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(54) **EXHAUST PURIFYING APPARATUS OF AN INTERNAL COMBUSTION ENGINE**

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(57) **ABSTRACT**

An exhaust purifying apparatus has an adsorbent capable of adsorbing hydrocarbons in an exhaust passage of an internal combustion engine, estimates the temperature of the adsorbent by repeated processing to estimate the current value by adding an added value to the previous estimated value, and changes the added value in response to the intake air amount and the ignition timing of the internal combustion engine.

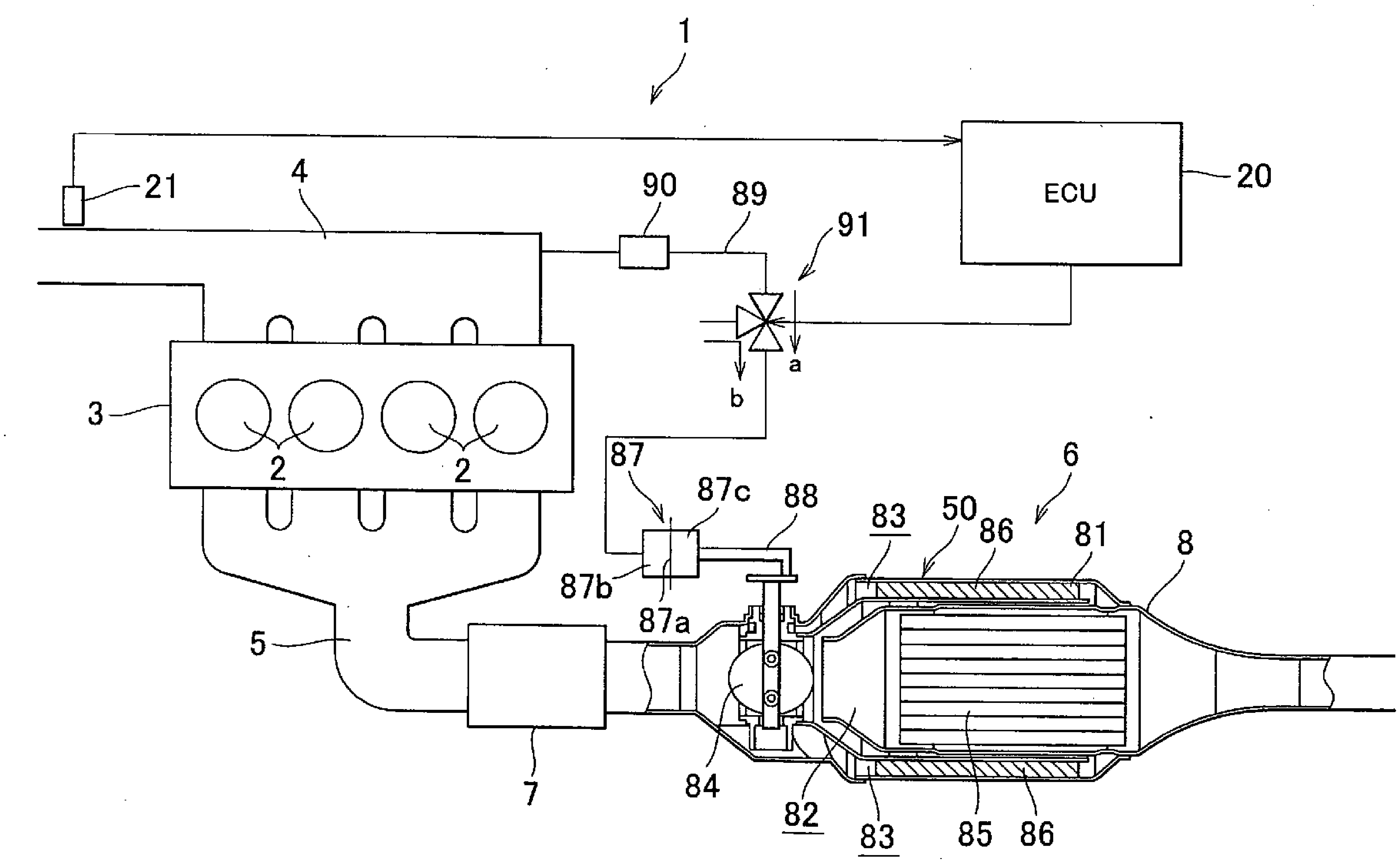
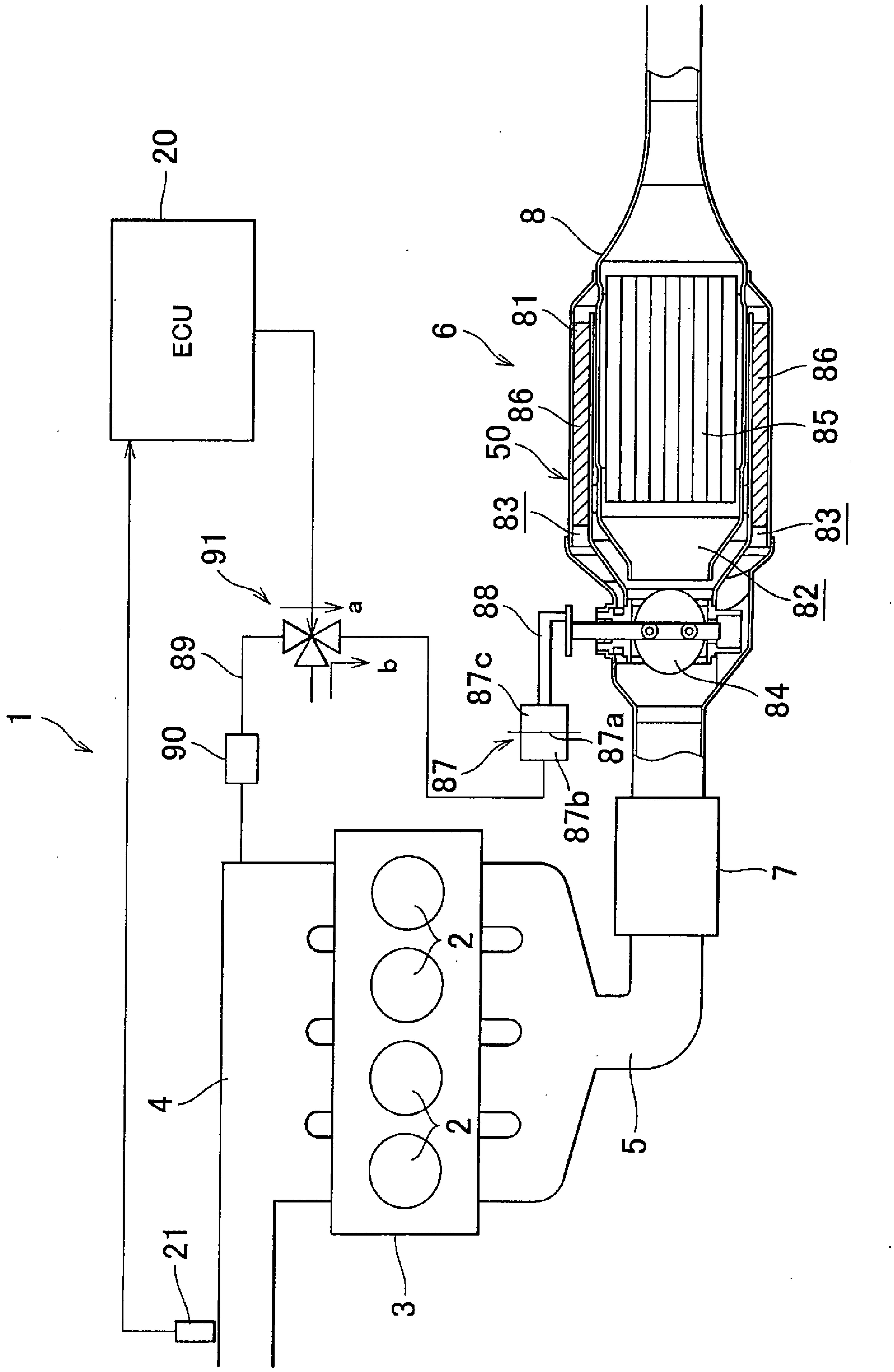


FIG. 1


1
20
ECU
91
a
b
89
90
88
87c
87
87a
87b
84
82
83
50
86
85
81
6
8
7
2
4
5
3
21

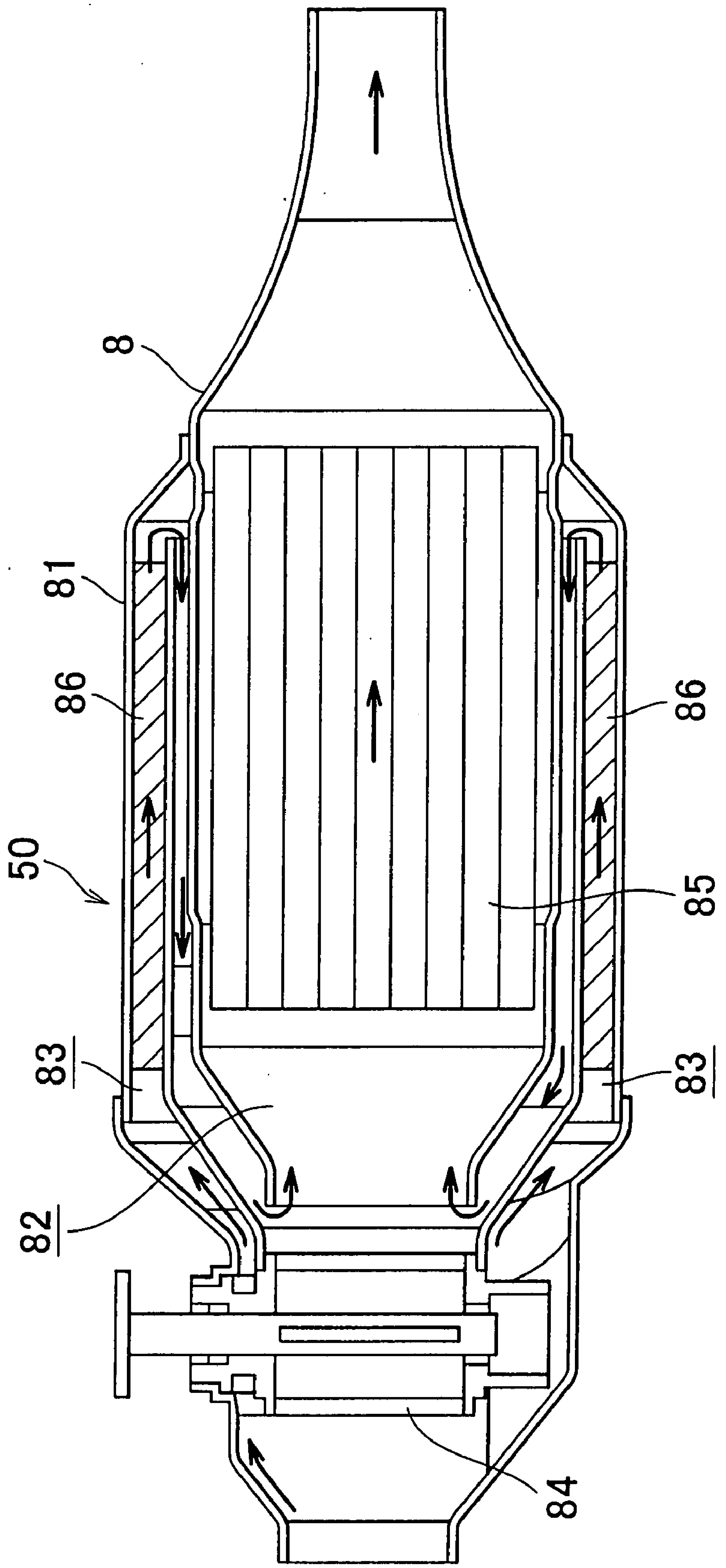


FIG. 2

FIG. 3

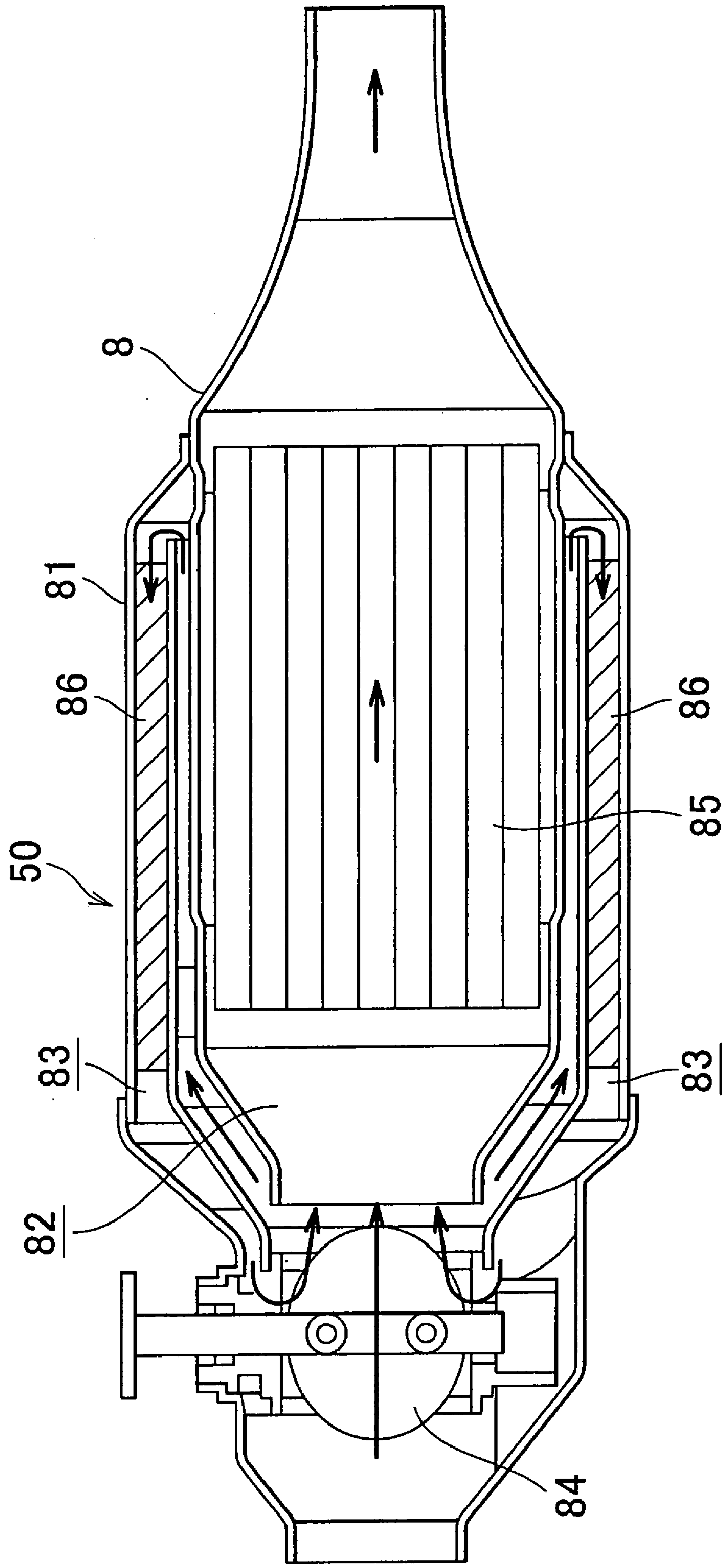


FIG. 4

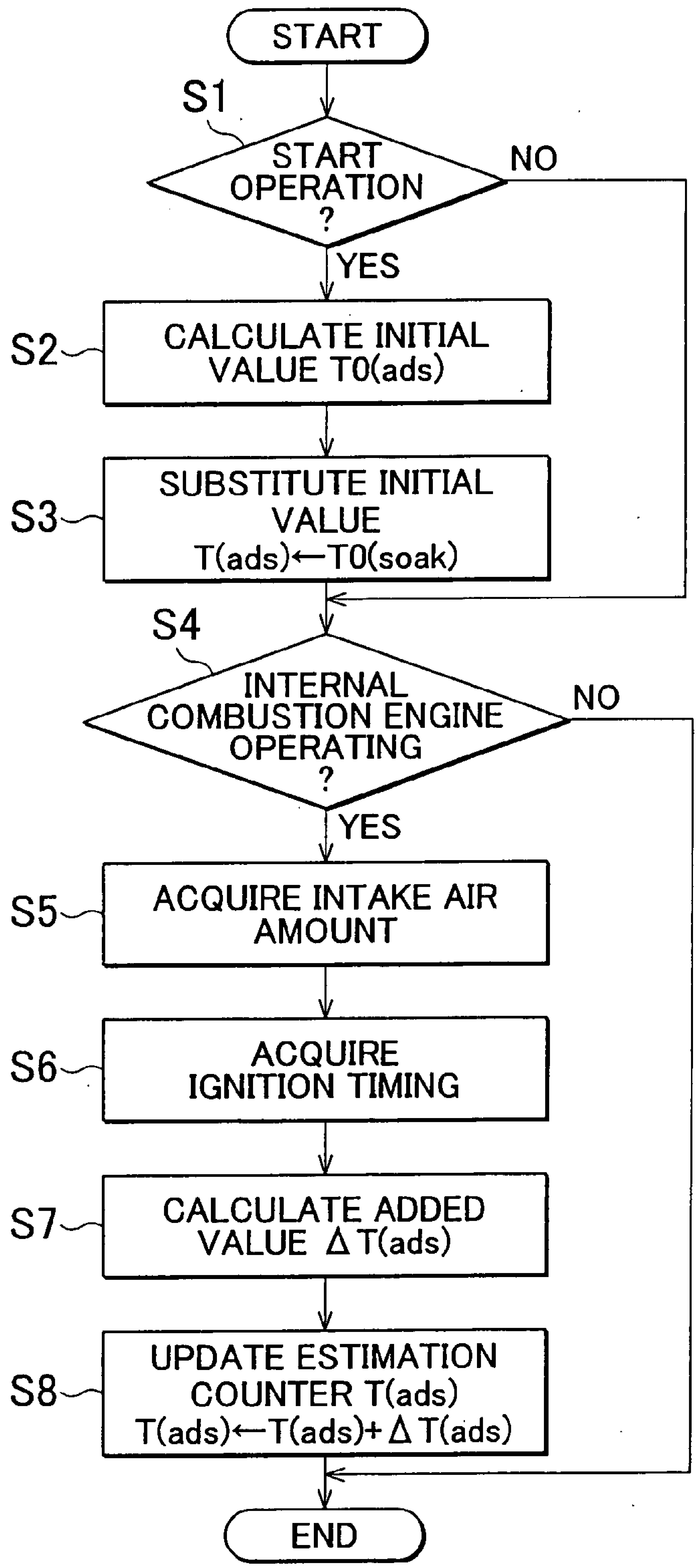

START
S1
START OPERATION ?
NO
YES
S2
CALCULATE INITIAL VALUE T0(ads)
S3
SUBSTITUTE INITIAL VALUE T(ads)←T0(soak)
S4
INTERNAL COMBUSTION ENGINE OPERATING ?
NO
YES
S5
ACQUIRE INTAKE AIR AMOUNT
S6
ACQUIRE IGNITION TIMING
S7
CALCULATE ADDED VALUE ΔT(ads)
S8
UPDATE ESTIMATION COUNTER T(ads) T(ads)←T(ads)+ΔT(ads)
END

FIG. 5

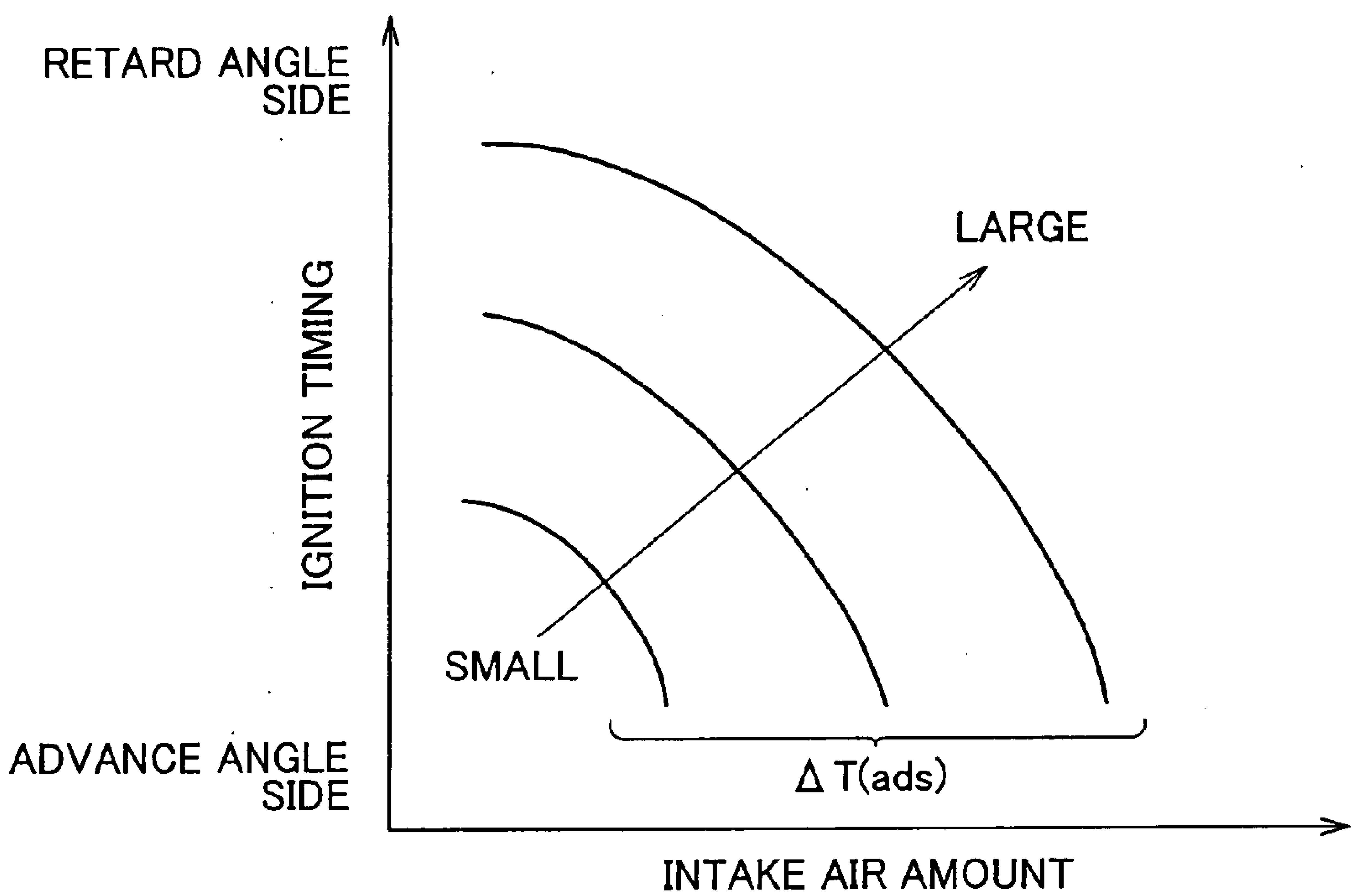

RETARD ANGLE SIDE
IGNITION TIMING
ADVANCE ANGLE SIDE
LARGE
SMALL
Δ T(ads)
INTAKE AIR AMOUNT

FIG. 6

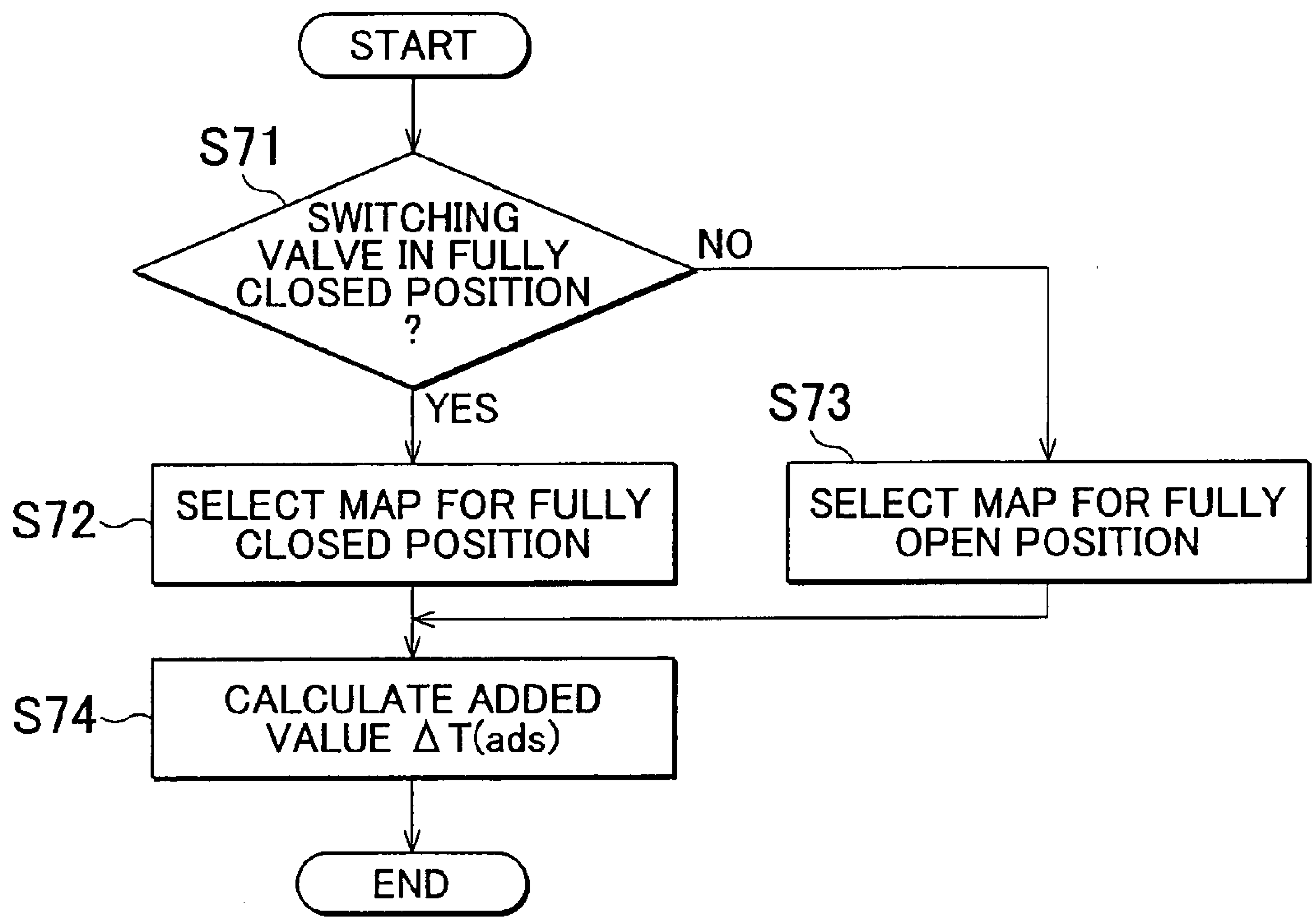

START
S71
SWITCHING VALVE IN FULLY CLOSED POSITION ?
NO
YES
S73
S72
SELECT MAP FOR FULLY CLOSED POSITION
SELECT MAP FOR FULLY OPEN POSITION
S74
CALCULATE ADDED VALUE ΔT(ads)
END

FIG. 7

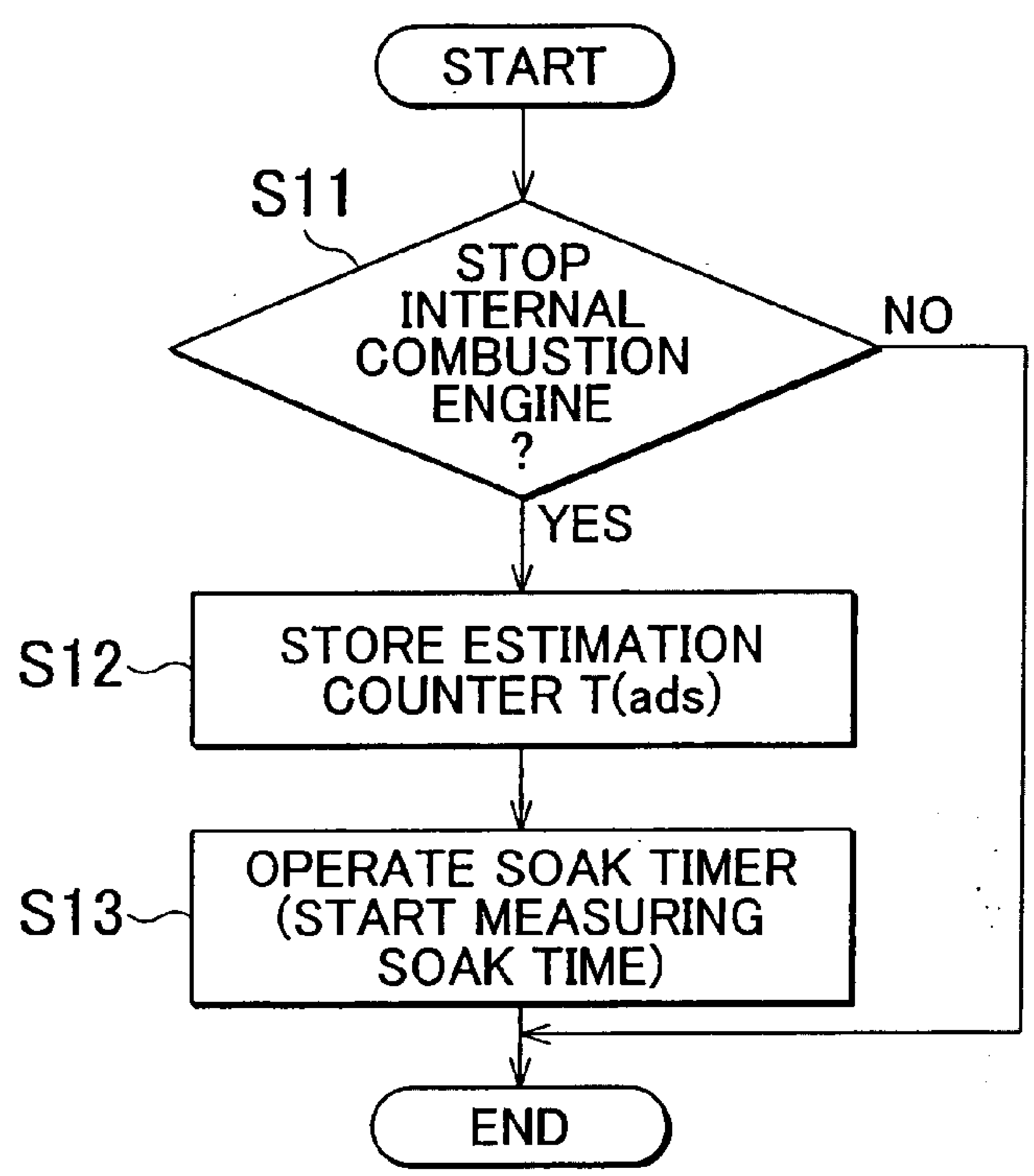

START
S11
STOP INTERNAL COMBUSTION ENGINE ?
NO
YES
S12
STORE ESTIMATION COUNTER T(ads)
S13
OPERATE SOAK TIMER (START MEASURING SOAK TIME)
END

FIG. 8

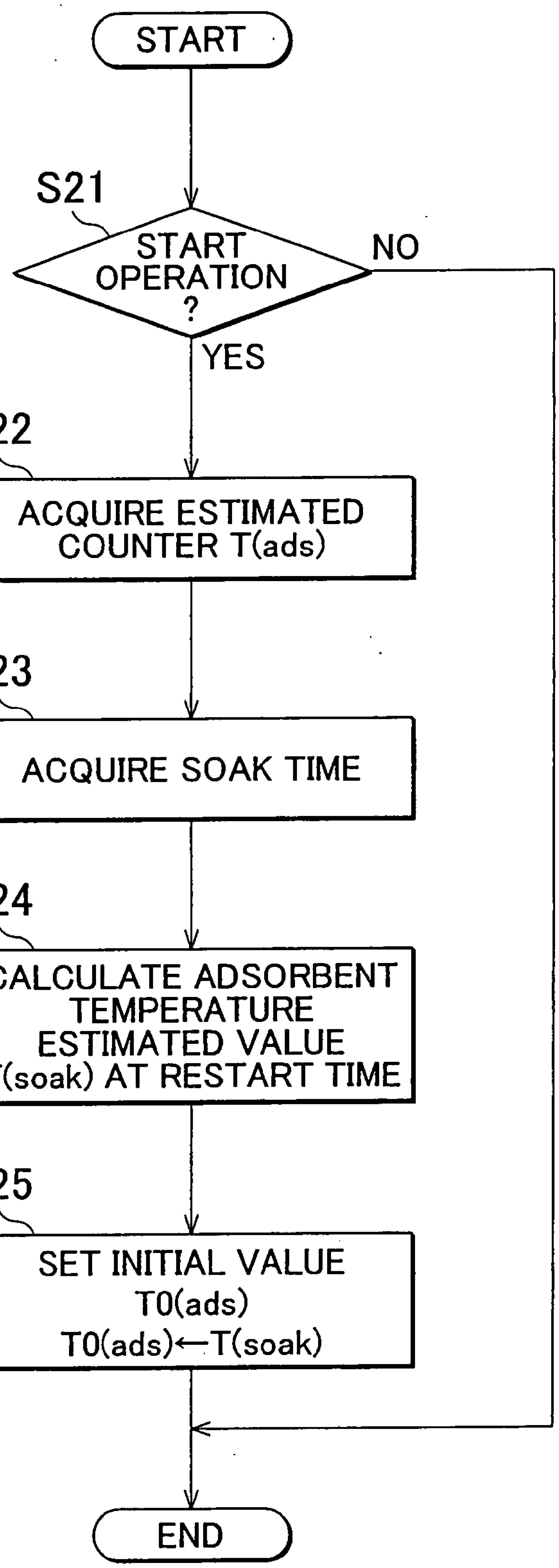

START
S21
START OPERATION ?
NO
YES
S22
ACQUIRE ESTIMATED COUNTER T(ads)
S23
ACQUIRE SOAK TIME
S24
CALCULATE ADSORBENT TEMPERATURE ESTIMATED VALUE T(soak) AT RESTART TIME
S25
SET INITIAL VALUE T0(ads)
T0(ads)←T(soak)
END

FIG. 9

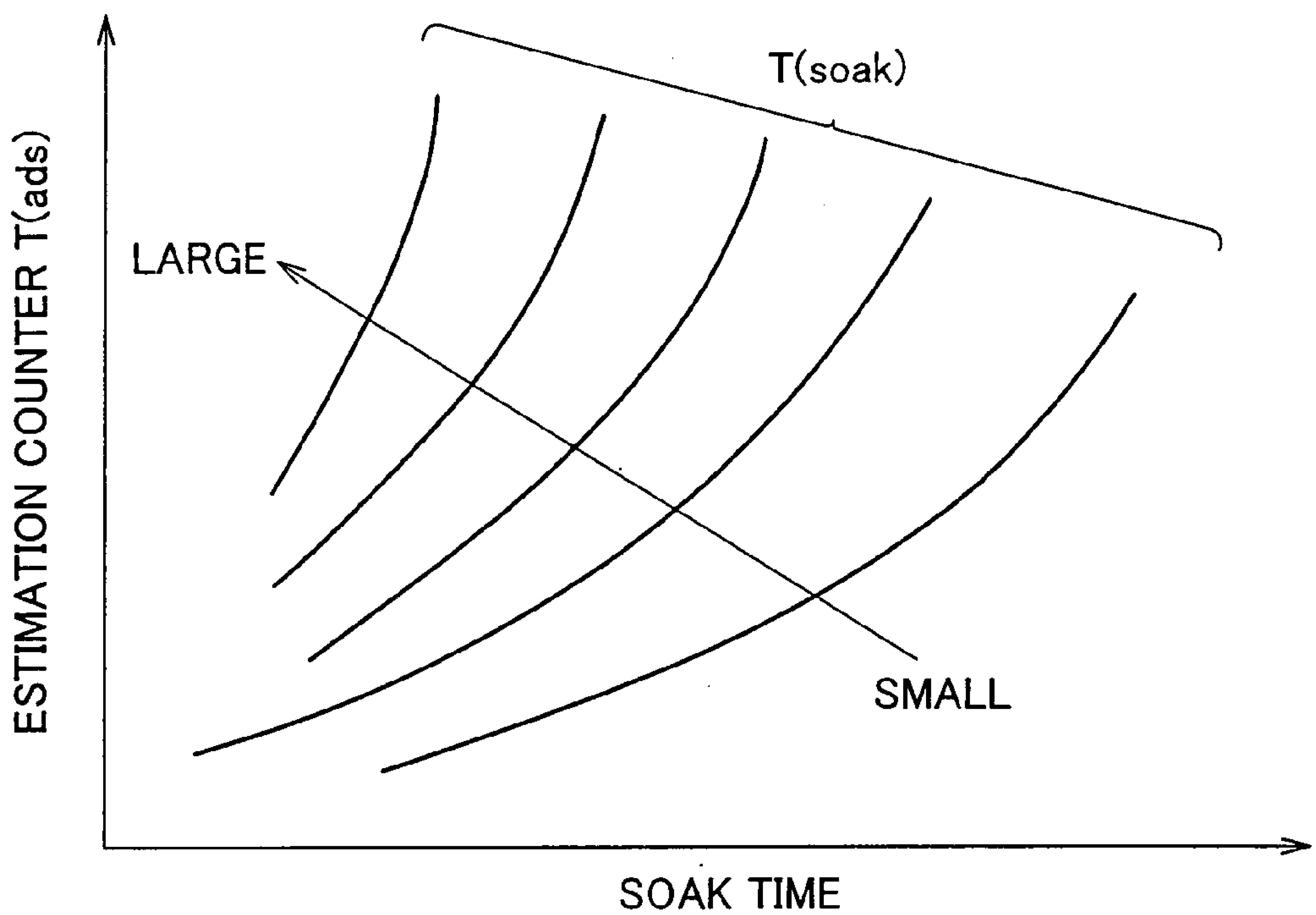


FIG. 10

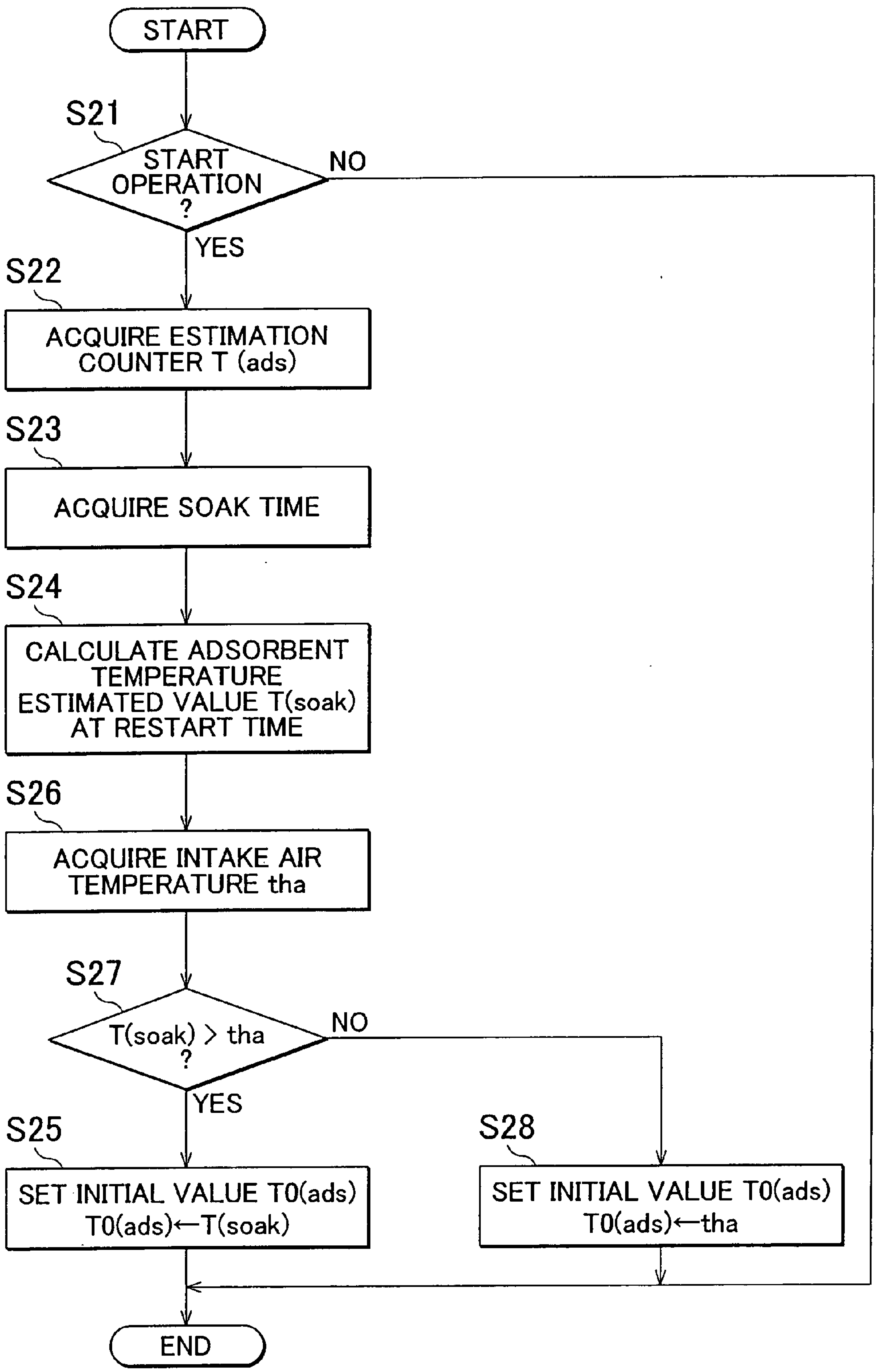

START
S21
START OPERATION ?
NO
YES
S22
ACQUIRE ESTIMATION COUNTER T (ads)
S23
ACQUIRE SOAK TIME
S24
CALCULATE ADSORBENT TEMPERATURE ESTIMATED VALUE T(soak) AT RESTART TIME
S26
ACQUIRE INTAKE AIR TEMPERATURE tha
S27
T(soak) > tha ?
NO
YES
S25
SET INITIAL VALUE T0(ads) T0(ads)←T(soak)
S28
SET INITIAL VALUE T0(ads) T0(ads)←tha
END

FIG. 11

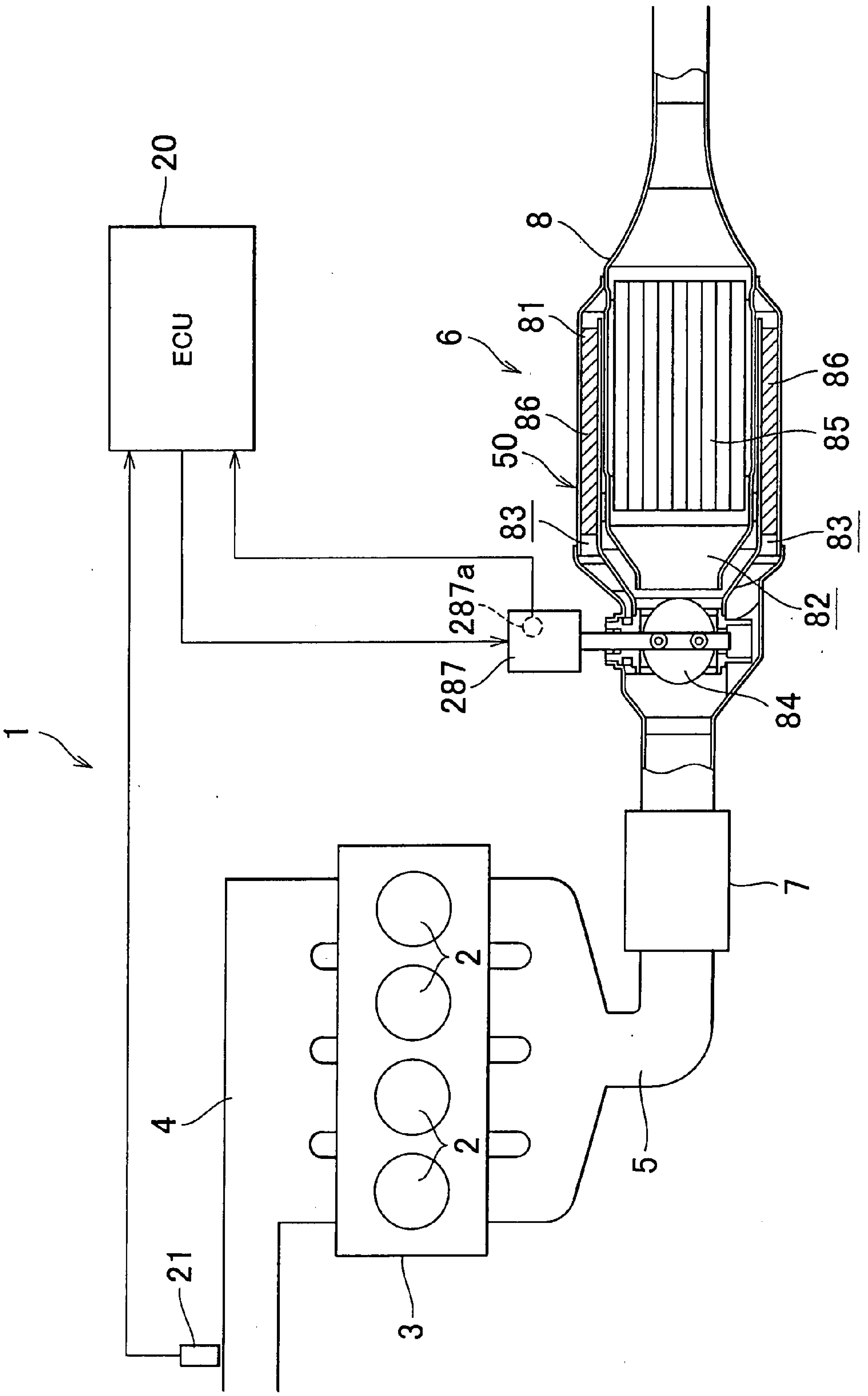
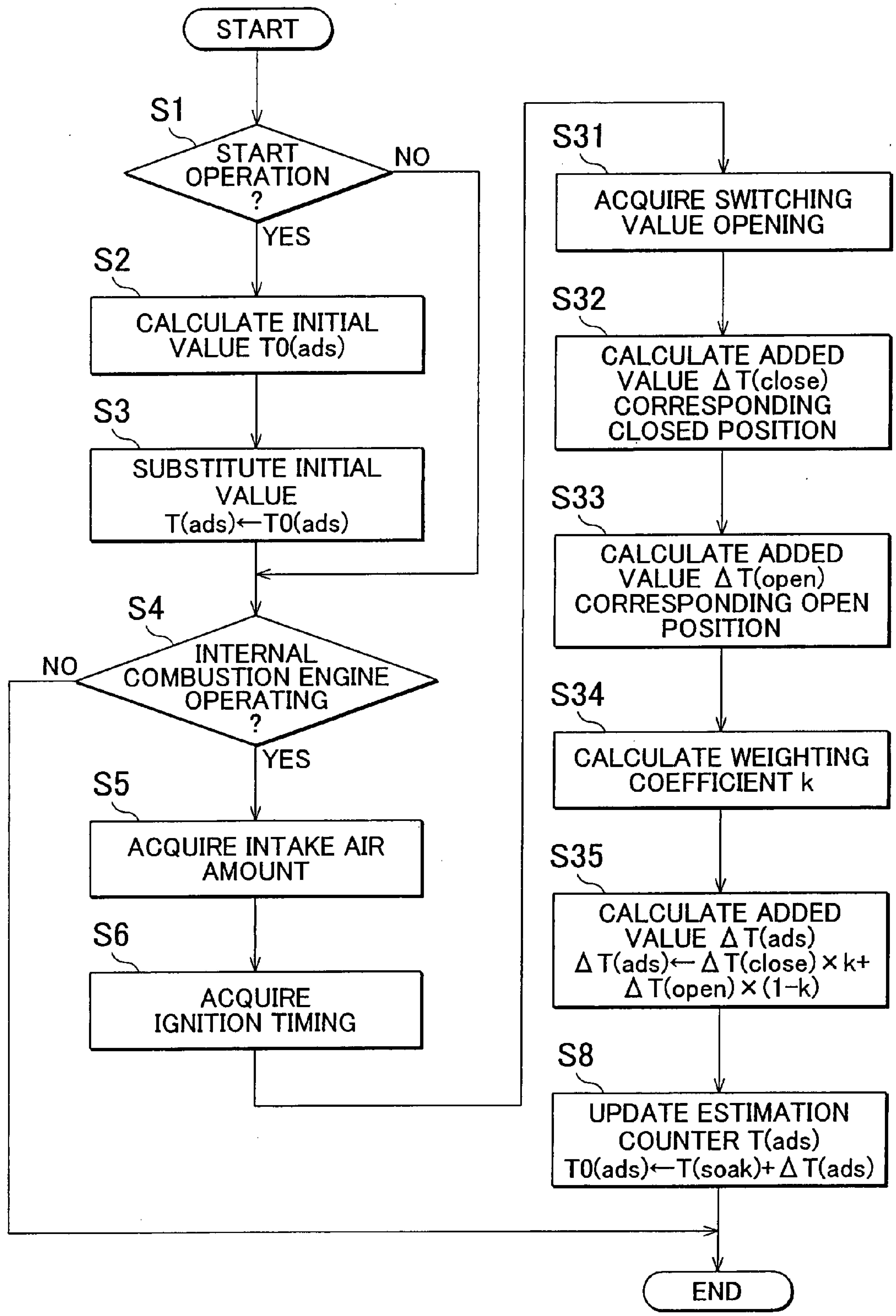
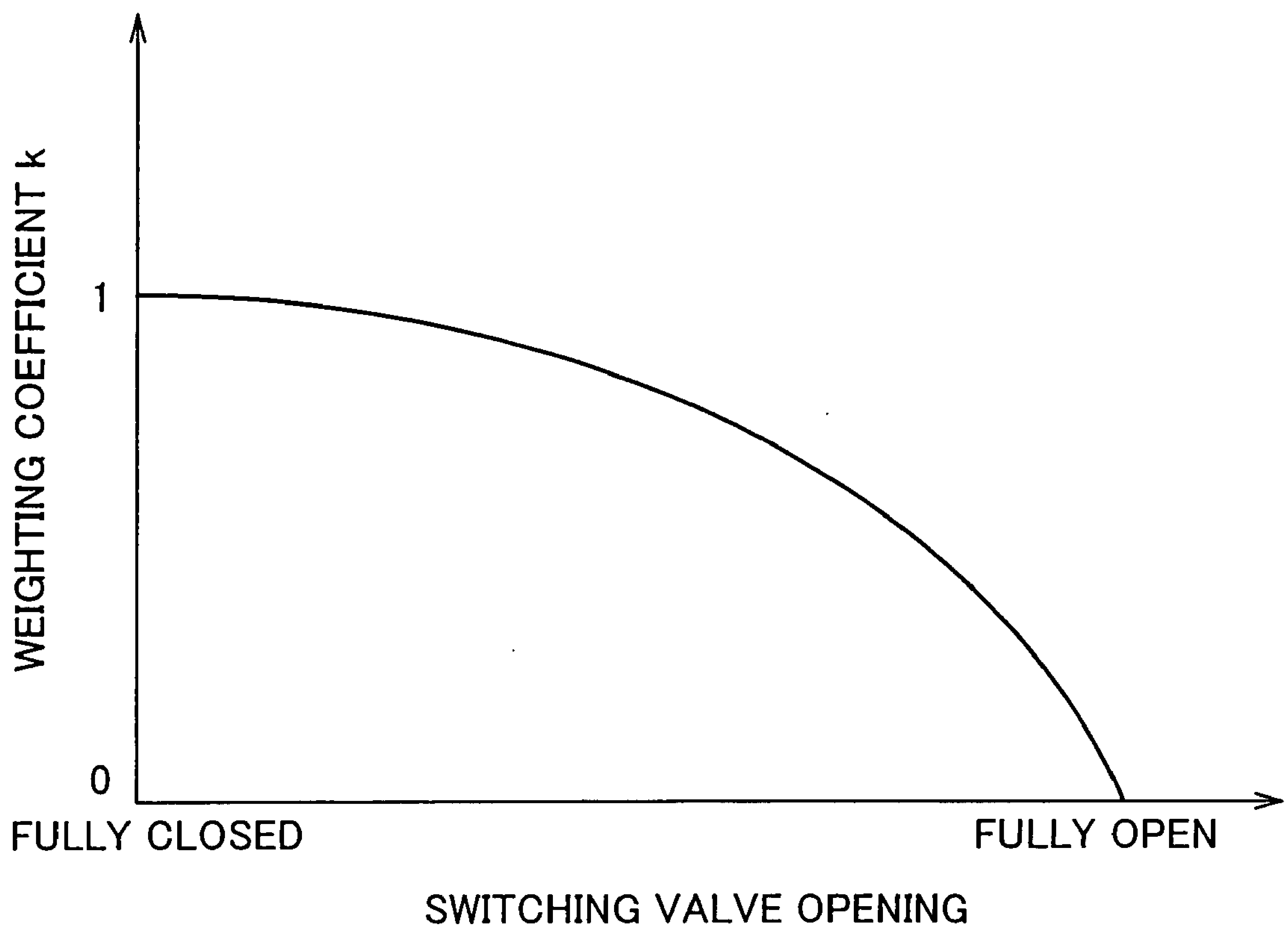


FIG. 12



START
S1
START OPERATION ?
NO
YES
S2
CALCULATE INITIAL VALUE T0(ads)
S3
SUBSTITUTE INITIAL VALUE T(ads)←T0(ads)
S4
INTERNAL COMBUSTION ENGINE OPERATING ?
NO
YES
S5
ACQUIRE INTAKE AIR AMOUNT
S6
ACQUIRE IGNITION TIMING
S31
ACQUIRE SWITCHING VALUE OPENING
S32
CALCULATE ADDED VALUE ΔT(close) CORRESPONDING CLOSED POSITION
S33
CALCULATE ADDED VALUE ΔT(open) CORRESPONDING OPEN POSITION
S34
CALCULATE WEIGHTING COEFFICIENT k
S35
CALCULATE ADDED VALUE ΔT(ads) ΔT(ads)←ΔT(close)×k+ΔT(open)×(1−k)
S8
UPDATE ESTIMATION COUNTER T(ads) T0(ads)←T(soak)+ΔT(ads)
END

FIG. 13



WEIGHTING COEFFICIENT k
1
0
FULLY CLOSED
FULLY OPEN
SWITCHING VALVE OPENING

FIG. 14

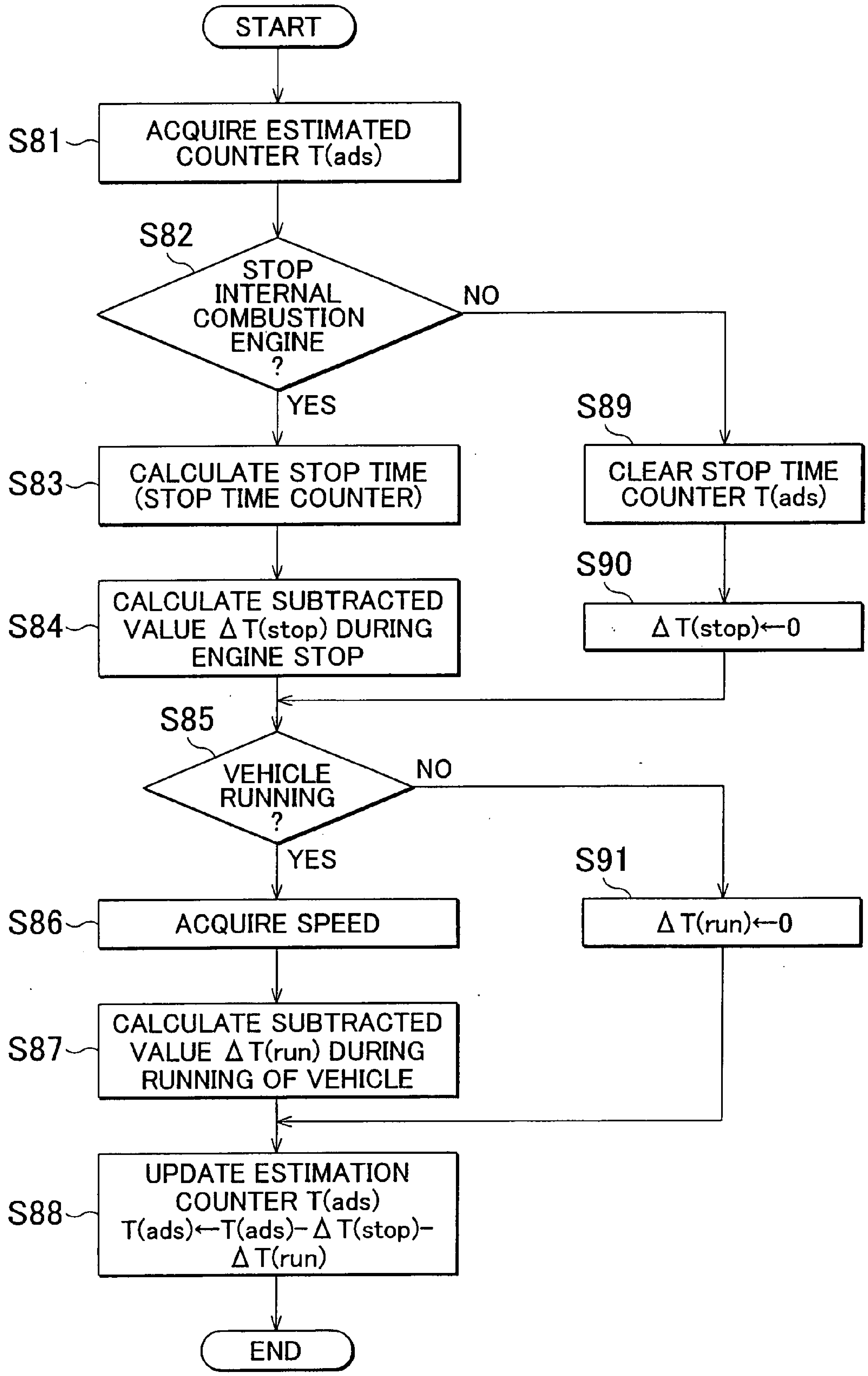

START
S81
ACQUIRE ESTIMATED COUNTER T(ads)
S82
STOP INTERNAL COMBUSTION ENGINE ?
NO
YES
S83
CALCULATE STOP TIME (STOP TIME COUNTER)
S84
CALCULATE SUBTRACTED VALUE ΔT(stop) DURING ENGINE STOP
S89
CLEAR STOP TIME COUNTER T(ads)
S90
ΔT(stop)←0
S85
VEHICLE RUNNING ?
NO
YES
S86
ACQUIRE SPEED
S91
ΔT(run)←0
S87
CALCULATE SUBTRACTED VALUE ΔT(run) DURING RUNNING OF VEHICLE
S88
UPDATE ESTIMATION COUNTER T(ads) T(ads)←T(ads)−ΔT(stop)−ΔT(run)
END

FIG. 15

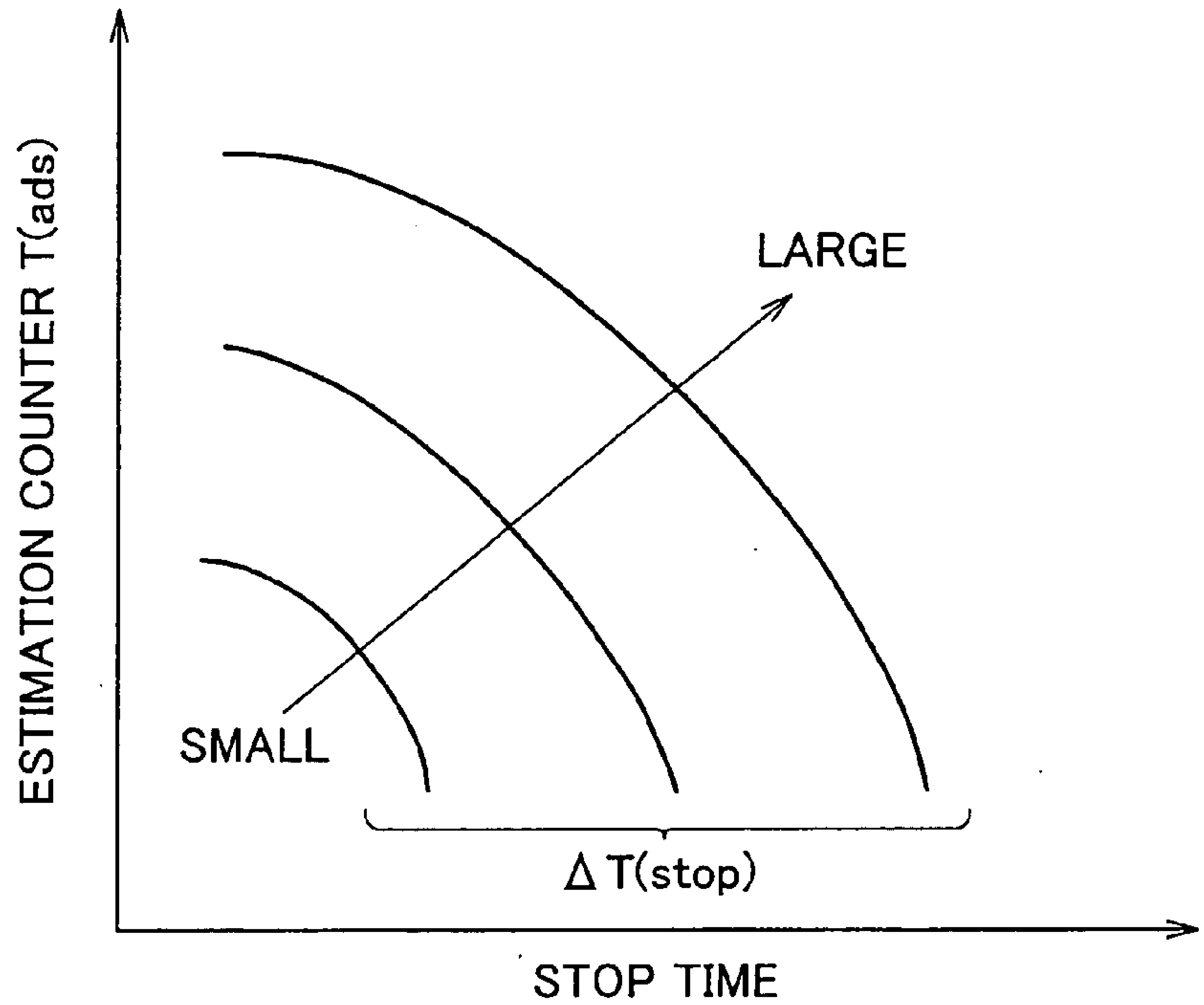
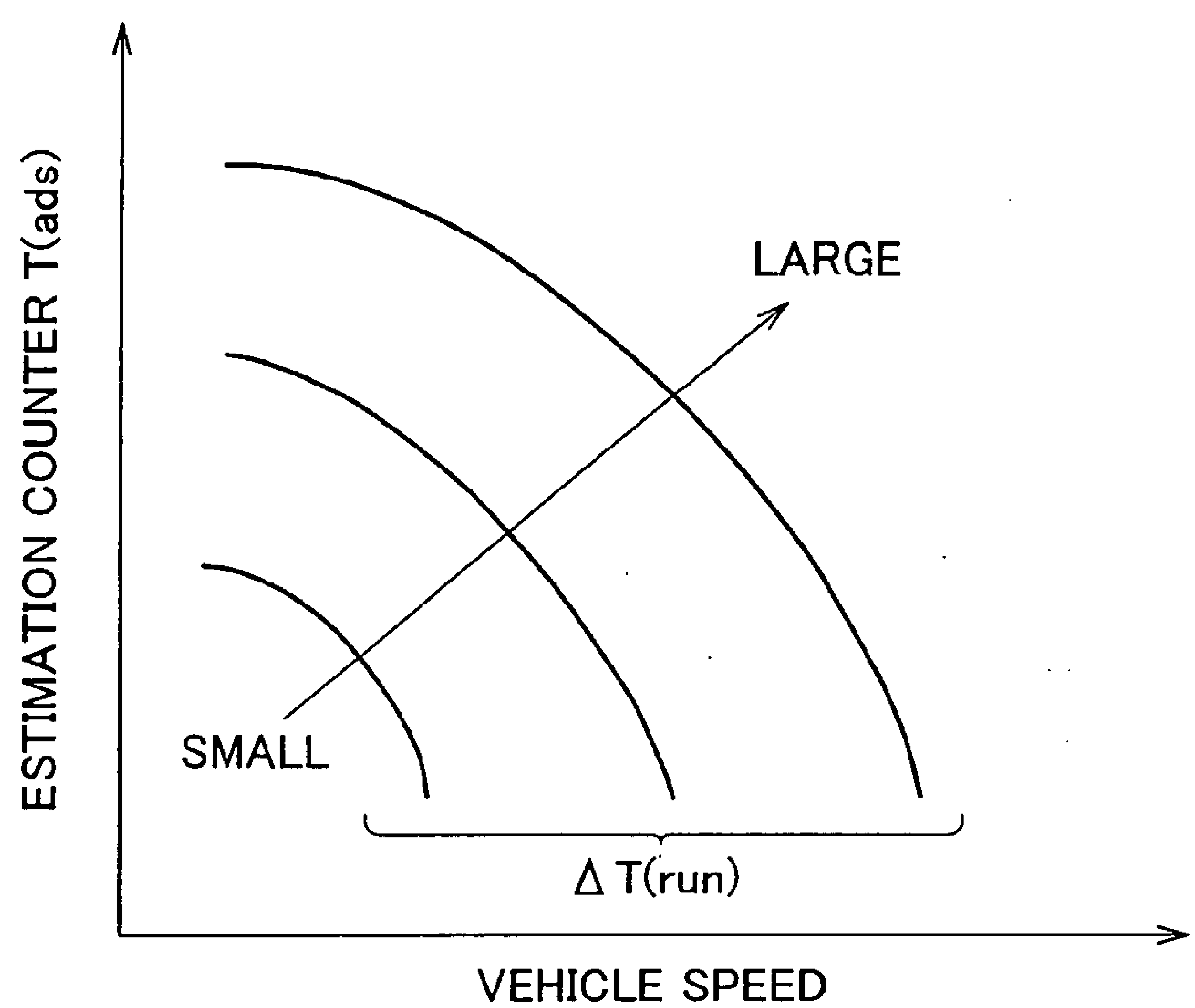

ESTIMATION COUNTER T(ads)
LARGE
SMALL
Δ T(stop)
STOP TIME

FIG. 16


ESTIMATION COUNTER T(ads)
LARGE
SMALL
Δ T(run)
VEHICLE SPEED

EXHAUST PURIFYING APPARATUS OF AN INTERNAL COMBUSTION ENGINE

INCORPORATION BY REFERENCE

[0001] The disclosure of Japanese Patent Application No. 2006-158288 filed on Jun. 7, 2006 including the specification, drawing, and abstract is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to an exhaust purifying apparatus of an internal combustion engine providing an adsorbent capable of adsorbing hydrocarbons in an exhaust passage.

[0004] 2. Description of the Related Art

[0005] In an internal combustion engine, at the time of a cold start, for example, there are cases in which a catalytic converter provided in an exhaust passage does not reach the activation temperature, making it impossible to purify hydrocarbons in the exhaust passage. For this reason, in a conventional method, a hydrocarbon adsorbent (hereinafter referred to simply as an adsorbent) capable of adsorbing hydrocarbons in a prescribed temperature range is provided to suppress a worsening of exhaust emissions before the catalytic converter reaches the activation temperature. The adsorption performance of such an adsorbent exhibits a temperature dependency, and when a prescribed upper temperature limit is exceeded, adsorbed hydrocarbons are desorbed. The adsorbent also exhibits a change in the amount of hydrocarbons that can be adsorbed dependent on the temperature. For this reason, the accurate determination of the temperature of the adsorbent is important in efficiently adsorbing hydrocarbons.

[0006] For example, there is a conventional exhaust purifying apparatus (Japanese Patent Application Publication No. 10-331625) in which temperature sensors are provided in both the input port of and on the inside of the adsorbent to detect the exhaust temperature at the input port and the temperature inside the adsorbent, the adsorbed heat occurring in the adsorbent being calculated in accordance with the difference between the detection results and a predicted temperature of the adsorbent to calculate the amount of adsorbed hydrocarbons. There is also a conventional apparatus (Japanese Patent Application Publication No. 2000-54829) that predicts the temperature of the adsorbent by determining the temperature of the exhaust gas based on a prescribed map, using the internal combustion engine load and engine rpm as parameters, and also successively determines an appropriately weighted moving average of the exhaust gas temperature.

[0007] The apparatus of Japanese Patent Application Publication No. 10-331625 requires additional parts such as temperature sensors to detect the temperature of the adsorbent, and the additional parts require space and time, and incur costs. Because the apparatus of Japanese Patent Application Publication No. JP-A-2000-54829 estimates the temperature of the adsorbent based on a moving average of the exhaust temperature, the quantitative change in the exhaust gas is not reflected in the estimated temperature results.

SUMMARY OF THE INVENTION

[0008] The present invention has an object to provide an exhaust purifying apparatus in an internal combustion engine that does not require an additional part for detecting a temperature of an adsorbent, resulting in reduction of space, time, and cost for detecting the temperature, and that obtains estimated results of the temperature in which the quantitative change of the exhaust gas is reflected.

[0009] The exhaust purifying apparatus of the internal combustion engine according to a first aspect of the present invention provides an adsorbent adsorbing hydrocarbons in an exhaust passage of the internal combustion engine; a temperature estimation part estimating a temperature of the adsorbent by repeating processing wherein an added value is added to the previous estimated value to obtain the current estimated value; and an added value calculation part calculating the added value to change the added value based on an intake air amount and an ignition timing of the internal combustion engine.

[0010] According to the present aspect of the exhaust purifying apparatus, the added value is calculated based on the intake air amount and the ignition timing, and the added value is added to the previous estimated value, thereby estimating the temperature of the adsorbent. It is therefore possible, without preparing additional parts, such as a temperature sensor, to estimate the temperature of the adsorbent and reduce space, time, and cost for detecting the temperature. Furthermore, for a given span of temperature of the exhaust gas, when the amount of exhaust gas varies, the span of the temperature rise of the adsorbent also varies. According to the exhaust purifying apparatus of this aspect, because the added value is calculated based on the ignition timing and the intake air amount, the quantitative change of the exhaust gas can be reflected in the estimated results.

[0011] According to the first aspect of the present invention, the exhaust purifying apparatus further has a valve mechanism that is provided in the exhaust passage, changing an opening amount to change the passage condition of exhaust gas toward the adsorbent. The added value calculation part may calculate the added value to change the added value based on the opening amount of the valve mechanism. Since adsorption performance of the adsorbent depends on a temperature, by changing the passage condition of the exhaust gas using the valve mechanism responsive to the change of the adsorbent performance, hydrocarbons can be efficiently adsorbed. In this case, the passage condition of the exhaust gas changes by changing the opening amount of the valve mechanism, thereby changing an amount of heat which the adsorbent receives from the exhaust gas. In this aspect, the added value based on the opening amount of the valve mechanism changes, resulting in the further improvement in the accuracy of estimating the temperature of the adsorbent.

[0012] In order to change the passage condition of the exhaust gas toward the adsorbent using the valve mechanism, various aspects can be adopted. For example, a bypass passage that bypasses the adsorbent may be provided in the exhaust passage and the limitation and the allowance of the exhaust gas flowing into the bypass passage may be switchable by the change of the opening amount of the valve mechanism. The exhaust passage may have a multiple structure partitioned into a first passage disposed in the central part and a second passage disposed to surround an outer periphery of the first passage and to provide the adsorbent. In this case, the valve mechanism provided upstream from the multiple structure may be structured to limit exhaust gas flowing into the first passage, and to change an opening amount between a fully closed position that allows exhaust gas to flow into the second passage and a fully open position that allows exhaust gas to flow into both the first passage and the second passage.

[0013] In the latter case of the foregoing aspects, when the valve mechanism is in the fully closed position, because the exhaust gas flowing into the first passage is limited and the exhaust gas is allowed to flow into the second passage, in which the adsorbent is disposed, the adsorbent receives heat directly from the exhaust gas. In contrast, when the valve mechanism is in the fully open position, because the flow of exhaust gas into both the first passage and the second passage is allowed, the adsorbent receives less heat directly from the exhaust gas, resulting in receiving most heat indirectly via the first passage. By calculating the added value based on the change of the opening amount of the valve mechanism, because the change of the amount of heat received by the adsorbent according to the change of the opening amount of the valve mechanism is considered, the accuracy of estimating the temperature of the adsorbent is improved.

[0014] In these aspects, there is no particular limitation with regard to the calculation of the added value based on the change of opening amount of the valve mechanism. The added value calculation part, for example, may calculate the added value using a weighting coefficient based on the opening amount of the valve mechanism. If the added value based on at least one opening amount is set in advance, the added value of the other opening amounts can be obtained by multiplying the added value by the weighting coefficient. Because it is not necessary to set the added values for every opening amount, the processing is simplified.

[0015] In the exhaust purifying apparatus of the internal combustion engine according to the first aspect of the present invention, the internal combustion engine may be provided in a vehicle as one of a plurality of driving power sources for running, and the vehicle may be configured to be runnable with only a driving power source for running other than the internal combustion engine. The temperature estimation part may estimate the temperature of the adsorbent when the internal combustion engine is in the stopped condition by successive subtraction of the subtracted value from the estimated temperature at the time the drive of internal combustion engine is stopped, and may further include a subtracted value calculation part wherein the subtracted value is calculated considering a running condition of the vehicle when the internal combustion engine is in the stopped condition. The vehicle that has a plurality of driving power sources for running including the internal combustion engine, and that is configured to be runnable with only a driving power source for running other than the internal combustion engine includes a so-called hybrid vehicle. This type of vehicle can run using another driving power source even if the internal combustion engine is stopped. In the case in which the internal combustion engine is stopped, because the exhaust gas is not discharged the temperature of the adsorbent is gradually decreased with the elapse of time. In the case in which the internal combustion engine is stopped and the vehicle is running, compared with the case in which the internal combustion engine is stopped and the vehicle is stationary, the temperature decrease of the adsorbent is accelerated by wind during running. According to the present aspect, because the subtracted value is calculated considering the running condition of the vehicle, the adsorbent temperature can be accurately estimated.

[0016] According to the present aspect of the exhaust purifying apparatus of the internal combustion engine may determine an initial value as a base of estimation of a temperature using any method, for example, by further providing a time-keeping apparatus measuring a stopped time up to a subsequent start time of the internal combustion engine as the starting point of the time during which the drive of the internal combustion engine is stopped; and a starting time temperature estimation part estimating the temperature of the adsorbent at the starting time of the internal combustion engine based on the stopped time measured by the time-keeping apparatus, wherein the temperature estimation part may use the estimation results from the starting time temperature estimation part as the initial value before adding the added valued. The longer the time in which the internal combustion engine is stopped becomes, the lower the temperature of the adsorbent becomes. According to this aspect, the temperature of the adsorbent at the starting time of the internal combustion engine is estimated considering a stopped time, a starting time temperature of the estimated results is used as the initial value. The deviation between the estimated temperature and the actual temperature can therefore be reduced. In this case, in the case in which the temperature of the estimated results by the starting time the temperature estimation part becomes lower than that of an intake air, the temperature estimation part may use the intake temperature as the initial value in place of the estimated results. By foregoing processing, it is possible to avoid the problem of using the estimated temperature that is lower than the intake temperature at the starting time as the initial value, resulting in a further improvement in the accuracy of estimating the temperature of the adsorbent after restarting.

[0017] As described in the above, according to the present invention, the added value is calculated based on the intake air amount and the ignition timing to be successively added to the prescribed initial value, thereby estimating the temperature of the adsorbent. Without preparing additional parts, such as a temperature sensor, the temperature of the adsorbent can be estimated and space, time, and cost for detecting a temperature can be reduced. Because the added value is calculated based on the ignition timing and the intake air amount, the quantitative change of the exhaust gas can be reflected the estimated results.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] 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:

[0019] FIG. **1** is a drawing showing an internal combustion engine provided with an exhaust purifying apparatus according to a first embodiment of the present invention;

[0020] FIG. **2** is a drawing showing details of a rear purifying apparatus of FIG. **1** in which a switching valve is a fully closed position;

[0021] FIG. **3** is a drawing showing details of a rear purifying apparatus of FIG. **1** in which a switching valve is a fully open position;

[0022] FIG. **4** is a flowchart showing an example of temperature estimation processing according to a first embodiment;

[0023] FIG. **5** is a drawing describing an example of a map giving an additional value ΔT (ads) with an intake air amount and ignition timing as variables;

[0024] FIG. **6** is a flowchart showing another replaceable example into a step S7 of FIG. **4**;

[0025] FIG. **7** is a flowchart showing an example of processing executed in preparation for a restart after stopping of an internal combustion engine;

[0026] FIG. **8** is a flowchart showing an example of processing calculating an initial value T**0** (ads) as a base of an estimated temperature in FIG. **4**;

[0027] FIG. **9** is a drawing describing an example of a map giving a temperature estimated value T (soak) with an estimation counter T (ads) and a soak time as variables;

[0028] FIG. **10** is a flowchart showing another example of processing calculating an initial value T**0** (ads);

[0029] FIG. **11** is a drawing showing an internal combustion engine provided with an exhaust purifying apparatus according to a second embodiment of the present invention;

[0030] FIG. **12** is a flowchart showing an example of temperature estimation processing according to the second embodiment;

[0031] FIG. **13** is a drawing describing an example of a map associating a weighting efficient k with a switching valve opening amount;

[0032] FIG. **14** is a flowchart showing an example of a temperature estimation processing of an adsorbent according to a third embodiment;

[0033] FIG. **15** is a drawing describing an example of a map giving a subtracted value ΔT (stop) with an estimation counter T (ads) and a stop time as variables; and

[0034] FIG. **16** is a drawing describing an example of a map giving a subtracted value ΔT (run) with an estimation counter T (ads) and a vehicle speed as variables.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0035] FIG. **1** shows a first embodiment of an internal combustion engine provided with a purifying apparatus according to the present invention. The internal combustion engine **1** in FIG. **1** mounted aboard a vehicle as a drive power source for running provides an engine body **3** having a plurality of cylinders **2** (four cylinders in FIG. **1**), an intake passage **4** and an exhaust passage **5** connected to each cylinder **2**, and an exhaust purifying apparatus **6**. An air flow meter **21** that outputs a signal based on an amount of intake air is provided in the intake passage **4**. The exhaust purifying apparatus **6** includes a front purifying apparatus **7** mounted in the exhaust passage **5** and a rear purifying apparatus **8** mounted downstream from the exhaust passage **5**. The front purifying apparatus **7** is used for preventing toxic substances from being exhausted before the rear purifying apparatus **8** is activated, for example when the internal combustion engine **1** is started, and is structured, for example, as a three-way catalytic converter in which the volume is set to be smaller than that of the rear purifying apparatus **8**.

[0036] As shown in FIG. **2** and FIG. **3**, the rear purifying apparatus **8** has a casing **81** that forms a part of the exhaust passage **5**, a first passage **82** disposed in a central part of the casing **81**, and a second passage **83** disposed to surround an outer periphery of the first passage **82**. By doing this, a multiple structure **50** is partitioned into the first passage **82** and the second passage **83** in the exhaust passage **5**. Both ends of the second passage **83** are turned to open toward upstream from the exhaust passage **5**, specifically, toward an intake of the first passage **82**. The three-way catalytic converter **85** is provided in the first passage **82**, and a hydrocarbon adsorbent **86** (hereinafter sometimes referred to simply as an adsorbent) is disposed in the second passage **83**. The adsorbent **86** adsorbs hydrocarbons in a prescribed temperature range and desorbs the hydrocarbons adsorbed at a high temperature beyond the prescribed temperature range.

[0037] The rear purifying apparatus **8** is provided upstream from the casing **81**, that is, upstream from the multiple structure **50**, and further includes a switching valve **84** as the valve mechanism to change the exhaust flow in the casing **81**. The switching valve **84** is structured to enable changing of the opening amount between a fully closed position shown in FIG. **2** and a fully open position shown in FIG. **3**, thereby changing the state of the passage of exhaust gas toward the adsorbent **86**. Specifically, in the rear purifying apparatus **8**, when the switching valve **84** is fully closed, because the exhaust gas flowing into the first passage **82** is limited, and the flow of exhaust gas into the second passage **83** is allowed, the exhaust gas passes through the second passage **83** and then the first passage **82**, as shown by the arrow in FIG. **2**. On the other hand, when the switching valve **84** is fully open, because exhaust gas is allowed to flow into both the first passage **82** and the second passage **83**, exhaust gas passes through both the first passage **82** and the second passage **83**, as shown by the arrow in FIG. **3**. When the switching valve **84** is in fully open position, however, the direction of exhaust gas passing through the second passage **83** is in the direction opposite from the case of the fully closed position. Exhaust gas guided into the second passage **83** passes through the first passage **82** after passing through the second passage **83**.

[0038] The rear purifying apparatus **8** has a diaphragm mechanism **87** for driving the switching valve **84** as shown in FIG. **1**. The diaphragm mechanism **87** is connected to the switching valve **84** via the operating rod **88**, and the inside of the diaphragm mechanism **87** is partitioned by a diaphragm **87***a* into a variable pressure chamber **87***b* and an atmospheric pressure chamber **87***c*, the internal pressure of which is held at atmospheric pressure. The operating rod **88** is linked to the diaphragm **87***a*. The diaphragm mechanism **87** places the switching valve **84** in the fully closed position when the pressure in the variable pressure chamber **87***b* is adjusted to be lower than the atmospheric pressure, and places the switching valve **84** in the fully open position when the pressure in the variable pressure chamber **87***b* is adjusted to the atmospheric pressure. The variable pressure chamber **87***b* and the intake passage **4** are connected by a negative pressure passage **89**, which is provided with a check valve **90** and a three-way valve **91**. The check valve **90** is a unidirectional valve that allows the flow of air from the variable pressure chamber **87***b* toward the intake passage **4** in the case in which the pressure in the intake passage **4** is lower than that in the variable pressure chamber **87***b*. The three-way valve **91** provides communication between the variable pressure chamber **87***b* and the intake passage **4**, and switches between the negative pressure introduction location a, which guides the negative pressure of the intake passage **4** toward the variable pressure chamber **87***b*, and the atmospheric open position b introducing atmospheric pressure into the variable pressure chamber **87***b* while blocking the communication between the variable pressure chamber **87***b* and the intake passage **4**. By doing this, in the case in which the three-way valve **91** is switched to the negative pressure introduction position a, the switching valve **84** is switched to the fully closed position, and in the case in which the three-way valve **91** is switched to the atmospheric open position b, the switching valve **84** is switched to the fully open position. That is, in the embodiment shown in FIG. **1**, the diaphragm mechanism **87** switches the switching valve **84** selectively between the fully closed position and the fully open position.

[0039] The opening amount control of the switching valve **84** is performed by an electric control unit (ECU) **20** that controls the operating condition of the internal combustion engine **1**. The ECU **20** is a computer, which includes a microprocessor and peripheral devices such as RAM and ROM necessary for the operation thereof. The ECU **20** performs various control based on input information from various sensors. In the control related to the exhaust purifying apparatus according to this embodiment of the present invention, when for example the temperature of the three-way catalytic converter **85** provided in rear purifying apparatus **8** is lower than the activation temperature, the ECU **20** switches the three-way valve **91** to the negative pressure introduction position a so that the switching valve **84** is switched to the fully closed position. By doing this, because the exhaust gas is guided into the three-way catalytic converter **85** after the hydrocarbons of the exhaust gas are adsorbed by the adsorbent, flow of hydrocarbons into an inactivated three-way catalytic converter **85** is prevented, thereby enabling prevention of a worsening of exhaust emissions.

[0040] The hydrocarbon adsorbing performing of the adsorbent **86** exhibits temperature dependency. For this reason, if the upper limit of a prescribed temperature range in which the adsorbent **86** can adsorb is exceeded, adsorbed hydrocarbons are desorbed. In order to efficiently adsorb hydrocarbons, therefore, it is necessary to accurately determine the performance of the adsorbent **86**, that is, the temperature of the adsorbent **86**. For this reason, the ECU **20** executes the temperature estimation processing described below.

[0041] FIG. **4** is a flowchart showing an example of temperature estimation processing executed by the ECU **20**. The processing program is stored in a ROM of the ECU **20**, which reads out the program when appropriate and repeats execution of the program at a prescribed time interval. First, at step S**1**, the ECU **20** determines whether there is a starting operation. The time of the start of operation is, for example, the time of an operation by an operator turning an ignition switch from off to on to indicate an intention to start, at which point the ECU **20** determines the existence or nonexistence of such operation. In the case in which a starting operation has occurred, processing proceeds to step S**2**, and if there was no starting operation, steps S**2** and S**3** are skipped, and processing proceeds to step S**4**.

[0042] At step S**2**, the value to serve as the base for temperature estimation of the adsorbent **86**, that is, the previous initial value T**0** (ads) before adding the added value, to be described below, is calculated. The initial value T**0** (ads) can be a physical quantity correlated to the temperature of the adsorbent **86**. For example, this can be calculated by estimation from the cooling water temperature of the internal combustion engine **1**, and can also be calculated by the initial value calculation processing to be described later. Next, at step S**3**, the initial value T**0** (ads) calculated at step S**2** is substituted into an estimation counter T (ads) provided as a variable for storing the estimated temperature value of the adsorbent **86**.

[0043] At step S**4**, determination is performed of whether the internal combustion engine **1** is operating. For example, if there is a starting operation but the internal combustion engine **1** has not yet started, or there is no starting operation and the internal combustion engine **1** is stopped, the subsequent processing is skipped and the current processing is ended. In the case in which the internal combustion engine **1** is operating, processing proceeds to step S**5**, at which the intake air amount is obtained based on a signal from an air flow meter **21**, and then step S**6**, at which the ignition timing is acquired. The ECU **20** executes an ignition timing control routine in parallel with this processing to set the ignition timing in response to the operating condition of the internal combustion engine **1**. At step S**6** the timing set by this ignition timing control is acquired.

[0044] Next, at step S**7**, an added value ΔT (ads) corresponding to the span of temperature rise of the adsorbent **86** responsive to the processing execution period is calculated. The added value ΔT (ads) is calculated considering the intake air amount acquired at step S**5** and the ignition timing acquired at step S**6**. Because the greater the intake air amount is, the greater is the amount (more precisely, the flow amount) of exhaust gas, the greater is the thermal energy of the exhaust gas. For this reason, compared to the case in which the intake air amount is small, when the intake air amount is large there is an increase in the amount of heat received by the adsorbent **86** from the exhaust gas, and the span of temperature rise per unit time becomes large. Also, because the more the ignition timing is retarded, that is, the more it approaches the retard angle side, the more non-combusted fuel there is, combustion of the non-combusted fuel being promoted within the exhaust passage, the higher is the exhaust gas temperature. For this reason, compared to the case in which the ignition timing is advanced, when the ignition timing is retarded the amount of heat received by the adsorbent **86** from the exhaust gas increases, resulting in an increase in the span of temperature rise per unit time.

[0045] The calculation of the added value ΔT (ads) reflecting the above points can be implemented by an appropriate method. For example, the ECU **20** can store beforehand a map such as shown in FIG. **5**, which gives the added value ΔT (ads) with the intake air amount and the ignition timing as variables, and can reference the map to calculate an appropriate added value ΔT (ads). The map shown in FIG. **5** is constituted so that, the greater is the intake air amount and the more retarded is the ignition timing, the larger is the added value ΔT (ads) that is given.

[0046] Next, at step S**8** the added value ΔT (ads) is added to the current estimation counter T (ads) to update the estimation counter T (ads), at which point the current processing is ended. By repeating the foregoing processing, the added value ΔT (ads) is added to the previous estimated value to obtain the current estimated value. By doing this, it is possible to accurately estimate the temperature of the adsorbent **86** and, in this embodiment in particular, the temperature of the adsorbent **86** during the process of a temperature rise.

[0047] FIG. **6** is a flowchart showing another example of the calculation processing (step S**7**) for calculating the added value ΔT (ads) of FIG. **4**. In this example, the opening amount of the switching valve **84** is considered when calculating the added value ΔT (ads). In this case, in order to calculate the added value ΔT (ads) a fully closed position map and a fully open position map are prepared, and a map is selected that is appropriate to the opening amount of the switching valve **84**. That is, as shown in FIG. **6**, at step S**71** the ECU **20** determines whether the opening amount of the switching valve **84** is the fully closed position and, in the case of the fully closed position, processing proceeds to step S**72**, at which the fully closed position map is selected. In the case of a position other than the fully closed position, that is, in the case of the fully open position, processing proceeds to step S**73**, at which the fully open position map is selected. Then, at step S**74**, the added value ΔT (ads) is calculated by referencing the selected map.

[0048] Although the foregoing maps are not illustrated, they are constituted to show the same trend as shown by the map shown in FIG. **5**. That is, the maps are constituted to give a larger added value ΔT (ads), the larger is the intake air amount and the more retarded is the ignition timing. If these maps are compared, it is seen that, for the same intake air amount and ignition timing conditions, the added value ΔT (ads) given by the fully closed position map is larger than the added value ΔT (ads) given by the fully open position map. In the case in which the switching valve **84** is in the fully closed position, the adsorbent **86** receives heat directly from the exhaust gas. In contrast, in the case of the fully open position, the heat directly received from the exhaust gas decreases, and the heat indirectly received via the first passage **82** increases. As a result, for the same intake air amount and ignition timing conditions, compared to the case of the fully open position, in the case of the fully closed position the span of temperature rise of the adsorbent **86** is greater.

[0049] Other processing executed by the ECU **20** is now described, with reference being made to FIG. **7** through FIG. **10**. FIG. **7** shows the processing executed to prepare for restarting after stopping of the internal combustion engine **1**. The processing program of FIG. **7** is stored in the ROM of the ECU **20**, which reads out the program when appropriate and repeats execution of the program at a prescribed time interval. First, at step S**11**, the ECU **20** determines whether the internal combustion engine **1** is stopped. For example, it is possible to determine whether the internal combustion engine **1** is stopped by detecting the operation of an operator turning an ignition switch from on to off to indicate an intention to stop, or by detecting that the rpm speed of the internal combustion engine **1** is zero based on a signal from a crank angle sensor (not illustrated). When it is determined that the internal combustion engine **1** is stopped, processing proceeds to step S**12**, and when the determination of stopping is not made subsequent processing is skipped and the current processing is ended.

[0050] At step S**12**, the estimation counter T (ads) at the current point in processing is stored. The estimation counter T (ads) is used in the processing of FIG. **4**. By doing this, the estimated temperature value of the adsorbent **86** at the point in processing at step S**12** is stored. Next, at step S**13**, a soak timer provided within the ECU **20** for measuring the stopped time (soak time) until the next time the internal combustion engine **1** is started with the point at which the internal combustion engine **1** was stopped as the starting point, is caused to operate. By doing this, the soak time measurement starts and the processing of FIG. **7** ends. After the soak timer has started operating, the measurement of the soak time continues until a prescribed operation stopping condition is satisfied.

[0051] FIG. **8** shows the processing of calculating the initial value T**0** (ads) that serves as the base for the temperature estimation of FIG. **4**, in which the processing results from FIG. **7**, that is, the estimation counter T (ads) at the time of stopping and the soak timer measured value (soak time) are used. The program for the processing of FIG. **8** is also stored in the ROM of the ECU **20**, which reads out the program when appropriate and repeats execution of the program at a prescribed time interval. First, at step S**21** the ECU **20** determines the existence of a starting operation and, if there is a starting operation, processing proceeds to step S**22**, but if there is not starting operation subsequent processing is skipped and the current processing is ended.

[0052] At step S**22**, the estimation counter T (ads) stored at step S**12** is acquired. At the following step S**23**, the measured value of the soak timer, that is, the soak time, is acquired. Next, at step S**24** the estimated temperature value T (soak) at the time of restarting is calculated, based on the estimation counter T (ads) acquired at step S**22**, that is, the estimated temperature value of the adsorbent **86** at the previous time of stopping of the internal combustion engine **1**, and based on the soak time acquired at step S**23**. The calculation of the estimated value T (soak) can be implemented, for example, as shown in FIG. **9**, by referencing a map that gives the estimated temperature value T (soak) with the estimation counter T (ads) and the soak time as variables. The map of FIG. **9** gives an estimated temperature value (soak) so that the span of decrease in the estimated value of temperature at the time of stopping is larger, the longer is the soak time, and also so that the span of decrease for a given soak time is larger, the higher is the estimated temperature at the previous time of stopping. Next, at step S**25**, the estimated temperature value T (soak) calculated at step S**24** is set as the initial value T**0** (ads), and the processing of FIG. **8** ends.

[0053] By the foregoing processing, when estimating the temperature of the adsorbent **86** by the processing of FIG. **4**, it is possible to use the initial value T**0** (ads) obtained by the processing of FIG. **8**. Because the initial value T**0** (ads) takes the soak time into consideration, the deviation between the actual temperature and the estimation results in the processing of FIG. **4** can be reduced.

[0054] Next, another example of the processing to calculate the initial value T**0** (ads) is described, with reference made to FIG. **10**. In FIG. **10**, processing parts that are the same as in FIG. **8** is assigned the same numerals and are described explicitly herein. The processing program is stored in the ROM of the ECU **20**, which reads out the program when appropriate and repeats execution of the program at a prescribed time interval. The processing of FIG. **10** is the processing of FIG. **8** with the processing of steps S**26** to S**28** added. That is, when the temperature estimated value T (soak) is calculated at step S**24**, at the following step S**26** the intake temperature tha is acquired. The intake temperature tha is acquired based on a signal from an intake temperature sensor (not illustrated). Next, at step S**27** determination is made of whether the temperature estimated value T (soak) is higher than the intake temperature tha. If the temperature estimated value T (soak) is higher than the intake temperature tha, processing proceeds to step S**25**, at which temperature estimated value T (soak) is set as the initial value T**0** (ads), whereupon processing ends. However, if the temperature estimated value T (soak) is not higher than the intake temperature tha, that is, if the temperature estimated value (soak) is lower than the intake temperature tha, processing proceeds to step S**28**, at which the intake temperature tha is set as the initial value T**0** (ads), whereupon processing ends.

[0055] By the foregoing processing, when estimating the temperature of the adsorbent **86** by the processing of FIG. **4**, it is possible to use the initial value T**0** (ads) obtained by the processing of FIG. **10**. That is, in the case in which the temperature estimated value T (soak) is lower than the intake temperature tha, it is possible to use the intake temperature tha as the initial value in place of the temperature estimated value T (soak). Therefore, even in the case in which the temperature estimated value T (soak) of the adsorbent **86** has decreases to lower than the intake temperature, because it is possible to avoid the problem of using the estimated value T (soak) as the initial value in the processing of FIG. **4**, resulting in a further improvement in the accuracy of estimating the temperature of the adsorbent **86** after restarting.

[0056] Next, the second embodiment of an exhaust purifying apparatus according to the present invention will be described. FIG. **11** shows an internal combustion engine **1** in which the exhaust purifying apparatus according to the second embodiment has been provided. The second embodiment, with the exception of a mechanism that performs switching of the switching valve **84**, has the same constitution as the embodiment shown in FIG. **1**. In the following, elements that are the same as in the first embodiment as assigned the same numerals and are not repeatedly described herein. As shown in FIG. **11**, the switching valve **84** is driven by a rotary actuator **287** serving as a driving apparatus. The rotary actuator **287** is structured to enabling holding of the switching valve **84** at any position between the fully closed position and the fully open position. The rotary actuator **287** incorporates therewithin a rotational position sensor **287***a* such as a resolver, capable of detecting the rotational position, that is, the opening amount of the switching valve **84**.

[0057] In this embodiment, because the opening amount of the switching valve **84** can be freely set, compared to the embodiment in which the exhaust gas condition of passing to the adsorbent **86** is switched between the fully open position and the fully closed position, as in the first embodiment, it is possible to establish a various conditions responsive to particular situations. The ECU **20** controls the operation of the rotary actuator **287**, and the signal from the rotational position sensor **287***a* is input to the ECU **20**.

[0058] FIG. **12** is a flowchart showing the processing in the second embodiment. The program for this processing is stored in the ROM of the ECU **20**, which reads out the program when appropriate and repeats execution of the program at a prescribed time interval. The only difference between the processing shown in FIG. **12** and the processing in the first embodiment is the method of calculating the added value ΔT (ads). Specifically, step S**7** of FIG. **4** is replaced by steps S**31** through S**35** in the processing of FIG. **12**. Processing parts that are the same as in FIG. **4** is assigned the same numerals and are not repeated described herein.

[0059] As shown in FIG. **12**, after acquiring the ignition timing at step S**6**, the opening amount of the switching valve is acquired at step S**31**. The acquisition of the opening amount is performed based on a signal from the rotational position sensor **287***a* within the rotary actuator **287**. Next, at step S**32**, the added value ΔT (close) corresponding to the fully closed position is calculated and, at step S**33**, the added value ΔT (open) corresponding to the fully open position is calculated. The calculations of the added values ΔT (close) and ΔT (open) can be implemented by using maps that are the same as the maps used at step S**72** and step S**73** in FIG. **6**.

[0060] Next, at step S**34**, the weighting coefficient k corresponding to the opening amount of the switching valve **84** is calculated. The characteristic of the weighting coefficient k is set with consideration given to the temperature change of the adsorbent **86** with respect to the opening amount of the switching valve **84**. For example, as shown in FIG. **13**, it is possible to create a map that associates the weighting coefficient k with the opening amount of the switching valve **84**, and to reference the map to calculate the weighting coefficient k corresponding to the opening amount. Next, at step S**35**, the calculated weighting coefficient k is used to calculate the added value ΔT (ads) corresponding to the opening amount of the switching valve **84**. In this embodiment, because the weighting coefficient k is set in the range from 0 to 1, with the fully closed position as a reference, the added value ΔT (ads) is calculated by the following equation.

$$T(\text{ads}) \leftarrow \Delta T(\text{close}) \times k + \Delta T(\text{open}) \times (1-\text{k})$$

[0061] In the processing of FIG. **12**, if a map that associates the added value ΔT (ads) with the intake air amount and the ignition timing is prepared for at least one opening amount, and if the weighting coefficient is set with that opening amount as a reference, it is possible to calculate the added value ΔT (ads) corresponding to an opening amount without preparing maps for each opening amount. It is possible, therefore, to reduce the amount of storage capacity needed in the ECU **20**.

[0062] Next, the third embodiment of an exhaust purifying apparatus of the present invention will be described. In this embodiment, the internal combustion engine **1** shown in FIG. **1** and FIG. **11** is mounted aboard a so-called hybrid vehicle. In the hybrid vehicle, in addition to an internal combustion engine, another driving power source for running, such as a motor-generator, is installed, and the structure enables appropriate distribution of the driving power for running between the driving power of the internal combustion engine and the other driving power source. This distribution is set in response to various conditions, and there are cases in which, under specific conditions, the internal combustion engine is stopped and running is done with a different power source or running is done with only the internal combustion engine.

[0063] In a conventional vehicle aboard which an internal combustion engine is mounted, with the exception of unusual operation, for example, when the engine is stopped but the vehicle is running on momentum, when the internal combustion engine is stopped, the vehicle is also stationary. For this reason, the major cause of a drop in temperature of the adsorbent provided in the exhaust system is natural heat radiation. In a hybrid vehicle, however, because running is possible even with the internal combustion engine stopped, added to natural heat radiation is the amount of cooling caused by running wind. Given this, in the third embodiment the accuracy of estimating the temperature decrease of the adsorbent **86** is increased by considering the running condition of the vehicle. Also, unless otherwise noted, the processing in the foregoing embodiments may be executed in the third embodiment as well.

[0064] FIG. **14** is a flowchart showing the processing to estimate the temperature of the adsorbent **86** according to the third embodiment. First, at step S**81**, the ECU **20** acquires the estimation counter T (ads). The estimation counter T (ads) is the same as used in the processing of FIG. **4**. Next, processing proceeds to step S**82**, at which a determination is made of whether the internal combustion engine **1** is stopped. If the internal combustion engine **1** is stopped, processing proceeds to step S**83**, at which the stopped time of the internal combustion engine **1** is calculated. The stopped time is calculated based on the count value of the stopped time counter provided as a variable to manage the stopped time in the ECU **20**.

[0065] Next, at step S**84**, the subtracted time ΔT (stop) in the stopped time of the internal combustion engine **1** is calculated. The subtracted time ΔT (stop) corresponds to the span of temperature decrease of the adsorbent **86** by natural radiation during a processing time period. The calculation can be performed, for example, as shown in FIG. **15**, by referencing a map that gives the subtracted value ΔT (stop) with the estimation counter T (ads) and the stopped time as variables. The map shown in FIG. **15** is structured to give values of the subtraction value ΔT (stop) that are larger the longer is the stopped time and the higher is the value of the estimation counter T (ads).

[0066] However, if the internal combustion engine **1** is not stopped at step S**82**, that is, if the internal combustion engine **1** is operating, processing proceeds to step S**89**, at which the stopped time counter is cleared, after which, at step S**90**, zero is substituted into the subtraction value ΔT (stop) and processing proceeds to step S**85**. This is done because in the case in which the internal combustion engine **1** is operating there is no decrease in temperature caused by natural heat radiation.

[0067] At step S**85** a determination is made of whether the vehicle is running. If it is running, processing proceeds to step S**86**, at which the vehicle speed is acquired. The determination of whether the vehicle is running and the acquisition of the vehicle speed are performed based on a signal from a vehicle speed sensor (not illustrated) provided in the vehicle. Next, at step S**87**, the subtracted value ΔT (run) when the vehicle is running is calculated. The subtracted value ΔT (run) corresponds to the span of temperature decrease of the adsorbent **86** by running wind, responsive to the time period of processing. This calculation can be implemented, for example as shown in FIG. **16**, by referencing a map giving the subtracted value ΔT (run) with the estimation counter T (ads) and the vehicle speed as variables. The map shown in FIG. **16** gives values of the subtraction value ΔT (run) that are larger the faster is the vehicle speed and the higher is the value of the estimation counter T (ads).

[0068] However, if vehicle is not running at step S**85**, because there is no need to consider the running wind, processing proceeds to step S**91**, at which point zero is substituted into the subtracted value ΔT (run) and processing proceeds to step S**88**.

[0069] At step S**88**, the subtracted values ΔT (stop) and ΔT (run) are each added to the current estimation counter value T (ads) to update the estimation counter T (ads), this ending the current processing. By the processing of FIG. **14**, even in the case in which the internal combustion engine **1** is stopped and the vehicle is running, it is possible to accurately estimate the temperature of the adsorbent **86**.

[0070] In the foregoing embodiments, the switching valve **84** and the diaphragm mechanism **87** or rotary actuator **287** may serve as the valve mechanism of the present invention. Also, the soak timer provided in the ECU **20** may serve as the time-keeping apparatus of the present invention.

[0071] The ECU **20** may repeatedly execute the processing of FIG. **4** and FIG. **12** or repeatedly execute these processing parts in parallel with executing the processing of FIG. **14**, or may execute the processing of step S**25** in FIG. **8** or the processing of steps S**25** and S**28** in FIG. **10** to implement the function of the temperature estimation part of the present invention. The ECU **20** may execute step S**7** of FIG. **4**, the processing of FIG. **6** and steps S**31** to S**35** of FIG. **12** to implement the function of the added value calculation part of the present invention. Also, the ECU **20** may execute step S**87** of FIG. **14** to implement the function of the subtracted value calculation part of the present invention. The ECU **20** may execute step S**24** of FIG. **8** or FIG. **10** to implement the function of the starting time temperature estimation part of the present invention.

[0072] It will be noted, however, that the present invention is not restricted to the foregoing embodiment, and can be embodied in a variety of forms. The constitution of the exhaust purifying apparatus of the present invention is not restricted to the embodiments shown in FIG. **1** and FIG. **11**. For example, in addition to providing a bypass passage that bypasses the adsorbent in the exhaust passage, an embodiment may be structured so that the limitation or allowing of the exhaust gas to flow into the bypass passage is switched by changing the opening amount of the valve mechanism.

[0073] While the invention has been described with reference to example embodiments thereof, it is to be understood that the invention is not limited to the example embodiments and constructions. To the contrary, the invention is intended to cover various modifications and equivalent arrangements. In addition, while the various elements of the example embodiment are shown in various combinations and configurations, which are exemplary, other combinations and configurations, including more, fewer, or only a single element, are also within the sprit and scope of the invention.

What is claimed is:

1. An exhaust purifying apparatus of an internal combustion engine comprising:

an adsorbent that adsorbs a hydrocarbon in an exhaust passage of the internal combustion engine;

a temperature estimation part that estimates a temperature of the adsorbent by repeating processing wherein an added value is added to the previous estimated value to obtain the current estimated value; and

an added value calculation part that calculates the added value to change the added value based on an intake air amount and an ignition timing of the internal combustion engine.

2. The exhaust purifying apparatus of the internal combustion engine according to claim **1**, further comprising:

a valve mechanism, provided in the exhaust passage, that changes an opening amount to change the passage condition of exhaust toward the adsorbent, wherein

the added value calculation part calculates the added value to change the added value based on the opening amount of the valve mechanism.

3. The exhaust purifying apparatus of the internal combustion engine according to claim **2**, wherein

the exhaust passage has a multiple structure partitioned into a first passage disposed in the central part and a second passage disposed to surround an outer periphery of the first passage and to provide the adsorbent, and wherein

the valve mechanism provided upstream from the multiple structure is structured to limit exhaust flowing into the first passage, and is structured to change an opening amount between a fully closed position that allows exhaust to flow into the second passage and a fully open position that allows exhaust to flow into both the first passage and the second passage.

4. The exhaust purifying apparatus of the internal combustion engine according to claim **3**, further comprising:

a driving apparatus that drives the valve mechanism to change the opening amount of the valve mechanism, wherein

the valve mechanism maintains an arbitrary opening amount between the fully closed position and the fully open position.

5. The exhaust purifying apparatus of the internal combustion engine according to claim **2**, wherein

the added value calculation part calculates the added value using a weighting coefficient based on the opening amount of the valve mechanism.

6. The exhaust purifying apparatus of the internal combustion engine according to claim **4**, wherein

the added value calculation part calculates the added value using a weighting coefficient based on the opening amount of the valve mechanism.

7. The exhaust purifying apparatus of the internal combustion engine according to claim **1**, wherein

the internal combustion engine is provided in a prescribed vehicle as one of a plurality of driving power sources for running, and the vehicle is configured to be runnable with only a driving power source for running other than the internal combustion engine, and wherein

the temperature estimation part estimates the temperature of the adsorbent when the internal combustion engine is in the stopped condition by successive subtraction of the subtracted value from the estimated temperature at the time the drive of internal combustion engine is stopped, and includes a subtracted value calculation part wherein the subtracted value is calculated considering a running condition of the vehicle when the internal combustion engine is in the stopped condition.

8. The exhaust purifying apparatus of the internal combustion engine according to claim **1**, further comprising:

a time-keeping apparatus that measures a stopped time up to a subsequent start time of the internal combustion engine as the starting point of the time during which the drive of the internal combustion engine is stopped; and

a starting time temperature estimation part that estimates the temperature of the adsorbent at the starting time of the internal combustion engine based on the measured by the time-keeping apparatus, wherein

the temperature estimation part uses the estimation result from the starting time temperature estimation part as an initial value before adding the added valued.

9. The exhaust purifying apparatus of the internal combustion engine according to claim **1**, wherein

the temperature estimation part, in the case in which the temperature of the estimation result by the starting time temperature estimation part is lower than that of an intake air, the temperature of the intake air instead of the estimation result is used as the initial value.

10. A method of controlling of an exhaust purifying apparatus for an internal combustion engine comprising:

calculating an initial value as a temperature estimation base of an adsorbent that adsorbs a hydrocarbon in an exhaust passage of the internal combustion engine;

acquiring an amount of intake air taken into the internal combustion engine;

acquiring an ignition timing of the internal combustion engine;

calculating an added value based on the intake air amount and the ignition timing;

estimating the temperature of an adsorbent by adding the added value to the initial value; and

controlling an exhaust purifying apparatus based on the estimated temperature of the adsorbent.

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