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(71) Applicant: **TOYOTA JIDOSHA KABUSHIKI KAISHA**
Toyota-shi, Aichi-ken, 471-8571 (JP)

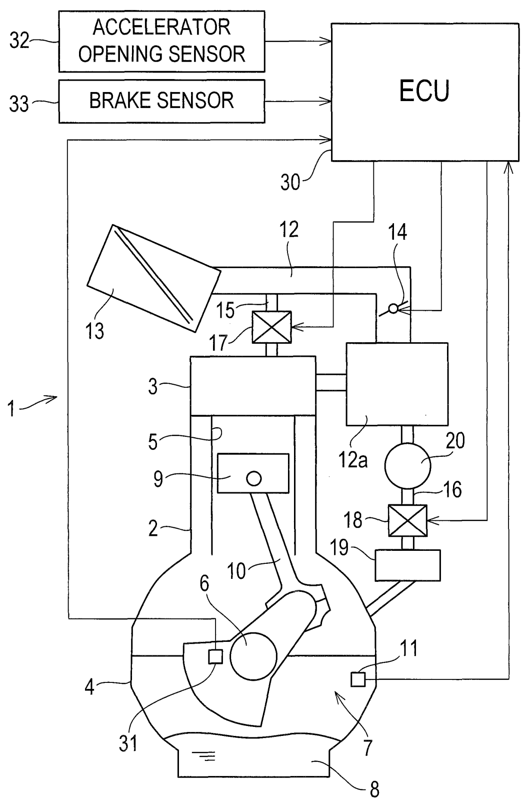
(72) Inventor: **UTSUMI, Shintaro**
Toyota-shi, Aichi-ken, 471-8571 (JP)

(74) Representative: **Albutt, Anthony John**
D Young & Co LLP
120 Holborn
London EC1N 2DY (GB)

(54) CRANKCASE VENTILATION DEVICE

(57) The crankcase ventilation apparatus comprises: a fresh air inlet passage (15) and a discharge passage (16) which connect an intake passage (12) and a crank chamber (7) of an internal combustion engine (1); an inlet valve (17) which opens and closes the fresh air inlet passage (15); a pump (20) which is provided in the discharge passage (16) ; and a discharge valve (18) which opens and closes the discharge passage (16). When a predetermined decompression condition for reducing the pressure in the crank chamber (7) is satisfied, the inlet valve (17) is closed, the discharge valve (18) is opened, and gas in the crank chamber (7) is discharged to the intake passage (12) by the pump (20).

FIG.1



EP 2 698 510 A1

Description

Technical Field

[0001] The present invention relates to a crankcase ventilation apparatus which keeps pressure in a crankcase of an internal combustion engine to be less than an atmospheric pressure.

Background Art

[0002] There is known an internal combustion engine that an intake passage and an inside of a crankcase are connected by two passages, a blow-by gas in the crankcase is discharged via one of the passages, and air is led into the crankcase from the intake passage via the other one of the passages. As such an internal combustion engine, there is known an internal combustion engine that: a one way valve and a pump is provided on the one passage and an open-close valve is provided on the other passage; the pump is stopped and the open-close valve is closed in normal times; and the pump is operated and the open-close valve is opened such as when the engine is stopped (see Patent Literature 1). In addition, there are Patent Literatures 2, 3 as prior art references in relation to the present invention.

Citation List

Patent Literature

[0003]

Patent Literature 1: WO 2009/122616
Patent Literature 2: JP-2009-293549A
Patent Literature 3: JP-2010-174734A

Summary of Invention

Technical Problem

[0004] In the internal combustion engine of the Patent Literature 1, in the normal times, pressure in the crankcase is kept at less than an atmospheric pressure by the one way valve, and the pump is stopped. And, the pump is operated only when the engine is stopped. However, the one-way valve cannot actively decrease the pressure in the crankcase. Furthermore, when an amount of generation of blow-by gas is greater than an amount of gas which is capable of discharging via the one-way valve, there is a possibility that the pressure in the crankcase is greater than the atmospheric pressure.

[0005] In view of the foregoing, one object of the present invention is to provide a crankcase ventilation apparatus capable of keeping the pressure in the crankcase to be less than the atmospheric pressure more appropriately as compared with a conventional technique.

Solution to Problem

[0006] A crankcase ventilation apparatus of the present invention comprises: a fresh air inlet passage which connects an intake passage of an internal combustion engine and an inside of a crankcase of the internal combustion engine; a fresh air adjusting valve which opens and closes the fresh air inlet passage; a discharge passage which connects a section of the intake passage, which is downstream more than a connecting position where the intake passage connects with the fresh air inlet passage, and the inside of the crankcase; a gas discharge device which includes a pump which is provided on the discharge passage to discharge gas in the inside of the crankcase to the intake passage, and which is capable of switching between a discharge state in which the gas in the inside of the crankcase is discharged to the intake passage and a discharge disabled state in which it is prevented to discharge of the gas; and a control device which closes the fresh air adjusting valve and switches the gas discharge device to the discharge state, when a predetermined decompression condition for reducing the pressure in the inside of the crankcase is satisfied.

[0007] According to the ventilation apparatus of the present invention, since the gas discharge device is switched to the discharge state when the decompression condition is satisfied, it is possible to discharge the gas in the crankcase to the intake passage by the pump in a coercive manner. Furthermore, at this time, since the fresh air adjusting valve is closed, it is possible to prevent an entry of outer air into the crankcase. Thereby, it is possible to keep the pressure in the crankcase to be less than the atmospheric pressure appropriately more than a conventional technique.

[0008] In one embodiment of the ventilation apparatus of the present invention, the ventilation apparatus may further comprise a pressure detection device which detects the pressure in the inside of the crankcase, wherein the control device may determine that the decompression condition is satisfied, when the pressure detected by the pressure detection device is greater than or equal to a predetermined target pressure. In this case, since the control device determines based on the pressure in the crankcase, it is possible to adjust the pressure in the crankcase to be less than the atmospheric pressure appropriately.

[0009] In one embodiment of the ventilation apparatus of the present invention, when a predetermined ventilation condition for ventilating the inside of the crankcase may be satisfied, first, the control device may switch the gas discharge device to the discharge state and opens the fresh air adjusting valve; next, the control device may close the fresh air adjusting valve while maintaining the gas discharge device in the discharge state; and then, the control device may switch the gas discharge device to the discharge disabled state. In this case, since first the air is led to the inside of the crankcase from the intake passage, it is possible to ventilate the inside of the crankcase. And then, an introduction of the air is stopped. Thereby, it is possible to reduce the pressure in the crankcase to be less than the atmospheric pressure.

[0010] In this embodiment, the control device may determine that the ventilation condition is satisfied when an accumulated value of time in which the internal combustion engine is operated after last ventilation of the inside of the crankcase becomes greater than or equal to a predetermined execution determination time. In this case, it is possible to ventilate the inside of the crankcase certainly each time the internal combustion engine is operated for predetermined time.

[0011] Furthermore, the ventilation apparatus may further comprise a memory device which stores correspondence relation between plural operating zones which are specified by rotational speed and load with respect to the internal combustion engine and weight coefficients which are set to operating zones respectively; and an evaluation value calculating device which specifies based on the rotational speed and the load with respect to the internal combustion engine, which operating zone the internal combustion engine being operated belongs to, and multiplies duration time when the internal combustion engine was operated in the specified operating zone by the weight coefficient of the specified operating zone to calculate an evaluation value, wherein the control device may determine that the ventilation condition is satisfied when an accumulation of the evaluation values becomes greater than or equal to a predetermined determination value, the evaluation values having been calculated since last ventilation of the inside of the crankcase was executed. As well known, an amount of generation of the blow-by gas changes depending on the rotational speed and the load with respect to the internal combustion engine. Thereby, by determining whether or not to ventilate based on the accumulation of the weight coefficient and duration time, it is possible to adjust an interval of the ventilation depending on the amount of generation of the blow-by gas.

[0012] The control device may determine that the ventilation condition is satisfied when rotational speed of the internal combustion engine is in a predetermined low rotational speed range or when the rotational speed of the internal combustion engine is expected to become within the low rotational speed range. In this case, even if the operating time of the internal combustion engine is short, it is possible to ventilate the inside of the crankcase each time the internal combustion engine is operated.

[0013] In one embodiment of the ventilation apparatus of the present invention, the internal combustion engine may be a single-cylinder engine or a two-cylinder engine. As well known, in the single-cylinder engine or the two-cylinder engine, a volume of the inside of the crankcase changes greatly by an up-and-down movement of the piston. In this case, since the pressure in the crankcase pulsates greatly, there is a possibility that a peak of the pulsation is greater than or equal to the atmospheric pressure. In the present invention, since it is possible to discharge the gas in the crankcase in a coercive manner, it is possible to decrease the peak of the pulsation. Thereby, in such the internal combustion engine, it is possible to keep the pressure in the crankcase to be less than the atmospheric pressure.

Brief Description of Drawings

[0014]

Fig. 1 is a diagram showing an internal combustion engine where a crankcase ventilation apparatus according to one embodiment of the present invention is incorporated.

Fig. 2 is a flowchart showing a pressure control routine executed by the ECU.

Fig. 3 is a flowchart showing a ventilation control routine executed by the ECU.

Description of Embodiments

[0015] Fig. 1 shows an internal combustion engine where a crankcase ventilation apparatus according to one embodiment of the present invention is incorporated. The internal combustion engine (hereinafter, referred to as an engine) 1 is a four-stroke engine mounted on a vehicle as a traveling power source. The engine 1 includes a cylinder block 2, a cylinder head 3, and a crankcase 4. The cylinder block 2 is provided with two cylinders 5 which are arranged in one direction. Thereby, the engine 1 is a straight-twin engine. Furthermore, in the engine 1, explosive phases of the two cylinders 5 are displaced by crank angle 360 degrees from each other, and thereby, an equal interval explosion is realized. In Fig. 1, only one cylinder 5 is shown. The cylinder head 3 is mounted on a top portion of the cylinder block 2 so that an opening section of each cylinder 5 is closed. The crankcase 4 is attached to a bottom portion of the cylinder block 2. By assembling the cylinder block 2 and the crankcase 4 so that a crankshaft 6 is sandwiched therebetween, a crank chamber 7 is formed. Oil 8 is pooled in a bottom of the crank chamber 7. A piston 9 is inserted in each cylinder 5 so as to be movable in a reciprocating manner. Two pistons 9 are connected to the crankshaft 6 via a connecting rod 10 so as to move up-and-down at the same time. The crank chamber 7 is provided with a pressure sensor 11 as a pressure detection device. The pressure sensor 11 outputs a signal corresponding to pressure in the crank chamber 7.

[0016] Each cylinder 5 is connected with an intake passage 12. The intake passage 12 includes an intake manifold 12a which distributes intake gas to each cylinder 5. The intake passage 12 is provided with an air cleaner 13 which filters the intake gas and a throttle valve 14 which adjusts an intake gas amount. The engine 1 has a fresh air inlet passage 15 and a discharge passage 16. These passages 15, 16 connect the intake passage 12 and the crank chamber 7. As shown in this figure, the discharge passage 16 connects a section of the intake passage 12, which is downstream more than a connecting position where the intake passage 12 connects with the fresh air inlet passage 15, and the crank chamber 7. The fresh air inlet passage 15 is provided with an inlet valve 17 which opens and closes this passage 15. The discharge passage 16 is provided with an oil separator 19, a discharge valve 18 which opens and closes this passage 16, and a pump 20 for discharging gas from the crank chamber 7 to the intake passage 12. The pump 20 is driven by a rotating shaft of the engine 1 such as a camshaft or a balance shaft. Thereby, the pump 20 keeps on operating while the engine 1 is operated. In this case, the gas in the crank chamber 7 is discharged when the discharge valve 18 is opened, and the discharge of the gas is stopped when the discharge valve 18 is closed. Thereby, a state in which the discharge valve 18 is opened corresponds to a discharge state of the present invention, and a state in which the discharge valve 18 is closed corresponds to a discharge disabled state of the present invention. Furthermore, the discharge valve 18 and the pump 20 correspond to a gas discharge device of the present invention. The inlet valve 17 corresponds to a fresh air adjusting valve.

[0017] The operations of the inlet valve 17 and the discharge valve 18 are controlled by an engine control unit (ECU) 30 respectively. The ECU 30 is a computer unit including a microprocessor and peripheral devices, such as a RAM and a ROM, which are necessary for operations of the microprocessor. The ECU 30 controls the engine 1 to be in a targeted operating state by controlling the throttle valve 14 and the like in accordance with a predetermined control program. The ECU 30 is connected with various sensors such as a crank angle sensor 31, an accelerator opening sensor 32, and a brake sensor 33 and the like in order to determine an operating state of the engine 1. The crank angle sensor 31 outputs a signal corresponding to rotational speed of the crankshaft 6. The accelerator opening sensor 32 outputs a signal corresponding to an accelerator opening degree. The brake sensor 33 outputs a signal corresponding to whether or not a brake pedal is pressed. In addition, the ECU 30 is also connected with the pressure sensor 11.

[0018] In the engine 1, since the two pistons 9 move up-and-down at the same time, a volume of the crank chamber 7 changes greatly. As a result, since the pressure in the crank chamber 7 pulsates greatly, a period in which the pressure is greater than or equal to the atmospheric pressure is generated if the pressure in the crank chamber 7 is not reduced appropriately. A target pressure is set for a minimum value of the pulsating pressure. And, the ECU 30 controls the pressure in the crank chamber 7 so that the minimum value is less than the target pressure. The target value is set so that a peak of the pressure pulsation is less than the atmospheric pressure. Fig. 2 shows a pressure control routine the ECU 30 executes for controlling the pressure in the crank chamber 7. The ECU 30 repeatedly executes the routine at predetermined intervals during operation of the engine 1. Furthermore, by executing this routine, the ECU 30 functions as a control device of the present invention.

[0019] In the routine of Fig. 2, the ECU 30 first obtains the operating state of the engine 1 in step S11. In this process, the ECU 30 obtains the rotational speed of the crankshaft 6, the accelerator opening degree, the state of the brake pedal, and the pressure in the crank chamber 7 and the like as the operating state of the engine 1. In next step S12, the ECU 30 determines whether or not a decompression condition is satisfied. The ECU 30 determines that the decompression condition is satisfied when the minimum value of the pressure pulsation of the crank chamber 7 is greater than or equal to the target pressure above mentioned, for example.

[0020] When the ECU 30 determines that the decompression condition is satisfied, the ECU 30 goes to step S13 and executes a decompression control. In the decompression control, the ECU 30 first closes the inlet valve 17, and then opens the discharge valve 18. As a result, the gas in the crank chamber 7 is discharged to the intake passage 12 by the pump 20, and the pressure in the crank chamber 7 is reduced. Thereafter, the ECU 30 ends the control routine of this time.

[0021] On the other hand, when the ECU 30 determines that the decompression condition is not satisfied, the ECU 30 goes to step S14 and closes the inlet valve 17 and the discharge valve 18 respectively. Thereafter, the ECU 30 ends the control routine of this time.

[0022] According to the present invention, when the decompression condition is satisfied, the gas in the crank chamber 7 is discharged by the pump 20 in a coercive manner. Furthermore, since the inlet valve 17 is closed at this time, it is possible to prevent an entry of outer air into the crank chamber 7. Thereby, it is possible to keep the pressure in the crank chamber 7 to be less than the atmospheric pressure appropriately more than a conventional technique.

[0023] Furthermore, in addition, the ECU 30 executes a ventilation control routine shown in Fig. 3 for ventilating the crank chamber 7. The ECU 30 repeatedly executes this routine at predetermined intervals during operation of the engine 1. Furthermore, the ECU 30 executes this routine in parallel to the other routines executed by the ECU 30. In Fig. 3, the same process as those of Fig. 2 are denoted by the same reference numerals respectively, and descriptions thereof will be omitted.

[0024] In the routine of Fig. 3, the ECU 30 first obtains the operating state of the engine 1 in step S11. In next step S21, the ECU 30 determines whether or not a predetermined ventilation condition is satisfied. For example, the ECU 30 accumulates operating time of the engine 1 after last ventilation of the crank chamber 7, and determines that the ventilation condition is satisfied when the operating time accumulated is greater than or equal to a predetermined execution determination time. The ECU 30 calculates the accumulated operating time by executing another routine different from this routine, and resets the accumulated operating time to zero when the ventilation is executed. The execution determination time may be set appropriately depending on a displacement of the engine 1, a volume of the crank chamber 7, and the like. When the ECU 30 determines that the ventilation condition is not satisfied, the ECU 30 skips subsequent processes, and ends the routine of this time.

[0025] On the other hand, when the ECU 30 determines that the ventilation condition is satisfied, the ECU 30 goes to step S22 to calculate a ventilation time. The ventilation time is set to time necessary for ventilating the crank chamber 7 adequately by air, for example, time necessary for a concentration of nitrogen oxide (NOx) and a concentration of carbon monoxide (CO) in the crank chamber 7 to become less than predetermined concentrations respectively. Such time changes depending on the rotational speed and a load of the engine 1, the volume of the crank chamber 7, and the like. Relations between: the rotational speed and the load with respect to the engine 1; and the ventilation time are obtained in advance through experiments, numerical calculations, or the like, and stored as a map in the ROM of the ECU 30. And, the ventilation time may be calculated based on the map. In next step S23, the ECU 30 opens the inlet valve 17 and the discharge valve 18. As a result, the gas is discharged from the crank chamber 7 in a coercive manner, and the air is led to the crank chamber 7. In next step S24, the ECU 30 resets a timer for measuring an elapsed time from when each valve 17, 18 is opened, and then starts count of the timer. In next step S25, the ECU 30 determines whether or not the ventilation time is elapsed from when each valve 17, 18 is opened.

[0026] When the ECU 30 determines that the ventilation time is not elapsed, the ECU 30 executes step S25 repeatedly until the ventilation time is elapsed. On the other hand, when the ECU 30 determines that the ventilation time is elapsed, the ECU 30 goes to step S26 to close the inlet valve 17. In next step S27, the ECU 30 determines whether or not the minimum value of the pressure pulsation of the crank chamber 7 is less than the target pressure. When the ECU 30 determines that the minimum value is greater than or equal to the target pressure, the ECU 30 executes step S27 repeatedly until the minimum value becomes less than the target pressure. On the other hand, when the ECU 30 determines that the minimum value is less than the target pressure, the ECU 30 goes to step S28 to close the discharge valve 18. Thereafter, the ECU 30 ends the routine of this time.

[0027] In the ventilation control, since the inlet valve 17 and the discharge valve 18 are opened first, it is possible to ventilate the crank chamber 7. And, since the inlet valve 17 only is closed after the ventilation time is elapsed, it is possible to reduce the pressure of the crank chamber 7 to less than the atmospheric pressure.

[0028] In the two controls above described, the inlet valve 17 and the discharge valve 18 are controlled. So, priority orders are given to the pressure control and the ventilation control respectively, and the control of each valve 17, 18 may be executed in accordance with the priority orders. For example, when each valve 17, 18 is opened for the ventilation control, the control of each valve 17, 18 for the pressure control may be canceled. As the result, it is possible to prevent a conflicted control with respect to each valve 17, 18.

[0029] It may be determined whether or not the ventilation condition is satisfied by using a following method besides the determination method above described. In the ROM of the ECU 30, stored as a map is correspondence relation between: plural operating zones which are specified by the rotational speed and the load with respect to the engine 1; and weight coefficients which are set to the operating zones respectively. Each operating zone is set so as not to be overlapped each other. The weight coefficient is set so as to increase as the rotational speed increases and as the load increases. When the engine 1 is operated, the ECU 30 specifies based on the rotational speed and the load, which operating zone the engine 1 being operated belongs to, and multiplies duration time when the engine 1 was operated in the specified operating zone by the weight coefficient of the specified operating zone to calculate an evaluation value. And, it may be determined that the ventilation condition is satisfied when an accumulation of the evaluation values becomes greater than or equal to a predetermined determination value, the evaluation values having been calculated since last ventilation of the crank chamber 7 was executed.

[0030] As well known, an amount of generation of the blow-by gas increases as the rotational speed increases and as the load increases. Thereby, by determining in this manner, it is possible to reduce an interval of the ventilation when the amount of generation of the blow-by gas is large. As the result, it is possible to ventilate before a concentration of the blow-by gas in the crank chamber 7 becomes high. Thereby, it is possible to suppress deterioration of oil by the blow-by gas. Furthermore, as the result, it is possible to avoid a deterioration of fuel efficiency. In this case, the ECU 30 corresponds to a memory device and an evaluation value calculating device.

[0031] Furthermore, when the rotational speed of the engine 1 is within a predetermined low rotational speed range or when the rotational speed is expected to become within the low rotational speed range, it may be determined that the ventilation condition is satisfied. In particular, for example, when a state in which an accelerator pedal is not pressed and the brake pedal is pressed is maintained for predetermined time, it may be determined that the ventilation condition is satisfied. Furthermore, when the vehicle is decelerated from an acceleration state or a steady running state, it may be determined that the ventilation condition is satisfied. In addition, when the engine 1 is idled, it may be determined that the ventilation condition is satisfied. If the engine 1 is an object of an idling stop control, when a condition for stopping the engine 1 is satisfied, it may be determined that the ventilation condition is satisfied. In this case, the operation of the engine 1 is maintained until the ventilation is completed. Then, after ventilation is completed, the engine 1 may be stopped.

[0032] In this case, it is possible to ventilate the crank chamber 7 certainly each time the engine 1 is operated, even if the operating time of the engine 1 is short. Thereby, it is possible to suppress the deterioration of the oil further. Furthermore, it is possible to avoid the deterioration of fuel efficiency. When the engine 1 is operated at low rotational speed, the pressure pulsation of the crank chamber 7 is small. Furthermore, the amount of generation of the blow-by gas is also small. Thereby, it is possible to reduce the pressure of the crank chamber 7 easily.

[0033] The present invention is not limited to the above-described embodiments, and various modifications of the present invention may be provided. For example, an engine which is applied to the present invention is not limited to the two-cylinder engine. The present invention may be applied to a single-cylinder engine or an engine having three or more cylinders. In the single-cylinder engine, as with the two-cylinder engine, the volume of the crank chamber changes greatly by an up-and-down movement of the piston. In this case, since the pressure pulsation of the crank chamber increases, there is a possibility that a peak of the pressure pulsation is greater than or equal to the atmospheric pressure. When the present invention is applied to even such engine, it is possible to keep the pressure of the crank chamber to be less than the atmospheric pressure.

[0034] The pump may be an electrical pump which is driven by a motor. In this case, by performing on-off control of the pump, it is possible to control discharge of gas and stop of the discharge. Thereby, it is possible to omit the discharge valve. In this case, the electrical pump corresponds to the gas discharge device of the present invention.

[0035] In the embodiment above described, the target pressure is set for the minimum value of the pulsating pressure. The target pressure may be set for an average value or a peak value with respect to the pulsating pressure. In these cases, the target value is also set so that the peak value is less than the atmospheric pressure.

Claims

1. A crankcase ventilation apparatus comprising:

    a fresh air inlet passage which connects an intake passage of an internal combustion engine and an inside of a crankcase of the internal combustion engine;
    a fresh air adjusting valve which opens and closes the fresh air inlet passage;
    a discharge passage which connects a section of the intake passage, which is downstream more than a connecting position where the intake passage connects with the fresh air inlet passage, and the inside of the crankcase;
    a gas discharge device which includes a pump which is provided on the discharge passage to discharge gas in the inside of the crankcase to the intake passage, and which is capable of switching between a discharge state in which the gas in the inside of the crankcase is discharged to the intake passage and a discharge disabled state in which it is prevented to discharge of the gas; and
    a control device which closes the fresh air adjusting valve and switches the gas discharge device to the discharge state, when a predetermined decompression condition for reducing the pressure in the inside of the crankcase is satisfied.

2. The crankcase ventilation apparatus according to claim 1, further comprising
    a pressure detection device which detects the pressure in the inside of the crankcase, wherein
    the control device determines that the decompression condition is satisfied, when the pressure detected by the pressure detection device is greater than or equal to a predetermined target pressure.

3. The crankcase ventilation apparatus according to claim 1 or 2, wherein
    when a predetermined ventilation condition for ventilating the inside of the crankcase is satisfied,
    first, the control device switches the gas discharge device to the discharge state and opens the fresh air adjusting valve;
    next, the control device closes the fresh air adjusting valve while maintaining the gas discharge device in the discharge state;
    and then, the control device switches the gas discharge device to the discharge disabled state.

4. The crankcase ventilation apparatus according to claim 3, wherein
    the control device determines that the ventilation condition is satisfied when an accumulated value of time in which the internal combustion engine is operated after last ventilation of the inside of the crankcase becomes greater than or equal to a predetermined execution determination time.

5. The crankcase ventilation apparatus according to claim 3, further comprising:

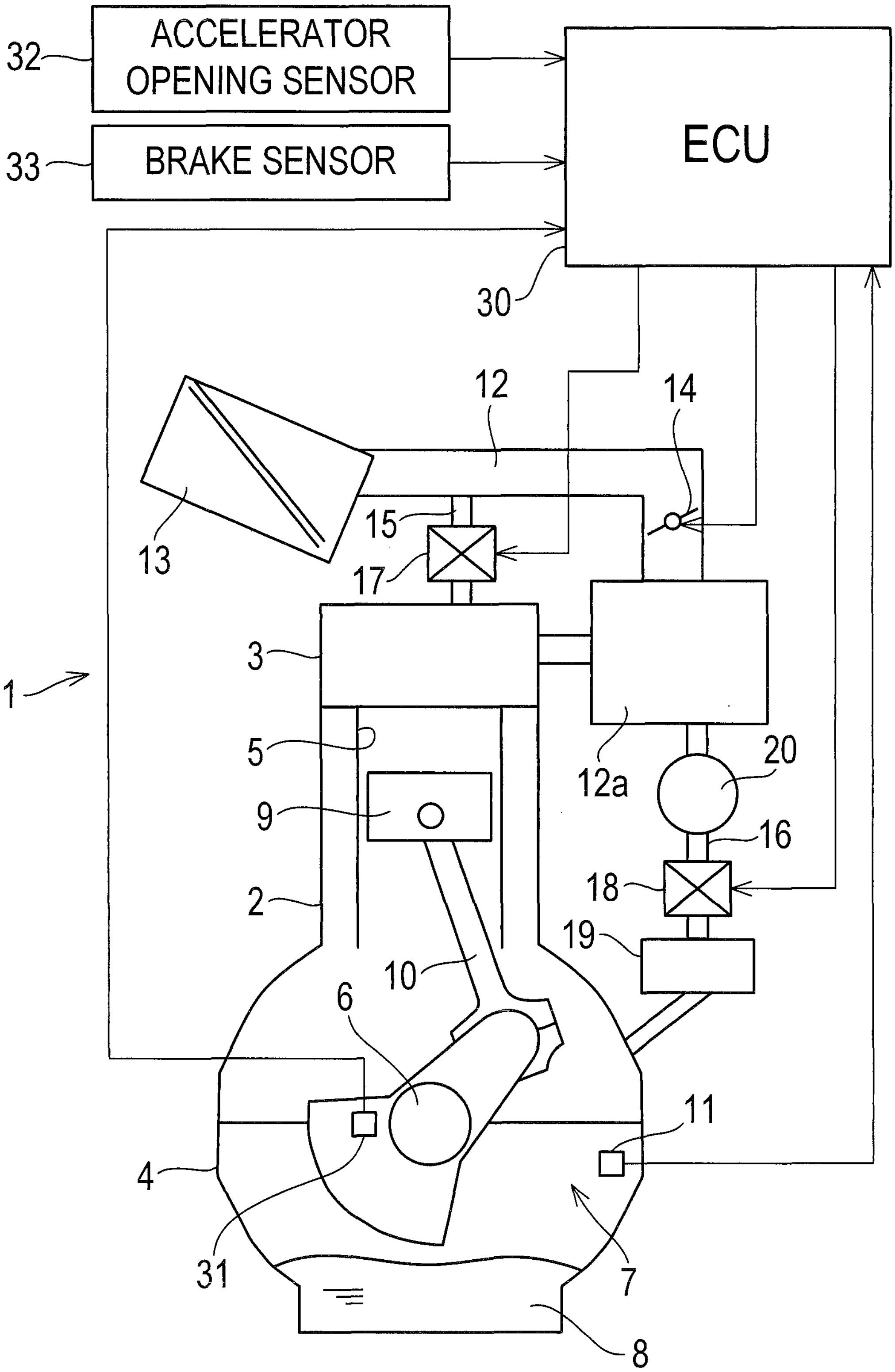
    a memory device which stores correspondence relation between plural operating zones which are specified by rotational speed and load with respect to the internal combustion engine and

weight coefficients which are set to operating zones respectively; and
an evaluation value calculating device which specifies based on the rotational speed and the load with respect to the internal combustion engine, which operating zone the internal combustion engine being operated belongs to, and multiplies duration time when the internal combustion engine was operated in the specified operating zone by the weight coefficient of the specified operating zone to calculate an evaluation value, wherein
the control device determines that the ventilation condition is satisfied when an accumulation of the evaluation values becomes greater than or equal to a predetermined determination value, the evaluation values having been calculated since last ventilation of the inside of the crankcase was executed.

6. The crankcase ventilation apparatus according to claim 3, wherein
the control device determines that the ventilation condition is satisfied when rotational speed of the internal combustion engine is in a predetermined low rotational speed range or when the rotational speed of the internal combustion engine is expected to become within the low rotational speed range.

7. The crankcase ventilation apparatus according to any one of claims 1 to 6, wherein
the internal combustion engine is a single-cylinder engine or a two-cylinder engine.

FIG.1



32
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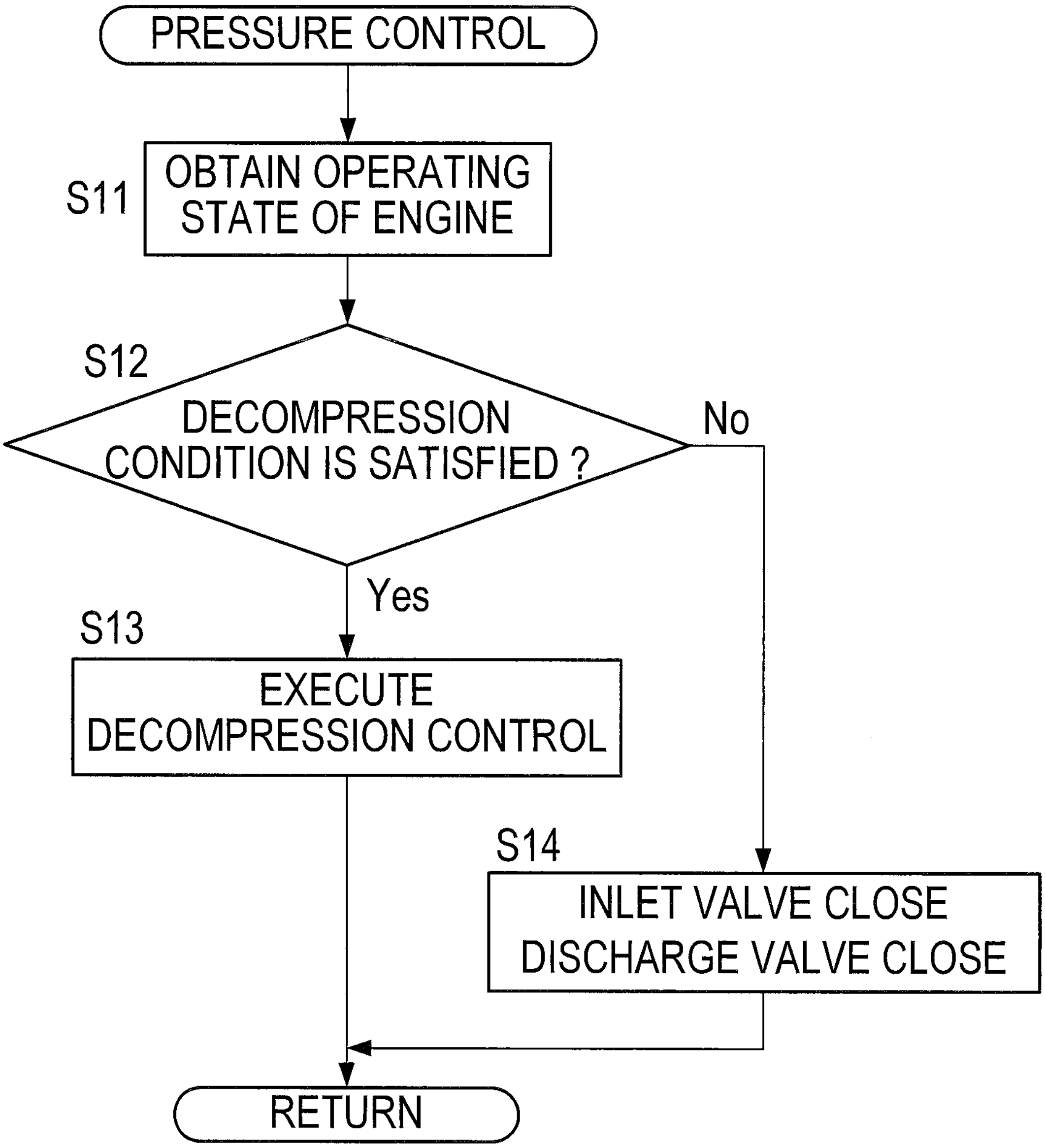
FIG.2


PRESSURE CONTROL
S11
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S12
DECOMPRESSION CONDITION IS SATISFIED ?
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Yes
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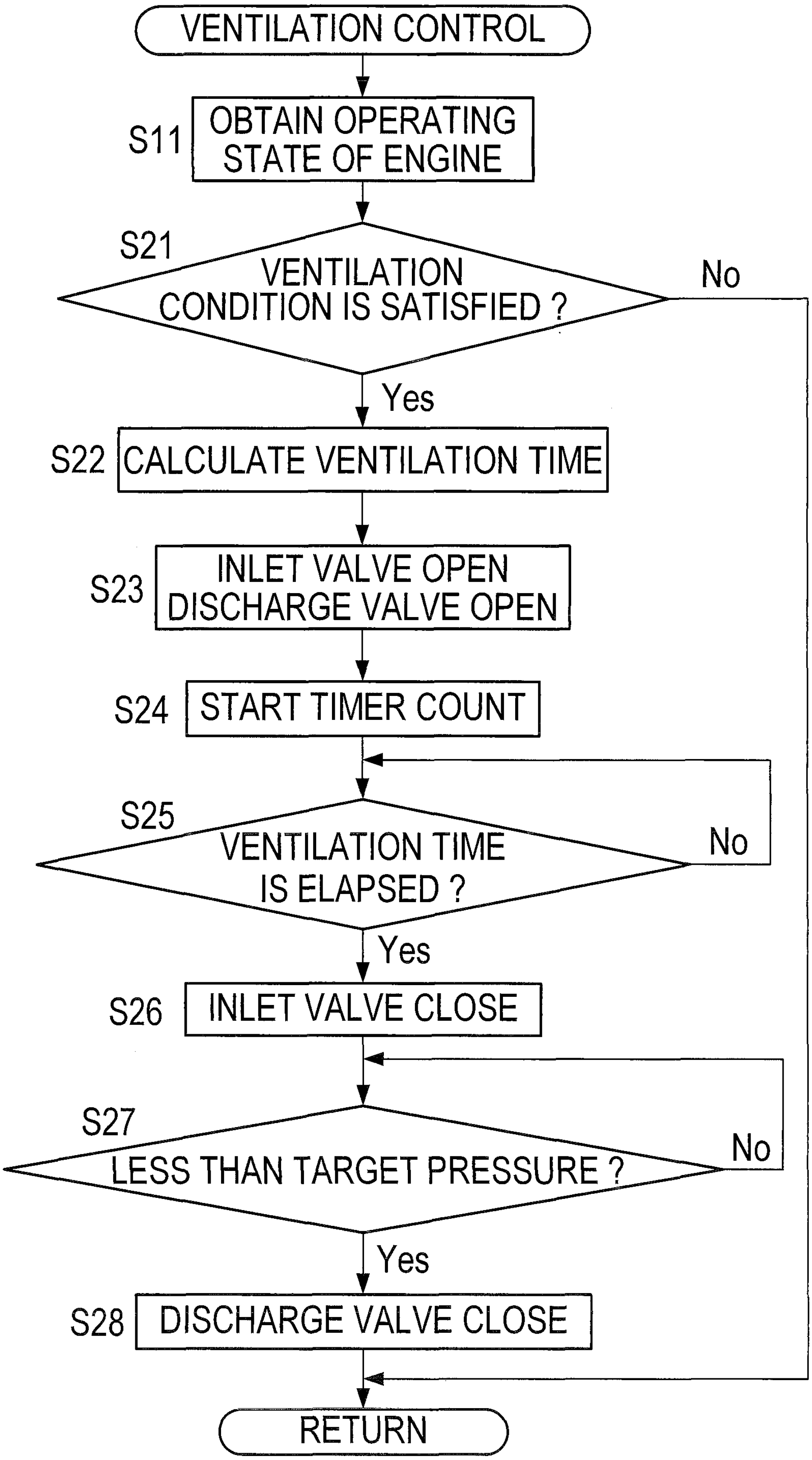
EXECUTE DECOMPRESSION CONTROL
S14
INLET VALVE CLOSE
DISCHARGE VALVE CLOSE
RETURN

FIG.3


VENTILATION CONTROL
S11
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S21
VENTILATION CONDITION IS SATISFIED ?
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Yes
S22
CALCULATE VENTILATION TIME
S23
INLET VALVE OPEN
DISCHARGE VALVE OPEN
S24
START TIMER COUNT
S25
VENTILATION TIME IS ELAPSED ?
No
Yes
S26
INLET VALVE CLOSE
S27
LESS THAN TARGET PRESSURE ?
No
Yes
S28
DISCHARGE VALVE CLOSE
RETURN

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/059073

A. CLASSIFICATION OF SUBJECT MATTER
F01M13/00(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)
F01M13/00

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2010-174659 A (Nippon Soken, Inc.), 12 August 2010 (12.08.2010), entire text; all drawings (Family: none)	1,2,7 3-6
Y A	JP 5-60000 A (Mazda Motor Corp.), 09 March 1993 (09.03.1993), entire text; all drawings (Family: none)	1,2,7 3-6
A	JP 2001-164918 A (Nissan Motor Co., Ltd.), 19 June 2001 (19.06.2001), entire text; all drawings (Family: none)	1-7

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

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search 12 May, 2011 (12.05.11)	Date of mailing of the international search report 24 May, 2011 (24.05.11)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/059073

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2009-191790 A (Toyota Motor Corp.), 27 August 2009 (27.08.2009), entire text; all drawings (Family: none)	1-7

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