(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 063 076 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
27.05.2009 Bulletin 2009/22

(21) Application number: **07791228.5**

(22) Date of filing: **24.07.2007**

(51) Int Cl.:
F01L 9/04 *(2006.01)* ***F01L 3/10*** *(2006.01)*

(86) International application number:
PCT/JP2007/064503

(87) International publication number:
WO 2008/032491 (20.03.2008 Gazette 2008/12)

(84) Designated Contracting States:
DE FR GB IT
Designated Extension States:
AL BA HR MK RS

(30) Priority: **13.09.2006 JP 2006247611**
12.12.2006 JP 2006334786

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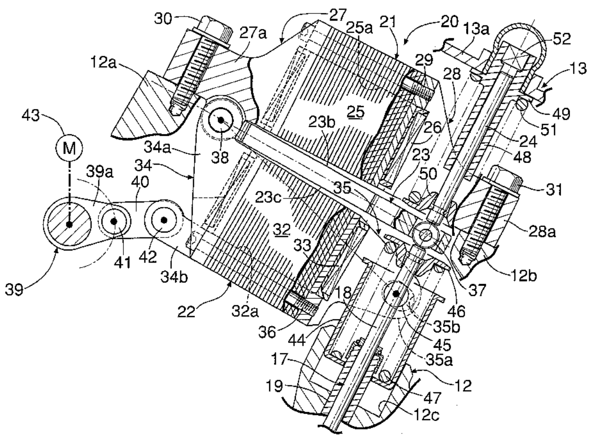
(54) ELECTROMAGNETIC VALVE DEVICE FOR ENGINE

(57) In an engine electromagnetic valve operating device (20), an intake valve (17) is opened and closed by means of a first electromagnet (21), which is fixed to a cylinder head, and a second electromagnet (22), which is pivotably supported on the cylinder head by a fixed shaft (38) so as to be capable of swinging, attracting a first attraction face (23b) and a second attraction face (23c) respectively of an armature (23) having one end pivotably supported on the cylinder head by the fixed shaft (38) so that it can swing and having the other end abutting against a stem (18) of the intake valve (17). In this arrangement, by changing the angle between the first and second electromagnets (21, 22) by swinging the second electromagnet (22), the amount of lift of the intake valve (17) can be changed freely. Furthermore, since only at least one of the first and second electromagnets (21, 22) needs to be made to swing and, moreover, it is unnecessary to move the position of the armature (23), it is possible to form the electromagnetic valve operating device (20) compactly.

FIG.2



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Description

TECHNICAL FIELD

[0001] The present invention relates to an engine electromagnetic valve operating device for opening and closing a valve by means of an armature that is alternately attracted by a first electromagnet and a second electromagnet so as to swing.

BACKGROUND ART

[0002] An arrangement in which supported on a disk base are an upper disk (armature) and a lower disk (armature) having extremities connected to a drive valve provided in a cylinder head of an engine and having base ends pivotably supported on the disk base, an electromagnet disposed inside the two disks, and a pair of permanent magnets disposed outside the two disks, the disk base being movable in a direction perpendicular to an open/close direction of the drive valve, and in which the two disks are alternately attracted by the electromagnet and the permanent magnet and made to swing to-and-fro by controlling the passage of current to the electromagnet thus opening and closing the drive valve, the amount of lift of the drive valve being varied by changing a lever ratio of the two disks by moving the disk base by means of an actuator, is known from Patent Publication 1 below.

Patent Publication 1: Japanese Patent Application Laid-open No. 2006-22776.

DISCLOSURE OF INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0003] In the above-mentioned conventional arrangement, since it is necessary to move the disk base, which supports one electromagnet, two permanent magnets, and two disks (armatures), by means of the actuator, the overall electromagnetic valve operating device increases in size, thus causing the problem that there are significant restrictions on its disposition in the confined space within the cylinder head of the engine.

[0004] The present invention has been accomplished in the light of the above-mentioned circumstances, and it is an object thereof to make a compact electromagnetic valve operating device that opens and closes a valve with any amount of lift by means of an electromagnet.

MEANS FOR SOLVING THE PROBLEMS

[0005] In order to attain the above object, according to a first aspect of the present invention, there is provided an engine electromagnetic valve operating device comprising an armature having one end pivotably supported on an engine main body so as to be capable of swinging and having the other end abutting against a stem of a valve, a first electromagnet that can attract a first attraction face of the armature, and a second electromagnet that can attract a second attraction face of the armature, at least one electromagnet of the first and second electromagnets being supported so as to be capable of swinging around a fixed shaft whose position is fixed relative to the engine main body.

[0006] According to a second aspect of the present invention, in addition to the first aspect, the one electromagnet causes the valve to lift, and defines the amount of lift of the valve.

[0007] According to a third aspect of the present invention, in addition to the first or second aspect, the device comprises a pair of valve springs for urging the armature to a neutral position, a spring seat supporting one valve spring being fixed to the engine main body and a spring seat supporting the other valve spring moving in response to swinging of the one electromagnet.

[0008] According to a fourth aspect of the present invention, in addition to the third aspect, the other valve spring and the spring seat supporting the valve spring are disposed on the outer periphery of the stem of the valve, and the spring seat is integrally connected to and moves with the one electromagnet.

[0009] According to a fifth aspect of the present invention, in addition to any one of the first to fourth aspects, the armature is pivotably supported via the fixed shaft.

[0010] According to a sixth aspect of the present invention, in addition to the fifth aspect, the other electromagnet of the first and second electromagnets is provided with a fixing part for fixing the fixed shaft.

[0011] According to a seventh aspect of the present invention, in addition to the first aspect, the device comprises a first valve spring for urging the valve in a valve-closing direction and a second valve spring for urging the valve in a valve-opening direction, the second valve spring urging a lever provided on the one end side of the armature.

[0012] According to an eighth aspect of the present invention, in addition to the seventh aspect, the one electromagnet comprises a lever provided on one end side via which the electromagnet is pivotably supported on the fixed shaft, an urging force of the second valve spring on the one end side acting on the lever of the armature, and an urging force of the second valve spring on the other end side acting on the lever of the one electromagnet.

[0013] According to a ninth aspect of the present invention, in addition to the eighth aspect, at least parts of the lever of the armature and the lever of the one electromagnet overlap when viewed in a cylinder line direction.

[0014] According to a tenth aspect of the present invention, in addition to the eighth or ninth aspect, a guide rod having one end pivotably supported on the lever of the armature and having a first spring seat provided at the other end runs through a second spring seat provided in the lever of the one electromagnet, and one end and the other end of the second valve spring supported on the outer periphery of the guide rod abut against the first spring seat and the second spring seat respectively.

[0015] According to an eleventh aspect of the present invention, in addition to any one of the eighth to tenth aspects, an actuator making the one electromagnet swing drives the other end side of the electromagnet.

[0016] A cylinder head 12 and a head cover 13 of embodiments correspond to the engine main body of the present invention, an intake valve 17 of the embodiments corresponds to the valve of the present invention, first electromagnets 21 of the embodiments correspond to the other electromagnet of the present invention, second electromagnets 22 of the embodiments correspond to the one electromagnet of the present invention, an inside block member 27 of the embodiments corresponds to the fixing part of the present invention, and a first valve spring 47 and a second valve spring 51 of the embodiments correspond to the valve spring of the present invention.

EFFECTS OF THE INVENTION

[0017] In accordance with the first aspect of the present invention, since the first and second electromagnetics respectively attract the first attraction face and the second attraction face of the armature having one end pivotably supported so that it can swing around the fixed shaft whose position is fixed relative to the engine main body and having the other end abutting against the stem of the valve, the amount of lift of the valve can be changed freely by making at least one of the first and second electromagnets swing. Furthermore, since only at least one of the first and second electromagnets needs to be made to swing and, moreover, it is unnecessary to move the position of the armature, it is possible to form the electromagnetic valve operating device compactly. In particular, since the amount of lift of the valve is varied by making the one of the electromagnets swing, the electromagnetic valve operating device can be made compact in the axial direction of the valve.

[0018] Furthermore, in accordance with the second aspect of the present invention, since the electromagnet that swings makes the valve lift and defines the amount of lift of the valve, not only is it possible to reliably open the valve, but it is also possible to vary the amount of lift of the valve while suppressing any degradation in collision noise when the valve closes.

[0019] Moreover, in accordance with the third aspect of the present invention, since, among the pair of valve springs for urging the armature to the neutral position, the spring seat supporting one of the valve springs is fixed to the engine main body, and the spring seat supporting the other valve spring is moved in response to swinging of the one electromagnet, even if the engine stops, regardless of the swing position of the one electromagnet at that time, the armature is prevented from being greatly displaced from the neutral position, and it is possible to reliably attract the armature by the first electromagnet or the second electromagnet when the engine is started.

[0020] Furthermore, in accordance with the fourth aspect of the present invention, since the other valve spring and the spring seat supporting the valve spring are disposed on the outer periphery of the stem of the valve, not only is it possible to make the electromagnetic valve operating device compact, but it is also possible to reliably urge the armature to the neutral position since the spring seat is connected integrally to the one electromagnet and moves in response to swinging of the one electromagnet.

[0021] Moreover, in accordance with the fifth aspect of the present invention, since the one electromagnet and the armature are pivotably supported on the same fixed shaft, the positional relationship between the one electromagnet and the armature attracted to the electromagnet is unchanged even if the electromagnet swings, and it is easy to control the attraction faces of the electromagnet and the armature.

[0022] Furthermore, in accordance with the sixth aspect of the present invention, since the fixing part via which the fixed shaft is fixed is provided in the other electromagnet among the first and second electromagnets, the positional relationship between the other electromagnet and the armature is stabilized, and not only is it easy to control the attraction faces of the other electromagnet and the armature, but it is also unnecessary to separately ensure that there is a member on which the fixed shaft is provided.

[0023] Moreover, in accordance with the seventh aspect of the present invention, since among the first valve spring for urging the valve in a valve-closing direction and the second valve spring for urging it in a valve-opening direction, the second valve spring urges the lever provided on the one end side via which the armature is pivotably supported on the fixed shaft, it is possible to eliminate the necessity for disposing the second valve spring on a line extended from the stem of the valve, thereby reducing the size of the electromagnetic valve operating device.

[0024] Furthermore, in accordance with the eighth aspect of the present invention, since the urging force from one end of the second valve spring and the urging force from the other end thereof act on the lever provided on one end side of the armature and the lever provided on one end side of the one electromagnet respectively, the armature can be made to swing by means of the resilient force of the second valve spring in response to swinging of the one electromagnet; even if the engine stops, regardless of the swing position of the one electromagnet at that time, the armature is prevented from being greatly displaced from the neutral position, and it is possible to reliably attract the armature by the first electromagnet or the second electromagnet when the engine is started.

[0025] Moreover, in accordance with the ninth aspect of the present invention, since the disposition is such that at least parts of the lever of the armature and the lever of the one electromagnet overlap when viewed in the cylinder line direction, it is possible to reduce the size of the electromagnetic valve operating device.

[0026] Furthermore, in accordance with the tenth aspect of the present invention, since the guide rod having one end pivotably supported on the lever of the armature and having the first spring seat provided on the other end runs through the second spring seat provided on the lever of the one electromagnet, and one end and the other end of the second valve spring supported on the outer periphery of the guide rod are made to abut against the first spring seat and the second spring seat respectively, it is possible to reduce the number of components by utilizing the guide rod as a support member for the second valve spring.

[0027] Moreover, in accordance with the eleventh aspect of the present invention, since the actuator making the one electromagnet swing drives the other end side of the electromagnet, that is, the side that is distant from the fixed shaft pivotably supporting the electromagnet, it is possible to reduce the burden on the actuator and enhance the positioning precision of the swing position of the electromagnet.

BRIEF DESCRIPTION OF DRAWINGS

[0028]

[FIG. 1] FIG. 1 is a sectional view of an engine cylinder head provided with an electromagnetic valve operating device related to a first embodiment (first embodiment).
[FIG. 2] FIG. 2 is an enlarged view of an essential part of FIG. 1 (first embodiment).
[FIG. 3] FIG. 3 is an exploded perspective view of the electromagnetic valve operating device (first embodiment).
[FIG. 4] FIG. 4 is an exploded perspective view of a swinging part of a second electromagnet (first embodiment).
[FIG. 5] FIG. 5 is a diagram for explaining the operation (neutral state) at a time of low lift and at a time of high lift (first embodiment).
[FIG. 6] FIG. 6 is a diagram for explaining the operation (maximum lift state) at a time of low lift and at a time of high lift (first embodiment).
[FIG. 7] FIG. 7 is a sectional view of an engine cylinder head provided with an electromagnetic valve operating device related to a second embodiment (second embodiment).
[FIG. 8] FIG. 8 is an enlarged view of an essential part of FIG. 7 (second embodiment).
[FIG. 9] FIG. 9 is a view from arrowed line 9-9 in FIG. 8 (second embodiment).
[FIG. 10] FIG. 10 is an exploded perspective view of the electromagnetic valve operating device (second embodiment).
[FIG. 11] FIG. 11 is an exploded perspective view of a second electromagnet and its swinging part (second embodiment).
[FIG. 12] FIG. 12 is a diagram for explaining the operation (neutral state) at a time of low lift and at a time of high lift (second embodiment).
[FIG. 13] FIG. 13 is a diagram for explaining the operation (maximum lift state) at a time of low lift and at a time of high lift (second embodiment).

EXPLANATION OF REFERENCE NUMERALS AND SYMBOLS

[0029]

12	Cylinder head (engine main body)
13	Head cover (engine main body)
17	Intake valve (valve)
18	Stem
21	First electromagnet (other electromagnet)
22	Second electromagnet (one electromagnet)
23	Armature
23b	First attraction face
23c	Second attraction face
23d	Lever
27	Inside block member (fixing part)
34d	Lever
38	Fixed shaft
44	Spring seat
47	First valve spring (valve spring)
49	Spring seat
51	Second valve spring (valve spring)
43	Actuator
150	Guide rod
151	First spring seat
152	Second spring seat
153	Second valve spring

BEST MODE FOR CARRYING OUT THE INVENTION

[0030] Modes for carrying out the present invention are explained below by reference to the attached drawings.

EMBODIMENT 1

[0031] FIG. 1 to FIG. 6 show a first embodiment of the present invention.

[0032] As shown in FIG. 1, a cylinder head 12 is joined to a top face of an engine cylinder block 11, and a head cover 13 is joined to a top face of the cylinder head 12. An intake port 14 is formed in the cylinder head 12, and a stem 18 of an intake valve 17 for opening and closing a valve hole 16 via which the intake port 14 opens in a combustion chamber 15 is slidably guided by a valve guide 19 provided in the cylinder head 12.

[0033] As shown in FIG. 1 to FIG. 4, an electromagnetic valve operating device 20 for opening and closing a pair of the intake valves 17 with the same timing and the same amount of lift includes a pair of first electromagnets 21, a pair of second electromagnets 22, a pair of armatures 23, and a pair of urging rods 24.

[0034] The first electromagnets 21 include a core 25 formed by laminating a large number of steel sheets, a pair of coils 26 wound around four coil grooves 25a formed in the core 25, an inside block member 27 superimposed on the inner end of the core 25, and an outside block member 28 superimposed on the outer end of the core 25, the inside block member 27, the core 25, and the outside block member 28 being integrally secured by means of four bolts 29. The first electromagnets 21 are fixed to the cylinder head 12 by securing three mounting arms 27a of the inside block member 27 to a mounting portion 12a of the cylinder head 12 by bolts 30 and securing three mounting arms 28a of the outside block member 28 to a mounting portion 12b of the cylinder head 12 by bolts 31.

[0035] The second electromagnets 22 include a core 32 formed by laminating a large number of steel sheets, a pair of coils 33 wound around four coil grooves 32a formed in the core 32, an inside block member 34 superimposed on the inner end of the core 32, and an outside block member 35 superimposed on the outer end of the core 32, the inside block member 34, the core 32, and the outside block member 35 being integrally secured by means of four bolts 36. The inside block member 34 is provided with two hinge arms 34a and two link arms 34b, and the outside block member 35 is provided with three spring seat support arms 35a.

[0036] The armatures 23 are plate-shaped members; two hinge arms 23a are provided at the inner end, and two rollers 37 are rotatably and axially supported at the outer end. A fixed shaft 38 is press-fitted into the three mounting arms 27a of the inside block member 27 of the first electromagnets 21, and the two hinge arms 23a of the armatures 23 and the two hinge arms 34a of the inside block member 34 of the second electromagnets 22 are fitted around the outer periphery of the fixed shaft 38 in a relatively rotatable manner. The armatures 23 and the second electromagnets 22 are therefore pivotably supported so that they can swing around the fixed shaft 38 independently from each other. The fixed shaft 38 referred to here means that its position does not move relative to the cylinder head 11, and it may rotate at the same position.

[0037] Two link arms 39a provided on a control shaft 39 rotatably supported on the cylinder head 12 and the two link arms 34b of the inside block member 34 of the second electromagnets 22 are pivotably supported at opposite ends of a control link 40 via pins 41 and 42 respectively. Therefore, when the control shaft 39 is rotated to-and-fro by means of an actuator 43 such as an electric motor, it makes the second electromagnets 22 swing around the fixed shaft 38 via the control link 40.

[0038] A cylindrical spring seat 44 is slidably fitted into a guide recess 12c formed in the cylinder head 12 coaxially with the intake valve 17, and a pin 45 provided on the spring seat 44 engages with an oblong hole 35b provided in the extremity of the spring seat support arm 35a of the outside block member 35 of the second electromagnets 22. Therefore, when the second electromagnets 22 swing, this is tracked by the spring seat 44 moving vertically along the guide recess 12c. The reason for the arrangement in which it is the oblong hole 35b that the pin 45 provided in the spring seat support arm 35a engages with is because the spring seat support arm 35a of the outside block member 35 swings around the fixed shaft 38 whereas the spring seat 44 moves linearly along the guide recess 12c.

[0039] A first valve spring 47 is provided in a compressed state between the spring seat 44 and a spring seat 46 provided at the upper end of the stem 18 of the intake valve 17. The first valve spring 47 urges the intake valve 17 in a valve-closing direction (upward), and the urging force makes the upper end of the stem 18 of the intake valve 17 abut against the roller 37 of the armature 23.

[0040] The urging rod 24, which is disposed coaxially with the stem 18 of the intake valve 17, is slidably supported in a rod guide 48 provided on a support portion 13a of the head cover 13. A second valve spring 51 is provided in a compressed state between a spring seat 49 formed integrally with the rod guide 48 and a spring seat 50 provided on a lower part of the urging rod 24, and the lower end of the urging rod 24, which is urged downward by the second valve spring 51, abuts against the roller 37 of the armature 23. A hydraulic cushion mechanism 52 for cushioning the impact when the intake valve 17 is seated is provided in an upper part of the rod guide 48.

[0041] The operation of the first embodiment of the present invention having the above-mentioned arrangement is now explained.

[0042] When the second electromagnets 22 are made to swing around the fixed shaft 38 via the control shaft 39 and the control link 40 by the actuator 43, the angle formed between the lower face of the first electromagnets 21 fixed to the cylinder head 12 and the upper face of the second electromagnets 22 that have been made to swing changes. FIG. 5 (A) corresponds to a case in which the angle is a small angle α and the intake valve 17 is driven with a small amount of lift, and FIG. 5 (B) corresponds to a case in which the angle is a large angle β and the intake valve 17 is driven with a large amount of lift.

[0043] When the first and second electromagnets 21 and 22 are not energized, regardless of whether the second electromagnets 22 are in a low lift state or in a high lift state, the armature 23 always stops at a substantially neutral position of the wedge-shaped space formed between the first and second electromagnets 21 and 22. The reason therefor is as follows.

[0044] In the low lift state, the armature 23 is pushed upward by the stem 18 of the intake valve 17, which is urged upward by the first valve spring 47, and is pushed downward by the urging rod 24, which is urged downward by the second valve spring 51, and the armature 23 stops at the neutral position at which the upward-pushing force and the downward-pushing force are balanced. The resilient forces of the first and second valve springs 47 and 51 are adjusted so that at the neutral position the armature 23 stops substantially midway between the first and second electromagnets 21 and 22.

[0045] When the second electromagnets 22 descend from this state to the high lift state, since the spring seat 44, which supports the lower end of the first valve spring 47, descends together with the second electromagnets 22, the first and second valve springs 47 and 51 expand equally. As a result, the armature 23 swings downward from the low lift state, and in the high lift state it also stops at a neutral position that is in substantially the middle of the space between the first and second electromagnets 21 and 22.

[0046] If the lower end of the first valve spring 47 were to be supported on the cylinder head 12 so that it could not move, in the high lift state even if the second electromagnets 22 were to swing downward the armature 23 would not move from the position in the low lift state, and the clearance between the armature 23 and the second electromagnets 22 would increase relative to the clearance between the armature 23 and the first electromagnets 21, which would be a problem.

[0047] In such an arrangement, if when the engine stops the armature 23 does not stop at around the midpoint between the first and second electromagnets 21 and 22, in a cylinder with a timing in which at the moment of starting the engine the second electromagnets 22 are energized and the armature 23 is attracted, a large attraction force would be required for the second electromagnets 22, which are at an increased distance from the armature 23, and problems such as an increase in the dimensions of the second electromagnets 22 and an increase in power consumption would occur.

[0048] In contrast thereto, in the present embodiment, since the armature 23 reliably stops substantially midway between the first and second electromagnets 21 and 22 when the engine stops, whichever of the first and second electromagnets 21 and 22 is first energized when the engine is started, an especially large attraction force is not required, and the above-mentioned problems are therefore eliminated.

[0049] Furthermore, not only is it possible to achieve a compact size since the first valve spring 47 and the spring seat 44 are disposed on the outer periphery of the stem 18 of the intake valve 17, but since the spring seat 44 is connected to the second electromagnets 22 via the pin 45 and the oblong hole 35b it is also possible to make the spring seat 44 move in response to swinging of the second electromagnets 22, thus reliably urging the armature 23 to the neutral position regardless of the swing position of the second electromagnets 22.

[0050] When the first electromagnets 21 are energized, a first attraction face 23b of the armature 23 is attracted to the lower face of the first electromagnets 21, and the armature 23 is thereby swung upward around the fixed shaft 38, thus pushing the urging rod 24 upward by means of the roller 37 while compressing the second valve spring 51. At the same time as this, the intake valve 17, whose stem 18 is pushed upward by means of the resilient force of the first valve spring 47, is seated on the valve hole 16 and closed. The dimensional relationships between the parts are set so that the first attraction face 23b of the armature 23 comes into intimate contact with the lower face of the first electromagnets 21 in a state in which the intake valve 17 is closed. The impact at the moment when the intake valve 17 is seated on the valve hole 16 is cushioned by the hydraulic cushion mechanism 52, which suppresses upward movement of the upper end of the urging rod 24.

[0051] When the first electromagnets 21 are de-energized and the second electromagnets 22 are energized in a state in which the intake valve 17 is closed, a second attraction face 23c of the armature 23 is attracted to the upper face of the second electromagnets 22. The armature 23 swings downward around the fixed shaft 38 and pushes the stem 18 downward via the roller 37 while compressing the first valve spring 47, thus opening the intake valve 17. In this process, the urging rod 24 descends so as to follow the armature 23 by virtue of the resilient force of the second valve spring 51. When the second attraction face 23c of the armature 23 comes into intimate contact with the upper face of the second electromagnets 22, the amount of lift of the intake valve 17 becomes a maximum amount of lift, and as shown in FIG. 6 the maximum amount of lift is freely changed by the swing position of the second electromagnets 22.

[0052] Since the second electromagnets 22 and the armature 23 swing around the common fixed shaft 38, in both the low lift state of FIG. 6 (A) and the high lift state of FIG. 6 (B), the second attraction face 23c of the armature 23 can be made to come to intimate contact with the upper face of the second electromagnets 22, and it becomes easy to control the upper face of the second electromagnets 22 and the second attraction face 23c of the armature 23. Furthermore, since the fixed shaft 38 is provided on the first electromagnets 21, which are fixed to the cylinder head 11, not only is it unnecessary to ensure a location on the cylinder head 11 for providing the fixed shaft 38, but also the positional relationship between the first electromagnets 21 and the armature 23 is stabilized, and control of the lower face of the first electromagnets 21 and the first attraction face 23b of the armature 23 becomes easy.

[0053] In this way, by changing the swing position of the second electromagnets 22, the maximum amount of lift of the intake valve 17 can be varied freely, and by changing the timing with which the first and second electromagnets 21 and 22 are energized and de-energized, the valve timing of the intake valve 17 can be varied freely. In this process, since only the position of the second electromagnets 22 need be changed, without the positions of the first electromagnets 21 and the armature 23 being changed, compared with an arrangement in which all of the first and second electromagnets 21 and 22 and the armature 23 are moved, the electromagnetic valve operating device 20 can be made more compact. Moreover, since the first electromagnets 21, which restrict the valve closing position of the intake valve 17, is fixed so that it cannot move, the intake valve 17 can be seated with good precision.

EMBODIMENT 2

[0054] FIG. 7 to FIG. 13 show a second embodiment of the present invention.

[0055] As shown in FIG. 7, a cylinder head 12 is joined to a top face of an engine cylinder block 11, and a head cover 13 is joined to a top face of the cylinder head 12. An intake port 14 is formed in the cylinder head 12, and a stem 18 of an intake valve 17 for opening and closing a valve hole 16 via which the intake port 14 opens in a combustion chamber 15 is slidably guided by a valve guide 19 provided in the cylinder head 12.

[0056] As shown in FIG. 7 to FIG. 11, an electromagnetic valve operating device 20 for opening and closing a pair of the intake valves 17 with the same timing and the same amount of lift includes a pair of first electromagnets 21, a pair of second electromagnets 22, and a pair of armatures 23.

[0057] The first electromagnets 21 include a core 25 formed by laminating a large number of steel sheets, a pair of coils 26 wound around four coil grooves 25a formed in the core 25, an inside block member 27 superimposed on the inner end of the core 25, and an outside block member 28 superimposed on the outer end of the core 25, the inside block member 27, the core 25, and the outside block member 28 being integrally secured by means of four bolts 29. The first electromagnets 21 are fixed to the cylinder head 12 by securing three mounting arms 27a of the inside block member 27 to a mounting portion 12a of the cylinder head 12 by bolts 30 and securing three mounting arms 28a of the outside block member 28 to a mounting portion 12b of the cylinder head 12 by bolts 31.

[0058] The second electromagnets 22 include a core 32 formed by laminating a large number of steel sheets, a pair of coils 33 wound around four coil grooves 32a formed in the core 32, an inside block member 34 superimposed on the inner end of the core 32, and an outside block member 35 superimposed on the outer end of the core 32, the inside block member 34, the core 32, and the outside block member 35 being integrally secured by means of four bolts 36. The inside block member 34 is provided with four hinge arms 34a and four levers 34c extending from these hinge arms 34a.

[0059] The two armatures 23 are plate-shaped members having a first attraction face 23b and a second attraction face 23c; two hinge arms 23a and two levers 23d extending therefrom are provided at the inner end, and two rollers 37 are rotatably and axially supported at the outer end. A fixed shaft 38 is press-fitted into the four mounting arms 27a of the inside block member 27 of the first electromagnets 21, and the total of four hinge arms 23a of the armatures 23 and four hinge arms 34a of the inside block member 34 of the second electromagnets 22 are fitted around the outer periphery of the fixed shaft 38 in a relatively rotatable manner. The armatures 23 and the second electromagnets 22 are therefore pivotably supported so that they can swing around the fixed shaft 38 independently from each other. The fixed shaft 38 referred to here means that its position does not move relative to the cylinder head 11, and it may rotate at the same position.

[0060] Two link arms 39a provided on a control shaft 39 rotatably supported on the cylinder head 12 and the outside block member 28 of the second electromagnets 22 are pivotably supported at opposite ends of a control link 40 via pins 41 and 42 respectively. Therefore, when the control shaft 39 is rotated to-and-fro by means of an actuator 43 such as an electric motor, it makes the second electromagnets 22 swing around the fixed shaft 38 via the control link 40. In this way, since the end part of the second electromagnets 22 that is distant from the fixed shaft 38 is driven by the actuator 43, not only is it possible to employ an actuator 43 that has a low output, but it is also possible to suppress rattling of the second electromagnets 22 around the fixed shaft 38.

[0061] A first valve spring 47 is provided in a compressed state between an upper face of the cylinder head 12 and a spring seat 46 provided at the upper end of the stem 18 of the intake valve 17. The first valve spring 47 urges the intake valve 17 in a valve-closing direction (upward), and the urging force makes the upper end of the stem 18 of the intake valve 17 abut against a lower face of the roller 37 of the armature 23 via a lash adjuster 145. Furthermore, a hydraulic cushion mechanism 148 provided on the cylinder head 12 abuts against an upper face of the roller 37 of the armature 23.

[0062] A base end of a guide rod 150 is pivotably supported via a pin 149 between extremities of the pair of levers 23d extending from the pair of hinge arms 23a of each of the armatures 23, and a first spring seat 151 is integrally formed with the extremity of the guide rod 150.

[0063] On the other hand, two squared U-shaped second spring seats 152 are pivotably supported via two pins 54 and 54 between the two pairs of levers 34c extending from the two pairs of hinge arms 34a of the inside block member 34 of the second electromagnets 22, and two of the guide rods 150 run loosely through guide holes 152a formed in the middle of the second spring seats 152. One end of a second valve spring 153 provided in a compressed state so as to be fitted around the outer periphery of the guide rod 150 abuts against the first spring seat 151, and the other end abuts against the second spring seat 152. Since the second valve spring 153 is supported on the outer periphery of the guide rod 150, not only is the structure compact, but it is also possible to stabilize the shape of the second valve spring 153, thus reliably urging the first and second spring seats 151 and 152.

[0064] A spring guide 55 is fixed to an upper face of the inside block member 27 of the first electromagnets 21 via two bolts 56 and 56, and the two second valve springs 153 and 153 are slidably fitted into two spring guide holes 55a and 55a formed in the spring guide 55. When the axis of the pin 149 coincides with the axes of the pins 54 and 54, the guide rod 150 swings around the pin 149 and the second spring seat 152 swings around the pins 54 and 54 at the same time, and there is a possibility that the position of the second valve spring 153 will not be defined, but by restricting the positions of the second valve springs 153 and 153 by means of the spring guide holes 55a and 55 of the spring guide 55 the above-mentioned problem can be solved.

[0065] The operation of the second embodiment of the present invention having the above-mentioned arrangement is now explained.

[0066] When the second electromagnets 22 are made to swing around the fixed shaft 38 via the control shaft 39 and the control link 40 by the actuator 43, the angle formed between the lower face of the first electromagnets 21 fixed to the cylinder head 12 and the upper face of the second electromagnets 22 that have been made to swing changes. FIG. 12 (A) corresponds to a case in which the angle is a small angle α and the intake valve 17 is driven with a small amount of lift, and FIG. 12 (B) corresponds to a case in which the angle is a large angle β and the intake valve 17 is driven with a large amount of lift.

[0067] When the first and second electromagnets 21 and 22 are not energized, regardless of whether the second electromagnets 22 are in a low lift state or in a high lift state, the armature 23 always stops at a substantially neutral position of the wedge-shaped space formed between the first and second electromagnets 21 and 22. The reason therefor is as follows.

[0068] In the low lift state, the armature 23 is pushed upward by the stem 18 of the intake valve 17, which is pushed upward by the first valve spring 47. On the other hand, the guide rod 150, which has the first spring seat 151 pushed by means of the one end of the second valve spring 153 that has its other end supported on the second spring seat 152 of the second electromagnets 22, increases in the amount by which it projects from the guide hole 152a of the second spring seat 152, and the armature 23 is urged downward around the fixed shaft 38, that is, urged so as to push down the stem 18 of the intake valve 17. In this way, by adjusting so that the resilient force of the first valve spring 47 urging the intake valve 17 toward the valve-closing direction balances the resilient force of the second valve spring 153 urging it toward the valve-opening direction, the armature 23 stops at a neutral position that is substantially midway between the first and second electromagnets 21 and 22.

[0069] When the second electromagnets 22 descend from this state to the high lift state via the control shaft 39 and the control link 40, which are operated by the actuator 43, as shown in FIG. 12 (B), the lever 34d integral with the second electromagnets 22 swings around the fixed shaft 38 in the clockwise direction and compresses the other end of the second valve spring 153 via the second spring seat 152 provided on the lever 34d. The guide rod 150 is then pushed upward together with the first spring seat 151 abutting against the one end of the second valve spring 153, and the armature 23 having the lever 23d pulled by the guide rod 150 swings downward around the fixed shaft 38.

[0070] As a result, the roller 37 of the armature 23 pushes down the upper end of the stem 18 of the intake valve 17, thus opening the intake valve 17 while compressing the first valve spring 47. In this process, since the resilient force of the compressed first valve spring 47 that pushes up the intake valve 17, that is, the armature 23, and the resilient force of the compressed second valve spring 153 that pushes down the armature 23 are balanced, in this high lift state also the armature 23 stops at a neutral position that is in substantially the middle of the space between the first and second electromagnets first and second electromagnets 21 and 22.

[0071] When the engine is stopped in a state in which the second electromagnets 22 are swung downward in order to change the valve lift, if the armature 23 does not stop at the neutral position that is in substantially the middle of the space between the first and second electromagnets first and second electromagnets 21 and 22 but is at a position at which it is in contact with the first electromagnets 21, in a cylinder with a timing in which at the moment of starting the engine the second electromagnets 22 are energized and the armature 23 is attracted, a large attraction force would be required for the second electromagnets 22, which are at an increased distance from the armature 23, and problems such as an increase in the dimensions of the second electromagnets 22 and an increase in power consumption would occur.

[0072] In contrast thereto, in the present embodiment, since the armature 23 reliably stops substantially midway between the first and second electromagnets 21 and 22 when the engine stops, whichever of the first and second electromagnets 21 and 22 are first energized when the engine is started, an especially large attraction force is not required, and the above-mentioned problems are therefore eliminated.

[0073] When the first electromagnets 21 are energized, a first attraction face 23b of the armature 23 is attracted to the lower face of the first electromagnets 21, and the armature 23 is thereby swung upward around the fixed shaft 38 while compressing the second valve spring 153, and at the same time as this, the intake valve 17, whose stem 18 is pushed upward by means of the resilient force of the first valve spring 47, is seated on the valve hole 16 and closed. The impact at the moment when the intake valve 17 is seated on the valve hole 16 is cushioned by the hydraulic cushion mechanism 148, and the intake valve 17 is seated on the valve hole 16 by means of the lash adjuster 145 in a state in which the first attraction face 23b of the armature 23 is in intimate contact with the lower face of the first electromagnets 21.

[0074] When the first electromagnets 21 are de-energized and the second electromagnets 22 are energized in a state in which the intake valve 17 is closed, a second attraction face 23c of the armature 23 is attracted to the upper face of the second electromagnets 22. The armature 23 swings downward around the fixed shaft 38 and pushes the stem 18 downward via the roller 37 while compressing the first valve spring 47 and expanding the second valve spring 153, thus opening the intake valve 17. When the second attraction face 23c of the armature 23 comes into intimate contact with the upper face of the second electromagnets 22, the amount of lift of the intake valve 17 becomes a maximum amount of lift, and as shown in FIG. 13 the maximum amount of lift is freely changed by the swing position of the second electromagnets 22.

[0075] Since the second electromagnets 22 and the armature 23 swing around the common fixed shaft 38, in both the low lift state of FIG. 13 (A) and the high lift state of FIG. 13 (B), the second attraction face 23c of the armature 23 can be made to come to intimate contact with the upper face of the second electromagnets 22, and it becomes easy to control the upper face of the second electromagnets 22 and the second attraction face 23c of the armature 23. Furthermore, since the fixed shaft 38 is provided on the first electromagnets 21, which are fixed to the cylinder head 12, not only is it unnecessary to ensure a location on the cylinder head 12 for providing the fixed shaft 38, but also the positional relationship between the first electromagnets 21 and the armature 23 is stabilized, and control of the lower face of the first electromagnets 21 and the first attraction face 23b of the armature 23 becomes easy.

[0076] In this way, by changing the swing position of the second electromagnets 22, the maximum amount of lift of the intake valve 17 can be varied freely, and by changing the timing with which the first and second electromagnets 21 and 22 are energized and de-energized, the valve timing of the intake valve 17 can be varied freely. In this process, since only the position of the second electromagnets 22 need be changed, without the positions of the first electromagnets 21 and the armature 23 being changed, compared with an arrangement in which all of the first and second electromagnets 21 and 22 and the armature 23 are moved, the electromagnetic valve operating device 20 can be made more compact. Moreover, since the first electromagnets 21, which restrict the valve closing position of the intake valve 17, are fixed so that they cannot move, the intake valve 17 can be seated with good precision.

[0077] Furthermore, the second valve spring 153 is conventionally disposed on a line extended from the first valve spring 47 on the outer periphery of the stem 18 of the intake valve 17, but in the present embodiment since the second valve spring 153 is moved toward the fixed shaft 38 side, it is unnecessary to ensure that there is space for the second valve spring 153 to be disposed on a line extended from the stem 18, and the electromagnetic valve operating device 20 can be made compact. Furthermore, since parts of the lever 23d of the armature 23 and the lever 34c of the second electromagnets 22 overlap when viewed in the cylinder line direction (see FIG. 12 and FIG. 13), the electromagnetic valve operating device 20 can be formed more compactly.

[0078] Embodiments of the present invention are explained above, but the present invention may be modified in a variety of ways as long as the modifications do not depart from the spirit and scope thereof.

[0079] For example, in the embodiments, the present invention is applied to the intake valve 17, but it may be applied to an exhaust valve.

[0080] Furthermore, in the embodiments, among the first and second electromagnets 21 and 22, only the second electromagnets 22 are made to swing, but both the first and second electromagnets 21 and 22 may be made to swing.

[0081] Moreover, in the embodiments, the pair of armatures 23 are driven with the same timing and amount of lift, but the armatures 23 may be driven with different timings and amounts of lift for each intake valve 17.

Claims

1. An engine electromagnetic valve operating device comprising an armature (23) having one end pivotably supported on an engine main body (12) so as to be capable of swinging and having the other end abutting against a stem (18) of a valve (17), a first electromagnet (21) that can attract a first attraction face (23b) of the armature (23), and a second electromagnet (22) that can attract a second attraction face (23c) of the armature (23),
   at least one electromagnet (22) of the first and second electromagnets (21, 22) being supported so as to be capable of swinging around a fixed shaft (38) whose position is fixed relative to the engine main body (12).

2. The engine electromagnetic valve operating device according to Claim 1, wherein said one electromagnet (21) causes the valve (17) to lift, and defines the amount of lift of the valve (17).

3. The engine electromagnetic valve operating device according to Claim 1 or Claim 2, wherein the device comprises a pair of valve springs (47, 51) for urging the armature (23) to a neutral position, a spring seat (49) supporting one valve spring (51) being fixed to the engine main body (13) and a spring seat (44) supporting the other valve spring (47) moving in response to swinging of said one electromagnet (22).

4. The engine electromagnetic valve operating device according to Claim 3, wherein said other valve spring (47) and the spring seat (44) supporting the valve spring (47) are disposed on the outer periphery of the stem (18) of the valve (17), and the spring seat (44) is integrally connected to and moves with said one electromagnet (22).

5. The engine electromagnetic valve operating device according to any one of Claim 1 to Claim 4, wherein the armature (23) is pivotably supported via the fixed shaft (38).

6. The engine electromagnetic valve operating device according to Claim 5, wherein the other electromagnet (21) of the first and second electromagnets (21, 22) is provided with a fixing part (27) for fixing the fixed shaft (38).

7. The engine electromagnetic valve operating device according to Claim 1, wherein the device comprises a first valve spring (47) for urging the valve (17) in a valve-closing direction and a second valve spring (153) for urging the valve (17) in a valve-opening direction, the second valve spring (153) urging a lever (23d) provided on said one end side of the armature (23).

8. The engine electromagnetic valve operating device according to Claim 7, wherein said one electromagnet (22) comprises a lever (34c) provided on one end side via which the electromagnet (22) is pivotably supported on the fixed shaft (38), an urging force of the second valve spring (153) on said one end side acting on the lever (23d) of the armature (23), and an urging force of the second valve spring (153) on the other end side acting on the lever (34d) of said one electromagnet (22).

9. The engine electromagnetic valve operating device according to Claim 8, wherein at least parts of the lever (23d) of the armature (23) and the lever (34c) of said one electromagnet (22) overlap when viewed in a cylinder line direction.

10. The engine electromagnetic valve operating device according to Claim 7 or Claim 8, wherein a guide rod (150) having one end pivotably supported on the lever (23d) of the armature (23) and having a first spring seat (151) provided at the other end runs through a second spring seat (152) provided in the lever (34c) of said one electromagnet (22), and one end and the other end of the second valve spring (153) supported on the outer periphery of the guide rod (150) abut against the first spring seat (151) and the second spring seat (152) respectively.

11. The engine electromagnetic valve operating device according to any one of Claim 8 to Claim 10, wherein an actuator (43) making said one electromagnet (22) swing drives the other end side of the electromagnet (22).

Amended claims under Art. 19.1 PCT

1. An engine electromagnetic valve operating device comprising an armature (23) having one end pivotably supported on an engine main body (12) so as to be capable of swinging and having the other end abutting against a stem (18) of a valve (17), a first electromagnet (21) that can attract a first attraction face (23b) of the armature (23), and a second electromagnet (22) that can attract a second attraction face (23c) of the armature (23),
at least one electromagnet (22) of the first and second electromagnets (21, 22) being supported so as to be capable of swinging around a fixed shaft (38) whose position is fixed relative to the engine main body (12).

2. (amended) The engine electromagnetic valve operating device according to Claim 1, wherein said one electromagnet (22) causes the valve (17) to lift, and defines the amount of lift of the valve (17).

3. The engine electromagnetic valve operating device according to Claim 1 or Claim 2, wherein the device comprises a pair of valve springs (47, 51) for urging the armature (23) to a neutral position, a spring seat (49) supporting one valve spring (51) being fixed to the engine main body (13) and a spring seat (44) supporting the other valve spring (47) moving in response to swinging of said one electromagnet (22).

4. The engine electromagnetic valve operating device according to Claim 3, wherein said other valve spring (47) and the spring seat (44) supporting the valve spring (47) are disposed on the outer periphery of the stem (18) of the valve (17), and the spring seat (44) is integrally connected to and moves with said one electromagnet (22).

5. The engine electromagnetic valve operating device according to any one of Claim 1 to Claim 4, wherein the armature (23) is pivotably supported via the fixed shaft (38).

6. The engine electromagnetic valve operating device according to Claim 5, wherein the other electromagnet (21) of the first and second electromagnets (21, 22) is provided with a fixing part (27) for fixing the fixed shaft (38).

7. The engine electromagnetic valve operating device according to Claim 1, wherein the device comprises a first valve spring (47) for urging the valve (17) in a valve-closing direction and a second valve spring (153) for urging the valve (17) in a valve-opening direction, the second valve spring (153) urging a lever (23d) provided on said one end side of the armature (23).

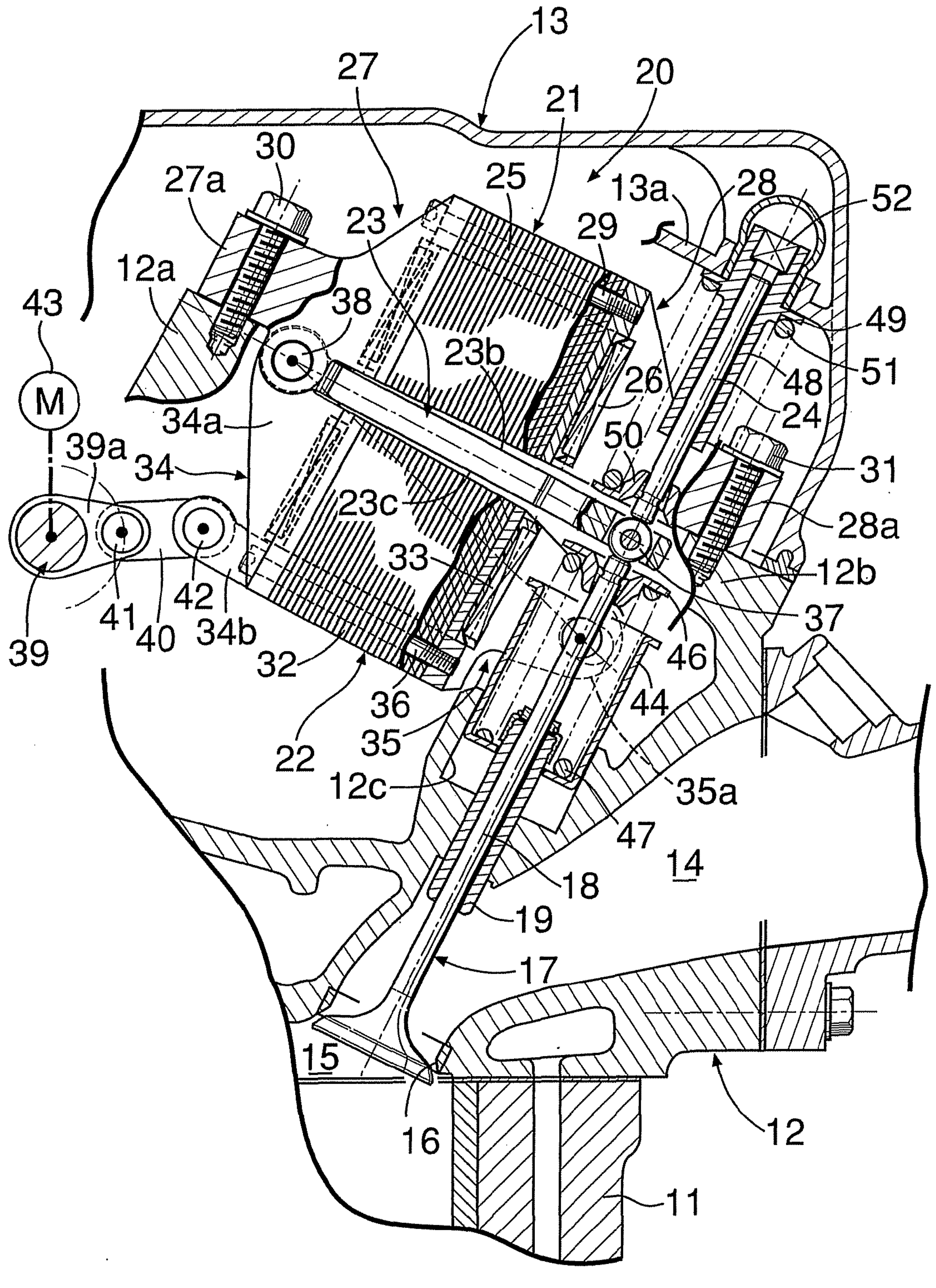
8. (amended) The engine electromagnetic valve operating device according to Claim 7, wherein said one electromagnet (22) comprises a lever (34d) provided on one end side via which the electromagnet (22) is pivotably supported on the fixed shaft (38), an urging force of the second valve spring (153) on said one end side acting on the lever (23d) of the armature (23), and an urging force of the second valve spring (153) on the other end side acting on the lever (34d) of said one electromagnet (22).

9. The engine electromagnetic valve operating device according to Claim 8, wherein at least parts of the lever (23d) of the armature (23) and the lever (34c) of said one electromagnet (22) overlap when viewed in a cylinder line direction.

10. The engine electromagnetic valve operating device according to Claim 7 or Claim 8, wherein a guide rod (150) having one end pivotably supported on the lever (23d) of the armature (23) and having a first spring seat (151) provided at the other end runs through a second spring seat (152) provided in the lever (34c) of said one electromagnet (22), and one end and the other end of the second valve spring (153) supported on the outer periphery of the guide rod (150) abut against the first spring seat (151) and the second spring seat (152) respectively.

11. The engine electromagnetic valve operating device according to any one of Claim 8 to Claim 10, wherein an actuator (43) making said one electromagnet (22) swing drives the other end side of the electromagnet (22).

FIG.1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M
34a
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39a
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23c
28a
33
12b
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37
39
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FIG.2

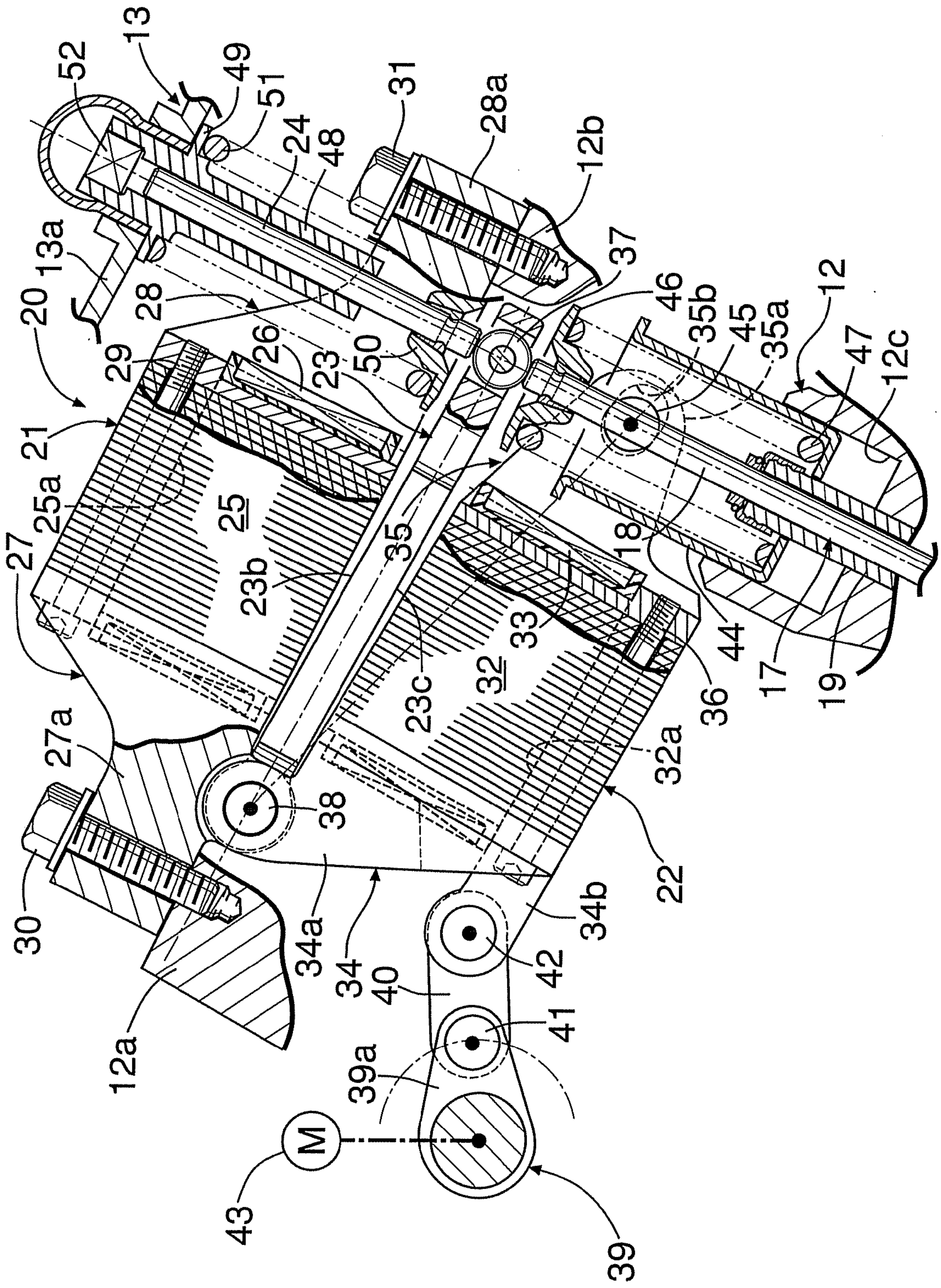

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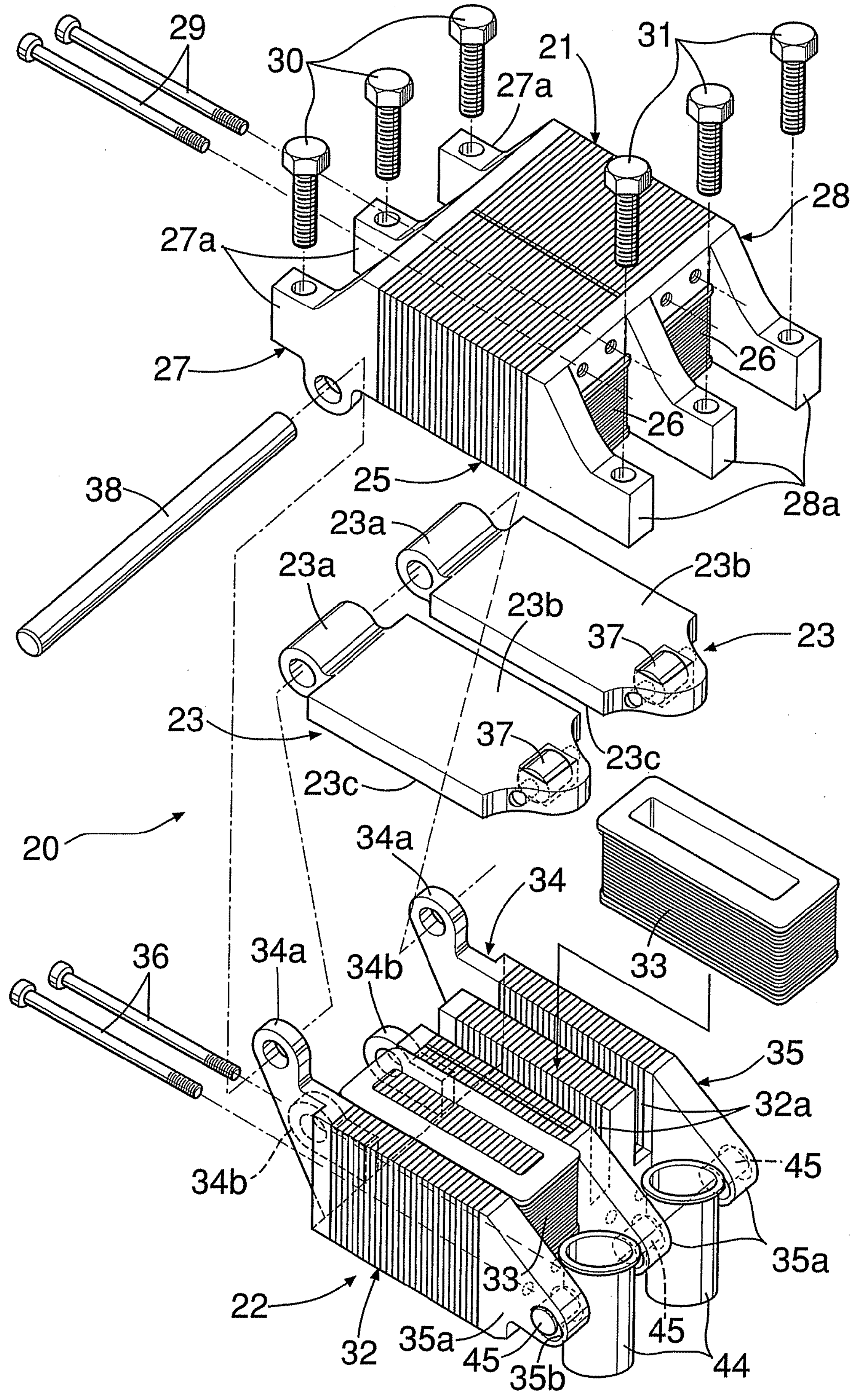
FIG.3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35b
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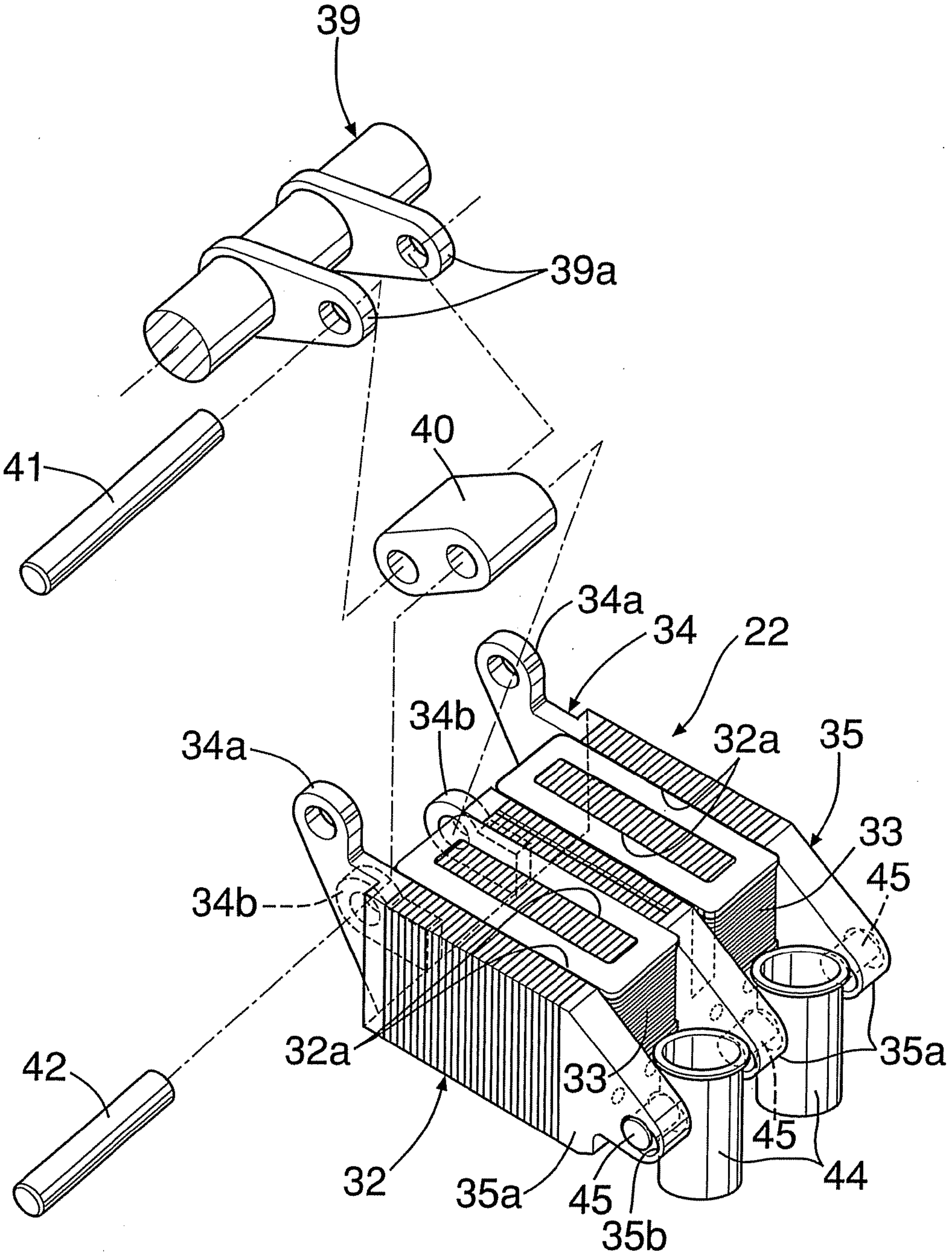
FIG.4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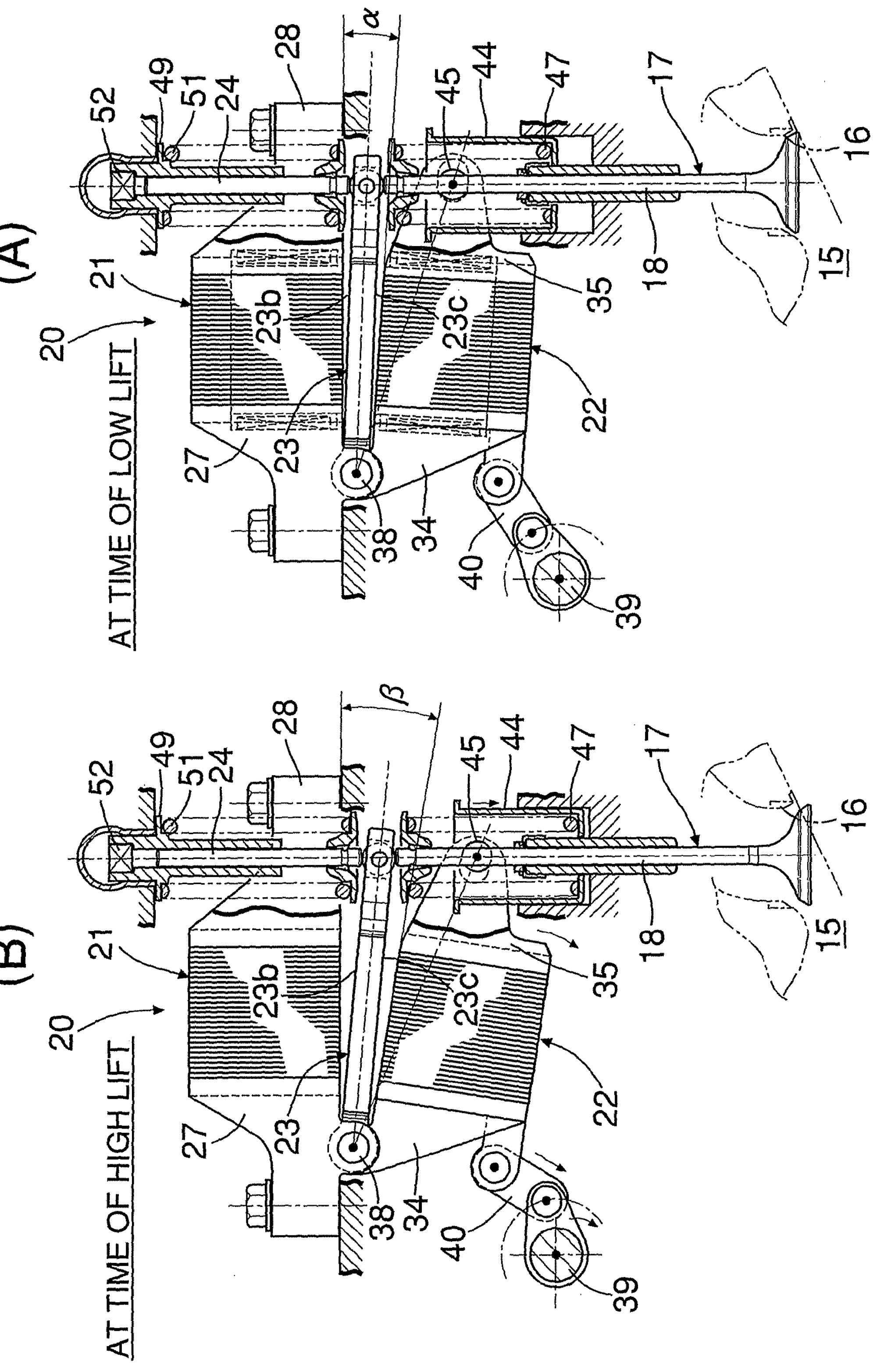
35b

FIG.5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23b
23c
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17
18
α
(B)
AT TIME OF HIGH LIFT
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23b
23c
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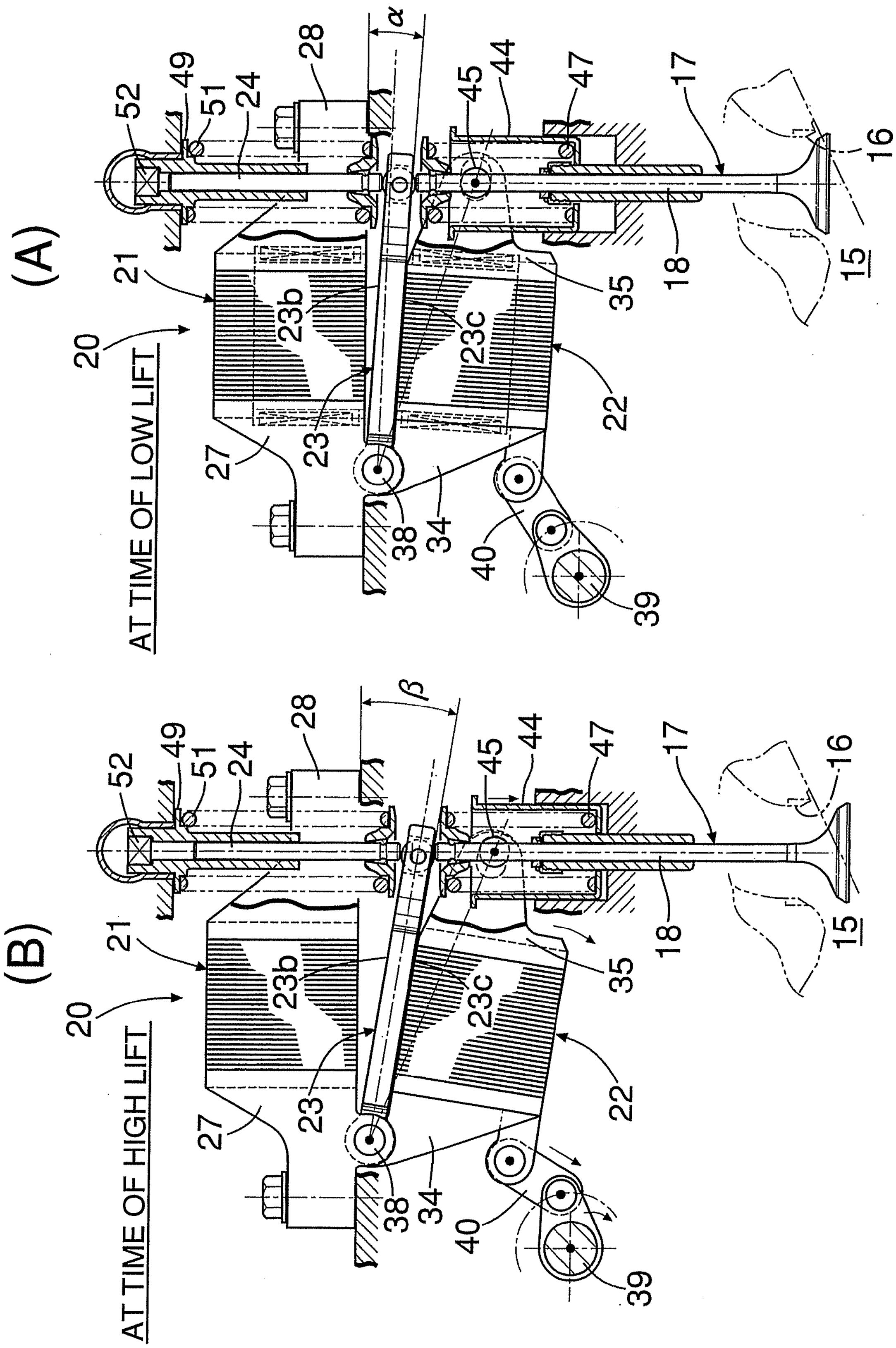
FIG.6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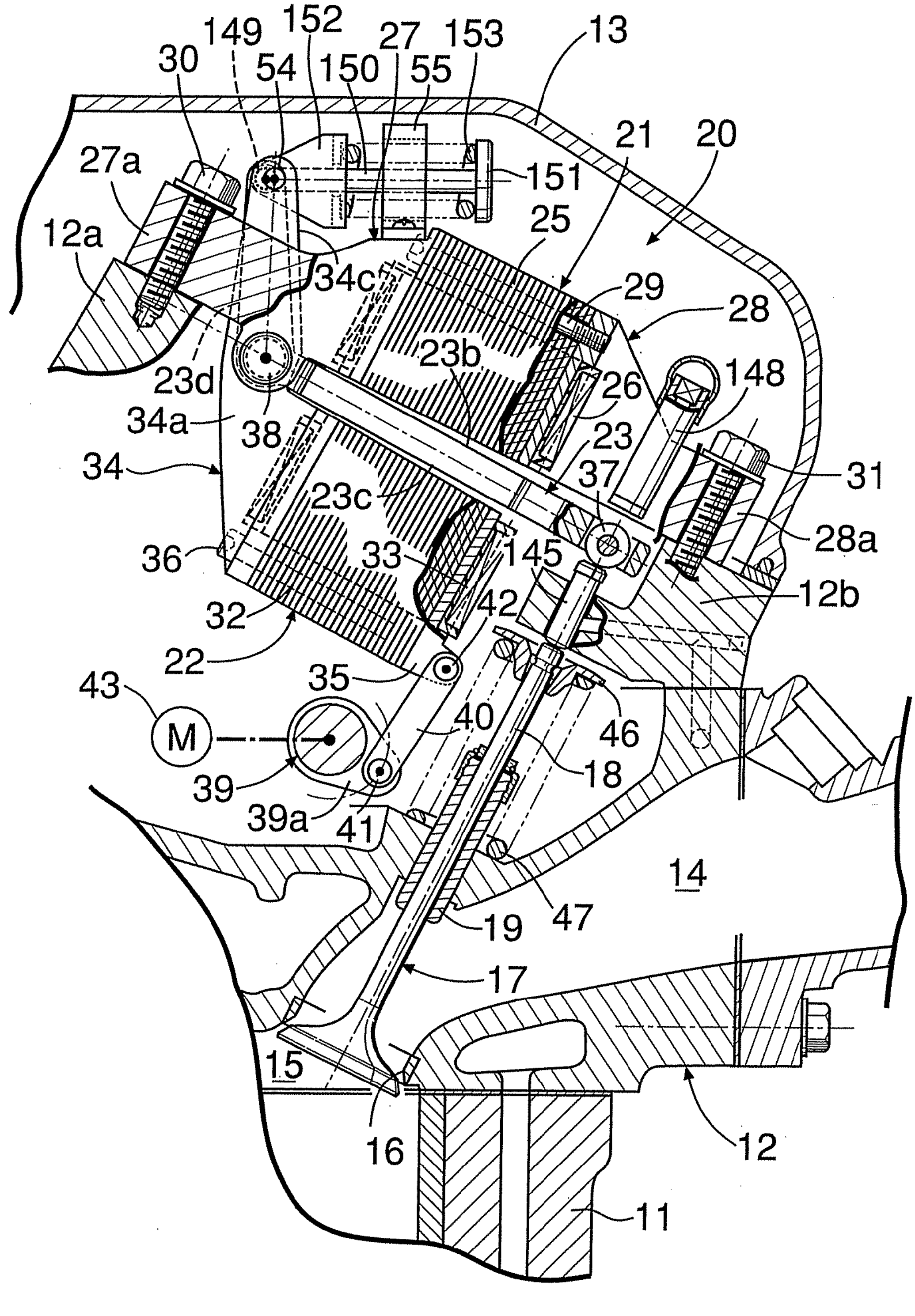
α
(B)
AT TIME OF HIGH LIFT
β

FIG.7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26
148
34a
38
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34
37
31
23c
28a
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145
12b
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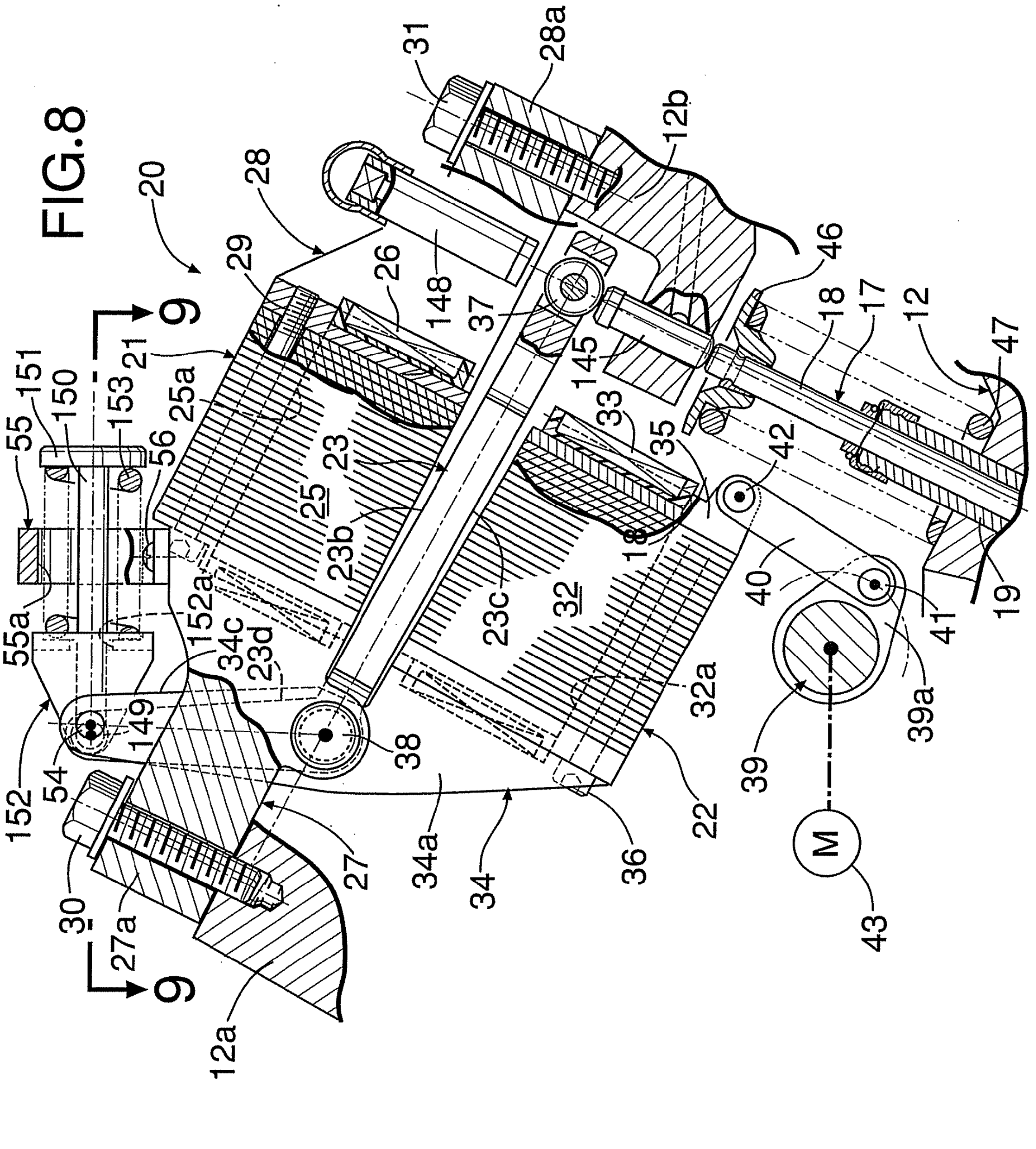
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34c
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42
43
M
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47
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12a
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152a
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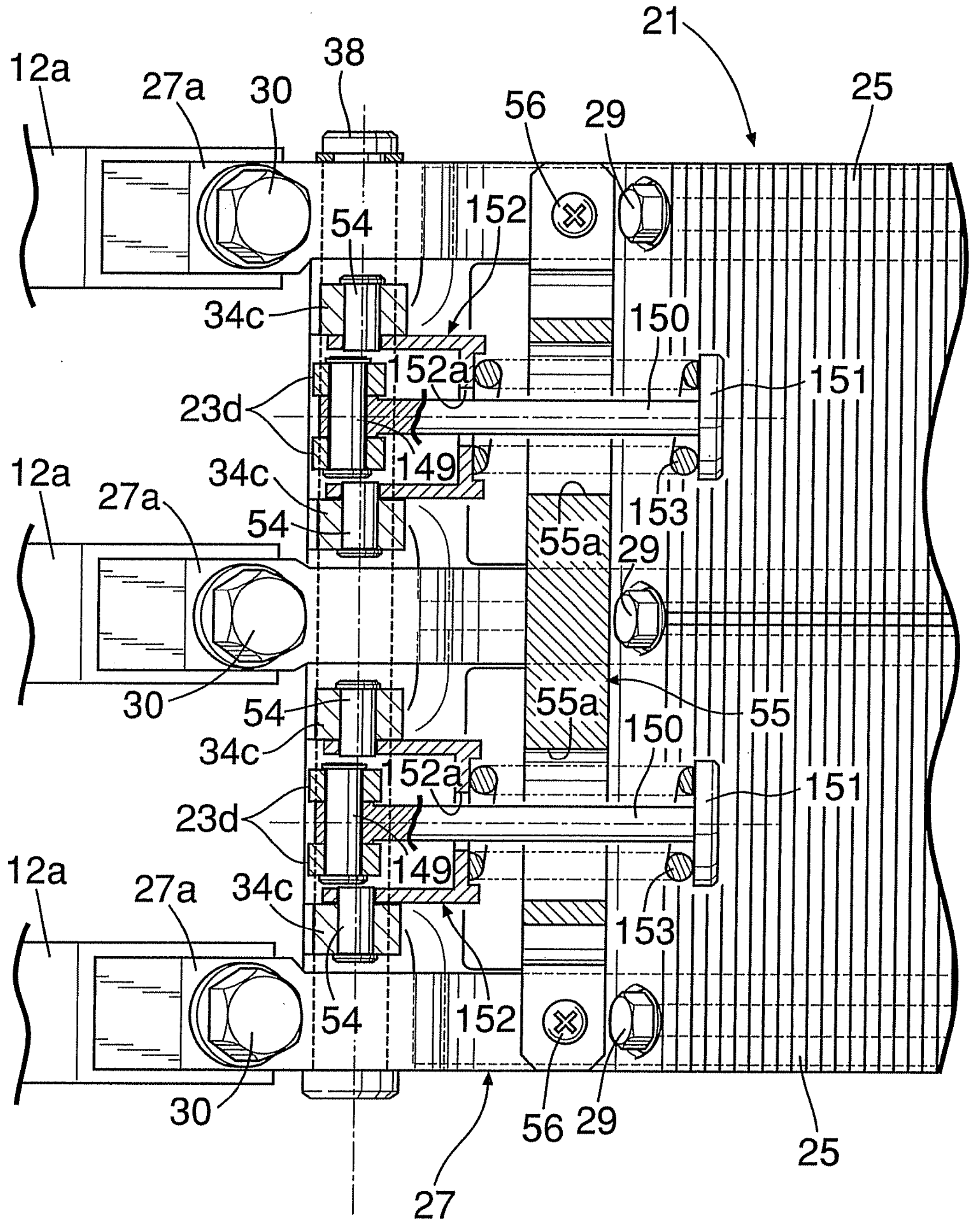
FIG.8

FIG.9



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27a
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30
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55a
55
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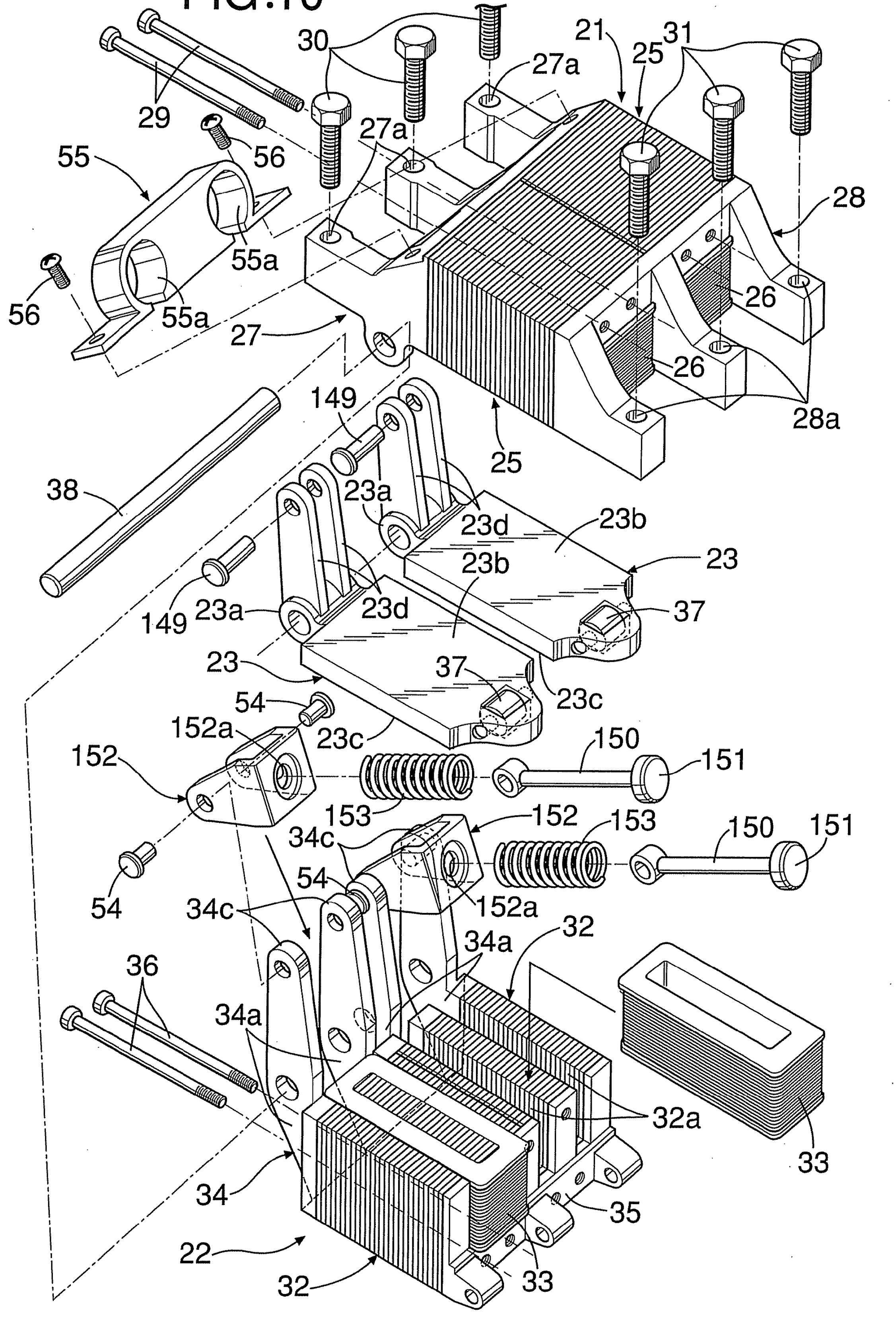
FIG.10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152a
153

FIG.11

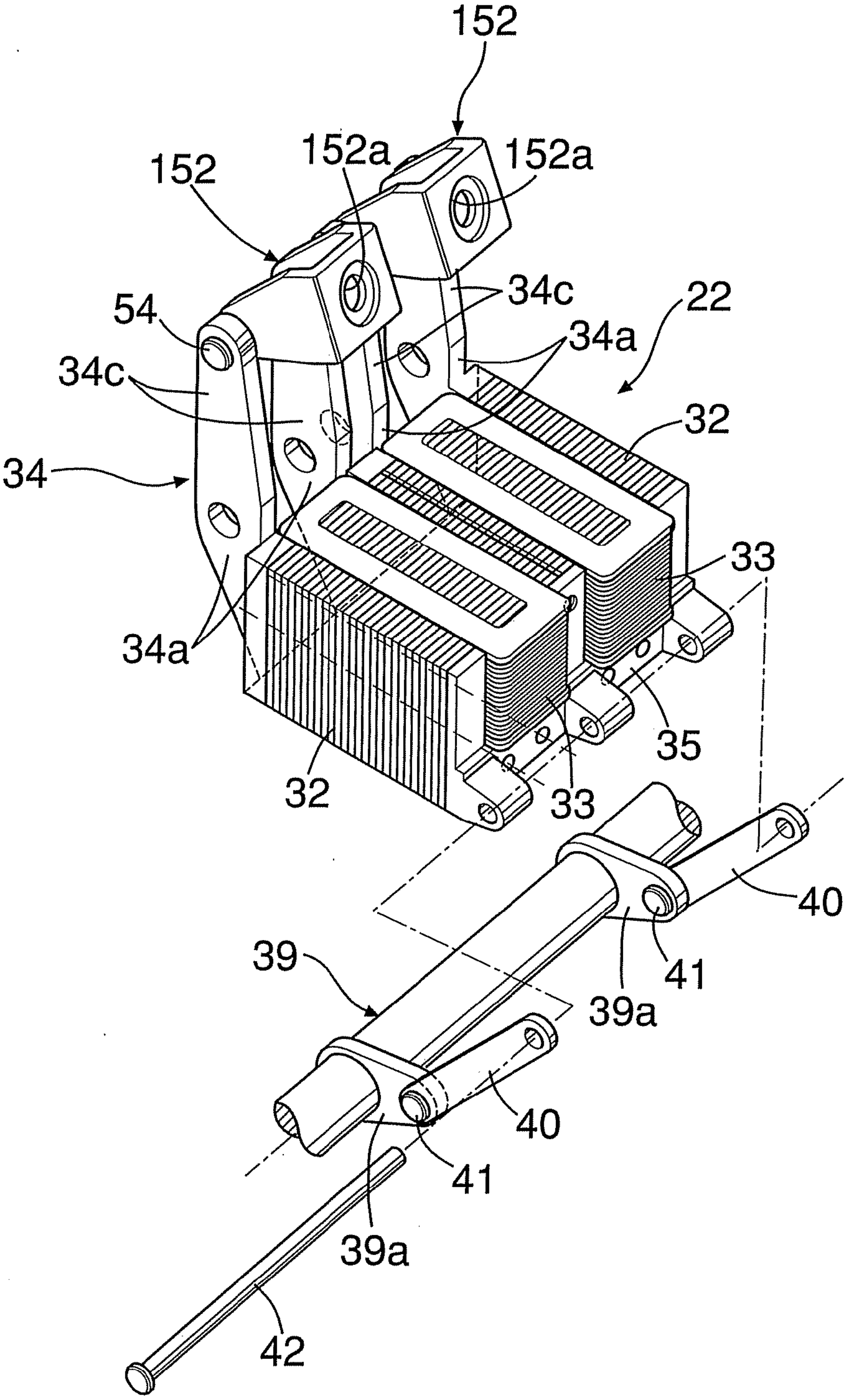
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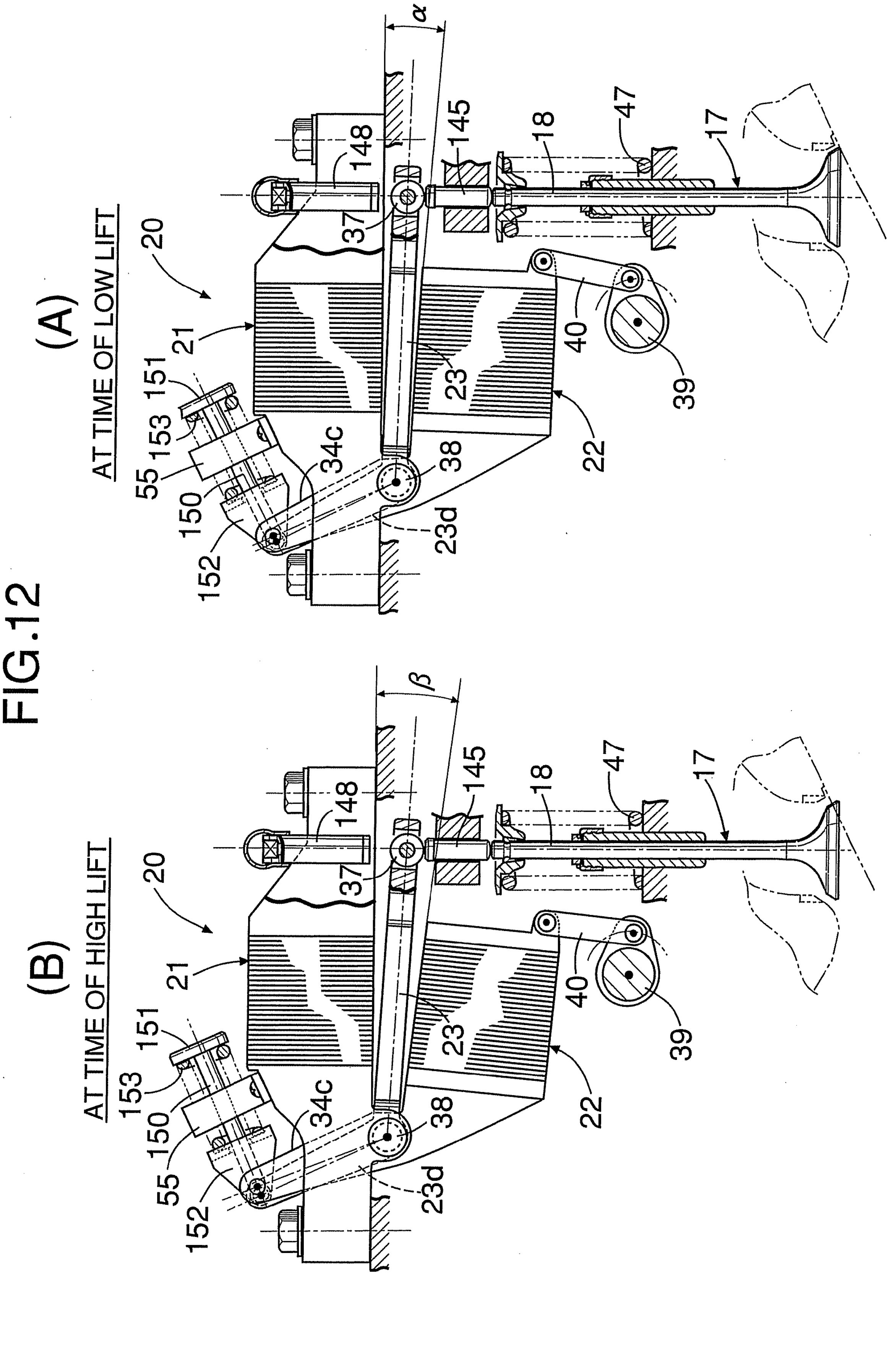
FIG.12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AT TIME OF LOW LIFT
(B)
AT TIME OF HIGH LIFT
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23d
34c
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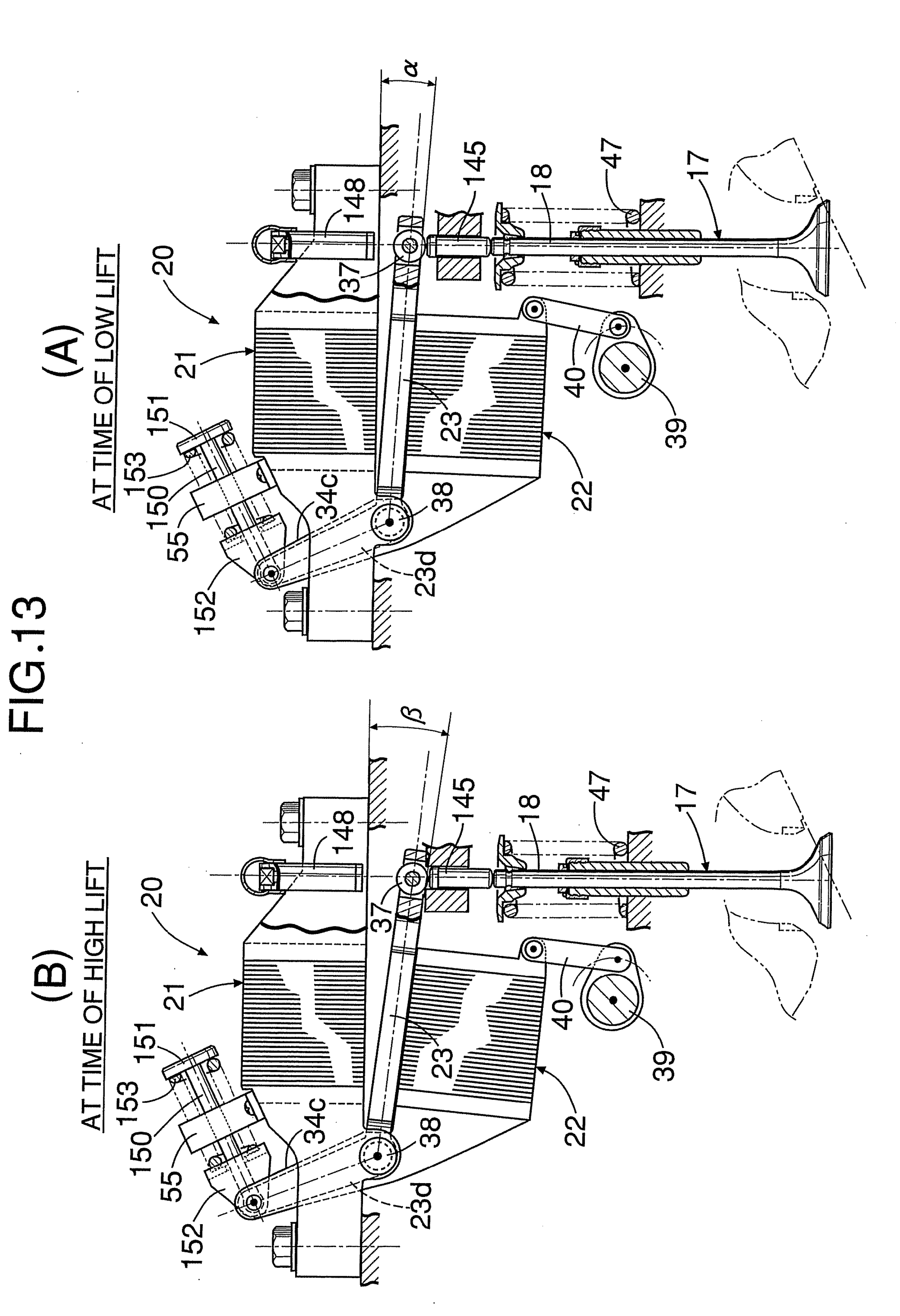
153
17
18
α
β


(A)
AT TIME OF LOW LIFT
(B)
AT TIME OF HIGH LIFT
α
β
17
18
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23d
34c
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38
39
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47
55
145
148
150
151
152
153

FIG.13

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2007/064503

A. CLASSIFICATION OF SUBJECT MATTER
F01L9/04(2006.01)i, *F01L3/10*(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)
F01L9/04, F01L3/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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Kokai Jitsuyo Shinan Koho	1971-2007	Toroku Jitsuyo Shinan Koho	1994-2007

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 A	JP 2006-46176 A (Toyota Motor Corp.), 16 February, 2006 (16.02.06), Fig. 1 & EP 1714010 A & WO 2006/13682 A1	1-6 7-11
Y A	JP 2001-303995 A (Toyota Motor Corp.), 31 October, 2001 (31.10.01), Fig. 2 (Family: none)	1-6 7-11
P,Y	JP 2007-46503 A (Toyota Motor Corp.), 22 February, 2007 (22.02.07), Par. No. [0043]; lines 2 to 4; Fig. 4 (Family: none)	1-6

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

* Special categories of cited documents:
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Date of the actual completion of the international search 23 October, 2007 (23.10.07)	Date of mailing of the international search report 06 November, 2007 (06.11.07)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2006022776 A **[0002]**