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(54) EXHAUST GAS PURIFICATION APPARATUS AND EXHAUST GAS PURIFICATION METHOD

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(57) ABSTRACT

An exhaust gas purification apparatus which is installed in a flow channel of an exhaust gas discharged from an engine, includes: a first purification device that purifies one component contained in the gas; a heating device that heats the purification device to a predetermined temperature in a period from before the engine is started to a first point in time that is after the engine is started; control device that controls an air-fuel ratio of the gas so as to obtain a air-fuel ratio suitable for purifying the one component in a period from the time when the engine is started to a point in time that is on or after a time at which the purification device is heated to the predetermined temperature; and an adsorption device that communicates with the downstream of the first purification device and adsorbs another component contained in the gas.

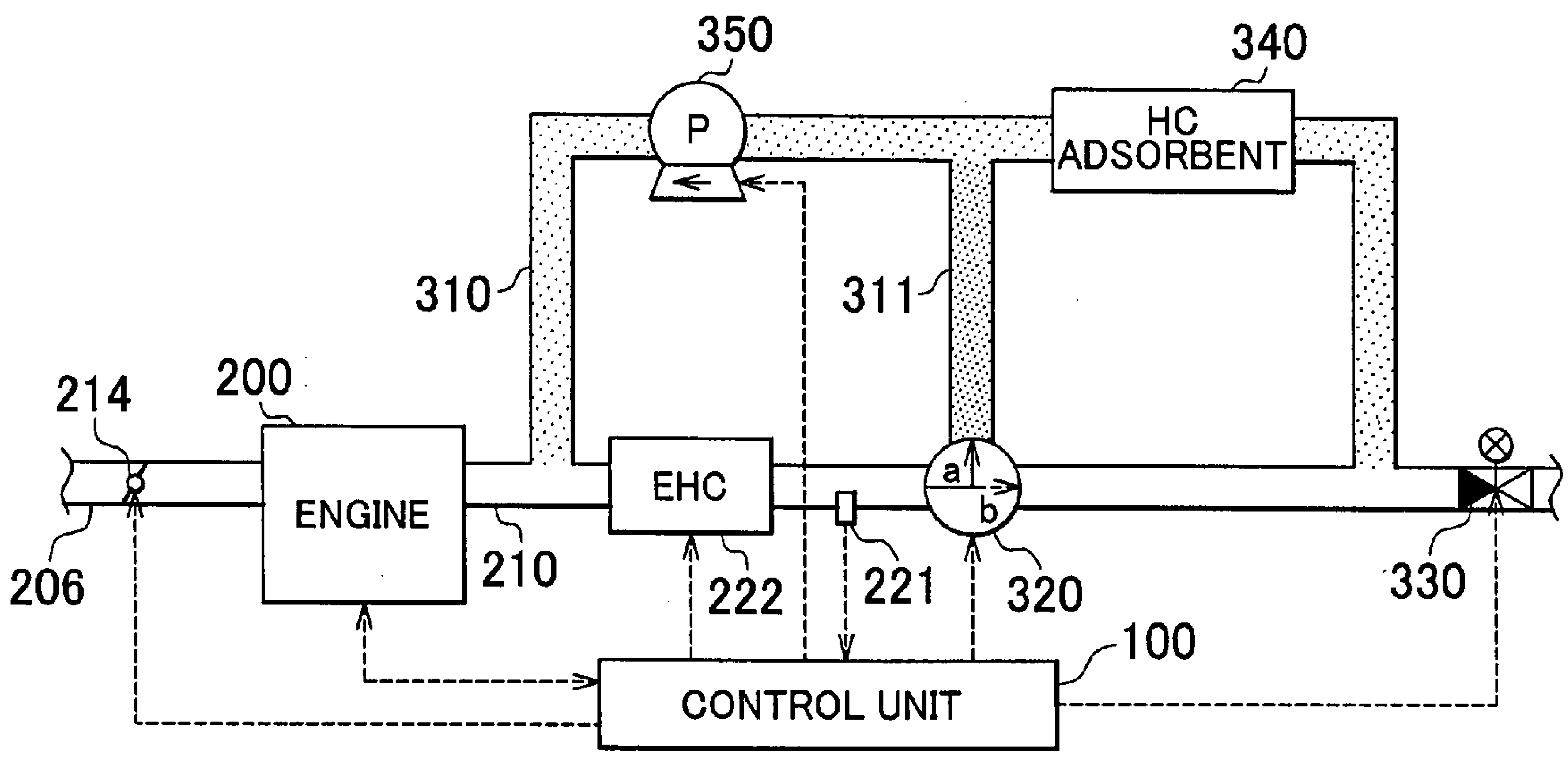
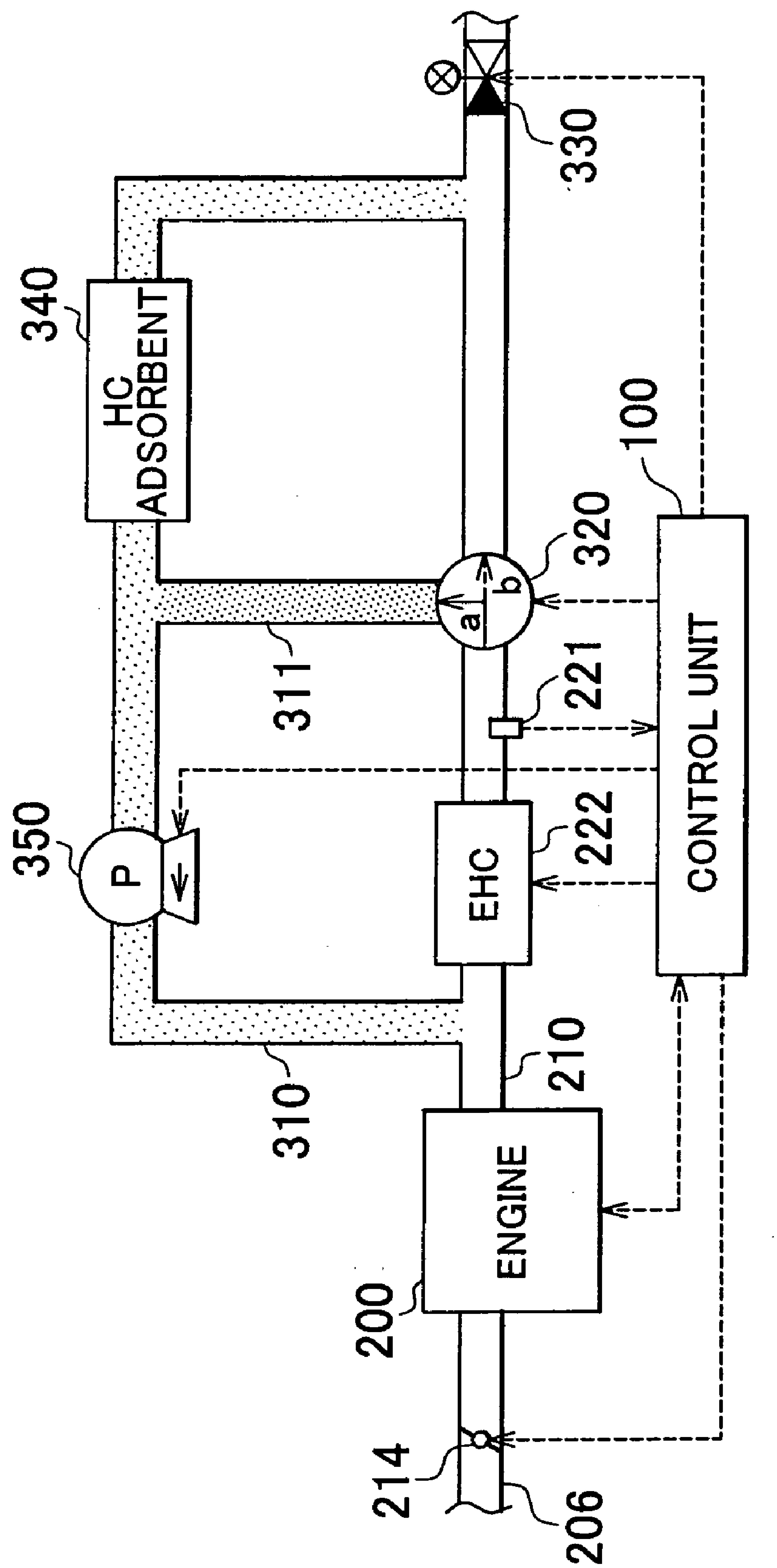


FIG. 1



HC ADSORBENT
340
330
350
P
311
320
a
b
221
100
EHC
222
CONTROL UNIT
310
210
ENGINE
200
214
206

FIG. 2

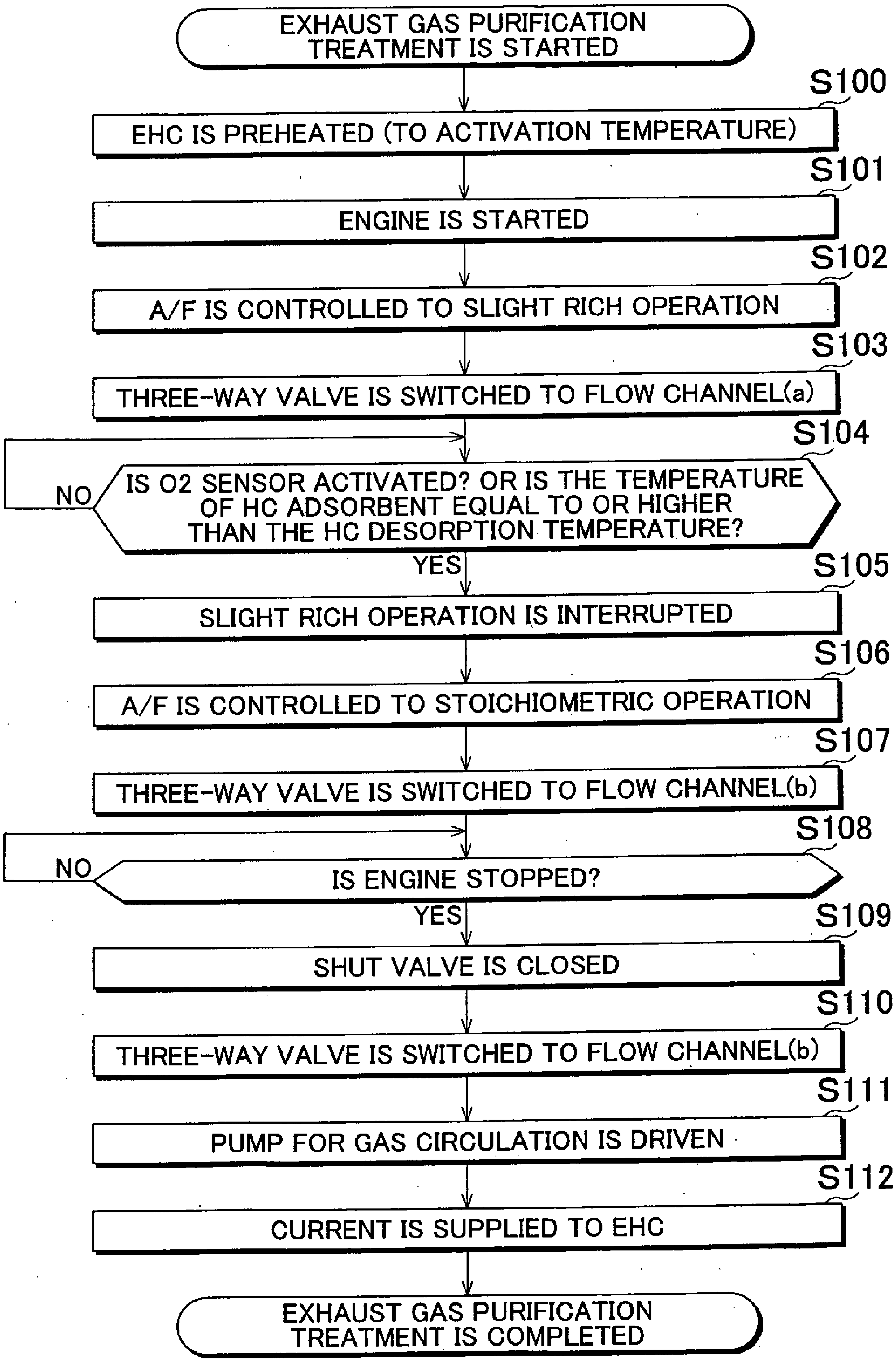

EXHAUST GAS PURIFICATION TREATMENT IS STARTED
S100
EHC IS PREHEATED (TO ACTIVATION TEMPERATURE)
S101
ENGINE IS STARTED
S102
A/F IS CONTROLLED TO SLIGHT RICH OPERATION
S103
THREE-WAY VALVE IS SWITCHED TO FLOW CHANNEL(a)
S104
IS O2 SENSOR ACTIVATED? OR IS THE TEMPERATURE OF HC ADSORBENT EQUAL TO OR HIGHER THAN THE HC DESORPTION TEMPERATURE?
NO
YES
S105
SLIGHT RICH OPERATION IS INTERRUPTED
S106
A/F IS CONTROLLED TO STOICHIOMETRIC OPERATION
S107
THREE-WAY VALVE IS SWITCHED TO FLOW CHANNEL(b)
S108
IS ENGINE STOPPED?
NO
YES
S109
SHUT VALVE IS CLOSED
S110
THREE-WAY VALVE IS SWITCHED TO FLOW CHANNEL(b)
S111
PUMP FOR GAS CIRCULATION IS DRIVEN
S112
CURRENT IS SUPPLIED TO EHC
EXHAUST GAS PURIFICATION TREATMENT IS COMPLETED

FIG. 3

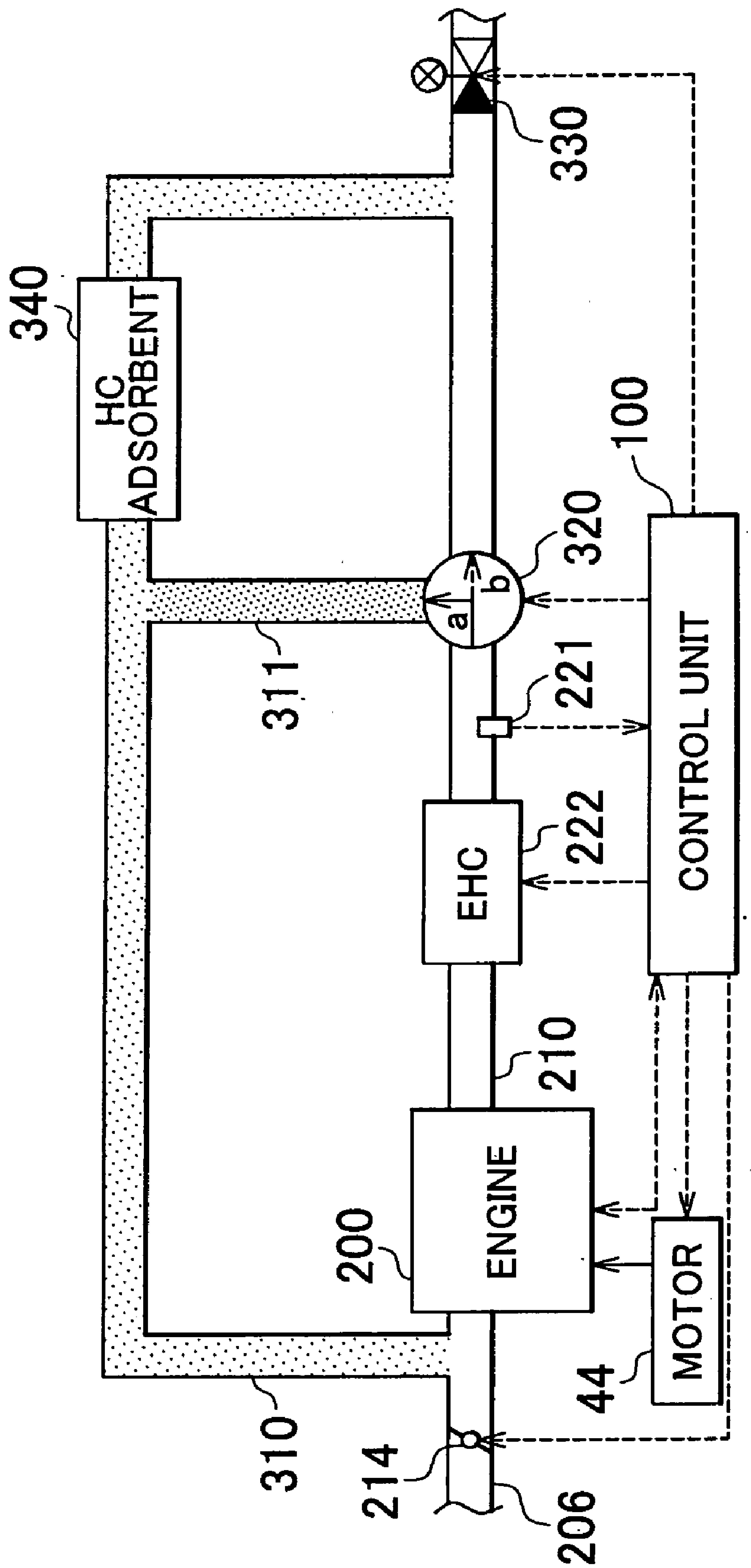
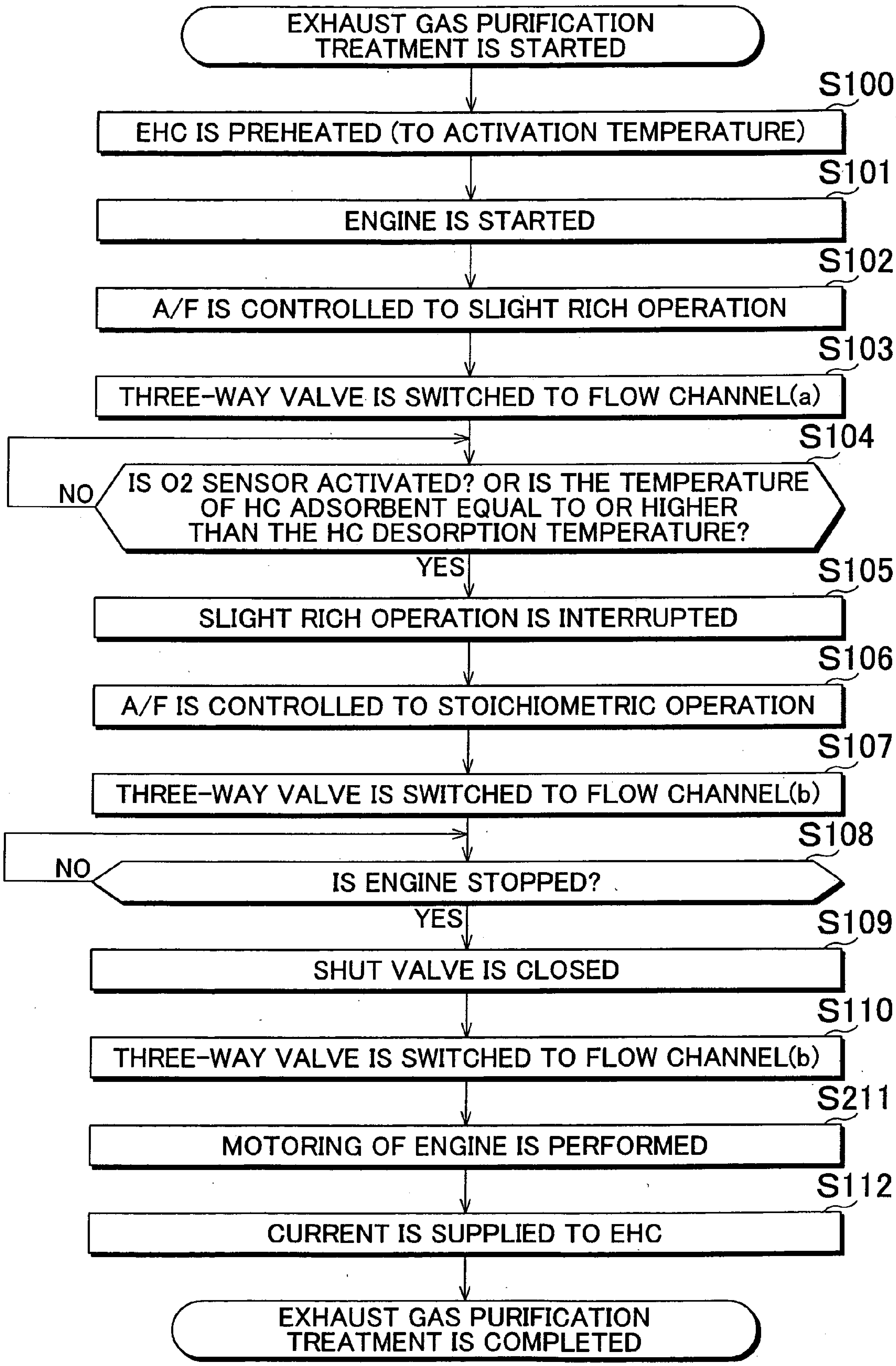

HC ADSORBENT
340
330
100
320
a
b
311
221
222
EHC
CONTROL UNIT
210
ENGINE
200
MOTOR
44
310
214
206

FIG. 4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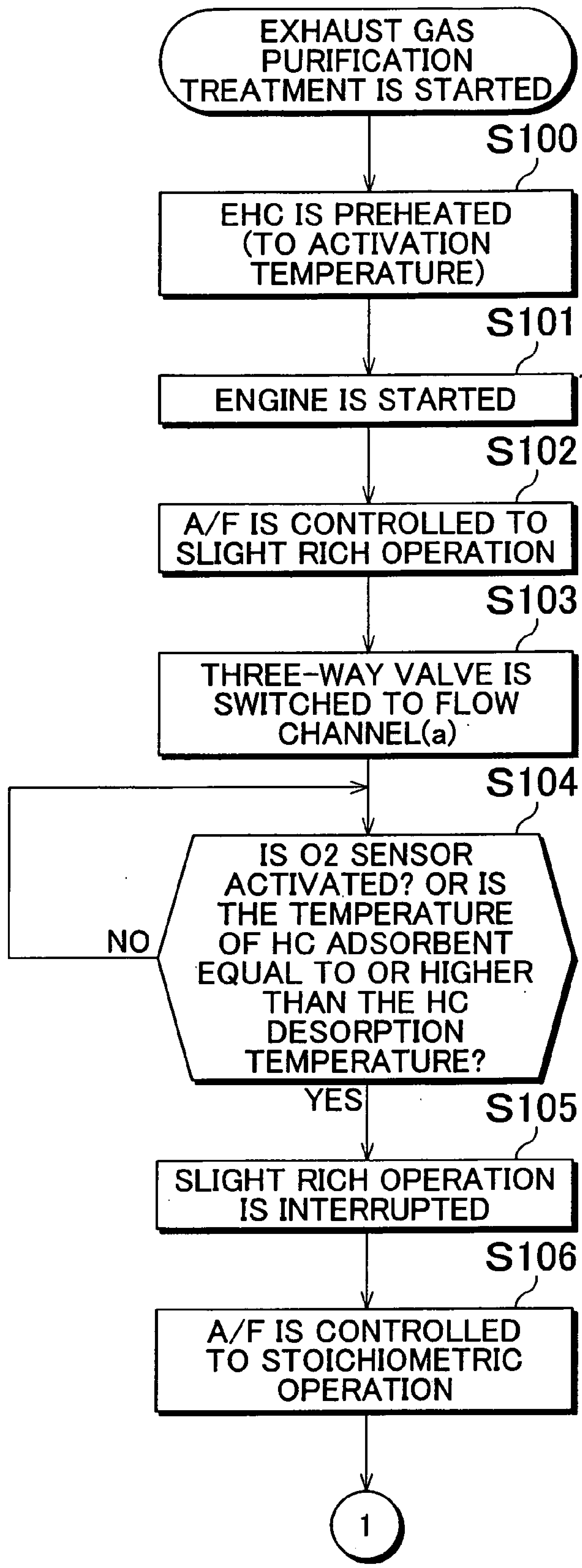
S100
EHC IS PREHEATED (TO ACTIVATION TEMPERATURE)
S101
ENGINE IS STARTED
S102
A/F IS CONTROLLED TO SLIGHT RICH OPERATION
S103
THREE-WAY VALVE IS SWITCHED TO FLOW CHANNEL(a)
S104
IS O2 SENSOR ACTIVATED? OR IS THE TEMPERATURE OF HC ADSORBENT EQUAL TO OR HIGHER THAN THE HC DESORPTION TEMPERATURE?
NO
YES
S105
SLIGHT RICH OPERATION IS INTERRUPTED
S106
A/F IS CONTROLLED TO STOICHIOMETRIC OPERATION
S107
THREE-WAY VALVE IS SWITCHED TO FLOW CHANNEL(b)
S108
IS ENGINE STOPPED?
NO
YES
S109
SHUT VALVE IS CLOSED
S110
THREE-WAY VALVE IS SWITCHED TO FLOW CHANNEL(b)
S211
MOTORING OF ENGINE IS PERFORMED
S112
CURRENT IS SUPPLIED TO EHC
EXHAUST GAS PURIFICATION TREATMENT IS COMPLETED

FIG. 5A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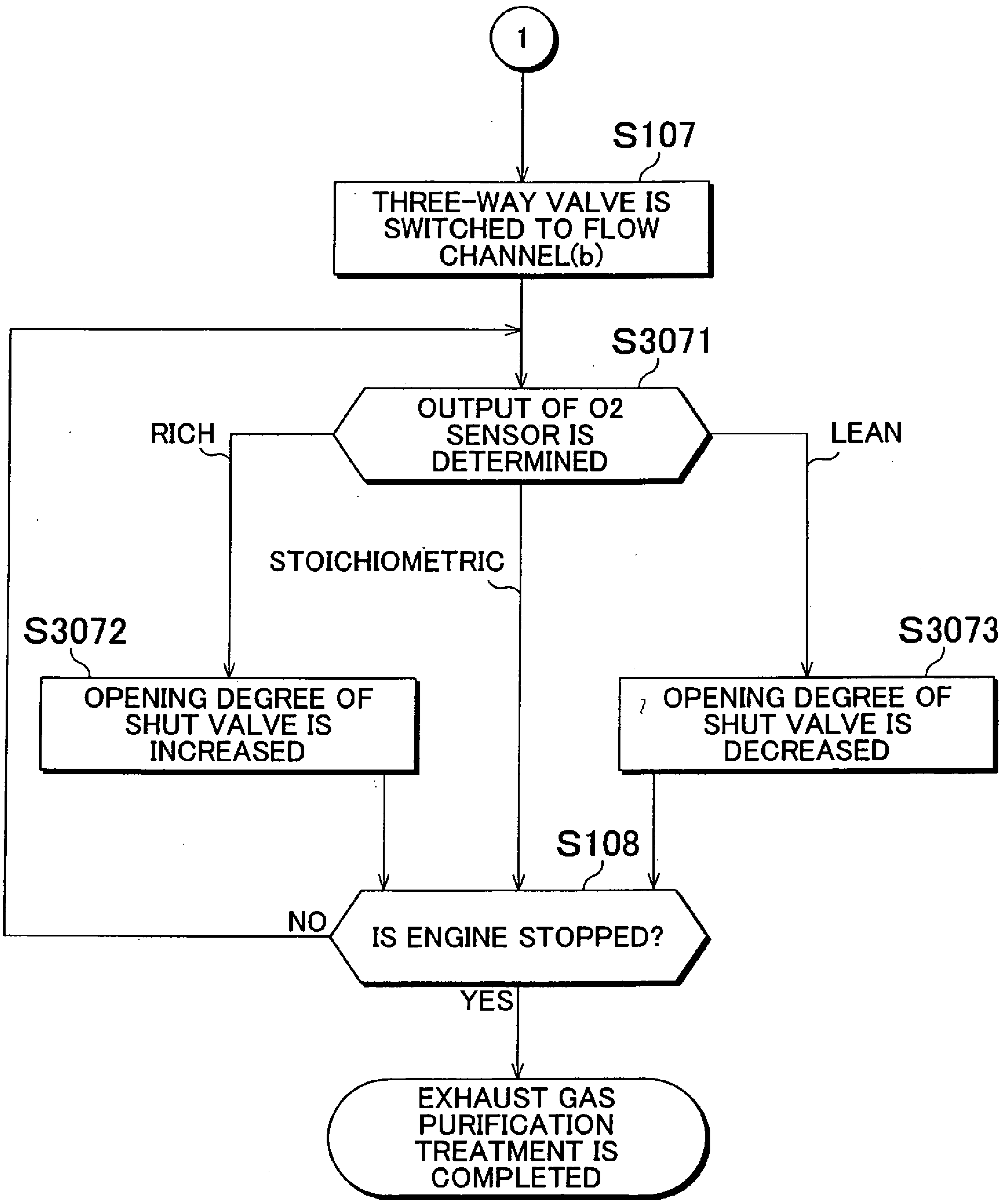
S100
EHC IS PREHEATED (TO ACTIVATION TEMPERATURE)
S101
ENGINE IS STARTED
S102
A/F IS CONTROLLED TO SLIGHT RICH OPERATION
S103
THREE-WAY VALVE IS SWITCHED TO FLOW CHANNEL(a)
S104
IS O2 SENSOR ACTIVATED? OR IS THE TEMPERATURE OF HC ADSORBENT EQUAL TO OR HIGHER THAN THE HC DESORPTION TEMPERATURE?
NO
YES
S105
SLIGHT RICH OPERATION IS INTERRUPTED
S106
A/F IS CONTROLLED TO STOICHIOMETRIC OPERATION
1

FIG. 5B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S107
THREE-WAY VALVE IS SWITCHED TO FLOW CHANNEL(b)
S3071
OUTPUT OF O2 SENSOR IS DETERMINED
RICH
LEAN
STOICHIOMETRIC
S3072
OPENING DEGREE OF SHUT VALVE IS INCREASED
S3073
OPENING DEGREE OF SHUT VALVE IS DECREASED
S108
IS ENGINE STOPPED?
NO
YES
EXHAUST GAS PURIFICATION TREATMENT IS COMPLETED

FIG. 6

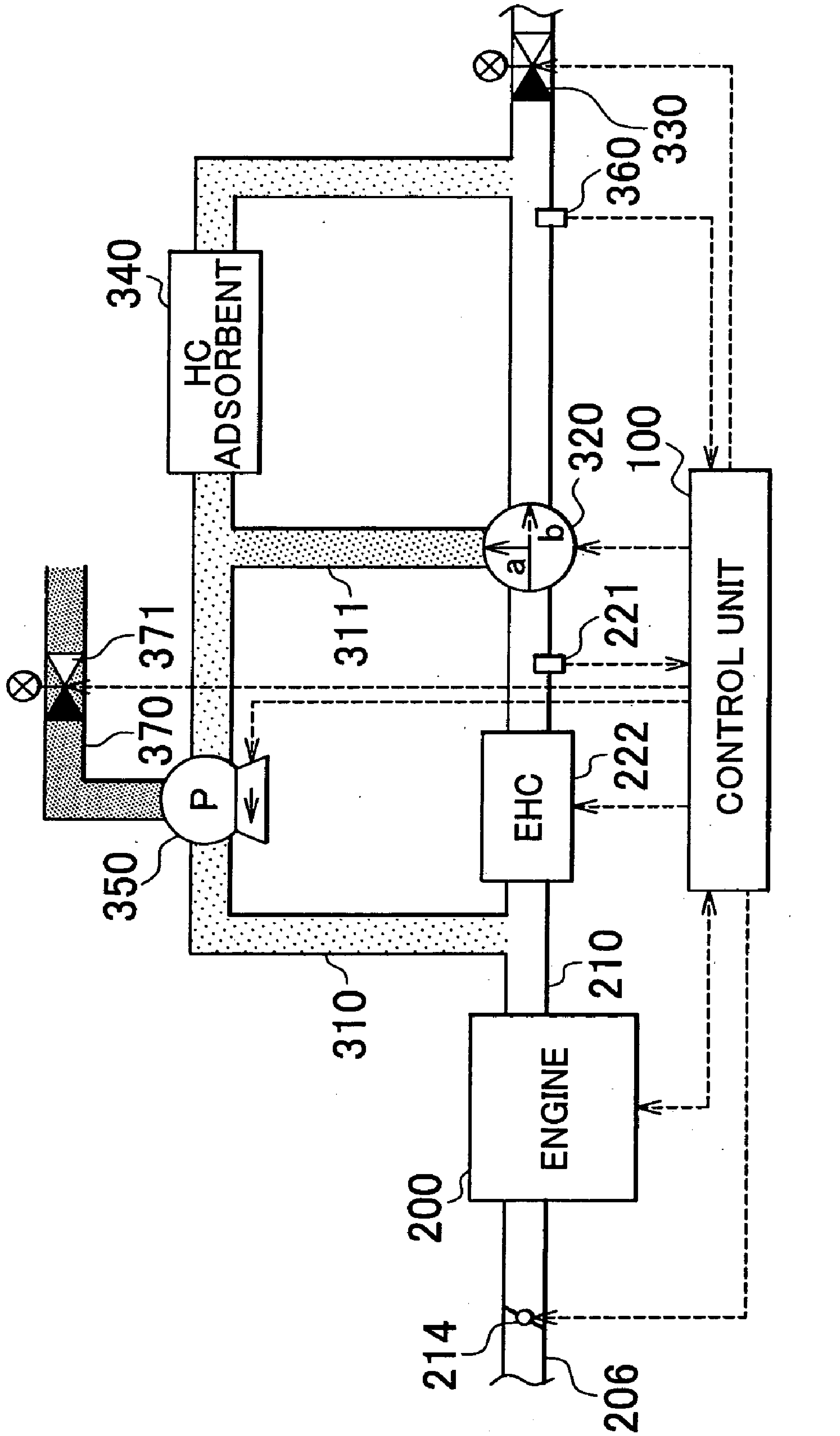

HC ADSORBENT
340
EHC
222
ENGINE
200
CONTROL UNIT
100
P
350
a
b
320
330
360
370
371
311
221
310
210
214
206

FIG. 7A

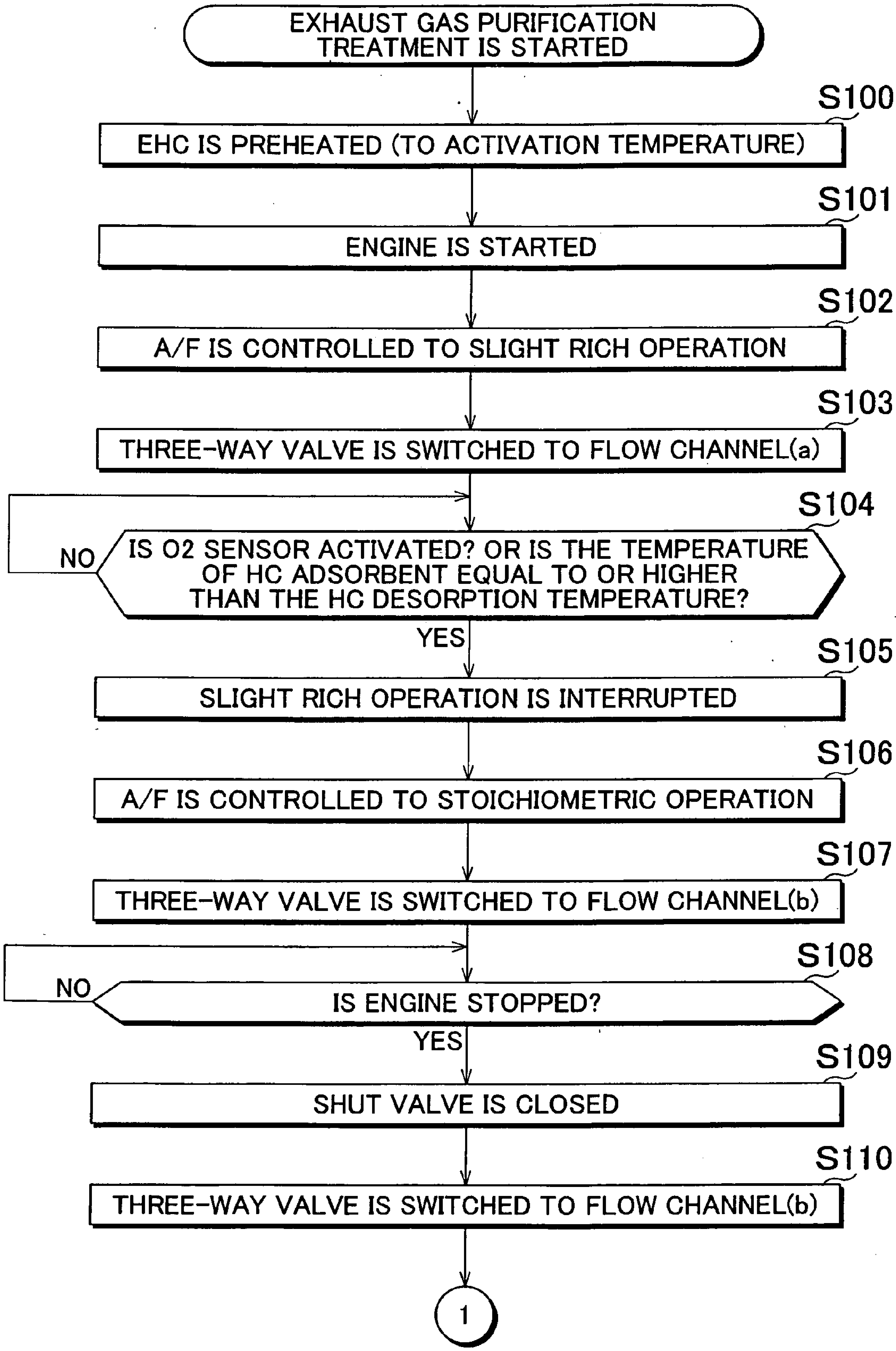

EXHAUST GAS PURIFICATION TREATMENT IS STARTED
S100
EHC IS PREHEATED (TO ACTIVATION TEMPERATURE)
S101
ENGINE IS STARTED
S102
A/F IS CONTROLLED TO SLIGHT RICH OPERATION
S103
THREE-WAY VALVE IS SWITCHED TO FLOW CHANNEL(a)
S104
IS O2 SENSOR ACTIVATED? OR IS THE TEMPERATURE OF HC ADSORBENT EQUAL TO OR HIGHER THAN THE HC DESORPTION TEMPERATURE?
NO
YES
S105
SLIGHT RICH OPERATION IS INTERRUPTED
S106
A/F IS CONTROLLED TO STOICHIOMETRIC OPERATION
S107
THREE-WAY VALVE IS SWITCHED TO FLOW CHANNEL(b)
S108
IS ENGINE STOPPED?
NO
YES
S109
SHUT VALVE IS CLOSED
S110
THREE-WAY VALVE IS SWITCHED TO FLOW CHANNEL(b)
1

FIG. 7B

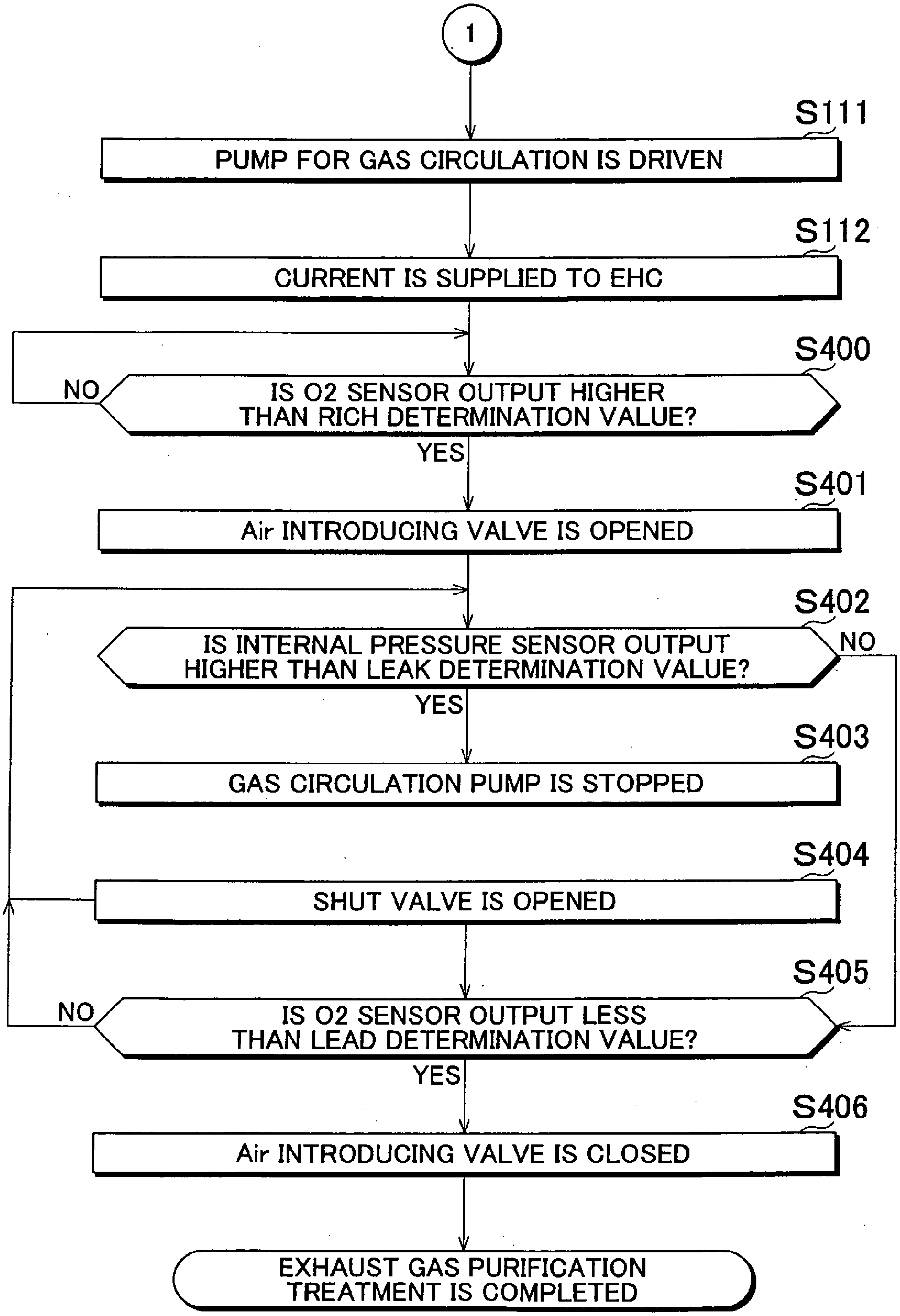
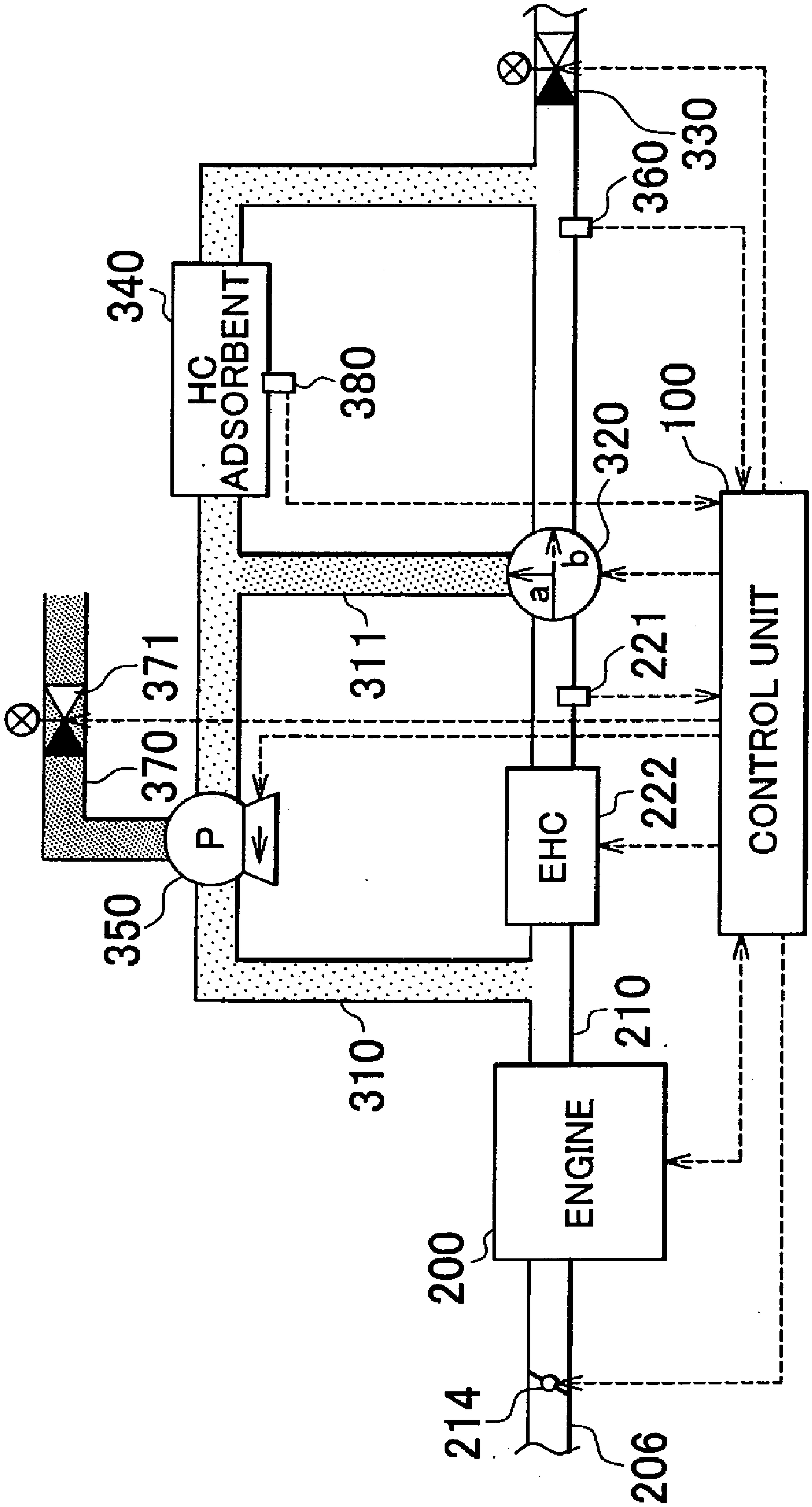

1
S111
PUMP FOR GAS CIRCULATION IS DRIVEN
S112
CURRENT IS SUPPLIED TO EHC
S400
IS O2 SENSOR OUTPUT HIGHER THAN RICH DETERMINATION VALUE?
NO
YES
S401
Air INTRODUCING VALVE IS OPENED
S402
IS INTERNAL PRESSURE SENSOR OUTPUT HIGHER THAN LEAK DETERMINATION VALUE?
NO
YES
S403
GAS CIRCULATION PUMP IS STOPPED
S404
SHUT VALVE IS OPENED
S405
IS O2 SENSOR OUTPUT LESS THAN LEAD DETERMINATION VALUE?
NO
YES
S406
Air INTRODUCING VALVE IS CLOSED
EXHAUST GAS PURIFICATION TREATMENT IS COMPLETED

FIG. 8


ENGINE
EHC
CONTROL UNIT
HC ADSORBENT
P
a
b
100
200
206
210
214
221
222
310
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320
330
340
350
360
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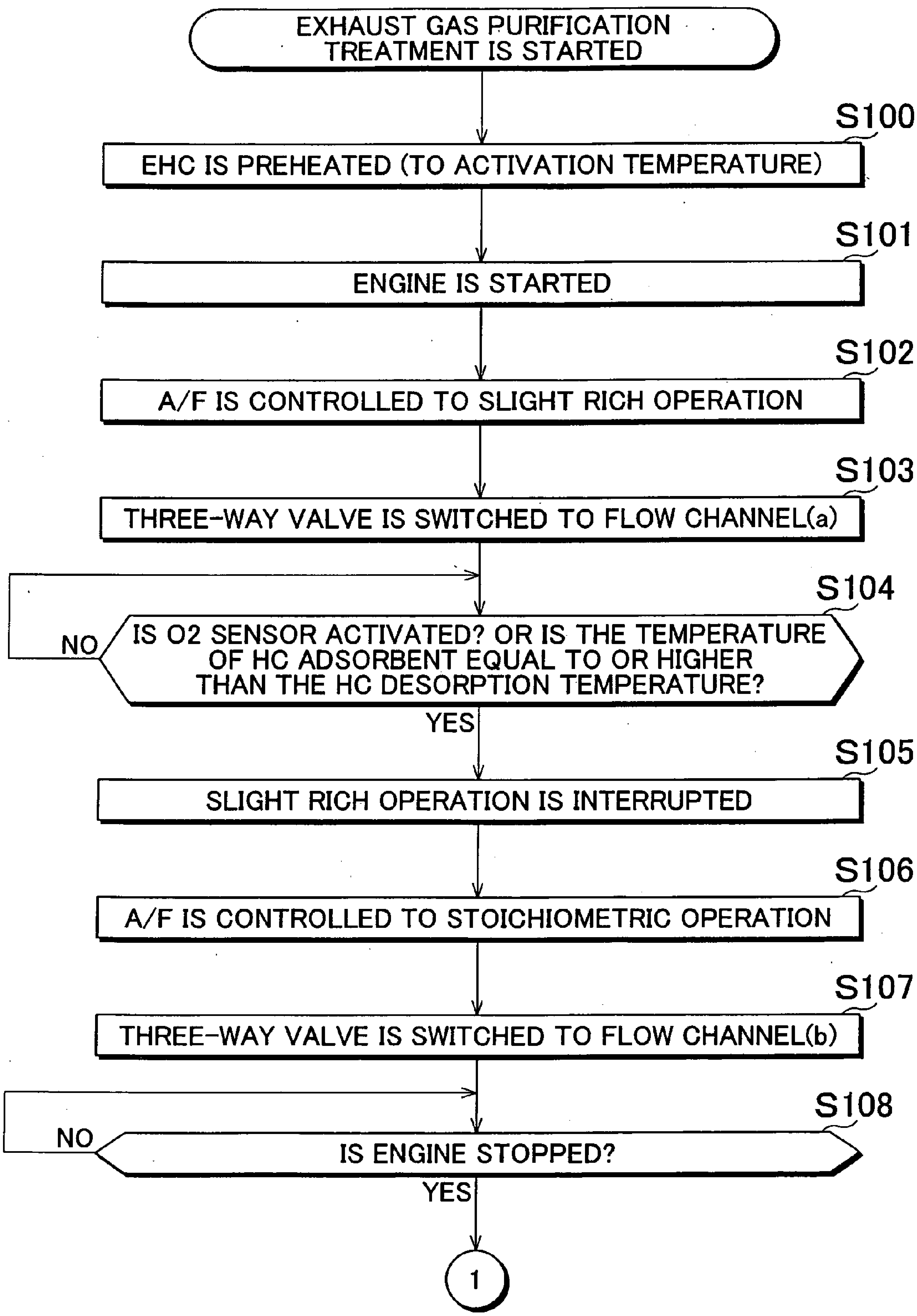
371
380

FIG. 9A


EXHAUST GAS PURIFICATION TREATMENT IS STARTED
S100
EHC IS PREHEATED (TO ACTIVATION TEMPERATURE)
S101
ENGINE IS STARTED
S102
A/F IS CONTROLLED TO SLIGHT RICH OPERATION
S103
THREE-WAY VALVE IS SWITCHED TO FLOW CHANNEL(a)
S104
IS O2 SENSOR ACTIVATED? OR IS THE TEMPERATURE OF HC ADSORBENT EQUAL TO OR HIGHER THAN THE HC DESORPTION TEMPERATURE?
NO
YES
S105
SLIGHT RICH OPERATION IS INTERRUPTED
S106
A/F IS CONTROLLED TO STOICHIOMETRIC OPERATION
S107
THREE-WAY VALVE IS SWITCHED TO FLOW CHANNEL(b)
S108
IS ENGINE STOPPED?
NO
YES
1

F I G . 9B

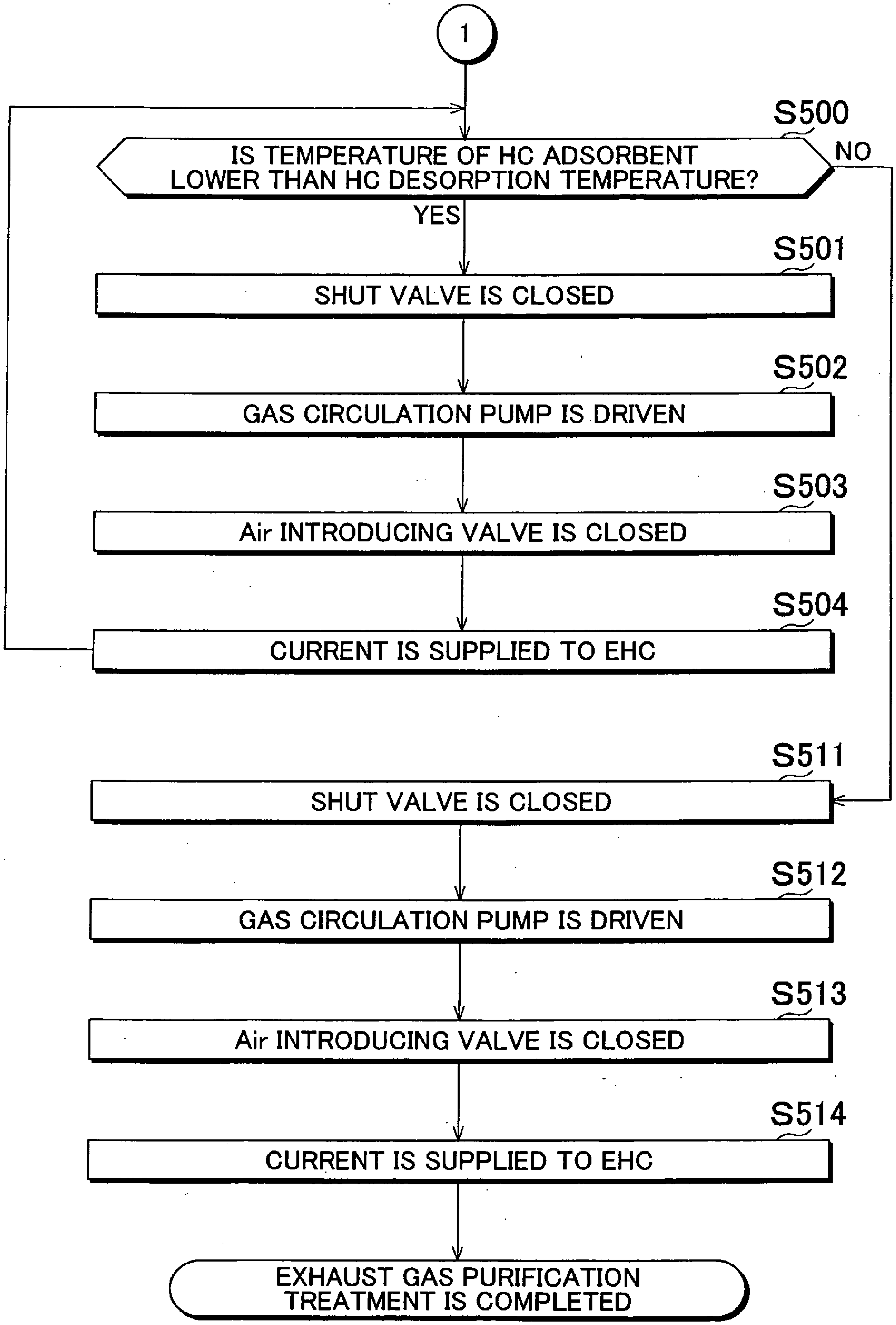

1
S500
IS TEMPERATURE OF HC ADSORBENT LOWER THAN HC DESORPTION TEMPERATURE?
NO
YES
S501
SHUT VALVE IS CLOSED
S502
GAS CIRCULATION PUMP IS DRIVEN
S503
Air INTRODUCING VALVE IS CLOSED
S504
CURRENT IS SUPPLIED TO EHC
S511
SHUT VALVE IS CLOSED
S512
GAS CIRCULATION PUMP IS DRIVEN
S513
Air INTRODUCING VALVE IS CLOSED
S514
CURRENT IS SUPPLIED TO EHC
EXHAUST GAS PURIFICATION TREATMENT IS COMPLETED

FIG. 10

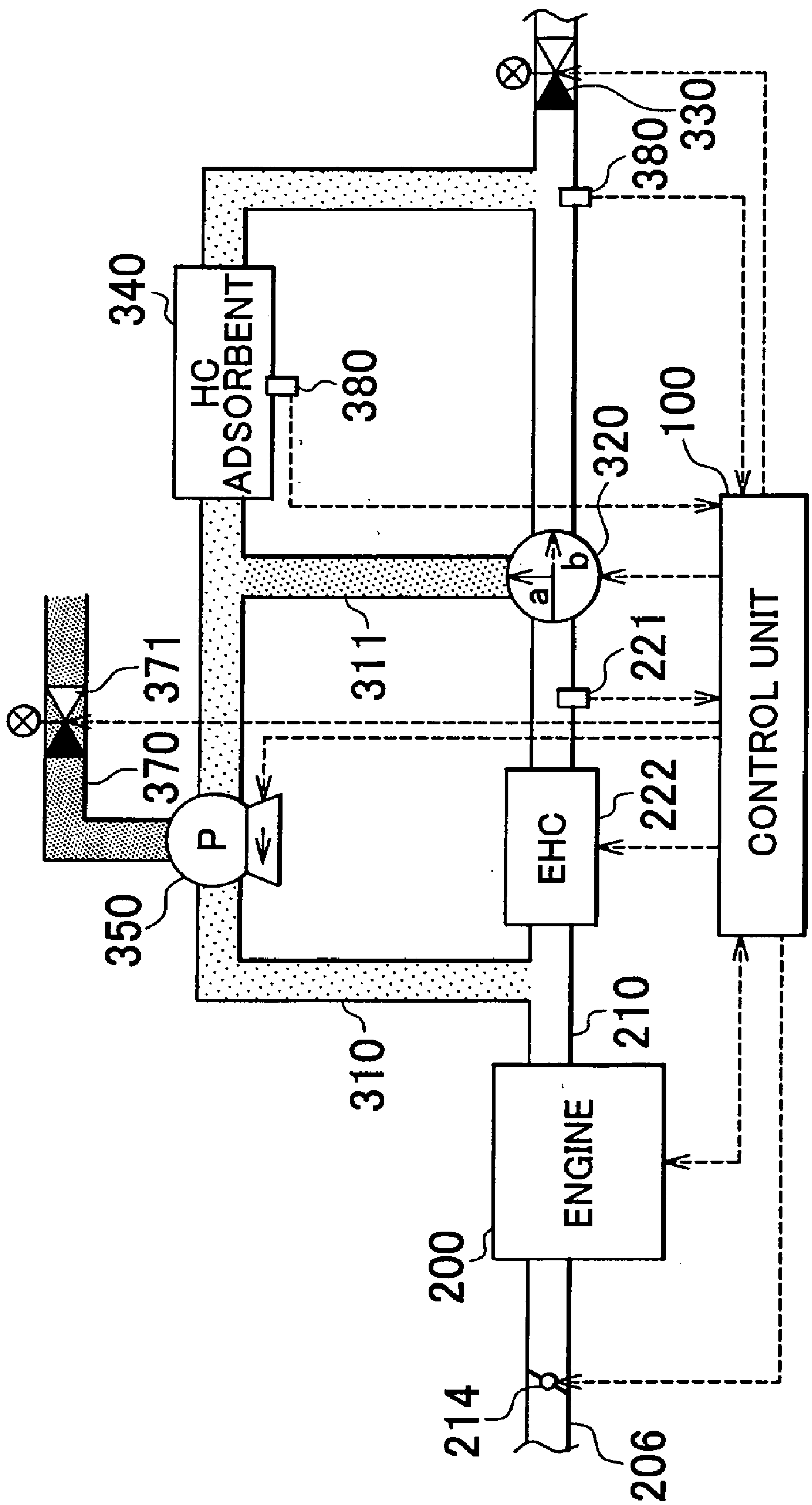
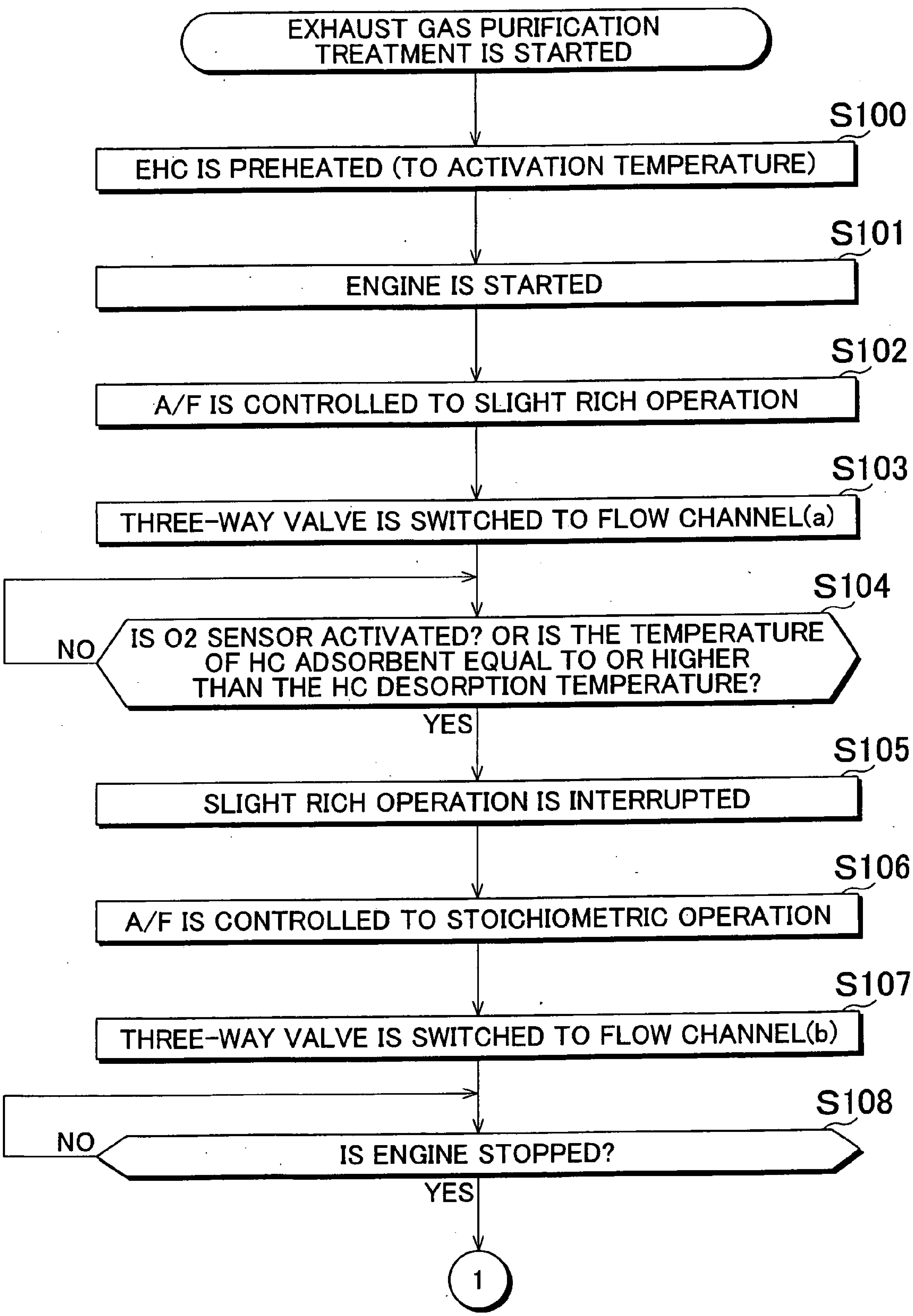

ENGINE
EHC
HC ADSORBENT
CONTROL UNIT
P
a
b
100
200
206
210
214
221
222
310
311
320
330
340
350
370
371
380
380

FIG. 11A


EXHAUST GAS PURIFICATION TREATMENT IS STARTED
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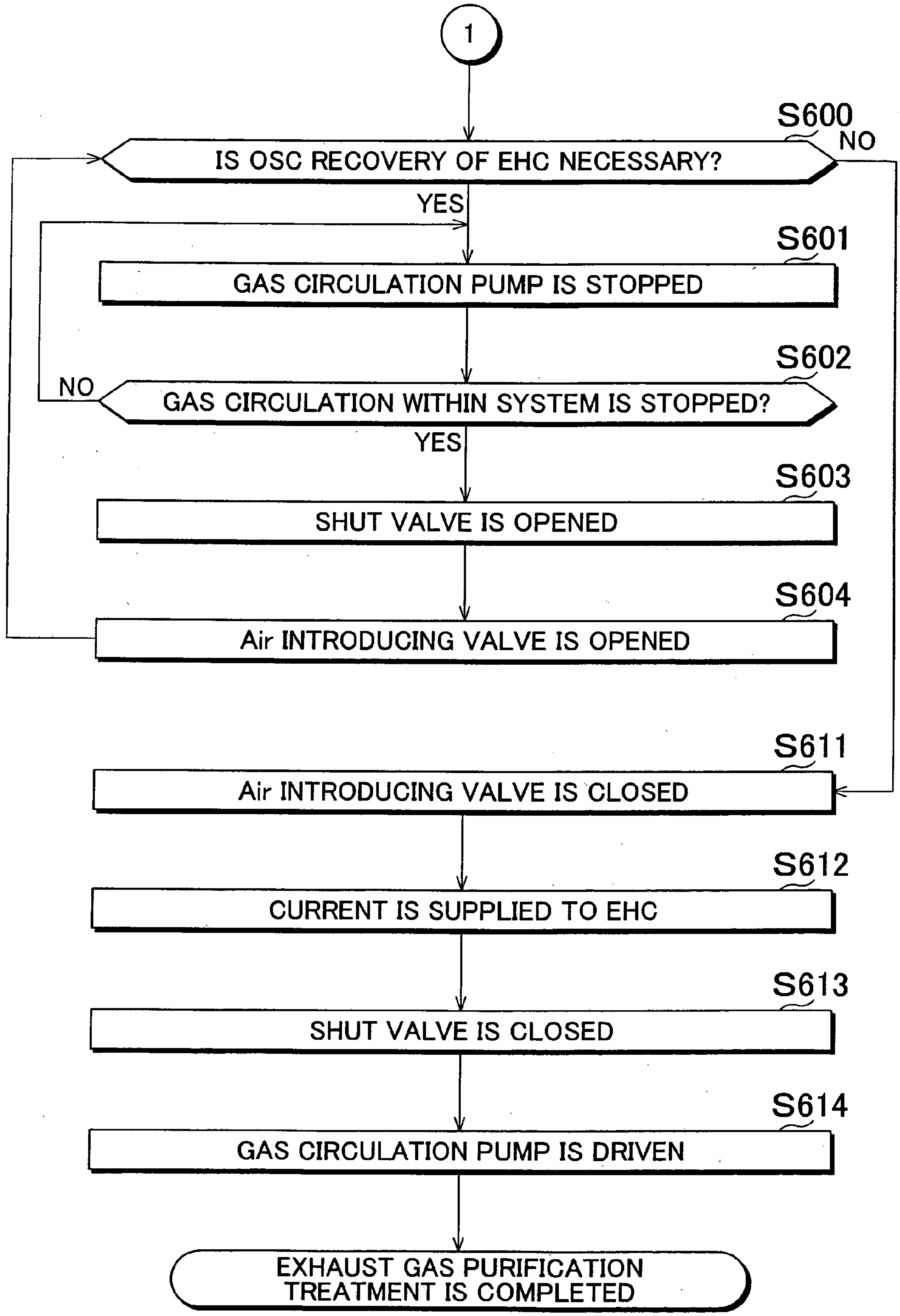
EHC IS PREHEATED (TO ACTIVATION TEMPERATURE)
S101
ENGINE IS STARTED
S102
A/F IS CONTROLLED TO SLIGHT RICH OPERATION
S103
THREE-WAY VALVE IS SWITCHED TO FLOW CHANNEL(a)
S104
IS O2 SENSOR ACTIVATED? OR IS THE TEMPERATURE OF HC ADSORBENT EQUAL TO OR HIGHER THAN THE HC DESORPTION TEMPERATURE?
NO
YES
S105
SLIGHT RICH OPERATION IS INTERRUPTED
S106
A/F IS CONTROLLED TO STOICHIOMETRIC OPERATION
S107
THREE-WAY VALVE IS SWITCHED TO FLOW CHANNEL(b)
S108
IS ENGINE STOPPED?
NO
YES
1

FIG. 11B


1
S600
IS OSC RECOVERY OF EHC NECESSARY?
NO
YES
S601
GAS CIRCULATION PUMP IS STOPPED
S602
NO
GAS CIRCULATION WITHIN SYSTEM IS STOPPED?
YES
S603
SHUT VALVE IS OPENED
S604
Air INTRODUCING VALVE IS OPENED
S611
Air INTRODUCING VALVE IS CLOSED
S612
CURRENT IS SUPPLIED TO EHC
S613
SHUT VALVE IS CLOSED
S614
GAS CIRCULATION PUMP IS DRIVEN
EXHAUST GAS PURIFICATION TREATMENT IS COMPLETED

EXHAUST GAS PURIFICATION APPARATUS AND EXHAUST GAS PURIFICATION METHOD

INCORPORATION BY REFERENCE

[0001] The disclosure of Japanese Patent Application No. 2007-305368 filed on Nov. 27, 2007 including the specification drawings and abstract is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The invention relates to an exhaust gas purification apparatus including, for example, a Hydrocarbon (HC) adsorbent and to an exhaust gas purification method.

[0004] 2. Description of the Related Art

[0005] Some hazardous components (for example, HC and Nitrogen Oxide (NO_x)) contained in the exhaust gas may be discharged without purification by an exhaust gas purification apparatus including an HC adsorbent, thereby decreasing exhaust purification ability of the apparatus. Accordingly, a variety of configurations employing a combination of an Electrically Heated Catalyst (EHC) and an HC adsorbent have been suggested to increase the exhaust purification ability.

[0006] Japanese Patent Application Publication No. 6-33747 (JP-A-6-33747) discloses an exhaust gas purification apparatus including an HC adsorbent and an EHC provided downstream thereof.

[0007] Japanese Patent Application Publication No. 10-252449 (JP-A-10-252449) discloses an exhaust gas purification apparatus including an HC adsorbent and an EHC provided downstream thereof, wherein the adsorbed HC is purified by the EHC, secondary air is supplied in this process, and the supplied amount of the secondary air is controlled based on the output of an oxygen sensor.

[0008] Japanese Patent Application Publication No. 7-63048 (JP-A-7-63048) (FIG. **5**) discloses a configuration including an HC adsorbent and an EHC (described as “a catalyst body A” in JP-A-7-63048) provided downstream thereof, wherein the downstream EHC is activated at a temperature at which the desorption of the adsorbed HC is started.

[0009] However, in the exhaust gas purification apparatuses disclosed in JP-A-6-33747, JP-A-10-252449, and JP-A-7-63048, the discharge of non-combusted gas components into the atmosphere cannot be suppressed to an almost complete level. More specifically, when the engine is started, the air-fuel ratio feedback control cannot be performed appropriately till the O2 sensor is activated and the Oxygen Storage Capacity (OSC) of the EHC cannot be accurately controlled. As a result, non-purified NOx or HC can be discharged into the atmosphere.

SUMMARY OF THE INVENTION

[0010] The invention provides an exhaust gas purification apparatus and an exhaust gas purification method that improve exhaust emission when the engine is started.

[0011] The first aspect of the invention relates to exhaust gas purification apparatus installed in an exhaust pipe serving as a flow channel of an exhaust gas discharged from an engine, including: first purification means for purifying at least one component from among a plurality of components contained in the exhaust gas; heating means for heating the first purification means to a predetermined temperature in at least part of a period from before the engine is started to a first point in time that is after the engine is started; and air-fuel ratio control means for controlling an air-fuel ratio of the exhaust gas so as to obtain a first air-fuel ratio suitable for the first purification means to purify the one component in at least part of a period from the time when the engine is started to a second point in time that is on or after a time at which the first purification means is heated to the predetermined temperature; and an adsorption means for communicating with the exhaust pipe and at least partially adsorbs another component from among the plurality of components.

[0012] With such a configuration, the heating means preheats the first purification means before the engine is started or immediately after the engine is started. Further, the second point in time is a point in time that is on or after a time at which the first purification means is heated to the predetermined temperature. There is a possibility of the O2 sensor being not activated immediately after the engine is started and the unpurified components can be discharged into the atmosphere, without the OSC of the first purification means being accurately controlled. However, the above-described configuration makes it possible to obtain the temperature and air-fuel ratio that are suitable for reliable purification of one component with the first purification means.

[0013] In the exhaust gas purification apparatus according to the present aspect, the adsorption means may communicate with the exhaust pipe downstream of the first purification means.

[0014] With the above-described configuration, the adsorption means at least partially adsorbs another component that is other than the one component and has not been adsorbed by the first purification means.

[0015] With the above-described configuration, the first purification means is activated by the heating means in advance and the air-fuel ratio is controlled to the first air-fuel ratio. Therefore, the one component can be advantageously purified in the first purification means. On the other hand, the other component passes through the first purification means, but can be adsorbed by the downstream adsorption means. As a result, neither the one component nor the other component is discharged to the outside of the exhaust pipe. The-exhaust emission at the time the engine is started can thus be improved.

[0016] In the exhaust gas purification apparatus according to the present aspect, the air-fuel ratio control means may control an air-fuel ratio of the exhaust gas so as to obtain a first air-fuel ratio suitable for purifying one component from among the plurality of components in a period from the time when the first purification means is heated to an activation temperature thereof to the second point in time.

[0017] With the above-described configuration, once the first purification means is heated to the activation temperature thereof, the first air-fuel ratio suitable for purifying the one component is set till the second point in time. As a result, the one component can be advantageously purified by the first purification means.

[0018] The exhaust gas purification apparatus according to the present aspect may further include air-fuel detection means for detecting an air-fuel ratio of the exhaust gas flowing in the exhaust pipe, and the air-fuel ratio control means may feedback-control the air-fuel ratio of the exhaust gas based at least on the detected air-fuel ratio.

[0019] With the above-described configuration, the air-fuel ratio of the exhaust gas flowing in the exhaust pipe is detected by air-fuel ratio detection means. The air-fuel ratio control means can feedback-control the air-fuel ratio of the exhaust gas based at least on the air-fuel ratio that is thus detected.

[0020] In the exhaust gas purification apparatus according to the present aspect, the second point in time may be a point in time at which activation of the air-fuel ratio detection means is started, and the air-fuel ratio control means may feedback-control the air-fuel ratio within an active period of the air-fuel ratio detection means that starts at the second point in time.

[0021] With the above-described configuration, the second point in time is a point in time at which the activation of the air-fuel ratio detection means is started and the active period of the air-fuel ratio detection means that starts at the second point in time can be recognized with a comparatively high reliability of detection results. Therefore, the air-fuel ratio can be feedback-controlled within the active period. Conversely, the first air-fuel ratio can be maintained so that the one component can be reliably purified with the first purification means till the reliability of the feedback control is ensured.

[0022] The exhaust gas purification apparatus according to the present aspect may further include desorption state specifying means for specifying a desorption state of the other component from the adsorption means, and the second point in time may be established according to the specified desorption state of the other component.

[0023] With the above-described configuration, the desorption state of the other component from the adsorption means is specified by the desorption state specifying means, and the second point in time (that is, the start of a period in which it is undesirable to set the air-fuel ratio to the first air-fuel ratio) is established correspondingly thereto. Accordingly, on or after the second point in time, it is possible to switch from the first air-fuel ratio, which is useful only for the one component and at which the other component is assumed to be adsorbed, to the air-fuel ratio that is useful to a certain degree for both components. Therefore, the case in which the other component is discharged without being purified by some means can be avoided.

[0024] The exhaust gas purification apparatus according to the present aspect may further include second purification means for purifying another component adsorbed by the adsorption means.

[0025] With the above-described configuration, the second purification means purifies another component adsorbed by the adsorption means. The adsorbed other component is thus purified in some form. As a result, the adsorption capacity of the adsorption means can be ensured prior to the arrival of the new other component.

[0026] In the exhaust gas purification apparatus according to the present aspect, the first purification means may also function as the second purification means and may further include restricting means for restricting the release of the exhaust gas from the exhaust pipe downstream of the first purification means and the adsorption means in the exhaust pipe, and recirculation means for desorbing the adsorbed other component and recirculating the other component via a recirculation channel to a zone upstream of the first purification means, while the release of the exhaust gas is restricted by the restricting means.

[0027] With the above-described configuration, the exhaust pipe can be shut off by the restricting means such as a shut valve in the zone of the exhaust pipe that is downstream of the first purification means. Therefore, the discharge of exhaust gas from the exhaust pipe can be appropriately restricted. Within this interval, the adsorbed other component is desorbed and recirculated via the recirculation channel to the zone upstream of the first purification means by the recirculation means configured by a combination of a recirculation channel and a pneumatic pump installed in the channel or motoring of the engine. Here, the first purification means also functions as the second purification means. As a result, the first purification means purifies the recirculated other component, while purifying the one component. Therefore, each component can be purified.

[0028] The exhaust gas purification apparatus according to the present aspect may further include supply means for supplying secondary air to the first purification means via the recirculation channel.

[0029] With the above-described configuration, the supply means supplies the secondary air to the first purification means via the recirculation channel. As a result, the OSC state of the first purification means can be restored and the purification capacity thereof can be ensured.

[0030] The exhaust gas purification apparatus according to the present aspect may further include desorption state specifying means for specifying a desorption state of the other component from the adsorption means, wherein the supply means may supply the secondary air according to the specified desorption state of the other component.

[0031] With the above-described configuration, the supply means supplies the secondary air according to the desorption state of the other component specified by the desorption state specifying means. Where it is detected that the temperature of the desorption means has risen close to the desorption temperature, it is possible that the other component will start desorbing from the adsorption means in the nearest future. In such case, it is possible to prepare for the arrival of the desorbed other component by supplying the secondary air in advance, thereby supplying oxygen to the first purification means and restoring the OSC state of the first purification means.

[0032] Alternatively, the exhaust gas purification apparatus according to the present aspect may further include OSC state specifying means for specifying an OSC state of the first purification means that also functions as the second purification means, wherein the supply means may supply the secondary air according to the specified OSC state.

[0033] With the above-described configuration, the OSC state of the first purification means that also functions as the second purification means is specified by the OSC state specifying means, and the supply means supplies the secondary air corresponding to the OSC state thereof. When the amount of the stored oxygen is extremely small and the OSC state is specified as poor, it is possible to prepare for the arrival of the desorbed other component by appropriately restoring the OSC state of the first purification means as necessary.

[0034] Alternatively, the exhaust gas purification apparatus according to the present aspect may further include internal pressure specifying means for specifying a pressure inside the exhaust pipe in a state in which the release of the exhaust gas is restricted by the restriction means, wherein the supply means may regulate the supplied amount of the secondary air according to the specified internal pressure.

[0035] With the above-described configuration, the supply means regulates the supplied amount of the secondary air according to the pressure inside the exhaust pipe specified by the internal pressure specifying means. As a result, when the internal pressure can be too high and can exceed the pressure resistance of the restricting means, it is possible to suppress the supply of the secondary air, thereby making it possible to avoid the leak of exhaust gas from the restricting means.

[0036] In the exhaust gas purification apparatus according to the present aspect, the heating means may heat the first purification means according to the amount of the secondary air supplied by the supply means.

[0037] With the above-described configuration, the temperature of the first purification means can decrease with the increase in the amount of secondary air supplied by the supply means. Therefore, the first purification means is heated accordingly. As a result, the first purification means can be maintained in the active state even as the secondary air is supplied.

[0038] In the exhaust gas purification apparatus according to the present aspect, the second purification means may purify the other component in a period during which the engine is stopped.

[0039] With the above-described configuration, by contrast with the first purification means, the second purification means purifies the other component in a period during which the engine is stopped. As a result, the other component adsorbed when the engine is started can be reliably purified by shutting off the exhaust pipe with the restricting means and recirculating the other component several times in a period during which the engine is stopped.

[0040] In the exhaust gas purification apparatus according to the present aspect, the first point in time may be a point in time at which the exhaust gas is practically not discharged from the engine. Further, in the exhaust gas purification apparatus according to the present aspect, the one component may be nitrogen oxide, and the first air-fuel ratio may be an air-fuel ratio on a rich side from a theoretical air-fuel ratio of the engine.

[0041] The second aspect of the invention relates to an exhaust gas purification method in purification means for purifying at least one component from among a plurality of components contained in an exhaust gas discharged from an engine. The exhaust gas purification method includes: heating the purification means to a predetermined temperature in a period that is at least part of a period from before the engine is started to a first point in time that is after the engine is started; controlling an air-fuel ratio of the exhaust gas so as to obtain a first air-fuel ratio suitable for the purification means to purify the one component in at least part of a period from the time when the engine is started to a second point in time that is on or after a time at which the purification means is heated to the predetermined temperature; and at least partially adsorbing another component from among the plurality of components.

BRIEF DESCRIPTION OF THE DRAWINGS

[0042] The foregoing and further objects, features and advantages of the invention will become apparent from the following description of preferred embodiments with reference to the accompanying drawings, wherein like numerals are used to represent like elements and wherein:

[0043] FIG. **1** is a schematic plan view illustrating an exhaust gas purification apparatus of the first embodiment of the invention;

[0044] FIG. **2** is a flowchart illustrating the operation of the exhaust gas purification apparatus of the first embodiment;

[0045] FIG. **3** is a schematic plan view illustrating the exhaust gas purification apparatus of the second embodiment;

[0046] FIG. **4** is a flowchart illustrating the operation of the exhaust gas purification apparatus of the second embodiment;

[0047] FIGS. **5**A and **5**B are a flowchart illustrating the operation of the exhaust gas purification apparatus of the third embodiment;

[0048] FIG. **6** is a schematic plan view illustrating the exhaust gas purification apparatus of the fourth embodiment;

[0049] FIGS. **7**A and **7**B are a flowchart illustrating the operation of the exhaust gas purification apparatus of the fourth embodiment;

[0050] FIG. **8** is a schematic plan view illustrating the exhaust gas purification apparatus of the fifth embodiment;

[0051] FIGS. **9**A and **9**B are a flowchart illustrating the operation of the exhaust gas purification apparatus of the fifth embodiment;

[0052] FIG. **10** is a schematic plan view illustrating the exhaust gas purification apparatus of the sixth embodiment; and

[0053] FIGS. **11**A and **11**B are a flowchart illustrating the operation of the exhaust gas purification apparatus of the sixth embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

[0054] An embodiment of the invention will be described below in greater details with reference to the appended drawings.

[0055] First, a basic configuration of the exhaust gas purification apparatus of the first embodiment will be described with reference to FIG. **1**. FIG. **1** is a schematic plan view illustrating an exhaust gas purification apparatus of the first embodiment of the invention.

[0056] As shown in FIG. **1**, the exhaust gas purification apparatus of the first embodiment is installed, for example, on a hybrid vehicle and has an intake pipe **206** equipped with a throttle valve **214**, an engine **200**, and an exhaust pipe **210** configured on a base. In a well-known process, an air-fuel mixture obtained by mixing a fuel with intake air from the intake pipe **206** is combusted in the engine **200** and exhaust gases generated by the combustion are discharged via the exhaust pipe **210**. The configuration of the present embodiment will be described below. In the present embodiment, "downstream" refers to a zone that is closer to the outlet port of the exhaust pipe **210**. Conversely, "upstream" refers to a zone closer to the inlet port of the intake port **206**.

[0057] An EHC **222** is a three-way catalyst equipped with a heater that is installed in a tube of the exhaust pipe **210** and can be heated to a desired temperature, for example, under the control by a control device **100**. For example, the EHC **222** reduces NOx and oxidizes HC with the stored oxygen. The EHC **222** assumes an active state or a passive state depending on whether the temperature thereof is higher than an active temperature inherent thereto and demonstrates good purification ability only in the active state.

[0058] An O2 sensor **221** is provided downstream of the EHC **222** and detects the concentration of oxygen contained in the exhaust gas that passed through the EHC **222**. As a result, the OSC state of the EHC **222** is detected. The O2 sensor **221** also assumes an active state or a passive state depending on whether the temperature thereof is higher than an active temperature inherent thereto and can detect oxygen concentration accurately only in the active state.

[0059] A recirculation channel **310** communicates with portions of the exhaust pipe **210** that are upstream and downstream of the EHC **222** and recirculates the exhaust gas from the zone downstream of the EHC **222** to the zone upstream thereof.

[0060] An HC adsorbent **340** is formed from a material (active carbon or zeolite) having an HC adsorption capacity and installed in a portion of the recirculation channel **310** that is downstream of the EHC **222**.

[0061] A bypass flow channel **311** links a portion of the exhaust **210** that is downstream of the EHC **222** with a portion of the recirculation channel **310** that is upstream of the HC adsorbent **340**. As a result, HC contained in the exhaust gas which has not been purified by the EHC **222** is adsorbed by the HC adsorbent **340** in a temperature range below a predetermined HC desorption temperature. On the other hand, the adsorbed HC is desorbed in a temperature range above the predetermined HC desorption temperature.

[0062] A three-way valve **320** electromagnetically or mechanically switches a flow channel between a flow channel a passing to the HC adsorbent **340** via the bypass flow channel **311** and a flow channel b through which the exhaust gas flows directly, without passing through the bypass flow channel **311**, in the exhaust pipe **210**.

[0063] A gas circulation pump **350** is installed in a portion of the recirculation channel **310** upstream of the HC adsorbent **340**. Where the gas circulation pump **350** is driven, the exhaust gas located in the recirculation channel **310** is recirculated from the downstream zone to the upstream zone by the suction force thereof.

[0064] A shut valve **330** is provided in the lowermost stage (more specifically, even downstream of the downstream portion of the exhaust pipe **210** that communicates with the recirculation channel **310**) of the exhaust system, and the discharge amount of exhaust gas is regulated by the opening degree of the shut valve **330**. For example, when the shut valve **330** is completely closed, the exhaust gas is shut down and a closed-loop circulation channel is formed.

[0065] The control device **100** is the so-called ECU (Engine Control Unit) configured as a logic computation circuit constituted mainly by a central processing unit (CPU), a read only memory (ROM) storing a control program, and a random access memory (RAM) storing a variety of data. The control device **100** is connected via a bus to an intake port receiving input signals from the O2 sensor **221** and a variety of sensors that indicate the revolution speed of the engine **200**. Further, the control device **100** is also connected via a bus to an output port that sends control signals to actuators of an opening drive unit of the throttle valve **214**, an ignition unit of the engine **200**, a current supply unit of the EHC **222**, a drive unit of the gas circulation pump **350**, a drive unit of the three-way valve **320**, and a drive unit of the shut valve **330**. As a result, it is possible to control the air-fuel ratio by controlling current supply to the EHC **222** or by adjusting the opening degree of the throttle valve **214** or adjusting the fuel injection amount in the engine **200**.

[0066] Basic operation of the exhaust gas purification apparatus of the first embodiment will be described below with reference to FIG. **2**. FIG. **2** is a flowchart illustrating the operation of the exhaust gas purification apparatus of the first embodiment.

[0067] As indicated hereinabove in the section relating to the problems associated with the related art, untreated NOx or HC can be discharged into the atmosphere after the engine **200** is started and before the O2 sensor **221** is activated.

[0068] Accordingly, in the exhaust gas purification apparatus of the first embodiment, The following treatment is performed to purify NOx almost completely at least with the EHC **222** after the engine **200** is started and before the O2 sensor **221** is activated. Thus, the EHC **222** is activated (step S**100**) by preheating before the engine **200** is started. The engine **200** is then started (step S**101**). The air-fuel ratio (more specifically, "slight rich") is controlled to a value optimum for NOx purification by the air-fuel control performed with the control device **100** (step S**102**). As a result, the EHC **222** can purify almost entirely the NOx contained in the exhaust gas discharged when the engine is started. The "slight rich" as referred to in the present embodiment, represents an air-fuel ratio slightly to a rich side from the stoichiometric ratio and is, for example, an air-fuel ratio from 14.2 to a stoichiometric ratio. This is an air-fuel ratio at which the reduction of NOx can be effectively performed at predetermined operation conditions.

[0069] On the other hand, in this interval, the three-way valve **320** is switched to the flow channel a on the side of the HC adsorbent **340** (step S**103**). As a result, HC that could not be purified by the EHC **222** during the operation of the EHC **222** at an air-fuel ratio (more specifically, "slight rich") optimum for NOx purification can be adsorbed by the HC adsorbent **340**.

[0070] The O2 sensor **221** located downstream of the EHC **222** is then activated, the OSC state of the EHC **222** is accurately detected, and the slight rich operation is continued in order to maintain an NOx purification ratio at an almost complete level till it becomes possible to control the air-fuel ratio according to the OSC state of the EHC **222**. Whether the O2 sensor **221** has been activated can be determined, for example, based on whether the amplitude of the output current of the O2 sensor **221** is higher than a predetermined value.

[0071] It is then determined whether the O2 sensor **221** has been activated, or whether the temperature of the HC adsorbent **340** has reached the predetermined HC desorption temperature (more specifically, an upper limit value of a temperature at which the HC adsorption ability can be advantageously demonstrated) (step S**104**). When it is determined that the O2 sensor **221** has been activated (step S**104**: Yes), the air-fuel feedback control is adequately performed. Therefore, the slight rich operation is interrupted (step S**10**) to switch from the slight rich operation to a stoichiometric operation. Alternatively, when it is determined that the temperature of the HC adsorbent **340** has reached the predetermined HC desorption temperature (step S**104**: Yes), the slight rich operation is interrupted to avoid the decrease in HC adsorption ability (step S**10**).

[0072] The control device **100** then performs switching from the slight rich operation to stoichiometric operation (step S**106**). As a result, not only NOx, but also HC can be almost completely purified in the EHC **222**. In this case, because it is not necessary to cause the adsorption of HC in the HC adsorbent **340**, the three-way valve **320** is switched to the flow channel b at the side of the bypass flow channel **311** of the HC adsorbent **340** and the purified gas is discharged (step S107). In this case, the HC that has already been adsorbed by the HC adsorbent 340 is retained without discharging.

[0073] The processing then waits till the engine 200 stops (step S108: No), and once the engine 200 stops (step S108: Yes), the control device 100 closes the shut valve 330 (step S109), switches the three-way valve 320 to the flow channel b (step S110), and drives the pump 350 (step S111) to cause the closed-loop circulation of the gas present in the system. In such closed-loop circulation, an electric current may be supplied to the EHC 222 (step S112). In this case, the active state of the EHC 222 can be maintained. In addition, the circulating gas is heated, the desorption of the HC adsorbed at the HC adsorbent 340 is enhanced, and the desorbed HC is recirculated to the EHC 222, thereby making it possible to purify the desorbed HC in the EHC 222.

[0074] As described hereinabove, with the exhaust gas purification apparatus of the first embodiment, the discharge of HC and NOx can be actively avoided or suppressed within an interval after the engine 200 is started and before the air-fuel ratio feedback control can be executed appropriately. Further, in the intermittent mode in which the engine 200 stops, the desorption of the adsorbed HC and purification of the desorbed HC can be performed in an exhaustless state. In this case, because the gas containing the desorbed HC is circulated and passed through the EHC 222 repeatedly, the desorbed HC can be thoroughly purified. In addition, because it is not necessary to operate the engine 200 to cause the desorption of the material adsorbed by the HC adsorbent 340 during circulation, the increase in fuel consumption can be avoided. Moreover, because only the gas having a volume within the close loop may be heated during circulation, the consumption of energy required for HC desorption can be significantly reduced.

[0075] The basic configuration of the exhaust gas purification apparatus of the second embodiment will be described below with reference to FIG. 3. FIG. 3 is a schematic plan view of the exhaust gas purification apparatus of the second embodiment. In FIG. 3, components identical to those shown in the above-described FIG. 1 are assigned with identical reference symbols and detailed explanation therefor is herein omitted.

[0076] As shown in FIG. 3, the configuration of the exhaust gas purification apparatus, of the second embodiment is different from that of the first embodiment as follows. More specifically, the recirculation channel 310 links the intake pipe 206 to the zone of the exhaust pipe 210 that is downstream of the EHC 222 and recirculates the exhaust gas from the zone downstream of the EHC 222 to the zone upstream thereof. In other words, in the first embodiment, the exhaust gas is recirculated completely in the exhaust system, whereas in the second embodiment, the exhaust gas is recirculated to the intake system.

[0077] Further, a motor 44 used for motoring the engine 200 is provided instead of the gas circulation-pump 350. The motor 44 is a motor generator or a starter motor and is so configured that even when the engine 200 is in an intermittent mode, the drive power is supplied from the battery (not shown in the figure) and the output thereof can be transmitted to the output shaft of the engine 200, for example, via a pulley.

[0078] The basic operation of the exhaust gas purification apparatus of the second embodiment will be described below with reference to FIG. 4. FIG. 4 is a flowchart illustrating the operation of the exhaust gas purification apparatus of the second embodiment.

[0079] As shown in FIG. 4, the exhaust gas purification apparatus of the second embodiment operates in the following manner. More specifically, in the desorption treatment process (steps S109 to S112) of the adsorbed HC that is implemented when the engine 200 assumes a stop state (intermittent mode of the engine), the shut valve is closed (step S109), the motor 44 is then driven, and motoring of the engine 200 is performed (step S211). As a result, the desorbed HC is recirculated to the intake pipe 206 via the recirculation channel 310 and is introduced in the EHC 222 via the engine 200. Therefore, the desorbed HC can be purified in the EHC 222.

[0080] As described hereinabove, in the exhaust gas purification apparatus of the second embodiment, the desorption treatment of the adsorbed HC can be performed, without adding the gas circulation pump 350 such as used in the first embodiment. As a result, the amount of energy consumed for the desorption treatment of the adsorbed HC can be greatly reduced and the increase in fuel consumption can be effectively prevented.

[0081] The basic configuration of the exhaust gas purification apparatus of the third embodiment may be identical to that of the second embodiment and detailed explanation thereof is herein omitted. This configuration can be represented by FIG. 3.

[0082] The basic operation of the exhaust gas purification apparatus of the third embodiment will be described below with reference to FIGS. 5A and 5B. FIGS. 5A and 5B are a flowchart illustrating the operation of the exhaust gas purification apparatus of the third embodiment.

[0083] As shown in FIGS. 5A and 5B, the exhaust gas purification apparatus of the third embodiment operates in the following manner. More specifically, the processing of throttling the shut valve 330 and desorbing the adsorbed HC (steps S3071 to S3073) is performed in the idling mode of the engine 200 (that is, before the result of determination in step S108 is Yes), rather than in the stop state of the engine 200. As a result, part of the exhaust gas is recirculated to the HC adsorbent 340, and this gas enhances the desorption of the adsorbed HC and can be introduced as an exhaust gas recirculation (EGR) gas into the intake system.

[0084] In this case, the larger is the throttling of the opening of the shut valve 330, the larger is the amount of the desorbed HC contained in the EGR introduced to the intake. This is because where a large amount of exhaust gas is recirculated to the HC adsorbent 340, the temperature of the adsorbent 340 rises and the desorption of the adsorbed HC is enhanced.

[0085] Accordingly, the opening degree of the shut valve 330 may be variably controlled according to the output of the O2 sensor 221 disposed behind the EHC 222 (step S3071).

[0086] More specifically, when the output of the O2 sensor 221 disposed behind the EHC 222 is a stoichiometric voltage (more specifically, close to 0.5 V) (S3071: STOICH), the opening degree of the shut valve 330 may be maintained. However, when the output of the O2 sensor 221 shifts from the stoichiometric voltage to the rich side (S3071: RICH), the opening degree of the shut valve 330 is increased, the amount of gas recirculated to the HC adsorbent 340 is reduced, the desorption of the adsorbed HC is reduced, and the amount of rich EGR containing the desorbed HC is decreased.

[0087] On the other hand, when the output of the O2 sensor 221 shifts from the stoichiometric voltage to the lean side

(S3071: LEAN), the opening degree of the shut valve **330** is decreased, the amount of gas recirculated to the HC adsorbent **340** is increased, the desorption of the adsorbed HC is enhanced, and the amount of rich EGR containing the desorbed HC is increased.

[0088] As a result, the EGR can be appropriately implemented so that the output of the O2 sensor **221** becomes a stoichiometric voltage.

[0089] Further, when the output of the O2 sensor **221** shifts from the stoichiometric voltage to the rich side, the amount of fuel supplied to the engine **200** may be decreased and the air-fuel ratio may be controlled to the lean side.

[0090] Furthermore, the HC amount in the EGR gas may be calculated from the amount of gas recirculated to the HC adsorbent **340**, air-fuel ratio, initial HC adsorption amount of the HC adsorbent **340**, temperature of the HC adsorbent **340**, and the like, and the fuel injection amount may be reduced in advance to match the calculated HC amount.

[0091] Moreover, it is also possible to calculate the HC amount that can be purified in the EHC **222** from the present OSC state of the EHC **222**, then calculate the desorbed HC amount corresponding to the recirculation gas amount from the initial HC adsorption amount of the HC adsorbent **340**, temperature of the HC adsorbent **340**, and the like, and adjust the degree of opening of the shut valve **330** and control the amount of gas recirculated to the HC adsorbent **340** so as to obtain the, HC amount that can be purified in the EHC **222**.

[0092] As described hereinabove, with the exhaust gas purification apparatus of the third embodiment, the EGR with a rich gas including the desorbed HC from the HC adsorbent **340** can be appropriately implemented and the deterioration of the purification capacity of the EHC **222** caused by implementation of the EGR with an excessively rich gas and worsening of combustion in the engine **200** can be effectively prevented. Furthermore, the desorption efficiency of the adsorbent **340** can be increased, without degrading the purification capacity of the EHC **222**.

[0093] The basic configuration of the exhaust gas purification apparatus of the fourth embodiment will be described below with reference to FIG. **6**. FIG. **6** is a schematic plan view of the exhaust gas purification apparatus of the fourth embodiment. In FIG. **6**, components identical to those shown in the above-described FIG. **1** are assigned with identical reference symbols and detailed explanation thereof is herein omitted.

[0094] As shown in FIG. **6**, the configuration of the exhaust gas purification apparatus of the fourth embodiment is different from that of the first embodiment as follows. More specifically, a system in which purging circulation is performed by the gas circulation pump **350** includes an Air introducing pipe **370** that communicates with the atmosphere for introducing Air (that is, secondary air) to the gas circulation pump **350** and an Air introducing valve **371** that adjusts the amount of introduced Air according to the degree of opening. In addition, an internal pressure sensor **360** that detects the pressure inside the system is provided to monitor the increase in the internal pressure of the system caused the by introduction of Air. The internal pressure sensor **360** is installed in the tube of the exhaust pipe **210**, preferably close to the shut valve **330**.

[0095] The Air may be also introduced from the intake side by motoring the engine **200**, instead of using the Air introducing valve **371**.

[0096] The basic operation of the exhaust gas purification apparatus of the fourth embodiment will be described below with reference to FIGS. **7**A and **7**B. FIGS. **7**A and **7**B are a flowchart illustrating the operation of the exhaust gas purification apparatus of the fourth embodiment.

[0097] As shown in FIGS. **7**A and **7**B, the exhaust gas purification apparatus of the fourth embodiment operates in the following manner. More specifically, in the desorption treatment process (steps S**109** to S**112**) of the adsorbed HC that is implemented when the engine **200** assumes a stop state, the O2 sensor **221** disposed downstream of the EHC **222** is used to determine whether the OSC state of the EHC **222** is periodic or a periodic (step S**400**). In this case, when it is not determined that the output of the O2 sensor **221** is larger than the predetermined rich determination value (for example, close to 0.8 V) (step S**400**: No), the Air introducing valve **371** remains closed. On the other hand, when it is determined that the output of the O2 sensor **221** is larger than the predetermined rich determination value (step S**400**: Yes), it is determined that a completely rich state is assumed and the oxygen contained in the system is almost completely consumed, and the Air introducing valve **371** is opened and oxygen is introduced-in the system to restore the OSC of the EHC **222** (step S**401**). Because it is possible that the temperature inside the system will be decreased by the introduction of Air, an electric current is passed to the EHC **222** to prevent the decrease in purification capacity (step S**112**). In addition, when the internal pressure in the system becomes too high because the Air is introduced, it is possible that the gas contained in the system will leak to the atmosphere. Therefore, it is periodically or a periodically determined whether the output of the internal pressure sensor **360** exceeds a predetermined leak determination value (step S**402**). In this case, when the output of the internal pressure sensor **360** exceeds the predetermined leak determination value (step S**402**: Yes), the gas circulation pump **350** is temporarily stopped (step S**403**), the shut valve **330** is opened, and the pressure is released till the output of the internal pressure sensor **360** somewhat decreases (step S**404**). On the other hand, when the output of the internal pressure sensor **360** does not exceed the predetermined leak determination value (step S**402**: No), there is some space for introducing Air. Therefore, the Air introducing valve **371** is opened till the output of the O2 sensor **221** located downstream of the EHC **222** becomes below a predetermined lean determination value (for example, close to 0.2 V) (step S**405**: No) and a completely lean state is assumed. Once the output of the O2 sensor **221** becomes below a predetermined lean determination value (step S**405**: Yes) and a completely lean state is assumed, subsequent Air introduction becomes unnecessary. Therefore, the Air introducing valve **371** is closed (step S**406**).

[0098] Alternatively, the Air may be also successively introduced into the system so as to maintain the output of the O2 sensor **221**, which is disposed downstream of the EHC **222**, close to 0 V. In this case, the amount of Air introduced into the system may be controlled by performing F/B control of the opening degree of the Air introducing valve **371** according to the variation of the output of the O2 sensor **221**. More specifically, at a predetermined amount of introduced Air, the introduced amount may be increased when the rich output is maintained.

[0099] As described hereinabove, with the exhaust gas purification apparatus of the fourth embodiment, by appropriately introducing oxygen into the system with the Air introducing valve **371** in the desorption treatment process of the adsorbed HC, the OSC insufficiency of the EHC **222** is eliminated, thereby making it possible to avoid the decrease in purification capacity of the desorbed HC. By passing an electric current to the EHC **222**, it is possible to avoid the decrease in temperature when the Air is introduced and prevent the purification capacity of the EHC **222** from decreasing. In addition, by monitoring the internal pressure in the system with the internal pressure sensor **360**, it is possible to prevent reliably the release of the gas contained in the system to the atmosphere caused by the rise in internal pressure.

[0100] The basic configuration of the exhaust gas purification apparatus of the fifth embodiment will be described below with reference to FIG. **8**. FIG. **8** is a schematic plan view of the exhaust gas purification apparatus of the fifth embodiment. In FIG. **8**, components identical to those shown in the above-described FIG. **6** are assigned with identical reference symbols and detailed explanation thereof is herein omitted.

[0101] As shown in FIG. **8**, the configuration of the exhaust gas purification apparatus of the fifth embodiment is different from that of the fourth embodiment as follows. More specifically, the exhaust gas purification apparatus of the fifth embodiment further includes a temperature sensor **380** that detects the temperature of the HC adsorbent **340**. The temperature sensor **380** may directly detect the temperature of the HC adsorbent **340**, or may indirectly evaluate the temperature by the conditions of the exhaust gas introduced into the HC adsorbent **340**.

[0102] The basic operation of the exhaust gas purification apparatus of the fifth embodiment will be described below with reference to FIGS. **9**A and **9**B. FIGS. **9**A and **9**B are a flowchart illustrating the operation of the exhaust gas purification apparatus of the fifth embodiment.

[0103] As shown in FIGS. **9**A and **9**B, the exhaust gas purification apparatus of the fifth embodiment operates as follows. More specifically, after the engine **200** has assumes a stop state (step S**108**: Yes), the shut valve **330** is opened or closed, or the Air introducing valve **371** is opened or closed according to whether or not the temperature of the HC adsorbent **340** has reached the predetermined HC desorption temperature (that is, the temperature at which the desorption of the HC adsorbed by the HC adsorbent **340** is enhanced), which is determined based on the output of the temperature sensor **380** (step S**500**).

[0104] Here, when the temperature of the HC adsorbent **340** has not reached the HC desorption temperature (step S**500**: Yes), the amount of HC desorbed from the HC adsorbent **340** is extremely small. Therefore, where a purge gas is passed one time to the EHC **222**, it will apparently be possible to purify practically the entire desorbed HC contained therein. Accordingly, the purging treatment is performed by opening the shut valve **330** (step S**501**) and driving the pump **350** in this state (step S**502**), thereby circulating the gas contained in the system in an open loop. The Air introducing valve **371** of the pump **350** is then opened (step S**503**), the Air is introduced in the system, and a state with a maximum OSC of the EHC **222** is maintained.

[0105] On the other hand, after the temperature of the HC adsorbent **340** has reached the HC desorption temperature (step S**500**: No), the amount of desorbed HC in the purge gas increases. Therefore, by passing the purge gas once through the EHC **222**, it will apparently be impossible to purify the desorbed HC contained therein. Accordingly, the purging treatment is performed by closing the shut valve **330** (step S**511**) and driving the pump **350** in this state (step S**512**), thereby circulating the gas contained in the system in a closed loop. In the course of circulation purging in the closed loop, the Air introducing valve **371** of the pump **350** is closed so as to prevent an excess increase in the internal pressure in the system (step S**513**).

[0106] In these processes, the conduction control of the EHC **222** is implemented so that the temperature of the EHC **222** is constantly maintained at a level equal to or higher than the active temperature (step S**504**) (step S**514**).

[0107] As described hereinabove, with the exhaust gas purification apparatus of the fifth embodiment, the Air is introduced in advance, prior to the desorption of HC. Therefore, the desorbed HC can be purified almost completely from the very start of HC desorption and the time required for the purification can be shortened. In addition, because no Air is introduced during circulation purging in the closed loop, the internal pressure increase in the system can be avoided.

[0108] The basic configuration of the exhaust gas purification apparatus of the sixth embodiment will be described below with reference to FIG. **10**. FIG. **10** is a schematic plan view of the exhaust gas purification apparatus of the sixth embodiment. In FIG. **10**, components identical to those shown in the above-described FIG. **8** are assigned with identical reference symbols and detailed explanation thereof is herein omitted.

[0109] As shown in FIG. **10**, the configuration of the exhaust gas purification apparatus of the sixth embodiment is different from that of the fifth embodiment as follows. More specifically, the exhaust gas purification apparatus of the sixth embodiment includes a flow rate sensor **380** that detects the gas flow rate in the system. The flow rate sensor **380** serves to determine, as will be described below, that gas circulation in the system has stopped, that is, serves to confirm that the gas contained in the system is not released although the shut valve **330** is opened. Therefore, it is preferred that the flow rate sensor be disposed close to the shut valve **330** in a location in which the gas flow rate during circulation purging in the closed loop is comparatively large. For example, as shown in FIG. **10**, the flow rate sensor **380** is disposed in a zone where the recirculation channel **310** and exhaust pipe **210** communicate before the shut valve **330**.

[0110] The basic operation of the exhaust gas purification apparatus of the sixth embodiment will be described below with reference to FIGS. **11**A and **11**B. FIGS. **11**A and **11**B are a flowchart illustrating the operation of the exhaust gas purification apparatus of the sixth embodiment.

[0111] As shown in FIGS. **11**A and **11**B, the exhaust gas purification apparatus of the sixth embodiment operates as follows. More specifically, in the very middle of the circulation purging, it is periodically or a periodically determined based on the output of the O2 sensor **221** as to whether the OSC of the EHC **222** has to be restored (step S**600**). When it is necessary to restore the OSC of the EHC **222** (step S**600**: Yes), gas circulation in the system is stopped prior to introducing the Air for restoration (step S**601**). For example, the drive of the gas circulation pump **350** is stopped. Alternatively, the intake recirculation by the monitoring of the engine **200** is stopped. Then, it is determined with the flow rate sensor **380** as to whether gas circulation in the system has stopped (step S**602**).

[0112] In this case, when it is determined that gas circulation in the system has stopped (step S**602**: Yes), the shut valve

330 is opened (step S603) and the Air introducing valve 371 is opened (step S604). As a result, the Air is introduced into the EHC 222 and the OSC of the EHC 222 is restored. Alternatively, monitoring of the engine 200 may be performed and the Air may be introduced into the EHC 222 from the intake side. Such Air introduction is implemented till the OSC of the EHC 222 is completely restored, for example, till the output of the O2 sensor 221 assumes an almost entirely lean state (close to 0 V). Alternatively, the amount of Air matching the OSC of the EHC 222 that has been found in advance may be determined and the introduced amount may be adjusted accordingly. In the case of the Air introducing valve 371, the adjustment of the amount of introduced Air can be performed by regulating the opening degree of the Air introducing valve 371, and when motoring of the engine 200 is performed, the adjustment can be performed based on the revolution speed of the motor and the opening degree of the throttle 214.

[0113] Once the OSC of the EHC 222 is restored as a result of Air introduction 'step S600: No), the Air introduction is stopped (step S611). Then, the temperature of the EHC 222 is detected and where the temperature of the EHC 222 is lower than the active temperature due to the Air introduction, an electric current is passed to the EHC 222 (step S612). Once the temperature of the EHC 222 reaches the active temperature, the shut valve 330 is closed again (step S613) and the circulation purge is restarted (step S614).

[0114] As described hereinabove, with the exhaust gas purification apparatus of the sixth embodiment, the shut valve 330 is opened prior to the introduction of Air into the system with the object of restoring the OSC of the EHC 222 in the course of circulation purging. Therefore, the increase in internal pressure caused by the Air introduction can be inhibited. Moreover, because the shut valve 330 is opened after the circulation of gas in the system has been stopped, the release of HC into the external atmosphere via the shut valve 330 can be effectively prevented even when the Air is introduced.

[0115] In the above-described embodiments, the exhaust gas purification apparatus is an example of the "exhaust gas purification apparatus" according to the invention, NOx is an example of the "one component" according to the invention, the HC is an example of the "other component" according to the invention, the EHC 222 is an example of the "first purification means", "second purification means", and "heating means" according to the invention, the control device 100 is an example of the "air-fuel ratio control means" according to the invention, the HC adsorbent 340 is an example of the "adsorption means" according to the invention, the O2 sensor 221 is an example of the "air-fuel ratio detection means" according to the invention, the temperature sensor 380 is an example of the "desorption state specifying means" according to the invention, the shut vale 330 is an example of the "restricting means" according to the invention, the recirculation channel 310 and the gas circulation pump 350 or motor 44 are examples of the "recirculation means" according to the invention, the Air introducing pipe 370 and Air introducing valve 371 are examples of the "supply means" according to the invention, the O2 sensor 221 is an example of the "OSC state specifying means" according to the invention, and the internal pressure sensor 360 is an example of the "internal pressure specifying means" according to the invention.

[0116] A resistance heater or a burner-type heater may be used as the first purification means or second purification means in accordance with the invention.

[0117] The "first point in time" after the start of the engine in accordance with the invention may be a point in time equivalent to that immediately after the engine is started, preferably a point in time at which practically no exhaust gas is discharged from the engine.

[0118] The "predetermined temperature" in accordance with the invention may be a temperature within an interval from the temperature close to the right-off of the first purification means to the active temperature. The "right-off" as referred to herein is a temperature obtained by adding a certain margin to a temperature established empirically or by simulation as a temperature at which the first purification means starts reacting with the one component or the active temperature of the first purification means at which the first purification means can demonstrate the purification capacity inherent thereto.

[0119] The state of desorption of the other component from the adsorption means, which is specified by the desorption state specifying means in accordance with the invention, may be a state in which the amount of the other component adsorbed by the adsorption means is saturated, or a state in which the other component is easily desorbed from the adsorption means.

[0120] When the temperature of the adsorption means is detected and this temperature exceeds the desorption temperature of the other component (that is, the temperature at which the desorption of the other component that has been adsorbed by the adsorption means is started), because the adsorption means cannot adsorb other component, this time may be established as the second point in time.

[0121] The invention is not limited to the above-described embodiments and can be changed appropriately without departing from the scope or essence of the invention as summarized in all the claims and the entire detailed description thereof, and an exhaust gas purification apparatus incorporating such changes is also included in the technical scope of the invention.

What is claimed is:

1. An exhaust gas purification apparatus installed in an exhaust pipe serving as a flow channel of an exhaust gas discharged from an engine, comprising:
   - a first purification device that purifies at least one component from among a plurality of components contained in the exhaust gas;
   - a heating device that heats the first purification device to a predetermined temperature in at least part of a period from before the engine is started to a first point in time that is after the engine is started;
   - an air-fuel ratio control device that controls an air-fuel ratio of the exhaust gas so as to obtain a first air-fuel ratio suitable for the first purification device to purify the one component in at least part of a period from the time when the engine is started to a second point in time that is on or after a time at which the first purification device is heated to the predetermined temperature; and
   - an adsorption device that communicates with the exhaust pipe and at least partially adsorbs another component from among the plurality of components.

2. The exhaust gas purification apparatus according to claim 1, wherein the air-fuel ratio control device controls an air-fuel ratio of the exhaust gas so as to obtain a first air-fuel ratio suitable for purifying one component from among the plurality of components in a period from the time when the

first purification device is heated to an activation temperature thereof to the second point in time.

3. The exhaust gas purification apparatus according to claim **1**, further comprising an air-fuel detection device that detects an air-fuel ratio of the exhaust gas flowing in the exhaust pipe, wherein the air-fuel ratio control device feedback-controls the air-fuel ratio of the exhaust gas based at least on the detected air-fuel ratio.

4. The exhaust gas purification apparatus according to claim **3**, wherein

the second point in time is a point in time at which activation of the air-fuel ratio detection device is started, and

the air-fuel ratio control device feedback-controls the air-fuel ratio within an active period of the air-fuel ratio detection device that starts at the second point in time.

5. The exhaust gas purification apparatus according to claim **1**, further comprising a desorption state specifying device that specifies a desorption state of the other component from the adsorption device, wherein the second point in time is established according to the specified desorption state of the other component.

6. The exhaust gas purification apparatus according to claim **1**, further comprising a second purification device that purifies another component adsorbed by the adsorption device.

7. The exhaust gas purification apparatus according to claim **1**, wherein the adsorption device communicates with the exhaust pipe downstream of the first purification device.

8. The exhaust gas purification apparatus according to claim **7**, wherein the first purification device also functions as the second purification device and comprises a restricting device that restricts the release of the exhaust gas from the exhaust pipe downstream of the first purification device and the adsorption device in the exhaust pipe, and a recirculation device that desorbs the adsorbed other component and recirculates the other component via a recirculation channel to a zone upstream of the first purification device, while the release of the exhaust gas is restricted by the restricting device.

9. The exhaust gas purification apparatus according to claim **8**, further comprising a supply device that supplies secondary air to the first purification device via the recirculation channel.

10. The exhaust gas purification apparatus according to claim **9**, further comprising a desorption state specifying device that specifies a desorption state of the other component from the adsorption device, wherein the supply device supplies the secondary air according to the specified desorption state of the other component.

11. The exhaust gas purification apparatus according to claim **9**, further comprising an OSC state specifying device that specifies an OSC state of the first purification device that also functions as the second purification device, wherein the supply device supplies the secondary air according to the specified OSC state.

12. The exhaust gas purification apparatus according to claim **9**, further comprising an internal pressure specifying device that specifies a pressure inside the exhaust pipe in a state in which the release of the exhaust gas is restricted by the restriction device, wherein the supply device regulates the supplied amount of the secondary air according to the specified internal pressure.

13. The exhaust gas purification apparatus according to claim **9**, wherein the heating device heats the first purification device according to the amount of the secondary air supplied by the supply device.

14. The exhaust gas purification apparatus according to claim **6**, wherein the second purification device purifies the other component in a period during which the engine is stopped.

15. The exhaust gas purification apparatus according to claim **1**, wherein the first point in time is a point in time at which the exhaust gas is practically not discharged from the engine.

16. The exhaust gas purification apparatus according to claim **1**, wherein the one component is nitrogen oxide, and

the first air-fuel ratio is an air-fuel ratio on a rich side from a theoretical air-fuel ratio of the engine.

17. An exhaust gas purification apparatus installed in an exhaust pipe serving as a flow channel of an exhaust gas discharged from an engine, comprising:

first purification means for purifying at least one component from among a plurality of components contained in the exhaust gas;

heating means for heating the first purification means to a predetermined temperature in at least part of a period from before the engine is started to a first point in time that is after the engine is started;

air-fuel ratio control means for controlling an air-fuel ratio of the exhaust gas so as to obtain a first air-fuel ratio suitable for the first purification means to purify the one component in at least part of a period from the time when the engine is started to a second point in time that is on or after a time at which the first purification means is heated to the predetermined temperature; and

adsorption means for communicating with the exhaust pipe downstream of the first purification means and at least partially adsorbing another component from among the plurality of components.

18. An exhaust gas purification method for a purification device that purifies at least one component from among a plurality of components contained in an exhaust gas discharged from an engine, comprising:

heating the purification device to a predetermined temperature in at least part of a period from before the engine is started to a first point in time that is after the engine is started;

controlling an air-fuel ratio of the exhaust gas so as to obtain a first air-fuel ratio suitable for purifying the one component in at least part of a period from the time when the engine is started to a second point in time that is on or after a time at which the purification device is heated to the predetermined temperature; and

at least partially adsorbing another component from among the plurality of components.

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