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BA ME(30) Priority: **30.03.2012 JP 2012082787**(71) Applicant: **Honda Motor Co., Ltd.****Tokyo 107-8556 (JP)**

(72) Inventors:

- **Warashina, Takuya**
Saitama, 351-0193 (JP)

• **Kosei, Kazuyuki****Saitama, 351-0193 (JP)**• **Terada, Yasuo****Saitama, 351-0193 (JP)**• **Fujikubo, Makoto****Saitama, 351-0193 (JP)**• **Kataoka, Dai****Saitama, 351-0193 (JP)**• **Nakamura, Yohei****Saitama, 351-0193 (JP)**(74) Representative: **Kiwit, Benedikt****Mitscherlich & Partner****Sonnenstraße 33****80331 München (DE)**(54) **Variable valve train for internal combustion engine**

(57) [Problem to be Solved]

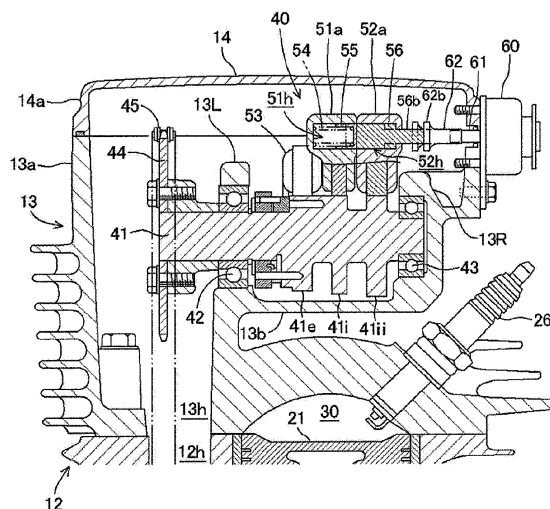
To provide a variable valve train for an internal combustion engine which duty controls an electromagnetic solenoid for moving a connecting pin, thereby reducing power consumption of the electromagnetic solenoid and preventing generation of a hitting sound.

[Solution]

In a variable valve train for an internal combustion

engine, control means (70) energizes an electromagnetic solenoid (60) to cause a moving core member (61, 62) to protrude, and thereby the connecting pin (56) to move against urging force of the spring (54) so that rocker arms (51, 52) are connected together and integrally rocked. The control means (70) duty controls the electromagnetic solenoid (60) and drives the moving core member (61, 62).

FIG. 4



Description

[Technical Field]

[0001] The present invention relates to a variable valve train for an internal combustion engine.

[Background Art]

[0002] As an example of the variable valve trains in which rocker arms journaled coaxially with and adjacent to each other are connected or disconnected by movement of a connecting pin, thereby allowing changes in the lift and valve timing of an intake valve, the case where an electromagnetic solenoid is used as an actuator for moving the connecting pin is found in an earlier application filed by the same applicant (see Patent Literature 1).

[Citation List]

[Patent Literature]

[0003] [Patent Literature 1] JP- A No. 2012- 036877

[0004] The variable valve train disclosed in the Patent Literature 1 has a structure in which the connecting pin for connecting the adjacent rocker arms together is urged from one side by a spring and pressed from the other side by a moving core of the electromagnetic solenoid.

[0005] When the electromagnetic solenoid is energized, the moving core is protruded to move the connecting pin against the action of the spring, thereby connecting the rocker arms together. When the electromagnetic solenoid is demagnetized, the connecting pin is forced back by the spring, thereby disconnecting the rocker arms from each other.

The Patent Literature 1 discloses no controls over the electromagnetic solenoid other than that described above.

[Summary of Invention]

[Technical Problem]

[0006] During the time the rocker arms are in the connected state, it is necessary to maintain the state after moving the connecting pin against the action of the spring. Therefore, a large amount of power is required to constantly energize the electromagnetic solenoid, leading to an increase in size of a battery.

It should be noted that unlike hydraulic pressure, the electromagnetic solenoid produces less pressure, and therefore a larger amount of power is required to maintain the connected state.

[0007] Furthermore, when the electromagnetic solenoid is demagnetized and the connection between both rocker arms is released, the demagnetization of the electromagnetic solenoid causes the connecting pin and the moving core to return quickly with the urging force of the

spring. Therefore, especially when the moving core is separated from the connecting pin and then further moved by inertia, the moving core is brought into abutting contact with the equivalent of a stopper in the electromagnetic solenoid, which might create a hitting sound.

[0008] Accordingly, the present invention has been made in view of the foregoing, and an object of the present invention is to provide a variable valve train for an internal combustion engine which duty controls an electromagnetic solenoid for moving a connecting pin, thereby reducing the power consumption of the electromagnetic solenoid and preventing the generation of a hitting sound while preventing an increase in the temperature of the electromagnetic solenoid.

[Solution to Problem]

[0009] In order to accomplish the above-mentioned object, the present invention, according to a feature of the invention described in Claim 1, provides a variable valve train for an internal combustion engine in which:

rocker arms (51, 52) journaled coaxially with and adjacent to each other rock in contact with cam lobes (41i, 41ii) having different profiles of a camshaft, and an intake valve (33) is opened and closed by rocking of one rocker arm (51) of the rocker arms;

a connecting pin (56) urged by a spring (54) moves between respective hole portions (51h, 52h) formed in the rocker arms (51, 52), thereby enabling a connection between the rocker arms (51, 52);

the connecting pin (56) is moved by forward and backward movement of a moving core member (61, 62) of an electromagnetic solenoid (60); and

control means (70) energizes the electromagnetic solenoid (60) to cause the moving core member (61, 62) to protrude, and thereby the connecting pin (56) to move against urging force of the spring (54) so that the rocker arms (51, 52) are connected together and integrally rocked,

wherein the control means (70) duty controls the electromagnetic solenoid (60) and drives the moving core member (61, 62).

[0010] A feature of the invention described in Claim 2 is that,

in the variable valve train for the internal combustion engine described in Claim 1,

in a disconnected state of the rocker arms (51, 52) in which the connecting pin (56) is fitted in the other hole portion (52h) of the hole portions to allow the rocker arms (51, 52) to rock independently, from a demagnetized state of the electromagnetic solenoid (60), the control means (70) duty controls the electromagnetic solenoid (60) with a normal movement starting duty ratio (a) that causes the connecting pin (56) to start to move against urging force of the spring (54), and then duty controls the electromagnetic solenoid (60) with a connection main-

taining duty ratio (b) smaller than the normal movement starting duty ratio (a) to insert the connecting pin (56) into one hole portion (51h) of the hole portions so that the connecting pin (56) extends across both hole portions (51h, 52h), thereby connecting the rocker arms (51, 52) together.

[0011] A feature of the invention described in Claim 3 is that,

in the variable valve train for the internal combustion engine described in Claim 2,

a process of duty controlling the electromagnetic solenoid (60) with the normal movement starting duty ratio (a) and then duty controlling the electromagnetic solenoid (60) with the connection maintaining duty ratio (b) is repeated multiple times.

[0012] A feature of the invention described in Claim 4 is that

the variable valve train for the internal combustion engine described in Claim 3,

further includes oil temperature detecting means (27) for detecting temperature of lubricating oil of the internal combustion engine (10).

The control means (70) presets a predetermined oil temperature range of approximately 60°C to 80°C.

When an oil temperature detected by the oil temperature detecting means (27) falls outside the predetermined oil temperature range, the control means (70) repeats multiple times the process of duty controlling the electromagnetic solenoid (60) with the normal movement starting duty ratio (a) that causes the connecting pin (56) to start to move against urging force of the spring (54), and then duty controlling the electromagnetic solenoid (60) with the connection maintaining duty ratio (b) smaller than the normal movement starting duty ratio (a).

When the oil temperature detected by the oil temperature detecting means (27) falls within the predetermined oil temperature range, the control means (70) repeats multiple times a process of controlling movement of the connecting pin (56) with a special movement starting duty ratio (a') smaller than the normal movement starting duty ratio (a) and greater than the connection maintaining duty ratio (b), and then duty controlling the electromagnetic solenoid (60) with the connection maintaining duty ratio (b).

[0013] A feature of the invention described in Claim 5 is that,

in the variable valve train for the internal combustion engine described in Claim 4,

the predetermined oil temperature range is a temperature range in which vibration generated in a cylinder head becomes larger than in other portions.

[0014] A feature of the invention described in Claim 6 is that,

in the variable valve train for the internal combustion engine described in Claims 4 and 5,

the normal movement starting duty ratio (a) and the special movement starting duty ratio (a') are determined from a map correlated with an oil temperature value.

[0015] A feature of the invention described in Claim 7 is that,

in the variable valve train for the internal combustion engine described in any one of Claims 1 to 6,

the control means (70) performs control to decrease the duty ratio in a stepwise fashion from the connection maintaining duty ratio (b) that maintains the connected state of the rocker arms (51, 52) by causing the connecting pin (56) to extend across both hole portions (51h, 52h), and adjusts movement speed of the moving core member (61, 62) to stop the moving core member (61, 62), thereby releasing the connection between the rocker arms (51, 52).

[0016] A feature of the invention described in Claim 8 is that,

in the variable valve train for the internal combustion engine described in any one of Claims 1 to 6,

the control means (70) changes the duty ratio to zero from the connection maintaining duty ratio (b) that maintains the connected state of the rocker arms (51, 52) by causing the connecting pin (56) to extend across both hole portions (51h, 52h), and then controls the duty ratio to a brake duty ratio (b') at a predetermined timing so that the moving core member (61, 62) is reduced in movement speed and stopped, thereby releasing the connection between the rocker arms (51, 52).

[0017] A feature of the invention described in Claim 9 is that,

in the variable valve train for the internal combustion engine described in Claim 8,

the brake duty ratio (b') is determined from the map correlated with the oil temperature value.

[0018] A feature of the invention described in Claim 10 is that,

in the variable valve train for the internal combustion engine described in Claim 8,

a position of the moving core member (61, 62) is detected by a position sensor, and at a predetermined position, control is performed with the brake duty ratio (b') so that the moving core member (61, 62) is reduced in movement speed and stopped, thereby releasing the connection between the rocker arms (51, 52).

[Advantageous Effects of Invention]

[0019] According to the variable valve train for the internal combustion engine described in Claim 1, the control means (70) duty controls the electromagnetic solenoid (60) and drives the moving core member (61, 62).

Thus, since the duty control is also performed when the connection is maintained, the power consumption of the electromagnetic solenoid (60) can be reduced.

Furthermore, the movement speed of the moving core member (61, 62) before stopped is reduced, and thus the generation of a hitting sound due to abutting contact of the moving core member (61, 62) with the equivalent of a stopper can be prevented.

[0020] According to the variable valve train for the in-

ternal combustion engine described in Claim 2, from a demagnetized state of the electromagnetic solenoid (60), the control means (70) duty controls the electromagnetic solenoid (60) with the normal movement starting duty ratio (a) that causes the connecting pin (56) to start to move against urging force of the spring (54), and then duty controls the electromagnetic solenoid (60) with the connection maintaining duty ratio (b) smaller than the normal movement starting duty ratio (a). A great pressure of the normal movement starting duty ratio (a) at the start of the movement of the connecting pin (56) forces the connecting pin (56) into the one hole portion (51h) to cause the connecting pin (56) to extend across both hole portions (51h, 52h), thereby allowing the connection between the rocker arms (51, 52). Thereafter, the connection can be maintained by the connection maintaining duty ratio (b) smaller than the normal movement starting duty ratio (a). Thus, the power consumption of the electromagnetic solenoid can be reduced. Also, when the movement speed of the connecting pin (56) is adjusted to stop the connecting pin (56), the generation of vibration caused by pressing the spring (54) all the way in can be avoided.

[0021] According to the variable valve train for the internal combustion engine described in Claim 3, the control means (70) repeats multiple times the process of duty controlling the electromagnetic solenoid (60) with the normal movement starting duty ratio (a), and then duty controlling the electromagnetic solenoid (60) with the connection maintaining duty ratio (b). Thus, even if the connecting pin (56) comes out of the one hole portion (51h), duty control is repeatedly performed with the normal movement starting duty ratio (a) so that the connecting pin (56) is inserted into the hole portion (51h). Thus the connected state can be ensured. Also, since the connection is finally maintained with the small connection maintaining duty ratio (b), the power consumption of the electromagnetic solenoid can be also reduced.

[0022] According to the variable valve train for the internal combustion engine described in Claim 4, when the engine temperature (oil temperature) of the internal combustion engine increases and the temperature of lubricating oil is greater than about 60°C, the lubricating oil for smooth sliding of the connecting pin (56) becomes less viscous. Also, when the oil temperature is smaller than about 80°C, the coil resistance of the electromagnetic solenoid is small and the coil current flows through easily, so that the projecting force of the moving core member (61, 62) increases. Thus, when the electromagnetic solenoid is energized in the oil temperature range of approximately 60°C to 80°C, the movement speed of the connecting pin (56) is likely to increase, and the connecting pin (56) is not smoothly stopped, thereby making the generation of vibration more likely. Therefore, the predetermined oil temperature range is preset between approximately 60°C and 80°C, and duty control of the electromagnetic solenoid (60) is varied according to within and outside the predetermined oil temperature range.

[0023] More specifically, when the oil temperature falls outside the predetermined oil temperature range, the control means (70) repeats multiple times the process of duty controlling the electromagnetic solenoid (60) with the normal movement starting duty ratio (a), and then duty controlling the electromagnetic solenoid (60) with the connection maintaining duty ratio (b) smaller than the normal movement starting duty ratio (a). Thus, the increase in the movement speed is adjusted by repeatedly changing a great pressure of the normal movement starting duty ratio (a) at the start of the movement of the connecting pin (56) to a smaller pressure of the connection maintaining duty ratio (b), so that the connecting pin (56) can be stopped in a manner extending across both hole portions (51h, 52h). Thus, the generation of vibration caused by pressing the spring (54) all the way in can be avoided.

[0024] When an oil temperature falls within the predetermined oil temperature range, the movement speed of the connecting pin (56) is likely to increase. Therefore, the control means (70) repeats multiple times a process of duty controlling the electromagnetic solenoid (60) with a special movement starting duty ratio (a') smaller than the normal movement starting duty ratio (a) and greater than the connection maintaining duty ratio (b), and then duty controlling the electromagnetic solenoid (60) with the connection maintaining duty ratio (b) smaller than the special movement starting duty ratio (a'). Thus, the pressure change from a value smaller than normal of the special movement starting duty ratio (a') at the start of the movement of the connecting pin (56) to a smaller value of the connection maintaining duty ratio (b) is repeated. Thus, the movement speed is adjusted to a value suitable for the oil temperature within the predetermined oil temperature range so that the connecting pin (56) can be stopped in a manner extending across both hole portions (51h, 52h).

[0025] In both cases where the oil temperature falls within and outside the predetermined oil temperature range, since the connection is finally maintained with the small connection maintaining duty ratio (b), the power consumption of the electromagnetic solenoid can be also reduced.

Also, even if the connecting pin (56) fails to be inserted into the hole portion (51h) on the first time and the connection does not succeed, duty control with the normal movement starting duty ratio (a) or the special movement starting duty ratio (a') is repeated so that the connecting pin (56) is inserted into the hole portion (51h). Thus, the connected state can be ensured.

[0026] According to the variable valve train for the internal combustion engine described in Claim 5, the predetermined oil temperature range is a temperature range in which vibration generated in the cylinder head becomes larger than in other portions. Thus, the insertion duty corresponding to the speed of the connecting pin (56) is applied by the oil temperature, thereby reducing the generation of a hitting sound.

[0027] According to the variable valve train for the internal combustion engine described in Claim 6, the movement normal starting duty ratio (a) and the special movement starting duty ratio (a') are determined from a map correlated with an oil temperature value. Thus, the speed of the moving core member (61, 62) is properly changed depending on the temperature state of the internal combustion engine (more specifically, the change in resistance of the electromagnetic solenoid or in viscosity of lubricating oil with temperature), thereby reducing the generation of a hitting sound.

[0028] According to the variable valve train for the internal combustion engine described in Claim 7, the control means (70) performs control to decrease the duty ratio in a stepwise fashion from the connection maintaining duty ratio (b) that maintains the connected state of the rocker arms (51, 52) by causing the connecting pin (56) to extend across both hole portions (51h, 52h), and adjusts movement speed of the moving core member (61, 62) to stop the moving core member (61, 62), thereby releasing the connection between the rocker arms (51, 52). Thus, the movement speed of the moving core member (61, 62) just before stopped can be easily reduced, and the generation of a hitting sound can be prevented.

[0029] According to the variable valve train for the internal combustion engine described in Claim 8, the control means (70) changes the duty ratio to zero from the connection maintaining duty ratio (b) that maintains the connected state of the rocker arms (51, 52) by causing the connecting pin (56) to extend across both hole portions (51h, 52h), and then controls the duty ratio to a brake duty ratio (b') at a predetermined timing so that the moving core member (61, 62) is reduced in movement speed and stopped, thereby releasing the connection between the rocker arms (51, 52). Thus, the movement speed of the moving core member (61, 62) is reduced by the duty control with the duty ratio to a brake duty ratio (b'), thereby allowing an easy reduction in movement speed of the moving core member (61, 62) just before stopped and the prevention of generation of a hitting sound.

[0030] According to the variable valve train for the internal combustion engine described in Claim 9, the brake duty ratio (b') is determined from the map correlated with the oil temperature value. Thus, the moving core member (61, 62) is properly braked depending on the temperature state of the internal combustion engine (more specifically, the change in resistance of the electromagnetic solenoid or in viscosity of lubricating oil with temperature), thereby reducing the generation of a hitting sound.

[0031] According to the variable valve train for the internal combustion engine described in Claim 10, the position of the moving core member (61, 62) is detected by the position sensor, and at a predetermined position, control is performed with the brake duty ratio (b') so that the moving core member (61, 62) is reduced in movement speed and stopped, thereby releasing the connection between the rocker arms (51, 52). Thus, the moving core

member (61, 62) is properly braked and the generation of a hitting sound is reduced.

[Brief Description of Drawings]

[0032]

[FIG. 1] FIG. 1 is a partial side view of a motorcycle mounted with an internal combustion engine in accordance with an embodiment of the present invention.

[FIG. 2] FIG. 2 is a longitudinal sectional view of the internal combustion engine.

[FIG. 3] FIG. 3 is a top plan view of a cylinder head, showing a valve operating mechanism of the internal combustion engine.

[FIG. 4] FIG. 4 is a sectional view taken along line IV-IV of FIG. 2.

[FIG. 5] FIG. 5 is a flowchart of a main control routine of an electromagnetic solenoid.

[FIG. 6] FIG. 6 is a flowchart of a disconnection control routine.

[FIG. 7] FIG. 7 is a flowchart of another disconnection control routine.

[FIG. 8] FIG. 8 is a flowchart of a connection control routine.

[FIG. 9] FIG. 9 is a graph showing changes of voltage duty control of the electromagnetic solenoid in the disconnection control routine.

[FIG. 10] FIG. 10 is a graph showing changes of voltage duty control of the electromagnetic solenoid in the connection control routine.

[Description of Embodiments]

[0033] Hereinafter, an embodiment of the present invention will be described with reference to FIGs. 1 to 10. FIG. 1 shows a partial side view of a motorcycle 1 mounted with an internal combustion engine 10 in accordance with this embodiment.

The motorcycle 1 includes the internal combustion engine 10 that is suspended through mounting members from a pair of left and right main frames 3 extending rearwardly from a head pipe 2 and bent obliquely downward halfway along its length, and down frames 4 extending obliquely rearward and downward from the head pipe 2.

[0034] The internal combustion engine 10 is the SOHC, two-valve, air-cooled single-cylinder four-stroke internal combustion engine 10. The internal combustion engine 10 is composed of a cylinder block 12, a cylinder head 13, and a cylinder head cover 14 sequentially superposed above a crankcase 11 that journals a crankshaft 25. The internal combustion engine 10 is provided to stand in a forward-leaning position.

[0035] An intake pipe 15 extends from a rear surface of the cylinder head 13 through a connecting pipe 15c and is connected to an air cleaner 17 through a throttle body 16.

A fuel injection valve 20 is attached to the intake pipe 15 (see FIG. 2).

An exhaust pipe 18 extending from a front surface of the cylinder head 13 is bent downward and extends rearwardly along the lower surface from the front of the crankcase 11 to be connected to a muffler 19.

[0036] Referring to FIG. 2, a piston 21 is fitted in a cylinder bore 12b of the cylinder block 12 of the internal combustion engine 10 in such a manner that the piston 21 can reciprocate and slide therein. The piston 21 is connected to the crankshaft 25 by a connecting rod 22 to constitute a crank mechanism.

[0037] A combustion chamber 30, facing the piston 21, is formed within the cylinder head 13 in position to correspond the cylinder bore 12b. An intake port 31 extends rearwardly from the combustion chamber 30, and an exhaust port 32 extends forwardly from the combustion chamber 30 (see FIG. 2). The intake pipe 15 is connected to the intake port 31, and the exhaust pipe 18 is connected to the exhaust port 32.

A spark plug 26 is mounted in a ceiling wall of the combustion chamber 30, with its tip facing the combustion chamber 30 (see FIG. 4).

[0038] As shown in FIG. 2, an intake valve 33 and an exhaust valve 34 are slidably supported by their respective valve guides that are integrally fitted into the cylinder head 13. The intake valve 33 and the exhaust valve 34 are upwardly urged by an intake valve spring 35 and an exhaust valve spring 36, respectively, so as to close an intake valve opening of the intake port 31 and an exhaust valve opening of the exhaust port 32, the intake and exhaust valve openings facing the combustion chamber 30. The intake valve 33 and the exhaust valve 34 are pressed from above in synchronism with the rotation of the crankshaft 25 by a variable valve train 40 formed above the cylinder head 13, so as to open the intake and exhaust valve openings.

[0039] The variable valve train 40 is formed with left and right opposed camshaft receiving walls 13L and 13R. The left and right camshaft receiving walls 13L and 13R each protrude upward on an upper surface of a cam chamber bottom wall 13b inside the cylinder head 13, surrounded by a peripheral wall 13a of the cylinder head 13. A camshaft 41, oriented in the left-right direction, is rotatably journaled to the left and right camshaft receiving walls 13L and 13R through bearings 42 and 43.

[0040] The camshaft 41 protrudes leftward through the left camshaft receiving wall 13L, and its protruding portion is mounted with a chain sprocket 44.

A chain 45 extends between the chain sprocket 44 and a chain sprocket (not shown) fitted into the crankshaft 25. The camshaft 41 rotates at a rotational speed of one-half that of the crankshaft 25.

[0041] A chain opening 13h through the cam chamber bottom wall 13b is formed on the left side of the left camshaft receiving wall 13L. The chain 45 wrapped around the chain sprocket 44 passes through the chain opening 13h and extends downward, and then passes through a

chain chamber 12h of the cylinder block 12 to be wrapped around the chain sprocket fitted into the crankshaft 25 in the crankcase 11.

[0042] It should be noted that, as shown in FIG. 3, an oil storage recess 13d recessed downward is formed in the cam chamber bottom wall 13b of the cylinder head 13 at the rear of the chain opening 13h. A sensing portion 27a at the tip of an oil temperature sensor 27 installed from the outside in a rear wall of the peripheral wall 13a of the cylinder head 13 is protruded into the oil storage recess 13d so that the oil temperature sensor 27 can detect the temperature of lubricating oil in the oil storage recess 13d.

[0043] Between the left and right camshaft receiving walls 13L and 13R, an intake rocker arm shaft 47 is disposed above and obliquely rearward of the camshaft 41, and an exhaust rocker arm shaft 48 is disposed above and obliquely forward of the camshaft 41. A first intake rocker arm 51 and a second intake rocker arm 52 adjacent to each other are rockably journaled to the intake rocker arm shaft 47. An exhaust rocker arm 53 is rockably journaled to the exhaust rocker arm shaft 48.

[0044] The first intake rocker arm 51 has a roller 51r at an end thereof toward the camshaft 41, and the roller 51r is in contact with a first intake cam lobe 41i of the camshaft 41. The first intake rocker arm 51 has an adjusting screw 51s at the other end thereof, and the adjusting screw 51s is in contact with the upper end of a valve stem of the intake valve 33.

The second intake rocker arm 52 has a roller 52r at an end thereof toward the camshaft 41, and the roller 52r is in contact with a second intake cam lobe 41ii of the camshaft 41. The other end 52a of the second intake rocker arm 52 is in contact with the upper end of a lifter 38 received in a receiving recess 13bd formed in the cam chamber bottom wall 13b, the lifter 38 being urged by a coil spring 37 (see FIG. 2).

[0045] The first intake cam lobe 41i and the second intake cam lobe 41ii have different profiles. The first intake cam lobe 41i and the second intake cam lobe 41ii have cam noses that protrude in the same direction from respective base circles of the same diameter. The second intake cam lobe 41ii for a high-load operation region has a higher cam nose and a greater cam operating angle than those of the first intake cam lobe 41i for a low-load operation region.

On the other hand, the exhaust rocker arm 53 has a roller 53r at an end thereof toward the camshaft 41, and the roller 53r is in contact with an exhaust cam lobe 41e of the camshaft 41. The exhaust rocker arm 53 has an adjusting screw 53s at the other end thereof, and the adjusting screw 53s is in contact with the upper end of a valve stem of the exhaust valve 34.

[0046] The first intake rocker arm 51 and the second intake rocker arm 52 respectively have protruding portions 51a and 52a that protrude upward. The protruding portions 51a and 52a are respectively formed with recesses 51h and 52h of circular holes of the same diam-

eter, the recesses 51h and 52h opening into adjacent surfaces of the protruding portions 51a and 52a.

[0047] Inside the recess 51h of the first intake rocker arm 51 located on the left side, a spring 54 is interposed and a bottomed cylindrical plunger 55 is inserted. The plunger 55 is urged by the spring 54 toward the protruding portion 52a of the second intake rocker arm 52 located in a right direction.

The recess 52h of the second intake rocker arm 52 located on the right side has a circular hole bored in a bottom wall of the recess 52h, that is, the right sidewall. A connecting pin 56 is fitted within the recess 52h. An extension rod 56b extending to the right of the connecting pin 56 protrudes through the circular hole in the bottom wall of the recess 52h.

[0048] As shown in FIGs. 3 and 4, when the connecting pin 56 is pressed by the plunger 55 urged by the spring 54, and completely fitted within the recess 52h, the left end surface of the connecting pin 56 is flush with the adjacent surfaces of the protruding portions 51a and 52a of the first and second intake rocker arms 51 and 52. At this time, the connecting pin 56 is fitted only within the recess 52h, and consequently the first intake rocker arm 51 and the second intake rocker arm 52 can rock independently.

[0049] It is to be noted that, if the recesses 51h and 52h are coaxially aligned while the first intake rocker arm 51 and the second intake rocker arm 52 rock independently, as shown in FIGs. 3 and 4, the connecting pin 56 is urged by the spring 54 and fitted only within the recess 52h, so that the left end surface of the connecting pin 56 is kept flush with the adjacent surfaces of the protruding portions 51a and 52a. Even if the recesses 51h and 52h become out of coaxial alignment, the left end surface of the connecting pin 56 is brought into contact with the adjacent surface of the protruding portion 51a of the first intake rocker arm 51, so that the left end surface of the connecting pin 56 is kept flush with the adjacent surface of the protruding portion 51a.

The plunger 55 is also urged by the spring 54 into contact with the adjacent surface of the protruding portion 52a of the second intake rocker arm 52, so that the plunger 55 is kept flush with the adjacent surface of the protruding portion 52a.

[0050] The cylinder head 13 and the cylinder head cover 14 are joined together with the peripheral wall 13a of the cylinder head 13 and a peripheral wall 14a of the cylinder head cover 14 mating with each other. An electromagnetic solenoid 60 is mounted from the outside at the level of right-hand mating faces of the peripheral walls 13a and 14a.

A pushrod 61 serving as a moving core of the electromagnetic solenoid 60 protrudes leftward through the right-hand mating faces of the peripheral walls 13a and 14a into a cam chamber. The pushrod 61 is mounted at the tip thereof with a metallic pressure body 62.

[0051] The pushrod 61 protrudes toward the protruding portion 52a of the second intake rocker arm 52. The right

end of the extension rod 56b of the connecting pin 56 protruding from the protruding portion 52a of the second intake rocker arm 52 is in contact with the end surface of an end diameter-increased portion 62b, increased in diameter toward the end, of the pressure body 62 provided at the tip of the pushrod 61.

[0052] When the electromagnetic solenoid 60 is in a demagnetized state, as shown by the solid lines in FIGs. 3 and 4, the connecting pin 56 urged by the spring 54 is fitted only within the recess 52h, so that the first intake rocker arm 51 and the second intake rocker arm 52 rock independently.

[0053] When the electromagnetic solenoid 60 is energized, a leftward projecting force acts on the pushrod 61, thereby pressing the connecting pin 56 leftward through the pressure body 62. Thus, when the recesses 51h and 52h of the protruding portions 51a and 52a of the first and second intake rocker arms 51 and 52 are coaxially aligned, the connecting pin 56 is inserted into the recess 51h while forcing the plunger 55 into the recess 51h of the first intake rocker arm 51 against the urging force of the spring 54, so that the connecting pin 56 extends across both recesses 51h and 52h (see the chain double-dashed lines in FIGs. 3 and 4). Consequently, the first intake rocker arm 51 and the second intake rocker arm 52 are connected by the connecting pin 56 to be integrally rocked.

[0054] When the internal combustion engine 10 is in a low-load operation state, the electromagnetic solenoid 60 is demagnetized to fit the connecting pin 56 only within the recess 52h so that the first intake rocker arm 51 and the second intake rocker arm 52 rock independently. The first intake rocker arm 51 is rocked by the first intake cam lobe 41i for the low-load operation region which has a small cam operating angle and a low cam nose. By rocking of the first intake rocker arm 51 based on the first intake cam lobe 41i, the intake valve 33 is driven to be opened and closed with a short valve-opening time period and a small lift for the low-load operation.

[0055] When the internal combustion engine 10 shifts to a high-load operation state, the electromagnetic solenoid 60 is energized to cause the pushrod 61 to press the connecting pin 56 into the recess 51h against the urging force of the spring 54, so that the connecting pin 56 extends across both recesses 51h and 52h to integrally connect the first intake rocker arm 51 and the second intake rocker arm 52. Thus, the first intake rocker arm 51 rocks integrally with the second intake rocker arm 52 that is rocked by the second intake cam lobe 41ii for the high-load operation region which has a great cam operating angle and a high cam nose. By rocking of the first intake rocker arm 51 based on the second intake cam lobe 41ii, the intake valve 33 is driven to be opened and closed with a long valve-opening time period and a large lift for the high-load operation.

[0056] The electromagnetic solenoid 60 is controlled by an ECU 70 serving as an engine control computer (see FIG. 3). The ECU 70 controls the movement of the

pushrod 61 during connection and disconnection by the connecting pin 56 and performs duty control of the applied voltage of the electromagnetic solenoid 60 so as to prevent the generation of a hitting sound when the pushrod 61 stops.

Hereinafter, control of the electromagnetic solenoid 60 will be described with reference to control flowcharts shown in FIGs. 5 to 8 and the duty control voltage of the electromagnetic solenoid 60 as shown in FIGs. 9 and 10.

[0057] The ECU 70 determines the operating condition of the internal combustion engine 10 on the basis of an engine speed, a throttle opening, a vehicle speed or the like, and an engine temperature corresponding to the temperature of lubricating oil detected by the oil temperature sensor 27. When the operating condition shifts from the low-load condition to the high-load condition, the ECU 70 performs connection control of the electromagnetic solenoid 60. When the operating condition shifts from the high-load condition to the low-load condition, on the other hand, the ECU 70 performs disconnection control of the electromagnetic solenoid 60.

[0058] Referring to the flowchart of FIG. 5 showing a main control routine of the electromagnetic solenoid 60, firstly, in step 1, the ECU 70 determines whether or not the internal combustion engine 10 is in the low-load condition. If the internal combustion engine 10 is in the low-load condition, the process goes to step 2. In step 2, the ECU 70 determines whether connection flag F is "1" or not. If the flag F is "1", the process goes to step 3. In step 3, the ECU 70 starts time measurement, and the process proceeds to a disconnection control routine of step 4. On the other hand, if the flag F is not "1" but "0", the process skips step 3 and proceeds to the disconnection control routine of step 4.

Once the process proceeds to the disconnection control routine, the connection flag F is set to "0" in step 5.

[0059] More specifically, when the internal combustion engine 10 shifts from the high-load condition to the low-load condition, the connection flag F is "1". In step 3, the time measurement is started, and the process proceeds to the disconnection control routine. And then the connection flag F becomes "0", and the process skips step 3 and proceeds to the disconnection control routine while the time measurement is running.

[0060] Also, in step 1, if the ECU 70 determines that the internal combustion engine 10 is not in the low-load condition, that is, the internal combustion engine 10 is in the high-load condition, the process goes to step 6. In step 6, the ECU 70 determines whether the connection flag F is "0" or not. If the flag F is "0", the process goes to step 7. In step 7, the ECU 70 starts time measurement, and the process proceeds to a connection control routine of step 8. On the other hand, if the flag F is not "0" but "1", the process skips step 7 and proceeds to the connection control routine of step 8.

Once the process proceeds to the connection control routine, the connection flag F is set to "1" in step 9.

[0061] More specifically, when the internal combustion

engine 10 shifts from the low-load condition to the high-load condition, the connection flag F is "0". In step 7, the time measurement is started, and the process proceeds to the connection control routine. And then the connection flag F becomes "1", and the process skips step 7 and proceeds to the connection control routine while the time measurement is running.

[0062] Here, when PWM duty control is executed and disconnection is performed, the electromagnetic solenoid 60 is in a demagnetized state and duty ratio Rd is 0%. The duty ratio Rd for maintaining the connected state, in which the connecting pin 56 is inserted into the recess 51h against the urging force of the spring 54 to extend across both recesses 51h and 52h, is set as a connection maintaining duty ratio of b% (for example, 70%) .

[0063] The disconnection control routine of step 4 will be described with reference to an exemplary flowchart of FIG. 6 and the voltage duty control shown in FIG. 9(1). When shifting from the high-load condition to the low-load condition, the process proceeds to the disconnection control routine. However, just before the process proceeds to the disconnection control routine, the duty ratio Rd is b% and the first and second intake rocker arm 51 and 52 are in the connected state.

[0064] When the time measurement is started (step 3) and the process proceeds to the disconnection control routine (step 4), the ECU 70 determines in step 11 of FIG. 6 whether or not measuring time t reaches t3 and determines in step 12 whether or not the measuring time t reaches time point t2 (<t3). Initially, the measuring time t has not reached not only the time point t3 but also the time point t2, and therefore the process goes to step 13. In step 13, the ECU 70 sets the duty ratio Rd to c% (<b%, for example, 50%) to decrease actual voltage and perform duty control of the electromagnetic solenoid 60 with a duty ratio Rd of c%.

[0065] And then when the measuring time t reaches the time point t2, the process goes from step 12 to step 14, in which the ECU 70 sets the duty ratio Rd to d% (<c%, for example, 30%) to further decrease the actual voltage and perform duty control of the electromagnetic solenoid 60 with a duty ratio Rd of d%.

Thereafter, when the measuring time t reaches the time point t3, the process goes from step 11 to step 15, in which the ECU 70 sets the duty ratio Rd to zero to bring the electromagnetic solenoid 60 into a demagnetized state.

[0066] FIG. 9(1) shows changes of the voltage duty control of the electromagnetic solenoid 60 in the above-described disconnection control.

The duty ratio Rd is decreased to c% at time point t1 (corresponding to the time measurement starting point, t=0) at which the internal combustion engine 10 shifts to the low-load condition from the state in which the first intake rocker arm 51 and the second intake rocker arm 52 are integrally connected by duty controlling the electromagnetic solenoid 60 with the connection maintaining duty ratio b% in the high-load condition and inserting the

connecting pin 56 into the recess 51h to cause the connecting pin 56 to extend across both recesses 51h and 52h. When the measuring time t reaches the time point t_2 , the duty ratio R_d is further decreased to $d\%$. Then when the measuring time t reaches the time point t_3 , the duty ratio R_d is set to 0%. Therefore, the actual voltage shown by dashed lines decreases in a stepwise fashion from the connection maintaining voltage to zero.

[0067] Consequently, the pressure to insert the connecting pin 56 into the recess 51h decreases in a stepwise fashion. Thus, the connecting pin 56 and the pushrod 61 are moved by the urging force of the spring 54 while being decelerated, and finally the connecting pin 56 comes out of the recess 51h, thereby releasing the connection between the first intake rocker arm 51 and the second intake rocker arm 52.

Since the connecting pin 56 comes completely out of the recess 51h in the vicinity of the time point t_3 , the movement speed just before the pushrod 61 stops can be easily reduced and the generation of a hitting sound can be prevented.

[0068] Furthermore, another exemplary disconnection control is shown in a flowchart of FIG 7.

When, in the connected state of the first intake rocker arm 51 and the second intake rocker arm 52, the internal combustion engine 10 shifts from the high-load condition to the low-load condition, the time measurement is started (step 3) and the ECU 70 determines in step 21 whether or not the measuring time t reaches t_3 and determines in step 22 whether or not the measuring time t reaches the time point t_2 ($<t_3$). Initially, the measuring time t has not reached not only the time point t_3 but also the time point t_2 , and therefore the process proceeds to step 23. In step 23, the ECU 70 sets the duty ratio R_d to 0% to demagnetize the electromagnetic solenoid 60. And then when the measuring time t reaches the time point t_2 that falls considerably short of the time point at which the connecting pin 56 comes out of the recess 51h, the process goes from step 22 to step 24. In step 24, the ECU 70 energizes the electromagnetic solenoid 60 with the duty ratio R_d set to a brake duty ratio of $b\%$ (for example, 60%) to brake the movement of the connecting pin 56 and the pushrod 61. Then when the measuring time t reaches the time point t_3 , the process goes from step 21 to step 25, in which the ECU 70 sets the duty ratio R_d to zero to demagnetize the electromagnetic solenoid 60.

[0069] FIG. 9(2) shows changes of the voltage duty control of the electromagnetic solenoid 60 in the above-described disconnection control.

At the time point t_1 (corresponding to the time measurement starting point, $t=0$) at which the internal combustion engine 10 shifts to the low-load condition from the state in which the first intake rocker arm 51 and the second intake rocker arm 52 are integrally connected by inserting the connecting pin 56 into the recess 51h in the high-load condition to cause the connecting pin 56 to extend across both recesses 51h and 52h, the ECU 70 demagnetizes the electromagnetic solenoid 60 with the duty ratio R_d

set to zero, so that the connecting pin 56 and the pushrod 61 move quickly with the urging force of the spring 54. However, the setting is made such that, at the time point t_2 , the electromagnetic solenoid 60 is energized with the brake duty ratio $b\%$ to brake the movement of the connecting pin 56 and the pushrod 61, and, in the vicinity of the time point T_3 at which the brake control ends, the connecting pin 56 comes out of the recess 51h. Thus, the movement speed just before the connecting pin 56 and the pushrod 61 stop can be easily reduced and the generation of a hitting sound can be prevented.

[0070] The time point t_2 to start the energization with the brake duty ratio $b\%$ and the brake duty ratio $b\%$ are preset to proper values. However, by previously obtaining and mapping optimum values of the time point t_2 and the brake duty ratio $b\%$ corresponding to oil temperature, it is possible to perform brake control with the optimum time point t_2 and the optimum brake duty ratio $b\%$ which correspond to oil temperature. Thus, the movement speed just before the pushrod 61 stops can be further reduced and the generation of a hitting sound can be prevented.

[0071] Further, as for the time point t_2 to start the energization with the brake duty ratio $b\%$ for braking, a position where the pushrod 61 returns with the urging force of the spring 54 is detected by a position sensor, and a time point at which the pushrod 61 has returned to an optimum position for braking is detected. This time point may be set as the time point t_2 to energize the electromagnetic solenoid 60 with the brake duty ratio $b\%$.

[0072] By previously obtaining and mapping the correlation between the above-described brake duty ratio (b') and oil temperature, it is possible to properly brake the moving core member (61, 62) on the basis of the map, depending on the temperature state of the internal combustion engine 10 (more specifically, the change in resistance of the electromagnetic solenoid with temperature or the change in viscosity of lubricating oil with temperature), and reduce the generation of a hitting sound.

[0073] Next, the connection control routine will be described with reference to an exemplary flowchart of FIG. 8 and the voltage duty control shown in FIG. 10.

When the internal combustion engine 10 shifts from the low-load condition to the high-load condition, the process proceeds to the connection control routine. Just before that, the duty ratio R_d is 0% and the first intake rocker arm 51 and the second intake rocker arm 52 are in the disconnected state.

[0074] When the time measurement is started (step 7) and the process proceeds to the connection control routine (step 8), the ECU 70 determines in step 31 of FIG. 8 whether or not lubricating oil temperature (oil temperature) Y_t detected by the oil temperature sensor 27 falls within a predetermined oil temperature range.

[0075] When the oil temperature is greater than about 60°C, the lubricating oil for smooth sliding of the connecting pin 56 becomes less viscous. Also, when the oil tem-

perature is smaller than about 80°C, the coil resistance of the electromagnetic solenoid 60 is small and the coil current flows through easily. For this reason, without change in applied voltage, the projecting force of the moving core member (61, 62) increases. Thus, when the electromagnetic solenoid is energized in the oil temperature range of approximately 60°C to 80°C, the movement speed of the connecting pin (56) is likely to increase, and a hitting sound is more likely to be generated. Therefore, a predetermined oil temperature range in which the movement speed is likely to increase is preset between approximately 60°C and 80°C, and duty control of the electromagnetic solenoid (60) is varied according to within and outside the predetermined oil temperature range.

[0076] In this embodiment, the predetermined oil temperature range is set to $60^{\circ}\text{C} < Yt < 80^{\circ}\text{C}$.

This predetermined oil temperature range is the temperature range in which vibration generated in the cylinder head becomes larger than that in other portions.

In step 31, the ECU 70 determines whether or not the oil temperature Yt falls within a predetermined oil temperature range ($60^{\circ}\text{C} < Yt < 80^{\circ}\text{C}$). If the ECU 70 determines that the oil temperature Yt falls outside the predetermined oil temperature range ($Yt \leq 60^{\circ}\text{C}$, $80^{\circ}\text{C} \leq Yt$), the process goes to step 32. In step 32, the ECU 70 determines whether or not the measuring time t reaches predetermined time T that is sufficient to complete the connection. Initially, the measuring time t has not reached the predetermined time T , and therefore the process proceeds to step 33. In step 33, the ECU 70 determines whether subtraction counting value i is zero or not. If the subtraction counting value i is not zero, the process goes to step 34. In step 34, the ECU 70 sets the duty ratio Rd to a normal movement starting duty ratio of $a\%$ (for example, 90%) for starting the movement of the connecting pin 56 and starts duty control of the electromagnetic solenoid 60 with the duty ratio $a\%$ greater than the connection maintaining duty ratio $b\%$, and energizes the electromagnetic solenoid 60 to cause the pushrod 61 to press the connecting pin 56 that is in position to release the connection. Then in step 35, the ECU 70 subtracts 1 from the subtraction counting value i .

[0077] The subtraction counting value i is initially set to initial value I (steps 39 and 41). When the subtraction counting value i becomes zero while steps 31 to 35 are repeated and duty control is performed with the normal movement starting duty ratio $a\%$, the process skips over step 33 to step 36. In step 36, the ECU 70 determines whether another subtraction counting value j is zero or not.

[0078] If the subtraction counting value j is not zero, the process goes to step 37. In step 37, the ECU 70 sets the duty ratio Rd to the connection maintaining duty ratio $b\%$ to perform duty control, and in next step 38, subtracts 1 from the subtraction counting value j .

The subtraction counting value j is initially set to initial value J (steps 39 and 41). When the subtraction counting value j becomes zero while steps 31, 32, 33, 36, 37, and

38 are repeated and duty control is performed with the connection maintaining duty ratio $b\%$, the process skips over step 36 to step 39. In step 39, the ECU 70 sets the subtraction counting values i and j to the initial value I and J , respectively.

[0079] At this point, if the measuring time t has not reached the predetermined time T , the process proceeds from step 32 to step 33, in which the duty control with the normal movement starting duty ratio $a\%$ and the duty control with the connection maintaining duty ratio $b\%$ are executed, and repeated until the measuring time t has reached the predetermined time T .

[0080] And finally, when the measuring time t has reached the predetermined time T , the process skips over step 32 to step 40. In step 40, the ECU 70 fixes the duty ratio Rd to the connection maintaining duty ratio $b\%$ for duty control, and in next step 41, reliably sets the subtraction counting values i and j to the initial value I and J , respectively.

[0081] FIG. 10(1) shows changes of the voltage duty control of the electromagnetic solenoid 60 in the above-described connection control.

At the time point $t1$ (corresponding to the time measurement starting point, $t=0$) at which the internal combustion engine 10 shifts to the high-load condition from the state in which the connection is released by demagnetizing the electromagnetic solenoid 60 with a duty ratio of 0% in the low-load condition and bringing the connecting pin 56 out of the recess 51h, the ECU 70 performs voltage duty control of the electromagnetic solenoid 60 with the duty ratio Rd set to the normal movement starting duty ratio $a\%$, and starts the energization of the electromagnetic solenoid 60. Thus, the pushrod 61 applies a large pressure to the connecting pin 56. At the time point $t2$ at which the subtraction counting value i becomes zero, the ECU 70 decreases the duty ratio Rd to the connection maintaining duty ratio $b\%$. Then at the time point $t3$ at which the subtraction counting value j becomes zero, the ECU 70 increases again the duty ratio Rd to the normal movement starting duty ratio $a\%$. The duty controls with the normal movement starting duty ratio $a\%$ and the connection maintaining duty ratio $b\%$ are repeated until the predetermined time T . Therefore, as shown by dashed lines in FIG. 10(1), the actual voltage repeats to turn from the normal movement starting voltage to the connection maintaining voltage, and, at the predetermined time T , is fixed to the connection maintaining voltage.

[0082] In this manner, the increase in the movement speed is adjusted by repeatedly changing a great pressure of the normal movement starting duty ratio $a\%$ at the start of the movement of the connecting pin 56 to a smaller pressure of the connection maintaining duty ratio $b\%$, so that the connecting pin 56 can be stopped in a manner extending across both recesses 51h and 52h. Thus, the generation of vibration caused by pressing the spring 54 all the way in can be avoided.

Furthermore, the duty control with the normal movement

starting duty ratio a% is performed, thereby inserting the connecting pin 56 into the recess 51h and achieving connection. Also, the duty control with the connection maintaining duty ratio b% is performed, thereby maintaining the connection. Thus, the power consumption of the electromagnetic solenoid 60 can be reduced.

[0083] On the other hand, in step 31, if it is determined that the oil temperature Yt falls within the predetermined oil temperature range ($60^{\circ}\text{C} < \text{Yt} < 80^{\circ}\text{C}$), the process goes to step 42.

Note that steps 42 to 51 correspond to the above-described steps 32 to 41. The difference therebetween is in that, in step 44, the duty ratio Rd is set to a special movement starting duty ratio of a' (for example, 80%) that is smaller than the normal movement starting duty ratio a% and greater than the connection maintaining duty ratio b%. As for the rest, the steps are the same.

[0084] When the oil temperature Yt falls within the predetermined oil temperature range ($60^{\circ}\text{C} < \text{Yt} < 80^{\circ}\text{C}$), the movement speed of the connecting pin 56 is likely to increase. Therefore, referring to FIG. 10 (2), the ECU 70 energizes the electromagnetic solenoid 60 with the special movement starting duty ratio a' that is smaller than the normal movement starting duty ratio a% and greater than the connection maintaining duty ratio b%, and controls the movement of the connecting pin 56. Then the ECU 70 drives the electromagnetic solenoid 60 while repeatedly performing control for changing to the connection maintaining duty ratio b% that is smaller than the special movement starting duty ratio a'. Thus, the movement speed is adjusted to a value suitable for an oil temperature in the predetermined oil temperature range ($60^{\circ}\text{C} < \text{Yt} < 80^{\circ}\text{C}$) by repeatedly changing the pressure from a value smaller than normal of the special movement starting duty ratio a' at the start of the movement of the connecting pin 56 to a smaller value of the connection maintaining duty ratio b%, so that the connecting pin 56 can be stopped in a manner extending across both recesses 51h and 52h. Thus, the generation of vibration caused by pressing the spring 54 all the way in can be avoided.

Furthermore, the duty control with the special movement starting duty ratio a' is performed, thereby inserting the connecting pin 56 into the recess 51h and connecting the first intake rocker arm 51 and the second intake rocker arm 52 together. Also, the duty control with the connection maintaining duty ratio b% is performed, thereby maintaining the connection. Thus, the power consumption of the electromagnetic solenoid 60 can be reduced.

[0085] In both cases where the oil temperature Yt falls within and outside the predetermined oil temperature range, even if the connecting pin 56 comes out of the recess 51h of one of the two recesses, duty control is repeatedly performed with the normal movement starting duty ratio a% or the special movement starting duty ratio a' so that the connecting pin 56 is inserted into the recess 51h. Thus, the connected state can be ensured.

[0086] In this embodiment, the predetermined oil tem-

perature range is set to $60^{\circ}\text{C} < \text{Yt} < 80^{\circ}\text{C}$, which is an optimum range. However, the lower limit is not limited to 60°C , but also can be set to an oil temperature of around 60°C . Also, the upper limit is not limited to 80°C , but also can be set to an oil temperature of around 80°C .

[0087] It should be noted that the special movement starting duty ratio a' is set, as the duty ratio Rd that permits the start of movement of the connecting pin 56, to a predetermined constant value that is smaller than the normal movement starting duty ratio a% and greater than the connection maintaining duty ratio b%. However, the optimum special movement starting duty ratio a' may be previously obtained and mapped corresponding to oil temperature (such a map that the higher the oil temperature, the smaller the special movement starting duty ratio a'). Thus, the movement speed is adjusted to a value more suitable for oil temperature by determining the special movement starting duty ratio a' in accordance with oil temperature, so that the connecting pin 56 can be stopped in a connecting position.

[0088] It also should be noted that the correlation of the normal movement starting duty ratio a and the special movement starting duty ratio a' with oil temperature may be previously obtained and mapped. Thus, it is possible to more properly change the speed of the moving core member (61, 62) on the basis of the map, depending on the temperature state of the internal combustion engine (more specifically, the change in resistance of the electromagnetic solenoid with temperature or the change in viscosity of lubricating oil with temperature), and reduce the generation of a hitting sound.

[Reference Signs List]

[0089]

1	Motorcycle
2	Head pipe
3	Main frame
4	Down frame
10	Internal combustion engine
11	Crankcase
12	Cylinder block
13	Cylinder head
14	Cylinder head cover
15	Intake valve
16	Throttle body
17	Air cleaner
18	Exhaust pipe
19	Muffler
20	Fuel injection valve
21	Piston
22	Connecting rod
25	Crankshaft
26	Spark plug

(continued)

27	Oil temperature sensor
30	Combustion chamber
31	Intake port
32	Exhaust port
33	Intake valve
34	Exhaust valve
35	Intake valve spring
36	Exhaust valve spring
37	Coil spring
38	Lifter
40	Variable valve train
41	Camshaft
42, 43	Bearing
44	Chain sprocket
47	Intake rocker arm shaft
48	Exhaust rocker arm shaft
51	First intake rocker arm
52	Second intake rocker arm
53	Exhaust rocker arm
54	Spring
55	Plunger
56	Connecting pin
60	Electromagnetic solenoid
61	Pushrod
62	Pressure body
70	ECU

Claims

1. A variable valve train for an internal combustion engine in which: rocker arms (51, 52) journaled coaxially with and adjacent to each other rock in contact with cam lobes (41i, 41ii) having different profiles of a camshaft, and an intake valve (33) is opened and closed by rocking of one rocker arm (51) of the rocker arms;
a connecting pin (56) urged by a spring (54) moves between respective hole portions (51h, 52h) formed in the rocker arms (51, 52), thereby enabling a connection between the rocker arms (51, 52);
the connecting pin (56) is moved by forward and backward movement of a moving core member (61, 62) of an electromagnetic solenoid (60); and
control means (70) energizes the electromagnetic solenoid (60) to cause the moving core member (61, 62) to protrude, and thereby the connecting pin (56) to move against urging force of the spring (54) so that the rocker arms (51, 52) are connected together and integrally rocked,
wherein the control means (70) duty controls the electromagnetic solenoid (60) and drives the moving core member (61, 62).

2. The variable valve train for the internal combustion engine according to Claim 1, wherein, in a disconnected state of the rocker arms (51, 52) in which the connecting pin (56) is fitted in the other hole portion (52h) of the hole portions to allow the rocker arms (51, 52) to rock independently, from a demagnetized state of the electromagnetic solenoid (60), the control means (70) duty controls the electromagnetic solenoid (60) with a normal movement starting duty ratio (a) that causes the connecting pin (56) to start to move against urging force of the spring (54), and then duty controls the electromagnetic solenoid (60) with a connection maintaining duty ratio (b) smaller than the normal movement starting duty ratio (a) to insert the connecting pin (56) into one hole portion (51h) of the hole portions so that the connecting pin (56) extends across both hole portions (51h, 52h), thereby connecting the rocker arms (51, 52) together.
3. The variable valve train for the internal combustion engine according to Claim 2, wherein a process of duty controlling the electromagnetic solenoid (60) with the normal movement starting duty ratio (a) and then duty controlling the electromagnetic solenoid (60) with the connection maintaining duty ratio (b) is repeated multiple times.
4. The variable valve train for the internal combustion engine according to Claim 3, further comprising:

oil temperature detecting means (27) for detecting temperature of lubricating oil of the internal combustion engine (10),
wherein: the control means (70) presets a predetermined oil temperature range of approximately 60°C to 80°C;
when the oil temperature detected by the oil temperature detecting means (27) falls outside the predetermined oil temperature range, the control means (70) repeats multiple times the process of duty controlling the electromagnetic solenoid (60) with the normal movement starting duty ratio (a) that causes the connecting pin (56) to start to move against urging force of the spring (54), and then duty controlling the electromagnetic solenoid (60) with the connection maintaining duty ratio (b) smaller than the normal movement starting duty ratio (a); and
when an oil temperature detected by the oil temperature detecting means (27) falls within the predetermined oil temperature range, the control means (70) repeats multiple times a process of controlling movement of the connecting pin (56) with a special movement starting duty ratio (a') smaller than the normal movement starting duty ratio (a) and greater than the connection maintaining duty ratio (b), and then duty control-

ling the electromagnetic solenoid (60) with the connection maintaining duty ratio (b).

5. The variable valve train for the internal combustion engine according to Claim 4, wherein the predetermined oil temperature range is a temperature range in which vibration generated in a cylinder head becomes larger than in other portions. 5

6. The variable valve train for the internal combustion engine according to Claims 4 and 5, wherein the normal movement starting duty ratio (a) and the special movement starting duty ratio (a') are determined from a map correlated with an oil temperature value. 10
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7. The variable valve train for the internal combustion engine according to any one of Claims 1 to 6, wherein the control means (70) performs control to decrease the duty ratio in a stepwise fashion from the connection maintaining duty ratio (b) that maintains the connected state of the rocker arms (51, 52) by causing the connecting pin (56) to extend across both hole portions (51h, 52h), and adjusts movement speed of the moving core member (61, 62) to stop the moving core member (61, 62), thereby releasing the connection between the rocker arms (51, 52). 20
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8. The variable valve train for the internal combustion engine according to any one of Claims 1 to 6, wherein the control means (70) changes the duty ratio to zero from the connection maintaining duty ratio (b) that maintains the connected state of the rocker arms (51, 52) by causing the connecting pin (56) to extend across both hole portions (51h, 52h), and then controls the duty ratio to a brake duty ratio (b') at a predetermined timing so that the moving core member (61, 62) is reduced in movement speed and stopped, thereby releasing the connection between the rocker arms (51, 52). 30
35
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9. The variable valve train for the internal combustion engine according to Claim 8, wherein the brake duty ratio (b') is determined from the map correlated with the oil temperature value. 45

10. The variable valve train for the internal combustion engine according to Claim 8, wherein a position of the moving core member (61, 62) is detected by a position sensor, and at a predetermined position, control is performed with the brake duty ratio (b') so that the moving core member (61, 62) is reduced in movement speed and stopped, thereby releasing the connection between the rocker arms (51, 52). 50
55

FIG. 1

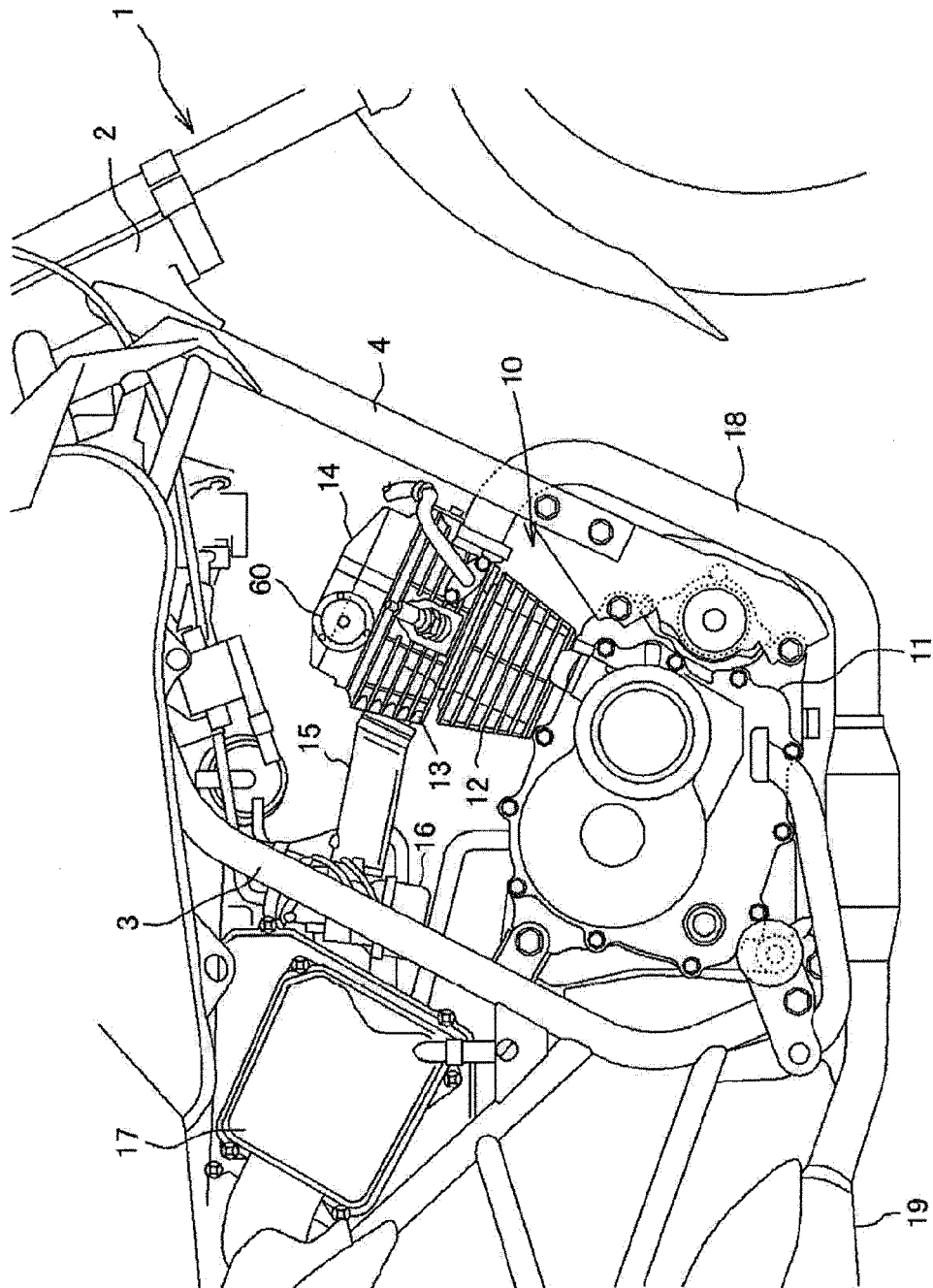


FIG. 2

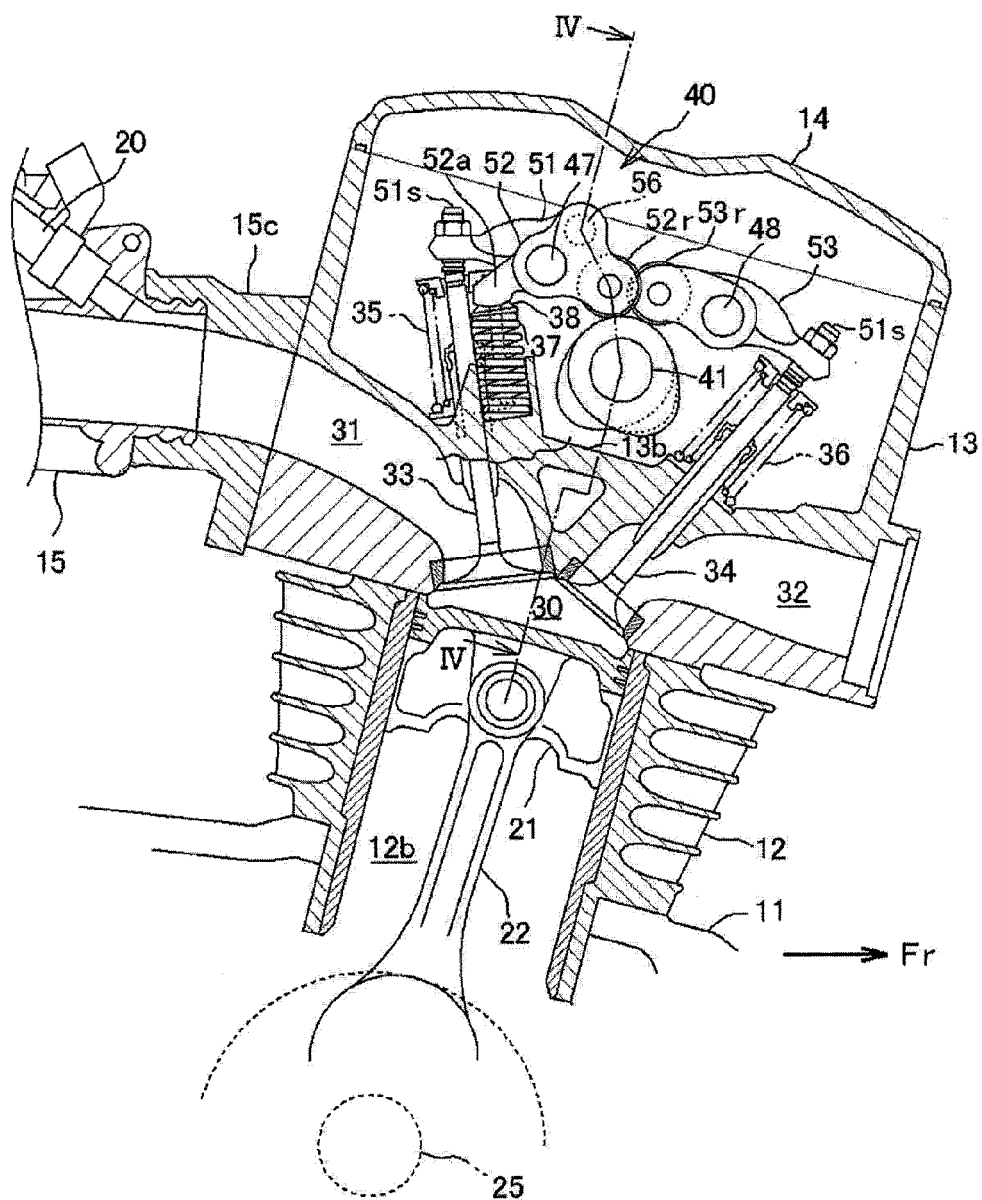


FIG. 3

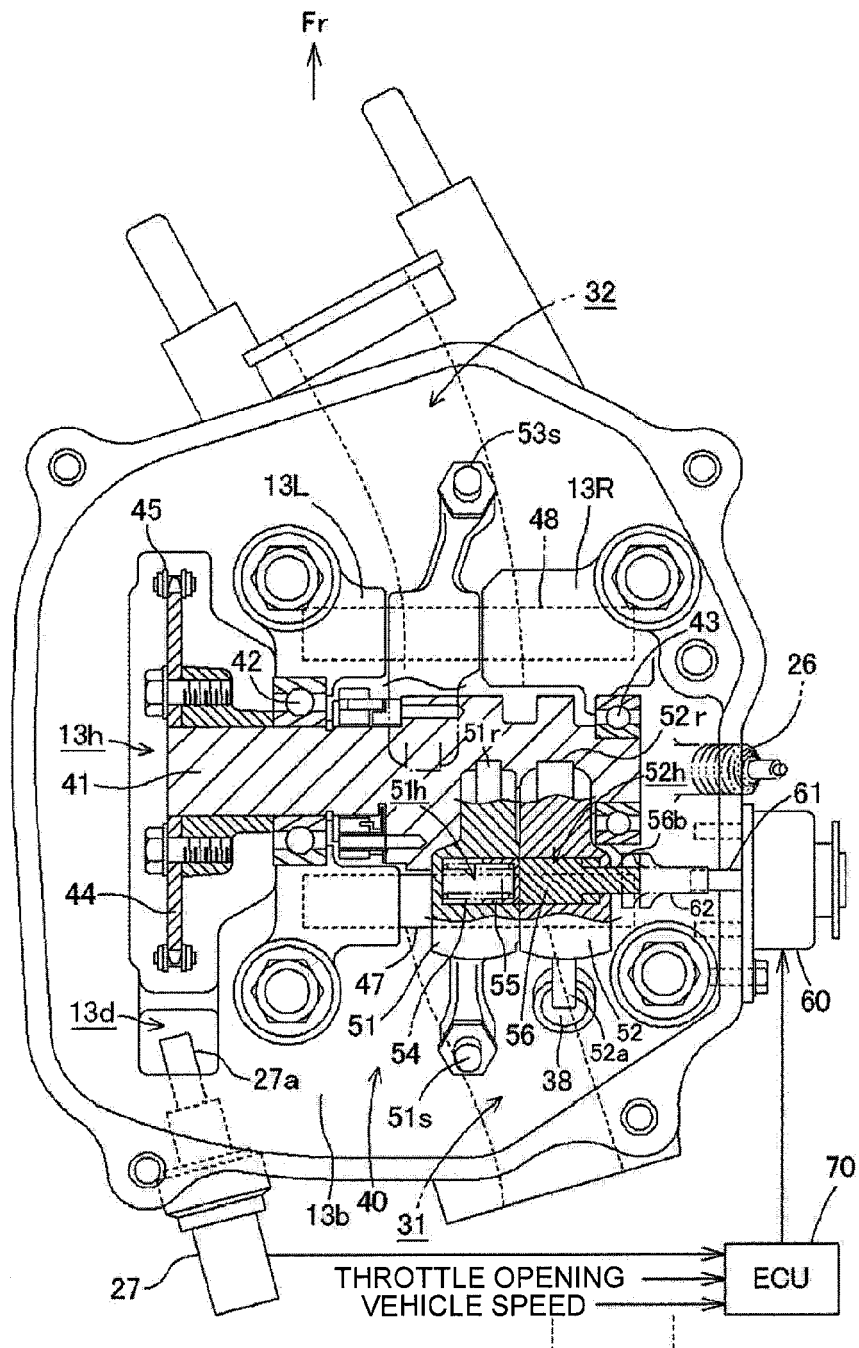


FIG. 4

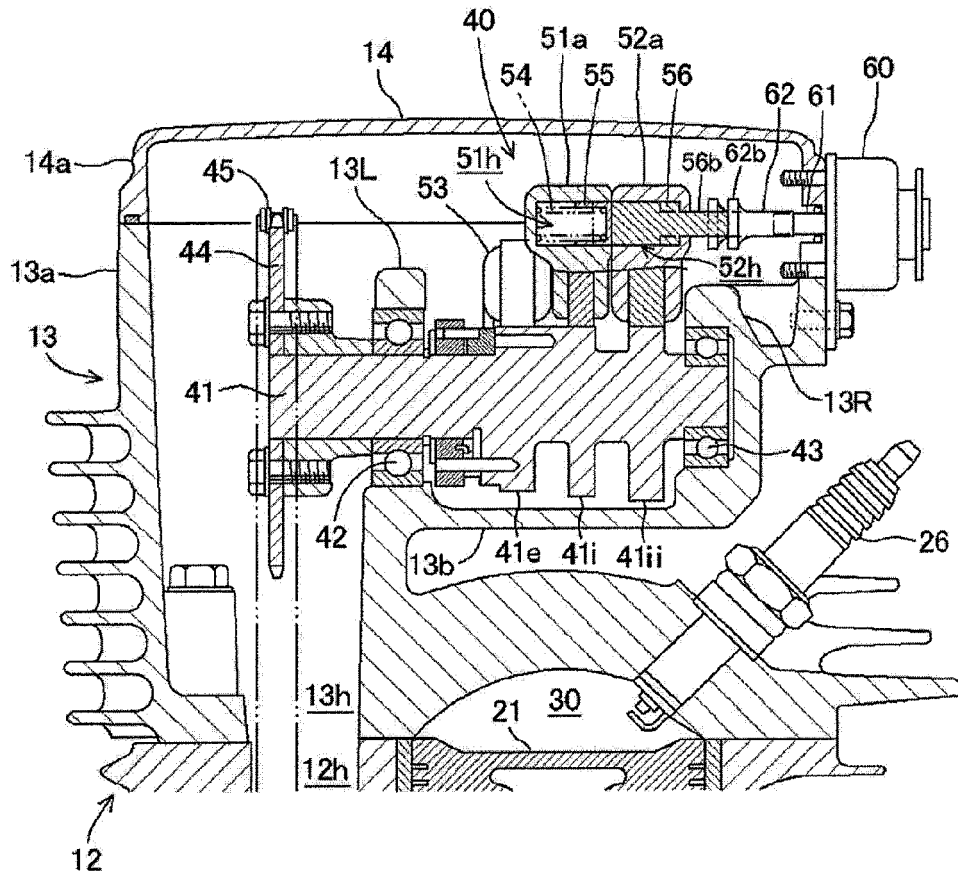


FIG. 5

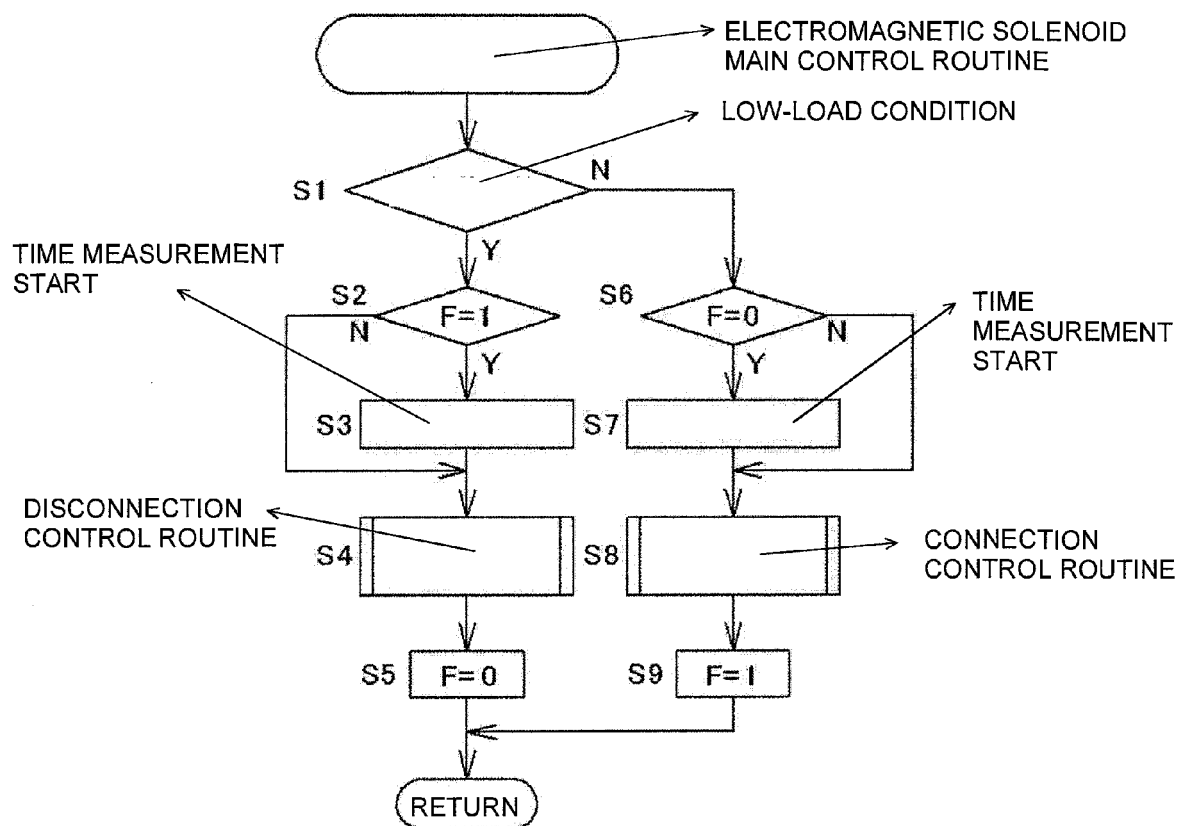


FIG. 6

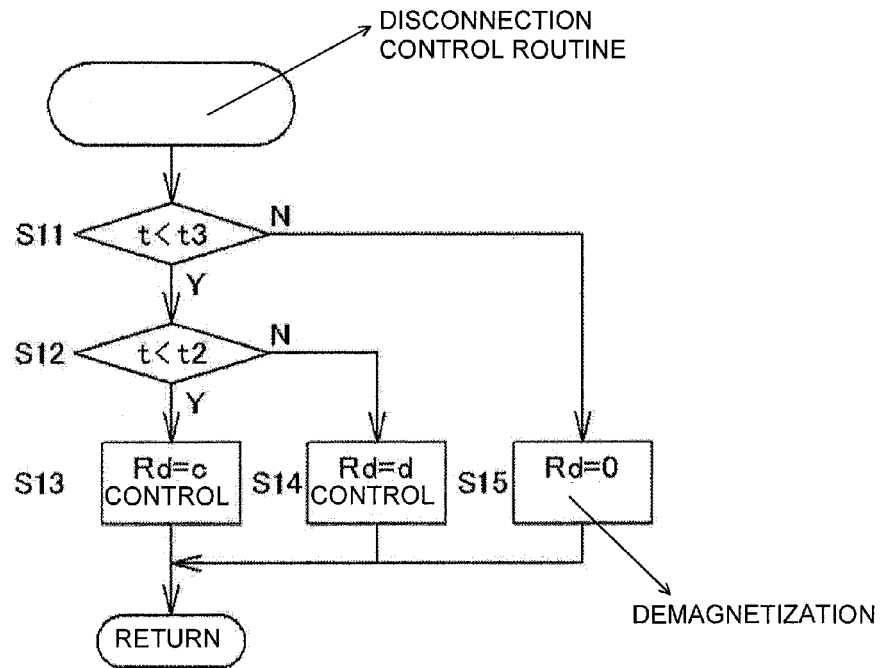


FIG. 7

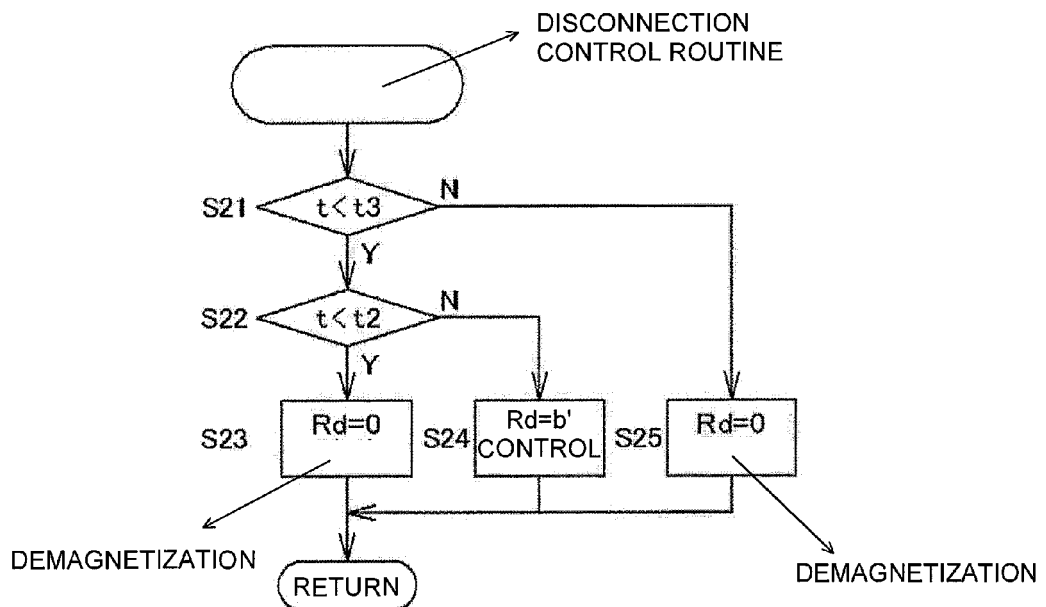


FIG. 8

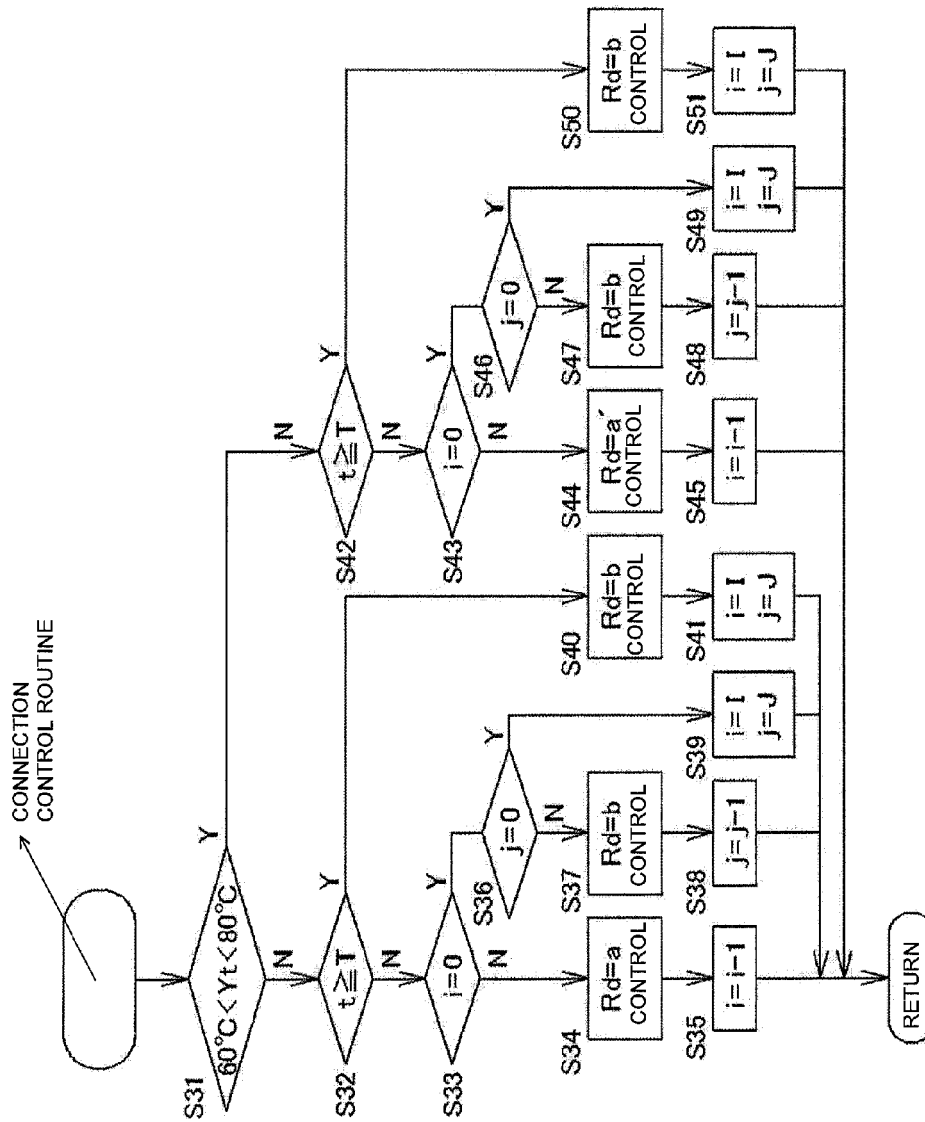


FIG. 9

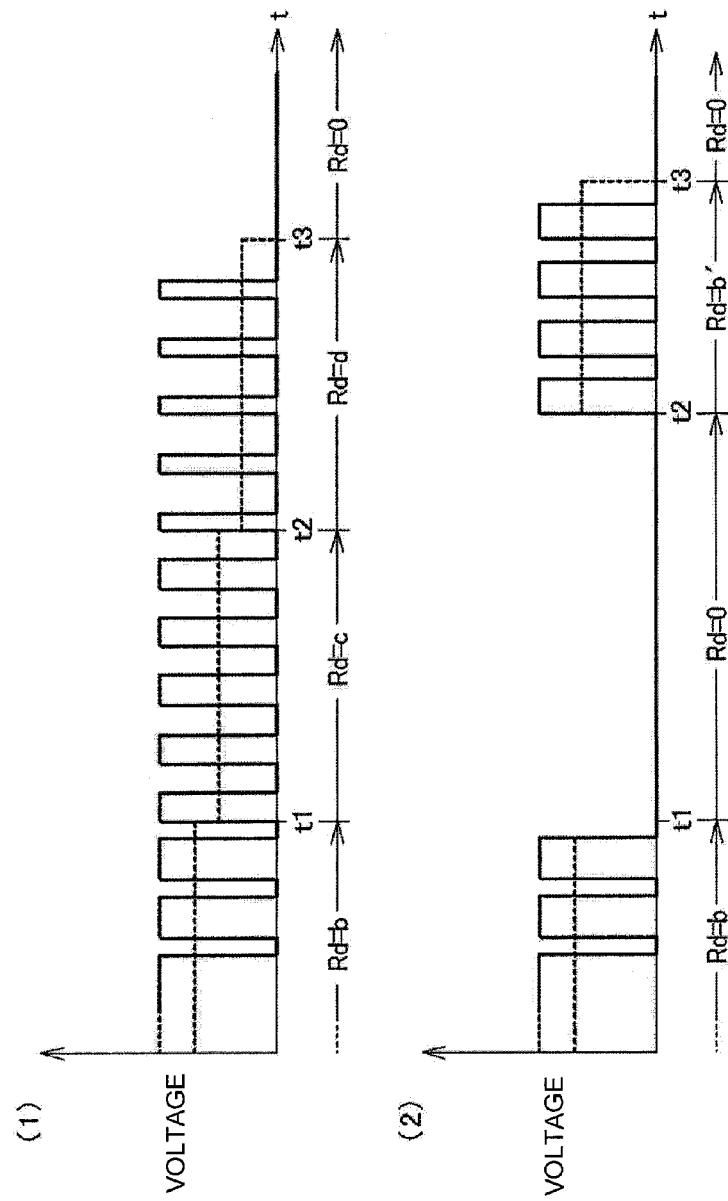
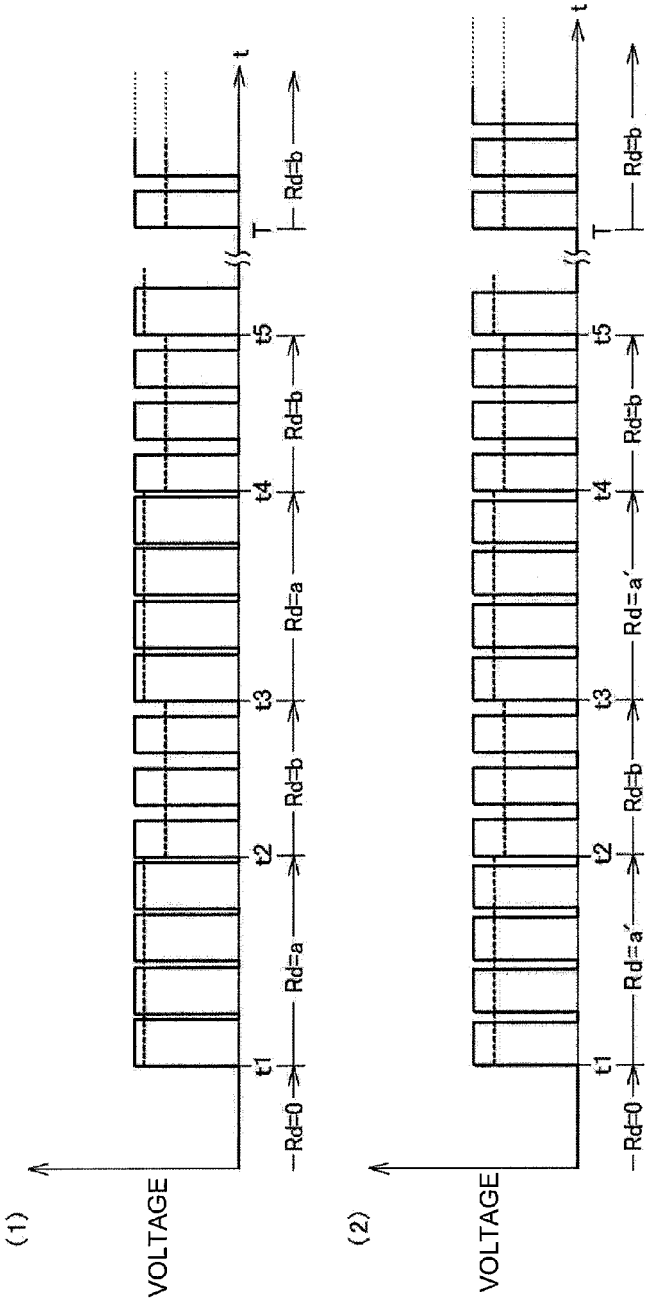


FIG. 10





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Application Number
EP 13 16 1086

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Place of search The Hague		Date of completion of the search 27 June 2013	Examiner Paquay, Jeannot
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