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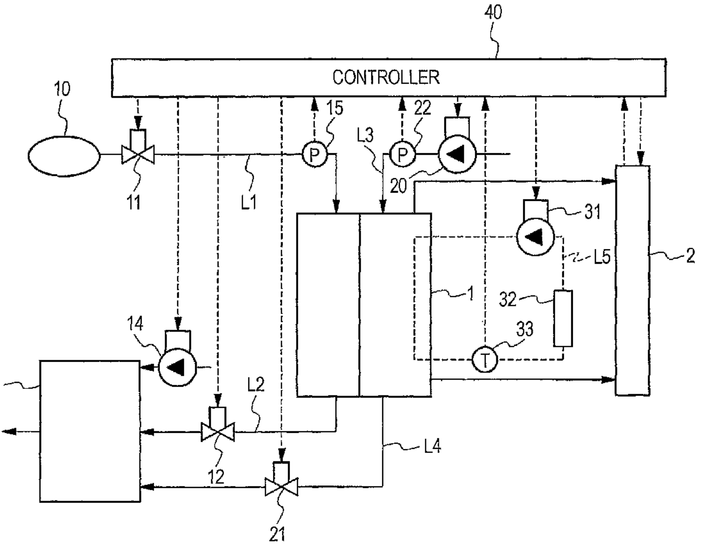
(54) Title: FUEL CELL SYSTEM AND METHOD FOR CONTROLLING FUEL CELL SYSTEM

FIG. 1



(57) Abstract: A fuel cell system includes an exhaust hydrogen processing device for discharging, in a dilute state, fuel electrode off-gas diluted with oxidizer electrode off-gas and air supplied from an exhaust hydrogen processing blower, which are used as a dilution processing gas. When a purge flow rate is larger than a target purge flow rate, a target air flow rate calculating section calculates as a target air flow rate a second target air flow rate which is increased from a stable generation flow rate (first target air flow rate) calculated on the basis of required electric power.

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FUEL CELL SYSTEM AND METHOD FOR CONTROLLING FUEL CELL SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority from Japanese Patent Application Serial Nos.2007-207772, filed August 9, 2007, each of which is incorporated herein in its entirety by reference.

TECHNICAL FIELD

[0002] The present invention relates to a fuel cell system and a method for controlling a fuel cell system.

BACKGROUND

[0003] Fuel cell systems are known that include a fuel cell in which a fuel gas (e.g., hydrogen) and an oxidizer gas (e.g., air) are supplied to a fuel electrode and an oxidizer electrode, respectively, so that electric power is generated by an electrochemical reaction between these gases. Such fuel cell systems are provided with a dilution device for diluting a gas (fuel electrode off-gas) discharged from the fuel electrode with a gas (oxidizer electrode off-gas) discharged from the oxidizer electrode before discharge to the outside. For example, Japanese Unexamined Patent Application Publication No. 2004-127621 discloses a method for controlling the flow rates of fuel electrode off-gas and oxidizer electrode off-gas supplied to a dilution device. The method disclosed therein controls the flow rate of the oxidizer electrode off-gas according to the concentration of fuel gas in a diluted gas and the minimum cell voltage of a fuel cell..

BRIEF SUMMARY

[0004] The present invention provides a fuel cell system and method for controlling the fuel cell. According to one embodiment a fuel cell system is taught herein having a fuel cell configured to generate electric power by an electrochemical reaction between a fuel gas supplied to a fuel electrode and an oxidizer gas supplied to an oxidizer electrode. The fuel system further includes a dilution device supplied with a fuel electrode off-gas discharged from the fuel electrode, an oxidizer electrode off-gas discharged from the oxidizer electrode, and a dilution gas supplied from a dilution gas supply device so that the fuel electrode off-gas is diluted with the oxidizer electrode off-gas and the dilution gas which are used as a dilution processing gas and is then discharged. At least one calculating device is provided for calculating a target purge flow rate, which is a target flow rate of the fuel electrode off-gas on the basis of required power of the fuel cell, and for calculating a target oxidizer gas flow rate, which is a target flow rate of the oxidizer gas supplied to the oxidizer electrode, on the basis of the required power of the fuel cell. A purge flow rate regulating device is provided for regulating the flow rate of the fuel electrode off-gas The fuel cell system further includes a purge flow rate control device for controlling the purge flow rate regulating device on the basis of the target purge flow rate calculated by the at least one calculating device, a supply flow rate regulating device for regulating the flow rate of the oxidizer gas supplied to the oxidizer electrode and a supply flow rate control device for controlling the supply flow rate regulating device on the basis of the target oxidizer gas flow rate calculated by the at least one calculating device wherein when the purge flow rate is larger than the target purge flow rate, the at least one calculating device calculates as the target oxidizer gas flow rate a second target oxidizer gas flow rate larger than a first target oxidizer gas flow rate calculated on the basis of the required power.

[0005] In another embodiment, a method for controlling a fuel cell system is provided including calculating a target oxidizer gas flow rate, which is a target flow rate of an oxidizer gas supplied to an oxidizer electrode of a fuel cell, on the basis of a required power of the fuel cell; controlling the flow rate of the oxidizer gas supplied to the oxidizer electrode on the basis of the calculated target oxidizer gas flow rate; supplying a dilution gas to a dilution device to which an oxidizer electrode off-gas discharged from the oxidizer electrode of the fuel cell and a fuel electrode off-gas discharged from a fuel electrode of the fuel cell are supplied so that the fuel electrode off-gas is diluted and then discharged; calculating a target purge flow rate, which is a target flow rate of the fuel electrode off-gas supplied to the dilution device, on the basis of the required power of the fuel cell; and controlling the flow rate of the fuel electrode off-gas supplied to the dilution device on the basis of the calculated target purge flow rate, wherein when the detected purge flow rate is larger than the target purge flow rate, calculating a target oxidizer gas flow rate includes calculating as the target oxidizer gas flow rate a second target oxidizer gas flow rate higher than a first target oxidizer gas flow rate calculated on the basis of the required

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout the several views, and wherein:

[0007] FIG. 1 is a block diagram showing the entire configuration of a fuel cell system;

[0008] FIG. 2 is a block diagram showing a controller according to a first embodiment of the invention;

[0009] FIG. 3 is an explanatory diagram illustrating a corresponding relation between required power TPG and target hydrogen pressure TPRA;

[0010] FIG. 4 is an explanatory diagram illustrating corresponding relations between purge flow rate MQP(x,y) and hydrogen pressure RPRA and operating temperature RT;

[0011] FIG. 5 is an explanatory diagram illustrating corresponding relations between required power TPG and target flow rate TQAP of dilution processing gas and stable generation flow rate TQAG;

[0012] FIG. 6 is an explanatory diagram illustrating a corresponding relation between required power TPG and target blower flow rate TQD;

[0013] FIG. 7 is an explanatory diagram illustrating a corresponding relation between stable generation flow rate TQAG and target flow rate TQAP of dilution processing gas;

[0014] FIG. 8 is an explanatory diagram illustrating corresponding relations between target operating temperature TT and target air flow rate TQC and target air pressure TPRC;

[0015] FIG. 9 is an explanatory diagram illustrating a corresponding relation between required power TPG and target purge flow rate TQP;

[0016] FIG. 10 is an explanatory diagram illustrating a corresponding relation between elapsed time T1 after start of purge prohibition and upper limit power UPG;

[0017] FIG. 11 is an explanatory diagram illustrating a corresponding relation between elapsed time T2 after release of purge prohibition and upper limit power UPG;

[0018] FIG. 12 includes explanatory diagrams illustrating changes with time of required electric power, the purge flow rate, the air flow rate from a compressor, and the air flow rate from an exhaust hydrogen processing blower;

[0019] FIG. 13 is a block diagram showing the entire configuration of a fuel cell system according to a second embodiment of the invention;

[0020] FIG. 14 is a block diagram showing a controller of a fuel cell system according to a third embodiment of the invention; and

[0021] FIG. 15 is a block diagram showing a controller of a fuel cell system according to a fourth embodiment of the invention.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0022] As mentioned, the method disclosed in Japanese Unexamined Patent Application Publication No. 2004-127621 controls the flow rate of the oxidizer electrode off-gas according to the concentration of fuel gas in a diluted gas and the minimum cell voltage of a fuel cell. Therefore, according to circumstances, the amount of water discharged from the fuel cell becomes excessive, and thus dry-out may occur.

[0023] FIG. 1 is a block diagram showing the entire configuration of a fuel cell system according to a first embodiment of the invention. The fuel cell system is mounted on, for example, a vehicle and functions as a power source.

[0024] The fuel cell system is provided with a fuel cell stack 1 formed by stacking a plurality of fuel cell structures, each sandwiched between separators and including an oxidizer electrode and a fuel electrode that are opposed to each other with a solid polymer electrolyte membrane provided therebetween. When a fuel gas and an oxidizer gas are supplied to the fuel electrodes and the oxidizer electrodes, respectively, in the fuel cell stack 1, these gases are electrochemically reacted to generate electric power. In this embodiment, hydrogen and oxygen are used as the fuel gas and the oxidizer gas, respectively.

[0025] The fuel cell system provided with the fuel cell stack 1 includes a hydrogen system for supplying hydrogen to the fuel cell stack 1, an air system for supplying air to the fuel cell stack 1 and a cooling system for cooling the fuel cell stack 1.

[0026] In the hydrogen system, hydrogen as the fuel gas is stored in a fuel tank 10 (e.g., a high-pressure hydrogen cylinder) and is supplied to the fuel electrodes of the fuel cell stack 1 from the fuel tank 10 through a hydrogen supply passage L1. Specifically, a fuel tank primary valve (not shown) is provided downstream of the fuel tank 10. When the fuel tank primary valve is opened, the pressure of the high-pressure hydrogen gas from the fuel tank 10 is mechanically reduced to a predetermined pressure by a pressure reducing valve (not shown) provided downstream of the fuel tank 10. The reduced pressure hydrogen gas is further reduced in pressure by a hydrogen regulating valve 11 provided downstream of the pressure reducing valve and is then supplied to the fuel cell stack 1. The hydrogen regulating valve 11 has the function of regulating the pressure and flow rate of hydrogen to be supplied to the fuel cell stack 1. The opening of the hydrogen regulating valve 11 is controlled by a controller 40, which will be described below.

[0027] On the other hand, the fuel electrode off-gas discharged from the fuel electrodes of the fuel cell stack 1 is discharged through a hydrogen discharge passage L2. The fuel electrode off-gas contains impurities such as nitrogen permeating from the oxidizer electrode side to the fuel electrode side and hydrogen not used for the reaction. The hydrogen discharge passage L2 is provided with a purge valve 12. The purge valve 12 functions as a purge flow rate regulating unit for regulating the flow rate of the fuel electrode off-gas discharged from the fuel electrodes, i.e., the flow rate of the fuel electrode off-gas supplied to an exhaust hydrogen processing device 13, which will be described below. The opening of the purge valve 12 is controlled by the controller 40.

[0028] In the air system, air used as the oxidizer gas is pressurized by a compressor 20 after being taken in from the atmosphere, and the pressurized air is supplied to the oxidizer electrodes of the fuel cell stack 1 through an air supply passage L3. The air supply passage L3 is provided with a humidifier (not shown) so that air to be supplied to the fuel cell stack 1 is humidified so as not to decrease the generation performance of the fuel cell stack 1.

[0029] On the other hand, the oxidizer electrode off-gas discharged from the oxidizer electrodes of the fuel cell stack 1 is discharged through an air discharge passage L4. The oxidizer electrode off-gas mainly contains air from which oxygen has been consumed but also contains hydrogen permeating from the fuel electrode side to the oxidizer electrode side. The air discharge passage L4 is provided with an air pressure regulating valve 21 that functions as a supply pressure regulating unit for regulating the pressure of air to be supplied to the fuel cell stack 1. The opening of the air pressure regulating valve 21 is controlled by the controller 40. The compressor 20 functions as a supply flow rate regulating unit for regulating the flow rate of air to be supplied to the oxidizer electrodes. The rotational speed of the compressor 20 is controlled by the controller 40.

[0030] The fuel electrode off-gas and the oxidizer electrode off-gas are supplied to an exhaust hydrogen processing device (or dilution device) 13 through the hydrogen discharge passage L2 and the air discharge passage L4, respectively. Also, air (i.e., dilution gas) taken in by an exhaust hydrogen processing blower (also called a dilution gas supply unit) 14 is supplied to the exhaust hydrogen processing device 13. The exhaust hydrogen processing device 13 dilutes the fuel electrode off-gas with the oxidizer electrode off-gas and air, which are used as dilution processing gases, so that the concentration of hydrogen to be discharged to the outside is lower than an inflammability concentration before discharge to the outside. This is called exhaust hydrogen processing. As the exhaust hydrogen processing device 13, for example, a catalytic burner that reacts air oxygen and hydrogen using a platinum catalyst, a dilution device that mixes gases supplied thereto and then discharges the mixed gas to the outside, or the like can be used.

[0031] The cooling system has a closed-loop cooling passage L5 in which a refrigerant for cooling the fuel cell stack 1 is circulated. The cooling passage L5 is provided with a refrigerant pump 31 for circulating the refrigerant and a radiator 32 that collectively serve as a cooling unit for cooling the fuel cell stack 1. The refrigerant pump 31 is operated to circulate the refrigerant in the cooling passage L5. The refrigerant at a temperature increased by cooling the fuel cell stack 1 is passed to the radiator 32 through the cooling passage L5 and is cooled by the radiator 32. The cooled refrigerant is supplied to the fuel cell stack 1. The cooling passage L5 is finely branched in the fuel cell stack 1 so that the fuel cell stack 1 is cooled over the inside thereof. The drive amount of the refrigerant pump 31 is controlled by the controller 40.

[0032] Further, a load device 2 such as an electric motor for driving a vehicle is connected to the fuel cell stack 1. Therefore, required power is taken out from the fuel cell stack 1 by the controller 40 and is supplied to the load device 2.

[0033] FIG. 2 is a block diagram showing the controller 40 according to this embodiment. The controller 40 comprehensively controls the entire system and controls each section of the system according to a software control program to control the operating conditions of the fuel cell stack 1. As the controller 40, a microcomputer mainly including a central processing unit (CPU), read-only memory (ROM), random access memory (RAM) and an input/output (I/O) interface is used. The controller 40 performs various calculations on the basis of the system conditions and outputs the calculation results as control output to various actuators, for controlling the openings of the hydrogen regulating valve 11, the purge valve 12 and the air pressure regulating valve, and the rotational speeds of the exhaust hydrogen processing blower 14, the compressor 20 and the refrigerant pump 31. In order to detect the conditions of the system, signals of various sensors are input as control input to the controller 40.

[0034] A hydrogen pressure sensor 15 detects the pressure RPRA of hydrogen to be supplied to the fuel electrodes of the fuel cell stack 1. An air pressure sensor 22 detects the pressure RPRC of air to be supplied to the oxidizer electrodes of the fuel cell stack 1. A temperature sensor 33 detects the operating temperature RT of the fuel cell stack 1 on the basis of the temperature of the refrigerant discharged from the fuel cell stack 1. Further, required electric power TPG required for the fuel cell stack 1 is input to the controller 40 from the vehicle side.

[0035] From a functional viewpoint, the controller 40 includes a target hydrogen pressure calculating section 41, a target air flow rate calculating section 42, a target air pressure calculating section 43, a purge time calculating section 45, an output power calculating section 46, a hydrogen pressure regulating valve opening calculating section 47, a purge valve switching command section 48, a target blower rotational speed calculating section 49, a target compressor rotational speed calculating section 50, an air pressure regulating valve opening calculating section 51 and a target refrigerant pump rotational speed calculating section 52.

[0036] The target hydrogen pressure calculating section 41 calculates the target hydrogen pressure TPRA on the basis of the required electric power TPG. FIG. 3 is a diagram illustrating an example of a corresponding relationship between the required power TPG and the target hydrogen pressure TPRA. The target hydrogen pressure TPRA is a target value of the pressure of hydrogen to be supplied to the fuel electrodes. As shown in FIG. 3, the target hydrogen pressure TPRA consistently increases with increases in the required electric power TPG. The relationship between the required power TPG and the target hydrogen pressure TPRA is previously acquired through experiment or simulation. For example, the relationship is determined in view of the generation efficiency of the fuel cell stack 1 for hydrogen pressure, the power consumption sensitivity of each actuator for hydrogen pressure, the amount of water vapor taken out by exhaust air gas and a differential pressure from air pressure. The target hydrogen pressure calculating section 41 holds, as a table or an arithmetic expression, such a corresponding relationship between the required power TPG and the target hydrogen pressure TPRA as shown in FIG. 3 so that the target hydrogen pressure TPRA is calculated from the required electric power TPG on the basis of the table or the arithmetic expression. The calculated target hydrogen pressure TPRA is output to the hydrogen regulating valve opening calculating section 47.

[0037] The target air flow rate calculating section 42 calculates the target air flow rate (a target oxidizer gas flow rate) TQC and the target blower flow rate TQD on the basis of the required power TPG. The target air flow rate TQC is a target value of the flow rate of air to be supplied to the oxidizer electrodes of the fuel cell stack 1. The target blower flow rate TQD is a target value of the flow rate of air to be supplied to the exhaust hydrogen processing device 13 through the exhaust hydrogen processing blower 14.

[0038] First, a method of calculating the target blower flow rate TQD is described. When the purge valve 12 is opened, the flow rate of the fuel electrode off-gas discharged from the purge valve 12, i.e., the flow rate (hereinafter referred to as the "purge flow rate") MQP(x,y) of the fuel electrode off-gas to be supplied to the exhaust gas processing device 13, is shown by example in FIG. 4. In FIG. 4, x is a parameter corresponding to the hydrogen pressure RPRA, and y is a parameter corresponding to the operating temperature RT. The purge flow rate MQP(x,y) has a tendency to increase with increases in the hydrogen pressure RPRA and has a tendency to relatively decrease as the operating temperature RT increases at the same hydrogen pressure RPRA.

[0039] When the required electric power TPG is stable and the outside air conditions (e.g., atmospheric pressure) are typical conditions, the hydrogen pressure RPRA and the operating temperature RT of the fuel cell stack 1 for the required power TPG can be uniquely determined. Therefore, the target flow rate (hereinafter referred to as the "target purge flow rate") of the fuel electrode off-gas to be supplied to the exhaust hydrogen processing device 13 is exclusively calculated on the basis of the required power TPG. When hydrogen discharged from the exhaust hydrogen processing device 13 is kept at a target concentration R1 on the assumption of the target purge flow rate, the target flow rate TQAP of the dilution processing gas (the oxidizer electrode off-gas and air from the exhaust hydrogen processing blower 14) to be supplied to the exhaust hydrogen processing device 13 can be exclusively calculated on the basis of the required power TPG. The target flow rate TQAP of the dilution processing gas has the tendency to gently increase with increases in the required power TPG as shown in FIG. 5.

[0040] On the other hand, the flow rate (hereinafter referred to as the "stable generation flow rate") TQAG of air to be supplied to the oxidizer electrodes for stably generating electric power has the tendency to consistently increase with increases in the required power TPG as shown in FIG. 5. An increase in the stable generation flow rate TQAG is larger than that of the target flow rate TQAP of the dilution processing gas with an increase in the required power TPG. When exhaust hydrogen is processed with the dilution processing gas, the target blower flow rate TQD satisfies the following equation:

$$TQD = TQAP - TQAG. \qquad (1)$$

[0041] The target blower flow rate TQD is a value obtained by subtracting the stable generation flow rate TQAG from the target flow rate TQAP of the dilution processing gas. As shown in FIG. 6, a relationship of the target blower flow rate TQD shown in equation 1 to the required electric power TPG can be determined. The target air flow rate calculating section 42 holds, as a table or an arithmetic expression, such a corresponding relationship between the required power TPG and the target blower flow rate TQD as shown by example in FIG. 6 so that the target blower flow rate TQD is calculated from the required electric power TPG on the basis of the table or the arithmetic expression. The calculated target blower flow rate TQD is output to the target blower rotational speed calculating section 49.

[0042] Next, a method for calculating the target air flow rate TQC is described. The target air flow rate TQC is directly calculated on the basis of the following equation:

$$TQC = TQC(TQAP) + \mathrm{Max}[\{R1 \times MQP(RPRA, RT) - TQAP\}, O]. \qquad (2)$$

[0043] Herein, function TQC(x) is formed on the basis of the relationship between the target flow rate TQAP of dilution processing gas and the stable generation flow rate TQAG, which is based on the relationship of the target flow rate TQAP of dilution processing gas and the stable generation flow rate TQAG to the required power TPG (see FIG. 5). As shown in FIG. 7, the stable generation flow rate TQAG has the tendency to consistently increase with respect to the target flow rate TQAP of dilution processing gas. In FIG. 7, x represents a parameter corresponding to the target flow rate TQAP of dilution processing gas. Also, as shown in FIG. 4, function MQP(x, y) is formed on the basis of the relation of the purge flow rate MQP(x,y) to the hydrogen pressure RPRA and the operating temperature RT. R1 represents the target concentration of hydrogen discharged from the exhaust gas processing device 13.

[0044] In equation 2, TQC(TQAP) represents the stable generation flow rate TQAG calculated on the basis of the required power TPG.

[0045] TQAP represents the target flow rate of dilution processing gas calculated on the basis of the required power TPG and indirectly represents the target purge flow rate. Namely, the target air flow rate calculating section 42 calculates the target purge flow rate in the calculation process of the target air flow rate TQC.

[0046] The term MQP(RPRA, RT) represents the purge flow rate (i.e., actual purge flow rate) estimated on the basis of the hydrogen pressure RPRA and the operating temperature RT (specifically, the temperature of the oxidizer electrode off-gas). In other words, the target air flow rate calculating section 42 has the function as a detection unit for (indirectly) detecting the purge flow rate. Further, the term R1 × MQP(RPRA, RT) in equation 2 represents the required flow rate of dilution processing gas required to be supplied to the exhaust hydrogen processing device 13 when the hydrogen discharged from the exhaust hydrogen processing device 13 is kept at the target concentration R1 on the assumption of the estimated purge flow rate. This value indirectly represents the purge flow rate.

[0047] In consideration of this arithmetic expression, that is, equation 2, the target air flow rate TQC is primarily calculated as the stable generation flow rate TQAG (first target air flow rate) on the basis of the required power TPG. However, when the purge flow rate is larger than the target purge flow rate, the target air flow rate TQC is set as a second target air flow rate that is larger than the stable generation flow rate TQAG. The second target air flow rate is a value obtained by adding to the stable generation flow rate TQAG an increased flow rate corresponding to a difference between the purge flow rate and the target purge flow rate, specifically a value obtained by subtracting the target flow rate TQAP of dilution processing gas from the required flow rate of dilution processing gas. Therefore, the target air flow rate calculating section 42 functions as a supply flow rate calculating unit for calculating the target air flow rate TQC. The calculated target air flow rate TQC is output to the target operating temperature calculating section 44 and the target compressor rotational speed calculating section 50.

[0048] Also, the target air flow rate calculating section 42 decides whether or not the generation condition of the fuel cell stack 1 is likely to become unstable when the second target air flow rate is used as the target air flow rate TQC. Specifically, the target air flow rate calculating section 42 makes a decision on the basis of the following equation:

$$\int \{TQC - TQAG\} dt > V1. \qquad (3)$$

[0049] Equation 3 shows a cumulative value over time of a value obtained by subtracting the stable generation flow rate TQAG from the target air flow rate TQC. V1 is a constant that is set to as large a value as possible within an allowable range of a water balance of the fuel cell stack 1, i.e., a difference between the amount of water taken out from the fuel cell stack 1 and the amount of water produced in the fuel cell stack 1. When the cumulative value is larger than the decided value V1, a large amount of water is taken out from the oxidizer electrodes of the fuel cell stack 1, and thus dry out may occur, thereby causing the possibility of unstable generation condition of the fuel cell stack 1. In this case, purge prohibition flag FSP is set to "1" in order to prohibit purge of the fuel electrode off-gas, i.e., an instruction to stop the supply of the fuel electrode off-gas is sent to the exhaust hydrogen processing device 13. On the other hand, when the cumulative value is smaller than the criterion value V1, therefore, a small amount of water is taken out from the oxidizer electrodes of the fuel cell stack 1 such that dry out is unlikely to occur, there is no possibility of unstable generation conditions of the fuel cell stack 1. In this case, the purge prohibition flag FSP is set to "0" in order to issue an instruction to permit purge of the fuel electrode off-gas. The purge prohibition flag FSP is output to the target air pressure calculating section 43, the purge time calculating section 45 and the output power calculating section 46. In the case in which the purge prohibition flag is set to "1", the target air flow rate calculating section 42 changes the target air flow rate TQC to the stable generation flow rate (as a first target air flow rate) TQAG.

[0050] The target air pressure calculating section (also called the supply pressure calculating unit) 43 calculates the target air pressure (or target oxidizer gas pressure) TPRC, which is the target pressure of air to be supplied to the oxidizer electrodes, on the basis of the purge prohibition flag FSP and the hydrogen pressure RPRA. Specifically, when the purge prohibition flag FSP is set to "0", the target air pressure TPRC is calculated as a pressure (a normal value) corresponding to the hydrogen pressure RPRA such that TPRC = RPRA. On the other hand, when the purge prohibition flag FSP is set to "1", the target air pressure TPRC is set to a value obtained by subtracting a predetermined pressure ΔP1 from the hydrogen pressure RPRA (the normal value) such that TPRC = RPRA - ΔP1. The predetermined pressure ΔP1 is set lower than a differential pressure that is allowed for the electrolyte membrane of the fuel cell stack 1. The calculated target air pressure TPRC is output to the target operating temperature calculating section 44 and the air pressure regulating valve opening calculating section 51.

[0051] The target operating temperature calculating section (also called the operating temperature calculating unit) 44 calculates the target operating temperature TT, which is a target value of the operating temperature of the fuel cell stack 1 (i.e., the refrigerant control temperature), on the basis of the target air flow rate TQC and the target air pressure TPRC. The target operating temperature TT is set so that the amount of water taken out from the oxidizer electrodes of the fuel cell stack 1 does not exceed the amount of water produced by power generation on the basis of the target air flow rate TQC and the target air pressure TPRC.

[0052] FIG. 8 is an explanatory diagram illustrating corresponding relationships between the target operating temperature TT and the target air flow rate TQC and the target air pressure TPRC. Since the target air flow rate TQC and the target air pressure TPRC have differences from the stable generation flow rate TQAG and the target hydrogen pressure TPRA, respectively, which are designed to be stationary, it is necessary to correct the differences. In this case, the target operating temperature TT of the fuel cell stack 1 has relationships to the target air pressure TPRC and the target air flow rate TQC as shown in FIG. 8. Specifically, the target operating temperature TT has the tendency to decrease as the target air pressure TPRC increases and also has the tendency to relatively decrease as the target air flow rate TQC increases at the same target air pressure TPRC. In other words, the target operating temperature calculating section 44 sets the target operating temperature TT to decrease as the target air flow rate TQC increases.

[0053] The relationships between the target operating temperature TT and the target air flow rate TQC and the target air pressure TPRC are previously acquired through experiment or simulation. The target operating temperature calculating section 44 holds, as a table or an arithmetic expression, such corresponding relationships between the target operating temperature TT and the target air flow rate TQC and the target air pressure TPRC as shown in FIG. 8 so that the target operating temperature TT is calculated from the target air flow rate TQC and the target air pressure TPRC on the basis of the table or the arithmetic expression. The calculated target operating temperature TT is output to the target refrigerant pump rotational speed calculating section 52.

[0054] The purge time calculating section (also called the purge flow rate calculating unit) 45 calculates the purge time POT on the basis of the required power TPG and the purge prohibition flag FSP. The purge time POT is a time for which the purge valve 12 is set to an open state and substantially corresponds to the target purge flow rate based on the required power TPG. Namely, the purge time calculating section 45 functions as a purge flow rate calculating unit for calculating the target purge flow rate.

[0055] FIG. 9 is an explanatory diagram illustrating a corresponding relationship between the required power TPG and the target purge flow rate TQP. The target purge flow rate TQP has the tendency to consistently increase with increases in the required power TPG. The relationship between the required power TPG and the target purge flow rate TQP is related to the gas pressures at both electrodes in the fuel cell stack 1 and is previously set through experiment or simulation. When the time ratio of an open state of the purge valve 12 within a predetermined time Ts is the purge time POT, the purge time POT may be set so that the average purge flow rate within the predetermined time Ts is the target purge flow rate TQP. Therefore, the purge time POT is determined according to the following equation using the actual purge flow rate

MPQ(RPRA, RT):

$$POT = TQP \times Ts/\{MQP(RPRA, RT)\}. \quad (4)$$

[0056] Equation 4 indicates the purge time POT in the case in which the purge prohibition flag FSP is set to "0". The purge time is calculated as POT=0 in the case in which the purge prohibition flag FSP is set to "1". The calculated purge time POT is output to the purge valve switching command section 48.

[0057] The output power calculating section 46 calculates the output power TP, which is electric power to be taken out to the load device 2. FIG. 10 is a diagram illustrating a corresponding relationship between the elapsed time T1 after start of purge prohibition and the upper limit power UPG. FIG. 11 is a diagram illustrating a corresponding relationship between the elapsed time T2 after release of purge prohibition and the upper limit power UPG. In FIG. 10, the elapsed time T1 after start of purge prohibition is a time elapsed after switching of the purge prohibition flag FSP from "0" to "1", and the upper limit power UPG is set to a value that linearly decreases from the initial value as the elapsed time T1 increases. In FIG. 11, the elapsed time T2 after release of purge prohibition is a time elapsed after switching of the purge prohibition flag FSP from "1" to "0", and the upper limit power UPG is set to a value that linearly increases from the initial value as the elapsed time T1 increases. The relationship between the elapsed time T1 after start of purge prohibition and the upper limit power UPG and the relationship between the elapsed time T2 after release of purge prohibition and the upper limit power UPG are previously set through experiment or simulation. The output power calculating section 46 sets the upper limit power UPG on the basis of the elapsed time T1 after start of purge prohibition or the elapsed time T2 after release of purge prohibition. A value is calculated as the output power TP by limiting the required power TPG using the upper limit power UPG. Electric power corresponding to the calculated output power TP is taken out from the fuel cell stack 1 and supplied to the load device 2.

[0058] The hydrogen regulating valve opening calculating section 47 calculates an opening command value TAVP of the hydrogen regulating valve 11 on the basis of the hydrogen pressure RPRA and the target hydrogen pressure TPRA and controls the hydrogen regulating valve 11 on the basis of the opening command value TAVP. Specifically, the hydrogen regulating valve opening calculating section 47 calculates the opening command value TAVP of the hydrogen regulating valve 11 so that the hydrogen pressure RPRA coincides with the target hydrogen pressure TPRA and controls the opening by feedback.

[0059] The purge valve switching command section (also called the purge flow rate control unit) 48 outputs a switching command SPO to the purge valve 12 according to the purge time POT corresponding to the target purge flow rate TQP and controls a switching state of the purge valve 12 on the basis of the switching command SPO.

[0060] The target blower rotational speed calculating section 49 calculates a rotational speed command value TNB of the exhaust hydrogen processing blower on the basis of the target blower flow rate TQD and controls the exhaust hydrogen processing blower 14 on the basis of the rotational speed command value TNB.

[0061] The target compressor rotational speed calculating section (also called the supply flow rate control unit) 50 controls the compressor 30 on the basis of the target air flow rate TQC. Specifically, the target compressor rotational speed calculating section 50 calculates a rotational speed command value TNC of the compressor 20 according to the target air flow rate TQC and controls the compressor 20 on the basis of the rotational speed command value TNC.

[0062] The air pressure regulating valve opening calculating section (also called the supply pressure control unit) 51 controls the air pressure regulating value 21 on the basis of the target air pressure TPRC. Specifically, the target air pressure regulating valve opening calculating section 51 calculates an opening command value TCVP of the air pressure regulating value 21 so that the air pressure RPRC coincides with the target air pressure TPRC and controls the opening of the air pressure regulating value 21 by feedback.

[0063] The refrigerant pump rotational speed calculating section (also called the operating temperature control unit) 52 controls the refrigerant pump 31 on the basis of the target operating temperature TT. Specifically, the refrigerant pump rotational speed calculating section 52 calculates a rotational speed command value TNP of the refrigerant pump 31 according to the target operating temperature TT and controls the refrigerant pump 31 on the basis of the rotational speed command value TNP.

[0064] In this embodiment, the fuel cell system is provided with the exhaust hydrogen processing device 13, which dilutes the fuel electrode off-gas using the oxidizer electrode off-gas and air supplied from the exhaust hydrogen processing blower 14 as the dilution processing gas and discharges the diluted gas. When the purge flow rate MQP(RPRA, RT) is larger than the target purge flow rate, the target air flow rate calculating section 42 calculates as the target air flow rate TQC the second target air flow rate that is larger than the stable generation flow rate (i.e., the first target air flow rate) TQAG calculated on the basis of the required power TPG.

[0065] FIG. 12 shows changes with time of the required electric power, the purge flow rate, the flow rate of air from the compressor 20 and the flow rate of air from the exhaust hydrogen processing blower 14. In changes of the purge flow rate, a solid line shows the actual purge flow rate MQP(RPRA, RT), and a broken line shows the target purge flow rate. In changes of the flow rate of air from the compressor 20, a solid line shows the target air flow rate TQC, a broken line shows the required flow rate of the dilution processing gas, and a one-dot chain line shows the stable generation flow rate TQAG. As shown in FIG. 12, when the required power TPG transiently decreases, the target purge flow rate transiently decreases accordingly. However, the actual purge flow rate MQP(RPRA, RT) is larger than the target purge flow rate. Therefore, when the target air flow rate TQC is set to the stable generation flow rate TQAG according to the required power TPG, the required flow rate of the dilution processing gas cannot be secured. Therefore, in this embodiment, when the required power TPG transiently decreases, specifically when the actual purge flow rate MQP(RPRA, RT) is larger than the target purge flow rate, the target air flow rate TQC is set to the second target air flow rate. As a result, the flow rate of air supplied from the compressor 20 increases, thereby increasing the flow rate of oxidizer electrode off-gas. Therefore, the required flow rate of the dilution processing gas can be secured.

[0066] In this configuration, in a condition in which the fuel electrode off-gas transiently increases, the flow rate of air from the exhaust hydrogen processing blower 14 need not be increased, and thus the dilution system can be reduced in size. Also, in a condition in which the purge flow rate transiently increases to be higher than the target purge flow rate, the target air flow rate TQC is set to the second target air flow rate. Therefore, the time to increase the flow rate of air from the compressor 20 can be suppressed, and thus a state in which the flow rate of air supplied to the oxidizer electrodes is excessive can be minimized. Consequently, it is possible to suppress the occurrence of dry out while diluting the fuel electrode off-gas.

[0067] In this embodiment, the second target air flow rate is a value obtained by adding an increased flow rate corresponding to a difference between the target purge flow rate and the purge flow rate MQP(RPRA, RT) to the stable generation flow rate (i.e., the first target air flow rate) TQAG.

[0068] In this configuration, the target air flow rate TQC is increased according to a shortage of the required flow rate of the dilution processing gas. Therefore, it is possible to effectively dilute the fuel electrode off-gas while minimizing the amount of water taken out from the oxidizer electrodes.

[0069] Further, in this embodiment, the target air flow rate calculating section 42 indirectly detects the purge flow rate MQP(RPRA, RT) by estimating the purge flow rate MQP(RPRA, RT) on the basis of the pressure RPRA of hydrogen supplied to the fuel electrodes and the operating temperature (also called a temperature of oxidizer electrode off-gas) TT.

[0070] In this configuration, the purge flow rate MQP(RPRA, RT) can be detected without using a measurement device such as a sensor, thereby simplifying the system configuration.

[0071] Further, in this embodiment, when the fuel cell stack 1 may be put into unstable generation conditions by using the second target air flow rate as the target air flow rate TQC, the target air flow rate calculating section 42 sets the purge prohibition flag to "1". Then, the purge prohibition flag is output to the purge time calculating section 45 to change the target air flow rate TQC to the stable generation flow rate TQAG.

[0072] In this configuration, the occurrence of dry out is suppressed, and the discharge of hydrogen at a high concentration is also suppressed. Therefore, the reliability of the fuel cell stack 1 can be improved.

[0073] In the above-described case, preferably, the upper limit power UPG is set on the basis of the elapsed time T1 after start of purge prohibition, and a value is calculated as the output power TP by limiting the required power TPG using the upper limit power UPG. Thus, even when excessive required power TPG is required, the output power TP is limited, and stoichiometric shortage can be suppressed. On the other hand, the upper limit power UPG may be set on the basis of the elapsed time T2 after release of purge prohibition, and a value of the required power TPG limited by the upper limit power UPG may be calculated as the output power TP. Thus, even when the excessive required power TPG is required, the output power TP is limited, and hydrogen shortage in the fuel cell stack 1 can be suppressed.

[0074] In this embodiment, when the fuel cell stack 1 can be put into unstable generation conditions by using the second target air flow rate as the target air flow rate TQC, the target air pressure calculating section 43 sets the target air pressure TPRC to a value (RPRA - ΔP1) that is smaller than the hydrogen pressure RPRA (a value calculated by arithmetic operation).

[0075] In this configuration, the pressure on the oxidizer electrode side is decreased, and thus the amount of nitrogen permeating to the fuel electrode side can be decreased. Therefore, it is possible to suppress hydrogen shortage in the fuel cell stack 1.

[0076] Further, in this embodiment, the target operating temperature calculating section

44 sets the target operating temperature TT to a value decreased according to an increase in the target air flow rate TQC.

[0077] In this configuration, the amount of water taken out from the oxidizer electrodes can be decreased. Therefore, the occurrence of dry out can be suppressed.

[0078] FIG. 13 is a block diagram showing the configuration of a fuel cell system according to a second embodiment of the invention. The fuel cell system according to the second embodiment is different from the first embodiment in that the purge flow rate is measured. The system configuration and processing contents of the controller 40 are basically the same as in the first embodiment, and thus description of duplicated portions is omitted. Hereinafter, the difference is mainly described.

[0079] As shown in FIG. 13, a flow meter (also called a detection unit) 16 is provided on the hydrogen discharge passage L2 for detecting the flow rate of fuel electrode off-gas flowing therethrough, i.e., the purge flow rate. The purge flow rate detected by the flow meter 16 is input to the controller 40.

[0080] In the controller 40, when the target air flow rate TQC is calculated, the target air flow rate calculating section 42 performs calculation according to equation 1 in which the purge flow rate MQP(x,y) is substituted by the measured value input from the flow meter 16. When the purge time POT is calculated, the purge time calculating section 45 performs calculation according to equation 4 in which the purge flow rate MQP(x,y) is substituted by the measured value input from the flow meter 16.

[0081] In this embodiment, the flow meter 16 is used for detecting the purge flow rate. Therefore, the purge flow rate can be correctly detected, and thus the calculation precision of the target air flow rate TQC can be improved.

[0082] The method according to this embodiment can be applied to embodiments that are described below.

[0083] FIG. 14 is a block diagram showing a controller 40 of a fuel cell system according to a third embodiment of the invention. The fuel cell system according to the third embodiment is different from the first embodiment regarding a method for calculating the purge time POT by the controller 40. The system configuration and processing contents of the controller 40 are basically the same as in the first embodiment, and thus description of duplicated portions is omitted. Hereinafter, the difference is mainly described.

[0084] In the controller 40 of this embodiment, the target air flow rate calculating section

42 sets a purge time increase flag FEP in addition to calculation of the target air flow rate TQC and the target blower flow rate TQD and setting of the purge prohibition flag FSP. The purge time increase flag FEP is set on the basis of the following equation:

$$TQAP - R1 \times MQP(RPRA, RT) < 0. \qquad (5)$$

[0085] Equation 5 is used for deciding whether or not the control deviation between the target purge flow rate and the actual purge flow rate is smaller than 0. When the equation is established, i.e., when the control deviation between the target purge flow rate and the actual purge flow rate is smaller than 0, the purge time increase flag FEP is set to "1". On the other hand, when the equation is not established, i.e., when the control deviation between the target purge flow rate and the actual purge flow rate is not smaller than 0, the purge time increase flag FEP is set to "0". The purge time increase flag FEP is output to the purge time calculating section 45.

[0086] The purge time calculating section 45 calculates the purge time POT, which is a time for which the purge valve 12 is set to an open state on the basis of the required power TPG, the purge prohibition flag FSP and the purge time increase flag FEP. Specifically, as in the first embodiment, the purge time calculating section 45 calculates the target purge time TQP on the basis of the relation between the required power TPG and the target purge flow rate TQP and on the basis of the required power TPG. Also, the purge time calculating section 45 calculates the purge time POT on the basis of the purge prohibition flag FSP and the purge time increase flag FEP according to the following equations:

$$POT = 0; \qquad (6a)$$

$$POT = Ts; \text{ and} \qquad (6b)$$

$$POT = TQP \times Ts/\{MQP(RPRA, RT)\}. \qquad (6c)$$

[0087] Equation (6a) indicates the purge time POT where the purge prohibition flag FSP is set to "1" regardless of the purge time increase flag FEP. Equation (6b) indicates the purge time POT where the purge prohibition flag FSP is set to "0", and the purge time increase flag FEP is set to "1". Equation (6c) indicates the purge time POT where the purge prohibition flag FSP is set to "0", and the purge time increase flag FEP is set to "0".

[0088] In this embodiment, when the fuel cell stack 1 can be put into unstable generation conditions by using the second target air flow rate as the target air flow rate TQC, the purge time calculating section 45 sets the purge time POT to a value Ts, which is larger than the normal value (that is, TQP × T1/{MQP(RPRA, RT)}) and thus sets the target purge flow rate to a value larger than the normal value.

[0089] In this configuration, the hydrogen concentration in the fuel electrodes of the fuel cell stack 1 can be increased by increasing the target purge flow rate. Therefore, even when the purge prohibition flag FSP is set to "1" to prohibit discharge of the fuel electrode off-gas, it is possible to suppress the state in which power generation is inhibited by hydrogen shortage.

[0090] FIG. 15 is a block diagram showing a controller 40 of a fuel cell system according to a fourth embodiment of the invention. The fuel cell system according to the fourth embodiment is different from the first embodiment regarding a method for calculating the target blower flow rate TQD by the controller 40. The system configuration and processing contents of the controller 40 are basically the same as in the first embodiment, and thus description of duplicated portions is omitted. Hereinafter, the difference is mainly described.

[0091] In the controller 40 of this embodiment, the target air flow rate calculating section 42 calculates the target blower flow rate TQD on the basis of the following equation:

$$TQD = Min(R1 \times MQP(RPRA, RT), Q1), \qquad (7)$$

wherein Q1 is the maximum flow rate of air that can be supplied from the exhaust hydrogen processing blower 14 and is determined according to the size and performance of the blower. Namely, in this embodiment, the target blower flow rate TQD is set to the smaller value of the required flow rate of the dilution processing gas for diluting the fuel electrode off-gas at the purge flow rate MQP(RTRA, RT) to the target concentration R1 or less and the maximum flow air rate Q1 of the exhaust hydrogen processing blower 14.

[0092] Also, the target air flow rate calculating section 42 calculates the target air flow rate TQC on the basis of the following equation:

$$TQC = Max\{TQAG, R1 \times MQP(RPRA, RT) - TQD\}. \qquad (8)$$

[0093] Equation 8 indicates that the target air flow rate TQC is set to the larger value of the flow rate (i.e., a stable generation flow rate) TQAG of air to be supplied to the oxidizer electrodes for stable generation and a value obtained by subtracting the target blower flow rate TQD from the required flow rate of the dilution processing gas for diluting the fuel electrode off-gas at the purge flow rate MQP(x, y) to the target concentration R1 or less.

[0094] Further, the target air pressure calculating section 43 calculates the target air pressure TPRC on the basis of the following equation:

$$TPRC = Min\{TPRA + \Delta P1, TPRCL\}, \qquad (9)$$

wherein ΔP1 is a differential pressure allowable for the electrolyte membrane in the fuel cell stack 1, and TPRCL is the lower limit value of air pressure required for securing the water balance and is calculated on the basis of the target air pressure TQC and the operating temperature RT with reference to such a corresponding relationship between the operating temperature and the target air pressure as shown in FIG. 8. Therefore, the target air pressure TPRC is set to the smaller value of the total of the target hydrogen pressure TPRA and the allowable differential pressure ΔP1 and the lower limit value of air pressure required for securing the water balance.

[0095] Unlike in the first embodiment, the target operating temperature calculating section 44 is given a fixed value previously determined through experiment or simulation in order to secure the water balance by the air pressure.

[0096] As described above, in this embodiment the target air flow rate calculating section 42 calculates the required flow rate of the dilution processing gas on the basis of the purge flow rate MQP(RTRA, RT) and also sets as the second target air flow rate a value obtained by subtracting the maximum flow rate Q1 (= TQD) of air that can be supplied from the exhaust hydrogen processing blower 14 from the calculated required flow rate of the dilution processing gas.

[0097] In this configuration, the rate of increase in the second target air flow rate from the stable generation flow rate (that is, first target air flow rate) TQAG can be decreased as much as possible, and thus the dry-out tendency of the fuel cell stack 1 can be suppressed.

[0098] In this embodiment, the target air pressure calculating section 43 sets the target air pressure TPRC to a value (equal to TPRA + ΔP1) that is larger than the target hydrogen pressure TPRA (which is the normal value).

[0099] Further, in this configuration the target air pressure TPRC is increased according to an increase in the target air flow rate TQC. Therefore, the amount of water taken out from the oxidizer electrodes can be decreased, thereby suppressing the occurrence of transient dry-out.

[00100] The above-described embodiments have been described in order to allow easy understanding of the invention and do not limit the invention. On the contrary, the invention is intended to cover various modifications and equivalent arrangements included within the scope of the appended claims, which scope is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structure as is permitted under the law.

What is claimed is:

1. A fuel cell system comprising:

a fuel cell configured to generate electric power by an electrochemical reaction between a fuel gas supplied to a fuel electrode and an oxidizer gas supplied to an oxidizer electrode;

a dilution device supplied with a fuel electrode off-gas discharged from the fuel electrode, an oxidizer electrode off-gas discharged from the oxidizer electrode and a dilution gas so that the fuel electrode off-gas is diluted with the oxidizer electrode off-gas and the dilution gas and is then discharged;

at least one calculating device for calculating a target purge flow rate, which is a target flow rate of the fuel electrode off-gas, on the basis of required power of the fuel cell and for calculating a target oxidizer gas flow rate, which is a target flow rate of the oxidizer gas supplied to the oxidizer electrode, on the basis of the required power of the fuel cell;

a purge flow rate regulating device for regulating the flow rate of the fuel electrode off-gas;

a purge flow rate control device for controlling the purge flow rate regulating device on the basis of the target purge flow rate calculated by the at least one calculating device;

a detection device for detecting the flow rate of the fuel electrode off-gas as a purge flow rate;

a supply flow rate regulating device for regulating the flow rate of the oxidizer gas supplied to the oxidizer electrode; and

a supply flow rate control device for controlling the supply flow rate regulating device on the basis of the target oxidizer gas flow rate;

wherein when the purge flow rate detected by the detection device is larger than the target purge flow rate, the at least one calculating device calculates as the target oxidizer gas flow rate a second target oxidizer gas flow rate larger than a first target oxidizer gas flow rate calculated on the basis of the required power.

2. The fuel cell system according to claim 1 wherein the second target oxidizer gas flow rate is calculated by adding an increased flow rate corresponding to a difference between the purge flow rate detected by the detection device and the target purge flow rate to the first target oxidizer gas flow rate.

3. The fuel cell system according to claim 1 or 2 wherein the detection device is a flow meter for directly detecting the purge flow rate.

4. The fuel cell system according to claim 1 or 2 wherein the detection device indirectly detects the purge flow rate by estimating the purge flow rate on the basis of the pressure of the fuel gas supplied to the fuel electrode and the temperature of the oxidizer electrode off-gas.

5. The fuel cell system according to any one of claims 1 to 4 wherein when the fuel cell would likely be put into an unstable generation condition using the second target oxidizer gas flow rate as the target oxidizer gas flow rate, the at least one calculating device outputs an instruction to stop the supply of the fuel electrode off-gas to the dilution means and changes the target oxidizer gas flow rate to the first target oxidizer gas flow rate.

6. The fuel cell system according to claim 5, further comprising:

a supply pressure regulating device for regulating the pressure of the oxidizer gas supplied to the oxidizer electrode; and

a supply pressure control device for controlling the supply pressure regulating device on the basis of the target oxidizer gas pressure calculated by the at least one calculating device;

wherein the at least one calculating device further calculates a target oxidizer gas pressure, which is a target pressure of the oxidizer gas supplied to the oxidizer electrode when the fuel cell would likely be put into an unstable generation condition using the second target oxidizer gas flow rate as the target oxidizer gas flow rate, the at least one calculating device setting the target oxidizer gas pressure to a value lower than a normal value.

7. The fuel cell system according to any one of claims 1 to 6, further comprising:

a cooling device for cooling the fuel cell; and

an operating temperature control device for controlling the cooling device on the basis of the target operating temperature calculated by the at least one calculating device, wherein the at least one calculating device further calculates a target operating temperature, which is a target operating temperature of the fuel cell, and sets the target operating temperature to a value decreased according to an increase in the target oxidizer gas flow rate calculated by the at least one calculating device.

8. The fuel cell system according to any one of claims 1 to 7 wherein when the fuel cell would likely be put into an unstable generation condition using the second target oxidizer gas flow rate as the target oxidizer gas flow rate, the at least one calculating device sets the target purge flow rate to a value higher than a normal value.

9. The fuel cell system according to claim 1 wherein the at least one calculating device calculates the required flow rate of the dilution processing gas on the basis of the purge flow rate detected by the detection device, and the at least one calculating device sets as the second target oxidizer gas flow rate a value obtained by subtracting the maximum flow rate of the dilution gas which can be supplied from the dilution device from the calculated required flow rate of the dilution processing gas.

10. The fuel cell system according to claim 9, further comprising:

a supply pressure regulating device for regulating the pressure of the oxidizer gas supplied to the oxidizer electrode;

a supply pressure control device for controlling the supply pressure regulating device on the basis of the target oxidizer gas pressure calculated by at least one calculating device;

wherein the at least one calculating device further calculates target oxidizer gas pressure, which is a target pressure of the oxidizer gas supplied to the oxidizer electrode, and sets the target oxidizer gas pressure to a value above a normal value.

11. A fuel cell system comprising:

a fuel cell that generates electric power by an electrochemical reaction between a fuel gas supplied to a fuel electrode and an oxidizer gas supplied to an oxidizer electrode;

a dilution device supplied with a fuel electrode off-gas discharged from the fuel electrode, an oxidizer electrode off-gas discharged from the oxidizer electrode, and a dilution gas supplied from a dilution gas supply device so that the fuel electrode off-gas is diluted with the oxidizer electrode off-gas and the dilution gas and is then discharged;

at least one calculating device for calculating a target oxidizer gas flow rate, which is a target flow rate of the oxidizer gas supplied to the oxidizer electrode, on the basis of required power of the fuel cell;

a supply flow rate regulating device for regulating the flow rate of the oxidizer gas supplied to the oxidizer electrode; and

a supply flow rate control device for controlling the supply flow rate regulating means on the basis of the target oxidizer gas flow rate calculated by the supply flow rate calculating means,

wherein when the required power of the fuel cell is decreased, the at least one calculating device calculates as the target oxidizer gas flow rate a second target oxidizer gas flow rate higher than a first target oxidizer gas flow rate calculated on the basis of the required power in order to increase flow rate of the oxidizer electrode off-gas discharged from the oxidizer electrode and to secure a required flow rate of the dilution processing gas.

12. A method for controlling a fuel cell system comprising:

calculating a target oxidizer gas flow rate, which is a target flow rate of an oxidizer gas supplied to an oxidizer electrode of a fuel cell, on the basis of a required power of the fuel cell;

controlling the flow rate of the oxidizer gas supplied to the oxidizer electrode on the basis of the calculated target oxidizer gas flow rate;

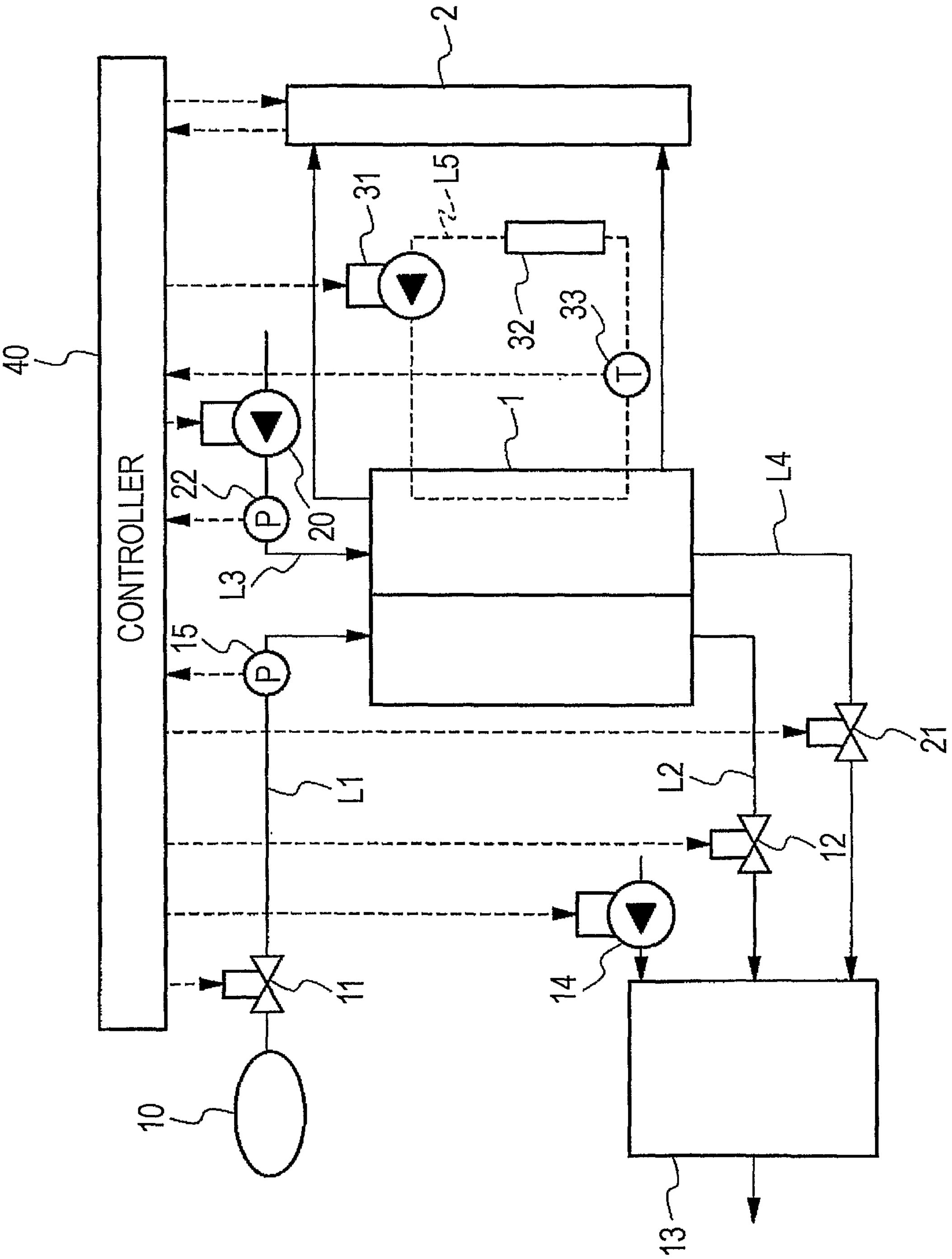
supplying a dilution gas to dilution device to which an oxidizer electrode off-gas discharged from the oxidizer electrode of the fuel cell and a fuel electrode off-gas discharged from a fuel electrode of the fuel cell are supplied so that the fuel electrode off-gas is diluted and then discharged;

calculating a target purge flow rate, which is a target flow rate of the fuel electrode off-gas supplied to the dilution device, on the basis of the required power of the fuel cell; and

controlling the flow rate of the fuel electrode off-gas supplied to the dilution device on the basis of the calculated target purge flow rate;

wherein when the detected purge flow rate is larger than the target purge flow rate, the calculating a target oxidizer gas flow rate includes calculating as the target oxidizer gas flow rate a second target oxidizer gas flow rate higher than a first target oxidizer gas flow rate calculated on the basis of the required power.

FIG. 1


CONTROLLER
40
2
31
L5
32
33
T
1
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P
20
L3
15
P
L4
L2
L1
21
12
14
11
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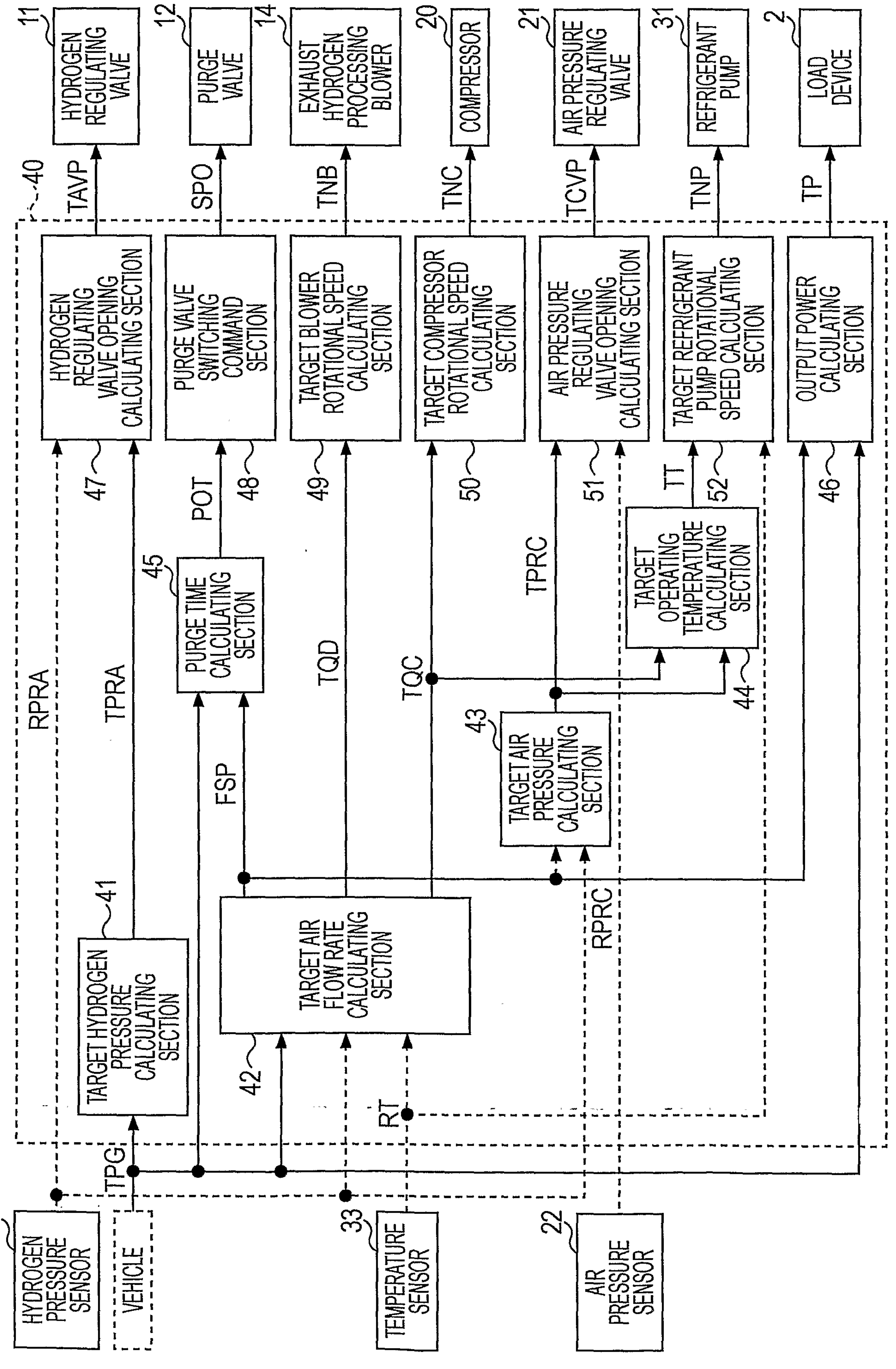
13

FIG. 2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VEHICLE
TEMPERATURE SENSOR
33
AIR PRESSURE SENSOR
22
TPG
RPRA
TPRA
RPRC
RT
40
TARGET HYDROGEN PRESSURE CALCULATING SECTION
41
TARGET AIR FLOW RATE CALCULATING SECTION
42
TARGET AIR PRESSURE CALCULATING SECTION
43
TARGET OPERATING TEMPERATURE CALCULATING SECTION
44
PURGE TIME CALCULATING SECTION
45
FSP
TQD
TQC
TPRC
POT
TT
HYDROGEN REGULATING VALVE OPENING CALCULATING SECTION
47
PURGE VALVE SWITCHING COMMAND SECTION
48
TARGET BLOWER ROTATIONAL SPEED CALCULATING SECTION
49
TARGET COMPRESSOR ROTATIONAL SPEED CALCULATING SECTION
50
AIR PRESSURE REGULATING VALVE OPENING CALCULATING SECTION
51
TARGET REFRIGERANT PUMP ROTATIONAL SPEED CALCULATING SECTION
52
OUTPUT POWER CALCULATING SECTION
46
TAVP
SPO
TNB
TNC
TCVP
TNP
TP
HYDROGEN REGULATING VALVE
11
PURGE VALVE
12
EXHAUST HYDROGEN PROCESSING BLOWER
14
COMPRESSOR
20
AIR PRESSURE REGULATING VALVE
21
REFRIGERANT PUMP
31
LOAD DEVICE
2

FIG. 3

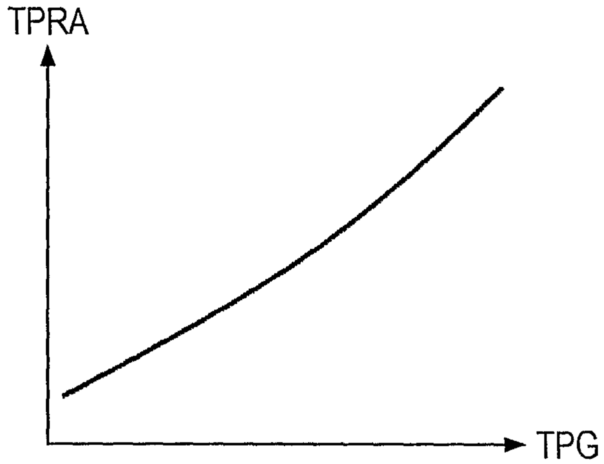


FIG. 4

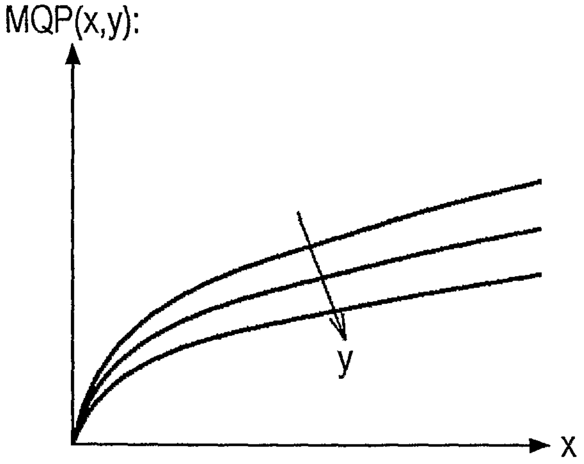


FIG. 5

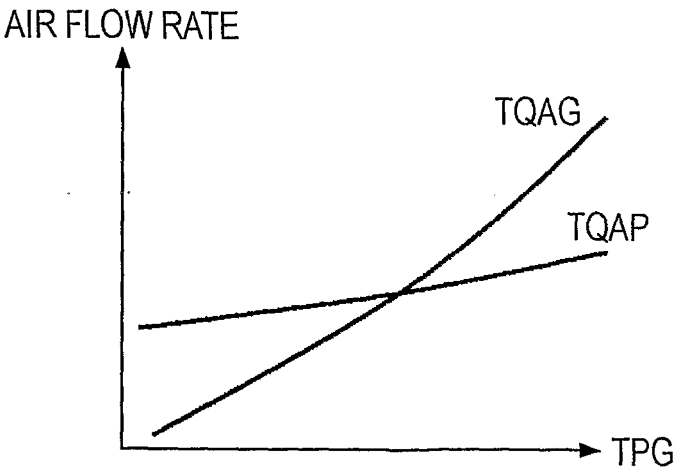


FIG. 6

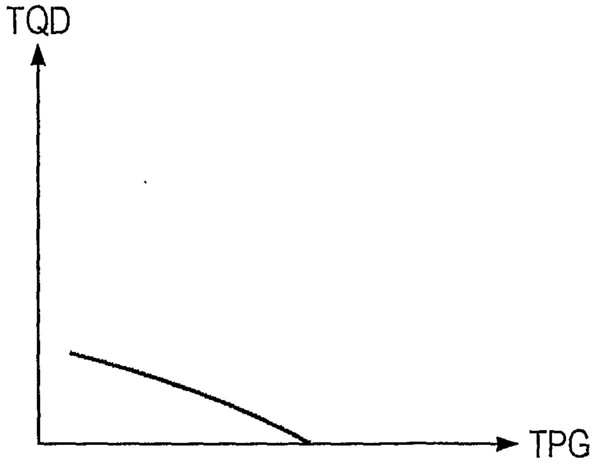


FIG. 7

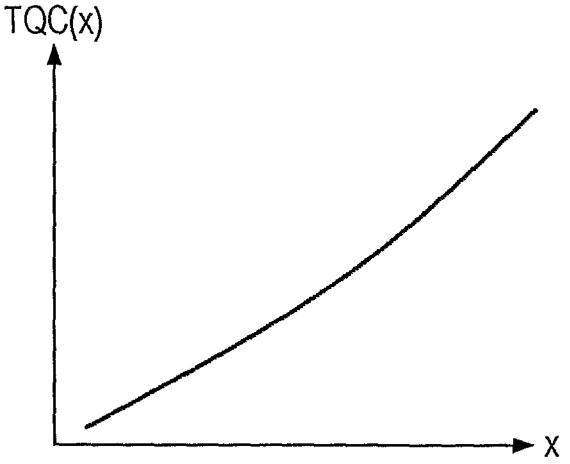


FIG. 8

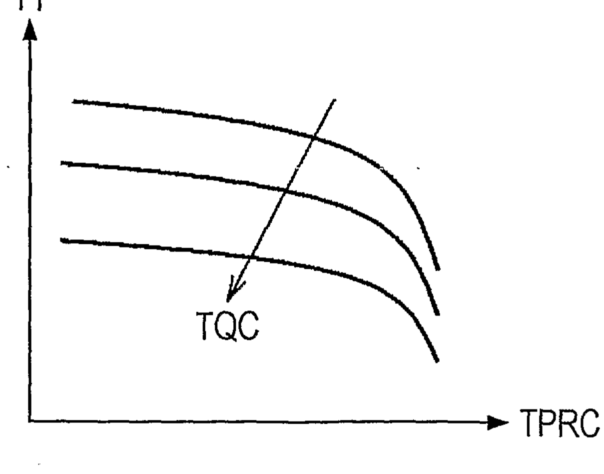


FIG. 9

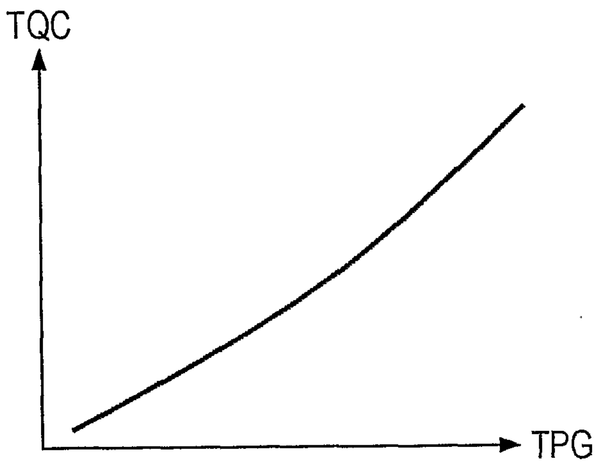


FIG. 10

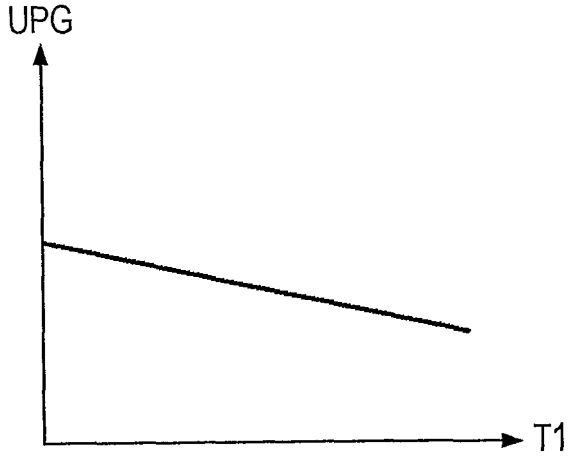


FIG. 11

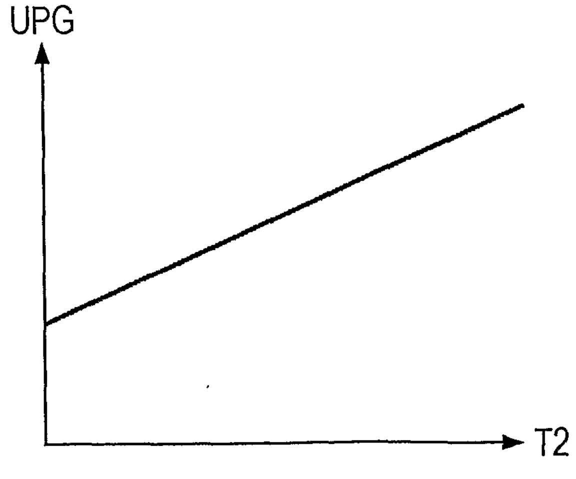


FIG. 12

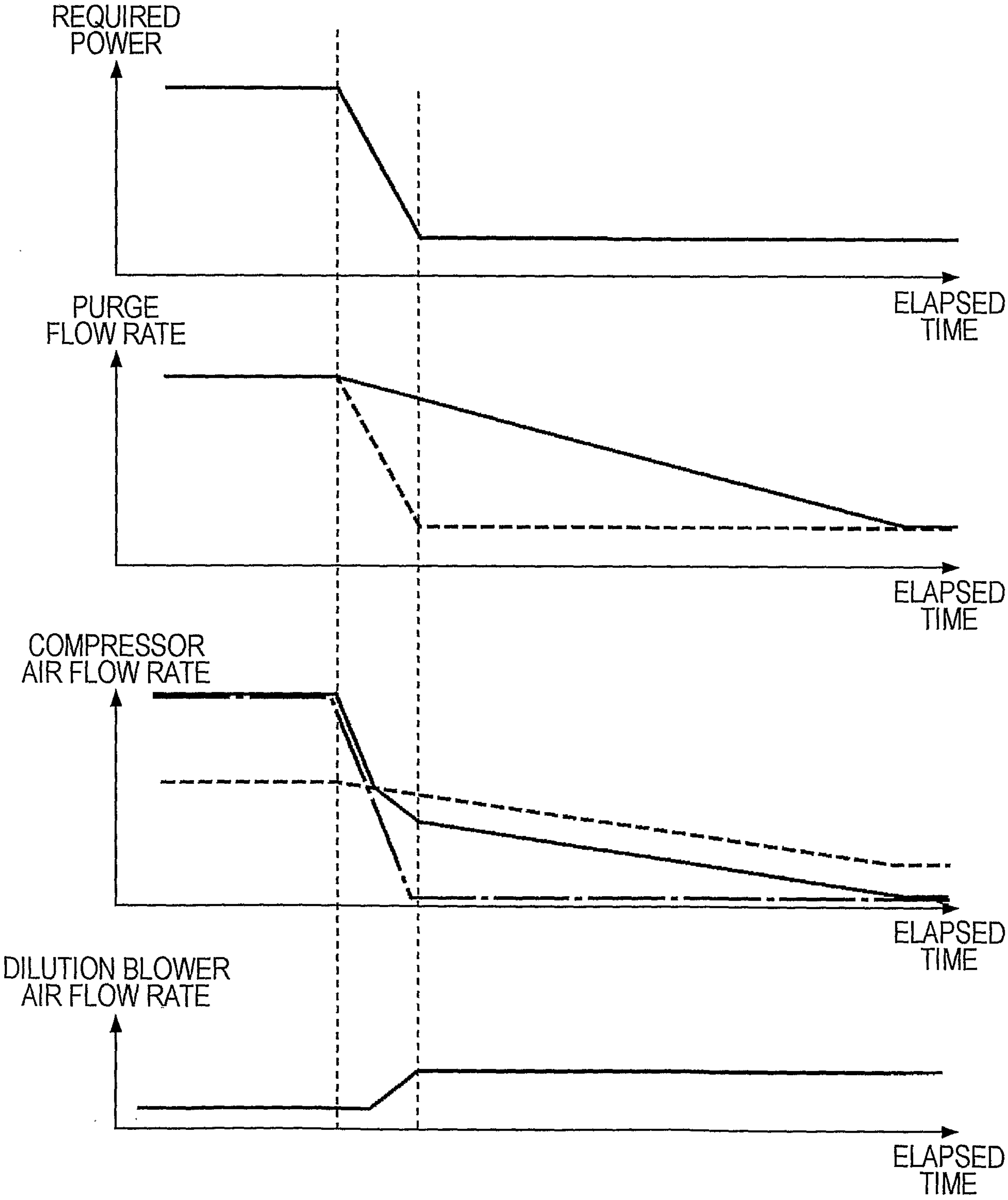

REQUIRED POWER
ELAPSED TIME
PURGE FLOW RATE
ELAPSED TIME
COMPRESSOR AIR FLOW RATE
ELAPSED TIME
DILUTION BLOWER AIR FLOW RATE
ELAPSED TIME

FIG. 13

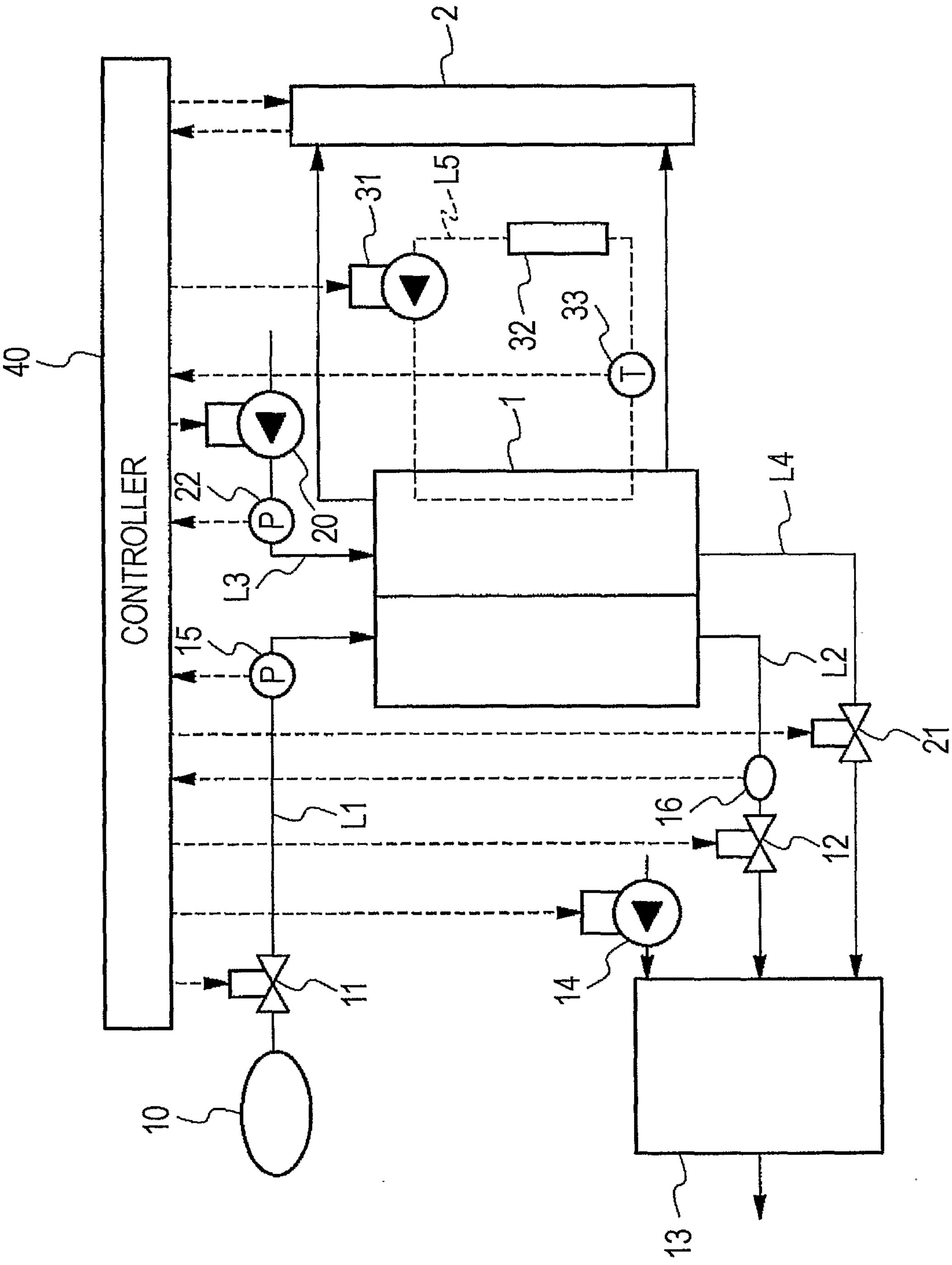

CONTROLLER
40
2
1
31
L5
32
33
T
P
22
20
L3
P
15
L1
L2
L4
16
12
21
14
11
10
13

FIG. 14

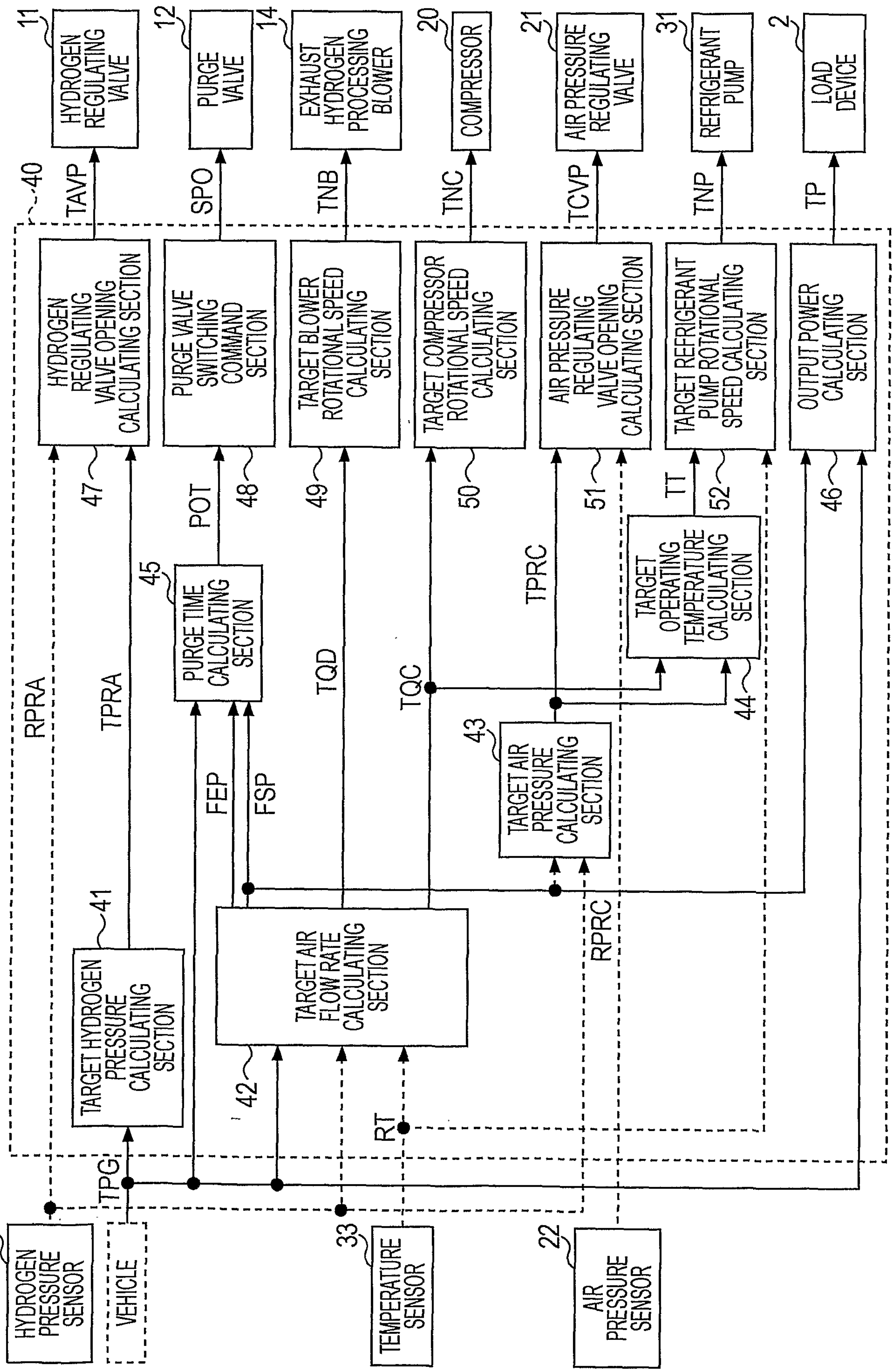
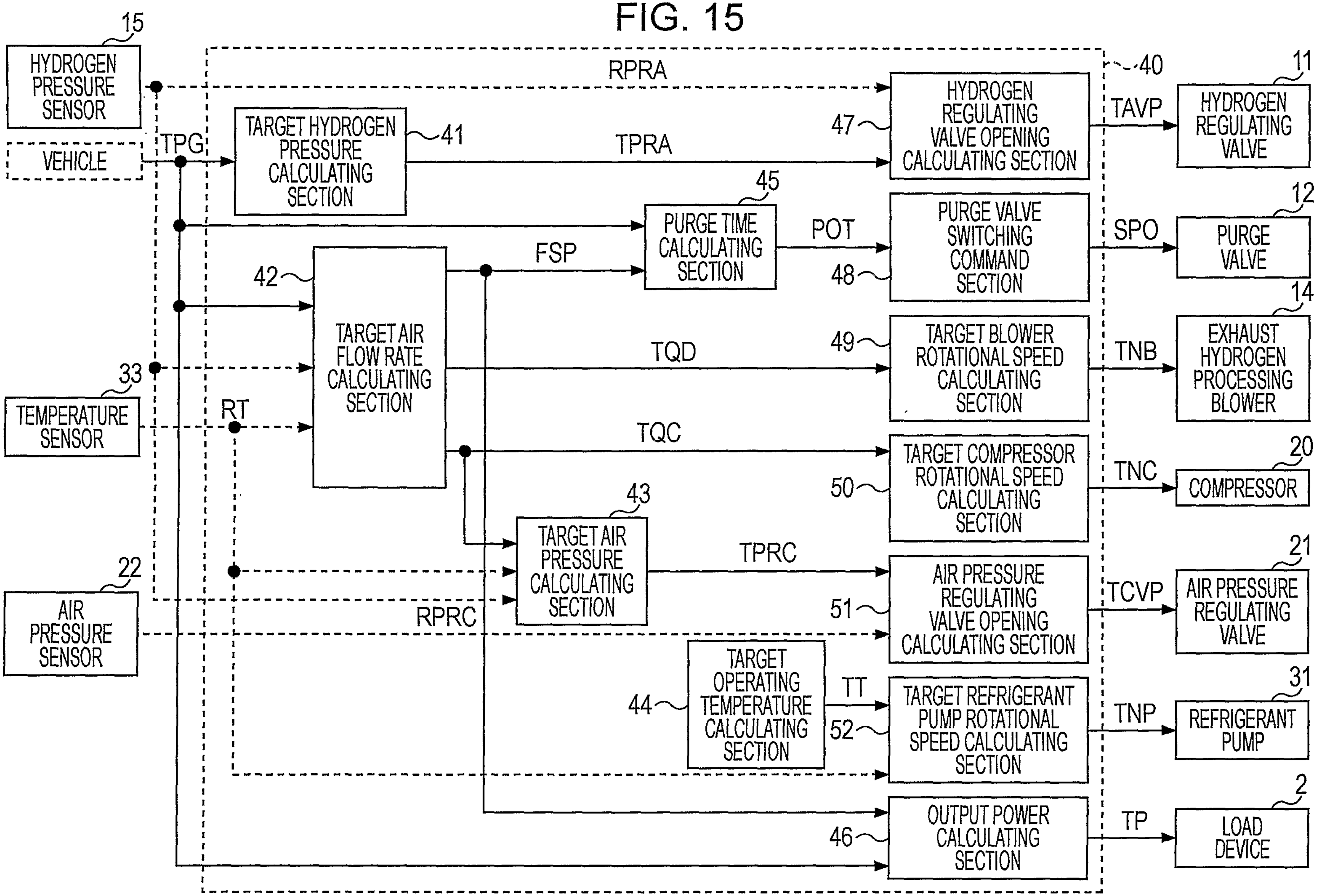

HYDROGEN PRESSURE SENSOR
15
VEHICLE
TEMPERATURE SENSOR
33
AIR PRESSURE SENSOR
22
TPG
RT
RPRA
RPRC
TARGET HYDROGEN PRESSURE CALCULATING SECTION
41
TARGET AIR FLOW RATE CALCULATING SECTION
42
TARGET AIR PRESSURE CALCULATING SECTION
43
TARGET OPERATING TEMPERATURE CALCULATING SECTION
44
PURGE TIME CALCULATING SECTION
45
TPRA
FEP
FSP
TQD
TQC
TPRC
POT
TT
HYDROGEN REGULATING VALVE OPENING CALCULATING SECTION
47
PURGE VALVE SWITCHING COMMAND SECTION
48
TARGET BLOWER ROTATIONAL SPEED CALCULATING SECTION
49
TARGET COMPRESSOR ROTATIONAL SPEED CALCULATING SECTION
50
AIR PRESSURE REGULATING VALVE OPENING CALCULATING SECTION
51
TARGET REFRIGERANT PUMP ROTATIONAL SPEED CALCULATING SECTION
52
OUTPUT POWER CALCULATING SECTION
46
40
TAVP
SPO
TNB
TNC
TCVP
TNP
TP
HYDROGEN REGULATING VALVE
11
PURGE VALVE
12
EXHAUST HYDROGEN PROCESSING BLOWER
14
COMPRESSOR
20
AIR PRESSURE REGULATING VALVE
21
REFRIGERANT PUMP
31
LOAD DEVICE
2

FIG. 15


15
HYDROGEN PRESSURE SENSOR
VEHICLE
33
TEMPERATURE SENSOR
22
AIR PRESSURE SENSOR
TPG
RT
RPRA
TPRA
FSP
POT
TQD
TQC
TPRC
RPRC
TT
40
41
TARGET HYDROGEN PRESSURE CALCULATING SECTION
42
TARGET AIR FLOW RATE CALCULATING SECTION
43
TARGET AIR PRESSURE CALCULATING SECTION
44
TARGET OPERATING TEMPERATURE CALCULATING SECTION
45
PURGE TIME CALCULATING SECTION
47
HYDROGEN REGULATING VALVE OPENING CALCULATING SECTION
48
PURGE VALVE SWITCHING COMMAND SECTION
49
TARGET BLOWER ROTATIONAL SPEED CALCULATING SECTION
50
TARGET COMPRESSOR ROTATIONAL SPEED CALCULATING SECTION
51
AIR PRESSURE REGULATING VALVE OPENING CALCULATING SECTION
52
TARGET REFRIGERANT PUMP ROTATIONAL SPEED CALCULATING SECTION
46
OUTPUT POWER CALCULATING SECTION
TAVP
SPO
TNB
TNC
TCVP
TNP
TP
11
HYDROGEN REGULATING VALVE
12
PURGE VALVE
14
EXHAUST HYDROGEN PROCESSING BLOWER
20
COMPRESSOR
21
AIR PRESSURE REGULATING VALVE
31
REFRIGERANT PUMP
2
LOAD DEVICE