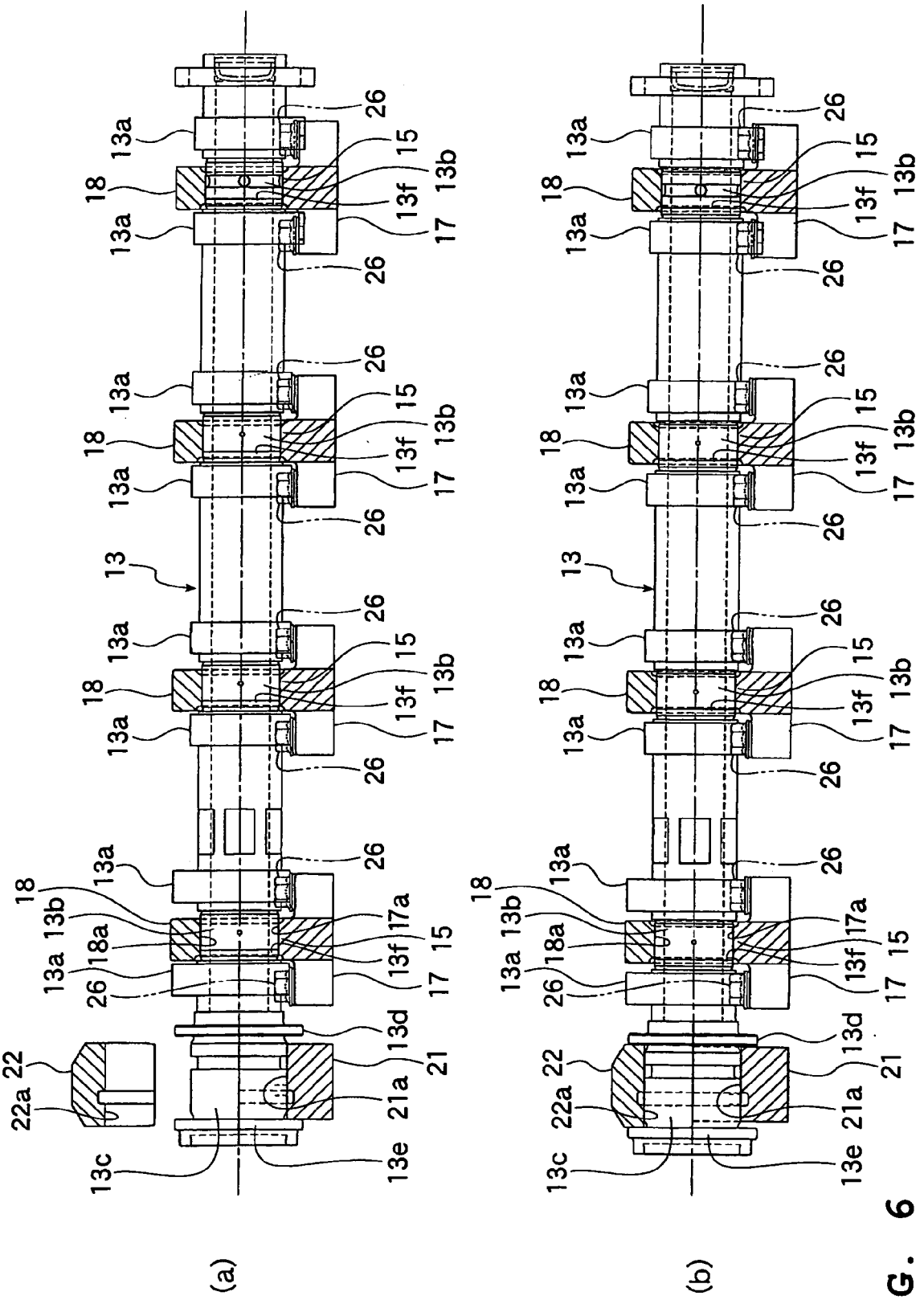

FIG. 6

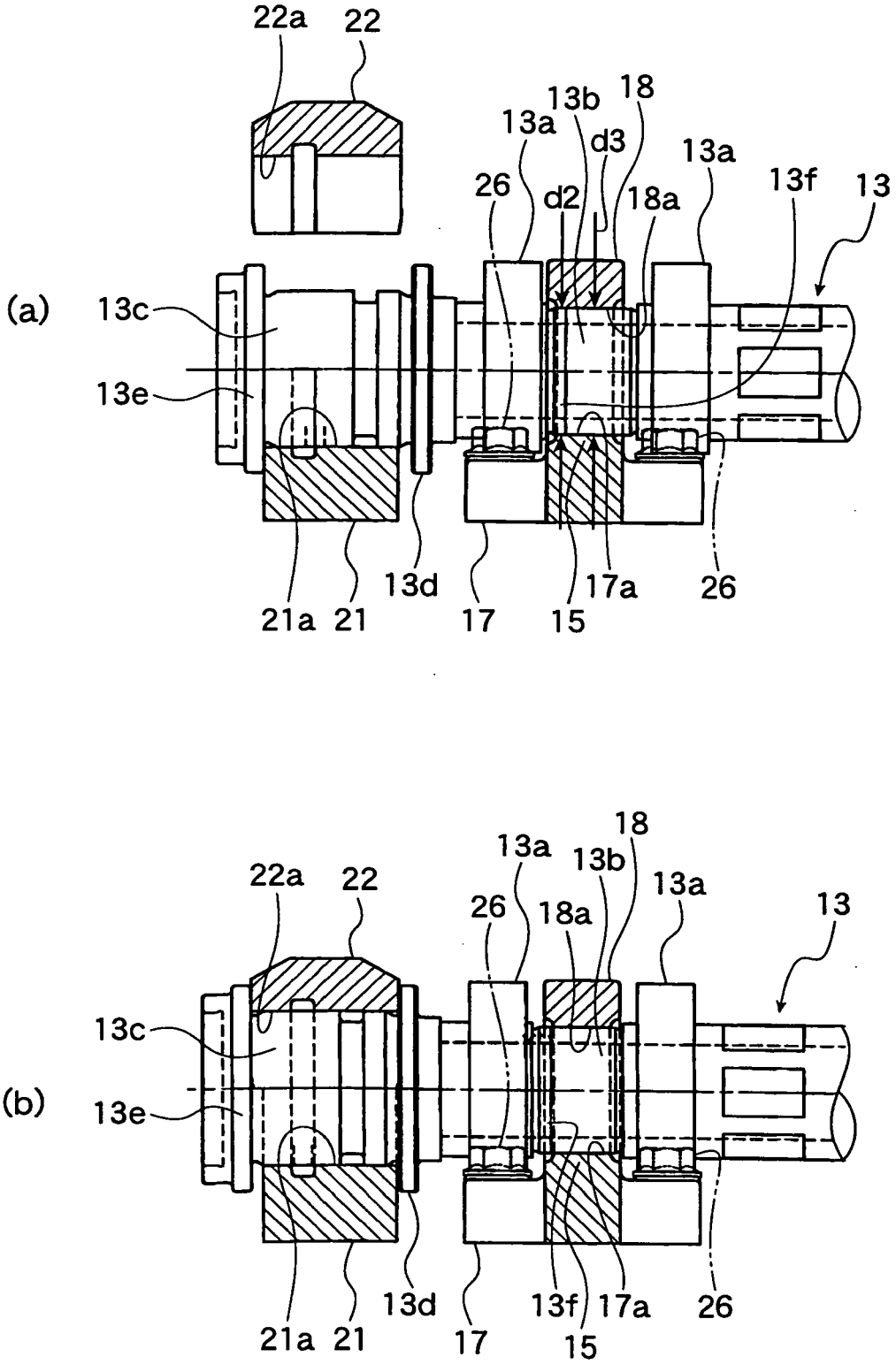
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FIG. 7

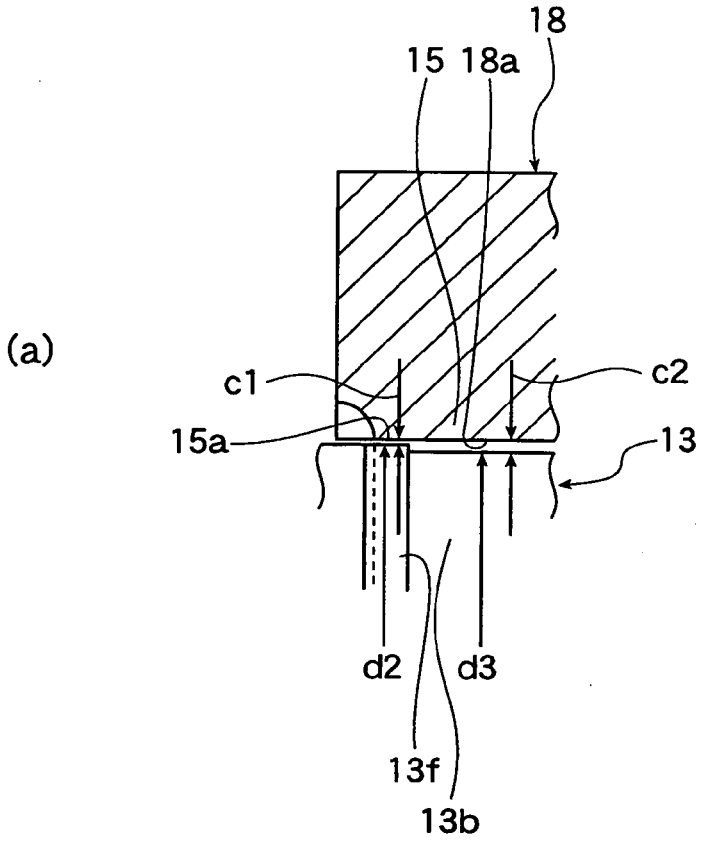

FIG. 8

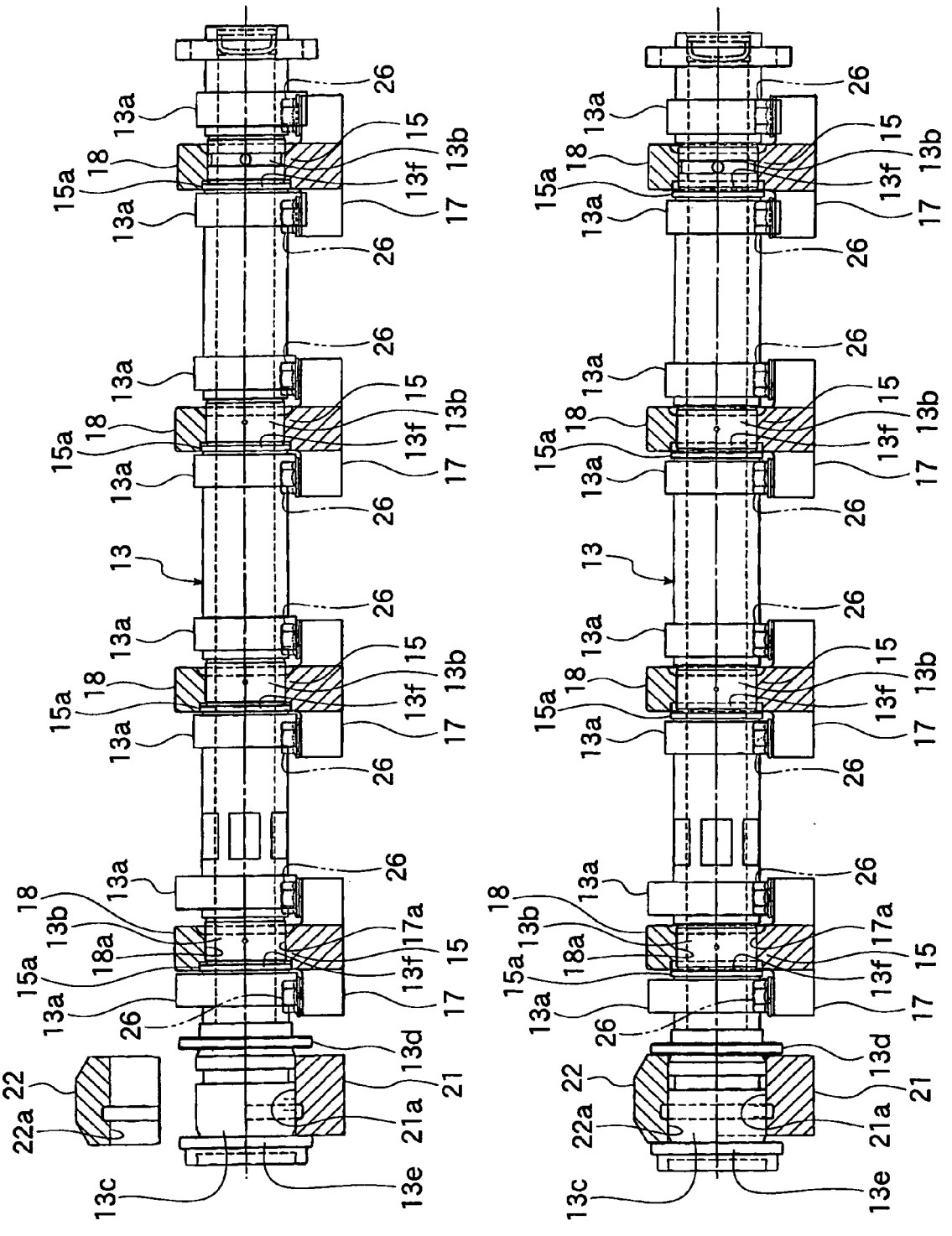

FIG. 9

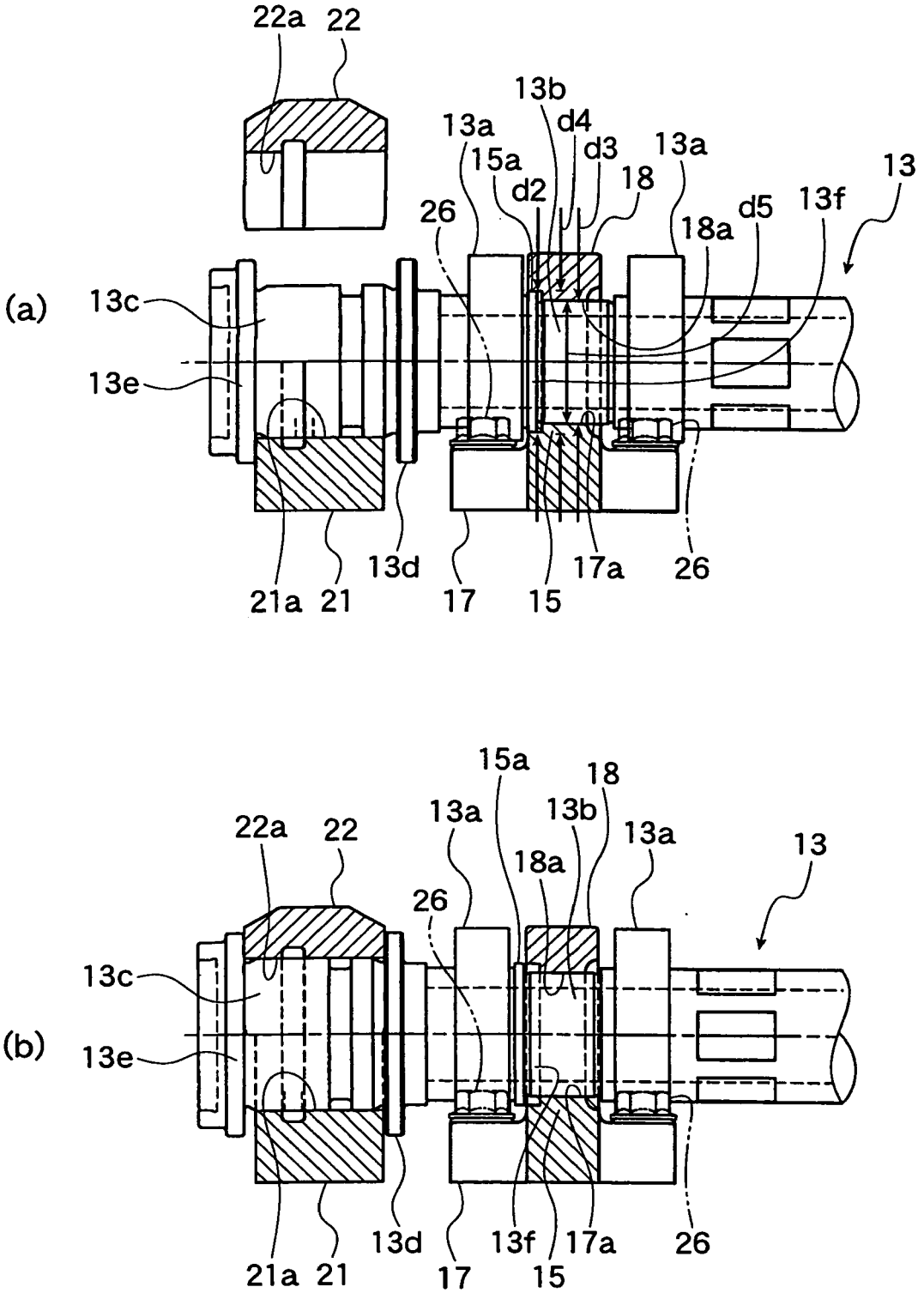
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FIG. 10

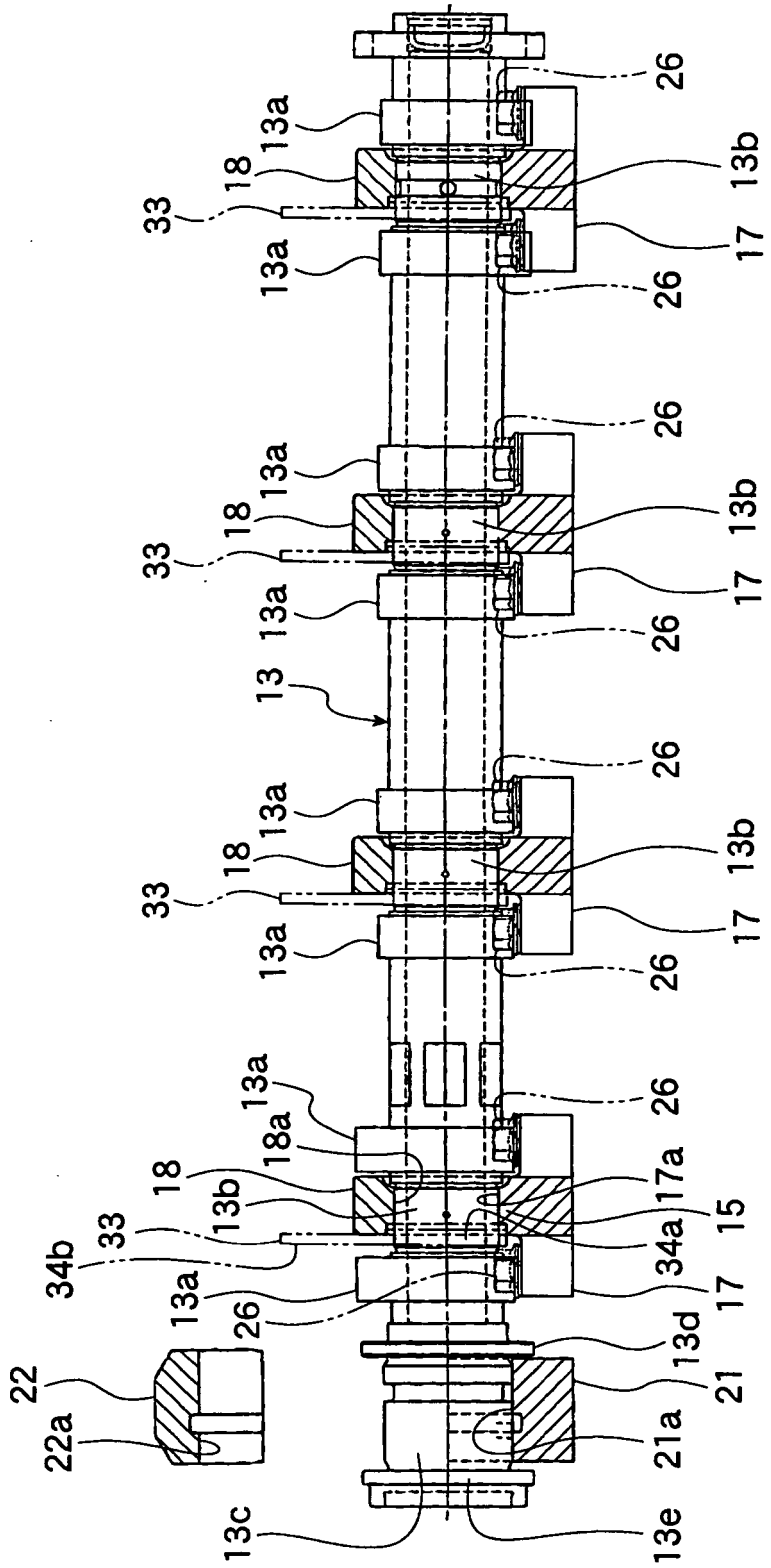
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FIG. 11

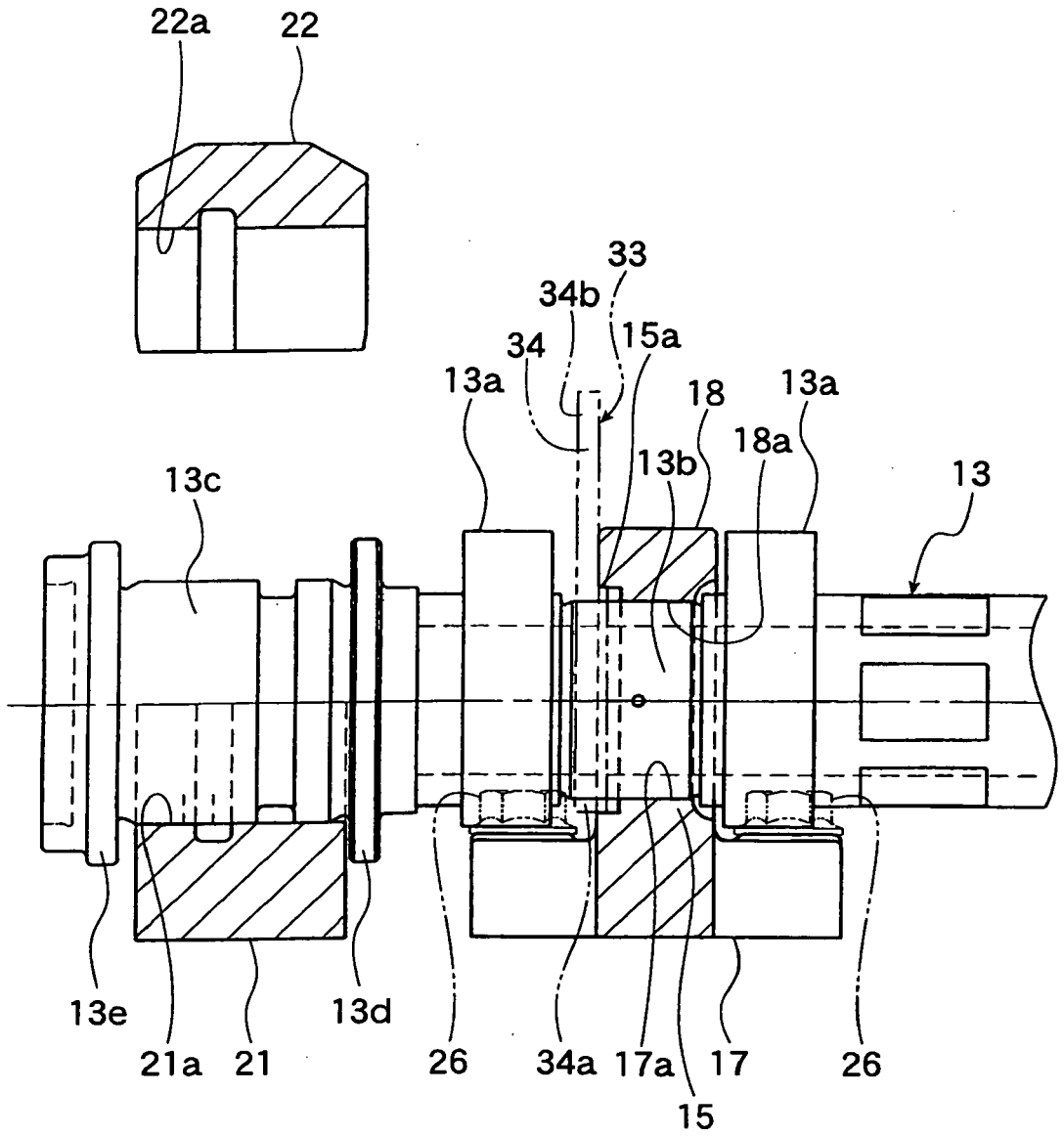
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FIG. 12

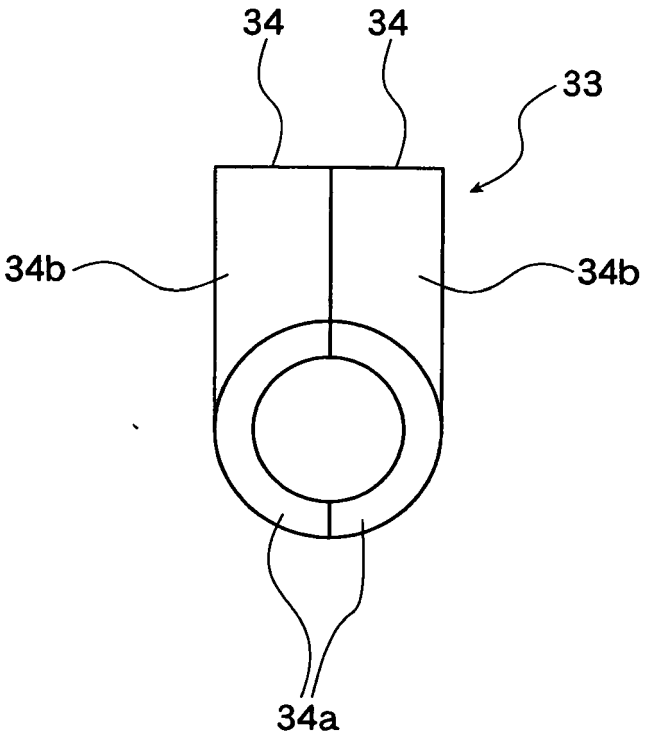

FIG. 13

REFERENCES CITED IN THE DESCRIPTION

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