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(72) Inventors:
• **OGASAWARA Kazuhiko**
Kumagaya-shi
Saitama 360-0831 (JP)
• **ABIKO Tomoki**
Kumagaya-shi
Saitama 360-0831 (JP)

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(74) Representative: **Piésold, Alexander James**
Dehns
St Bride's House
10 Salisbury Square
London EC4Y 8JD (GB)

(71) Applicant: **Nippon Oil Pump Co., Ltd.**
Kumagaya-shi, Saitama 360-0831 (JP)

(54) **BURNER**

(57) The purpose of the present invention is to provide a proportionally controlled burner that omits as many mechanical components as possible, reducing power consumption, and minimizes the amount of heat lost via a flue. To that end, in the present invention, a high-speed solenoid valve (11) is provided in a fuel-supply system (Lf); said high-speed solenoid valve (11) has the ability to open when an inputted pulse signal is on and close when said pulse signal is off; an oxygen-concentration

sensor (80) that is located on the combustion-exhaust side and measures the oxygen concentration of a flue gas is provided, as is a control device (60) to which measurement results from said oxygen-concentration sensor (80) are sent; and said control device (60) has the ability to change the frequency of an inverter (50) and regulate the amount of combustion air such that the flue-gas oxygen concentration detected by the oxygen-concentration sensor (80) approaches zero.

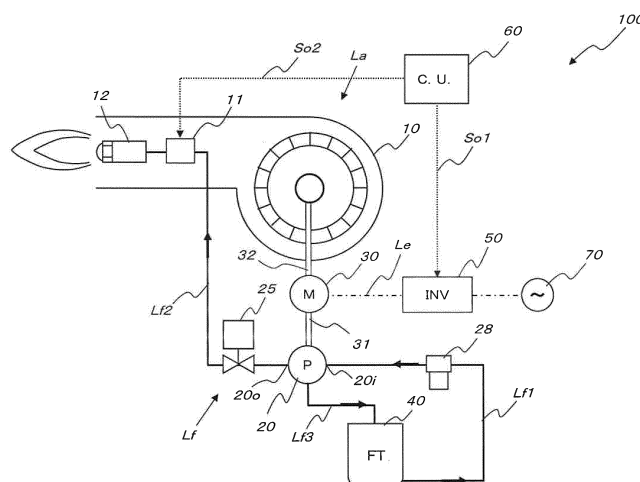


FIG.1

Description

TECHNICAL FIELD

[0001] The present invention relates to a combustion burner, more particularly, the present invention relates to a proportional control type burner.

BACKGROUND ART

[0002] A proportional control type burner according to a prior art will be described hereinafter with reference to FIG. 6.

[0003] In FIG. 6, a burner entirely indicated by reference character 100J includes mechanical component parts such as a blast fan 10J, a fuel injection nozzle 12 provided at a tip portion of the blast fan 10J, a fuel pump 20J, a fuel supply system Lf, an air damper 13, a damper motor 35, an air control disk 36, links 37 and 38, and others. Also, the fuel supply system Lf includes fuel control valves 21 to 23, an air bleeding valve 24, an oil strainer 28, and a fuel tank 40.

[0004] In combustion of the burner 100J, it is necessary to adjust not only a fuel injection amount from the fuel injection nozzle 12 but also an air supply amount provided by the blast fan 10J.

[0005] In adjustment of the fuel injection amount, assuming that a fuel supply amount supplied to the fuel injection nozzle 12 through a supply line Lf12 is indicated by a character QAJ and a fuel return amount which returns from the fuel injection nozzle 12 to the fuel pump 20J through a fuel return line Lf13 is indicated by a character QBj, a fuel QC injected by the fuel injection nozzle 12 is represented by the following expression $QC = QAJ - QBj$.

[0006] In the prior art burner J shown in FIG. 6, the fuel supply amount QAJ is a fixed amount. Thus, adjusting the return amount QBj with the use of a flow regulation valve 23 (controlling QBj) enables adjusting (controlling) an injection amount QC.

[0007] Further, in the prior art burner 100J, since the number of revolutions of the blast fan 10J is fixed, an amount of air which flows to the fuel injection nozzle 12 side is controlled by throttling the air damper 13.

[0008] An axis of ordinate in FIG. 7 shows a fuel amount and an air amount. Furthermore, as regards the burner 100J, FIG. 7 shows characteristics or relationships between the fuel supply amount QAJ, the fuel return amount QBj, the fuel injection amount QC from the nozzle 12, a circulation amount QR (a pump fuel return amount) of a fuel oil which returns from the fuel pump 20J to the fuel tank 40, and an air supply amount Qa supplied by the blast fan 10J.

[0009] In FIG. 7, reference character T-Qa indicates a change in air supply amount, reference character T-QAJ indicates a characteristic of the fuel supply amount QAJ (the fuel supply amount QAJ is fixed and invariable), reference character T-QBj indicates a characteristic of the fuel return amount QBj, reference character T-QC des-

ignates a characteristic of the fuel injection amount, and reference signal T-QR indicates a characteristic of the pump fuel return amount QR.

[0010] In Fig. 7, the burner 100J is in a maximum combustion state which state is shown in a left region of a line LH extending in a vertical direction. In a right region of the line LH, combustion adjustment is performed, the fuel QCj injected by the fuel injection nozzle 12 decreases with shifting toward the right side, and the fuel return amount QBj increases with shifting toward the right side.

[0011] In order to perform excellent combustion with the use of the burner 100J, a ratio of the air supply amount and the fuel supply amount is fixed. Thus, in FIG. 7, the air supply amount characteristic T-Qaj and the fuel injection amount characteristic T-QCj extend parallel.

[0012] To realize these characteristics, in the proportional control type burner according to the prior art, the air damper 13 in the blast fan 10J is adjusted (controlled) in synchronization with controlling the flow adjustment valve 23 in the fuel return line Lf13 in FIG. 6, thereby adjusting (controlling) an air volume of the blast fan 10J.

[0013] In the burner 100J according to the prior art shown in FIG. 6, the control of the flow adjustment valve 23 and the adjustment (control) of the air damper 13 described above are achieved by a damper motor 35, an air control disk 36, links 37 and 38, and others.

[0014] However, in order to carry out the above-mentioned adjustment (control) by the damper motor 35, the air control disk 36, the links 37 and 38 and others, it is necessary to be provided with mechanical components having complicated constructions.

[0015] Moreover, in the burner 100J according to the prior art which includes the mechanical components having complicated constructions, the constructions are complicated, and highly accurate control is difficult.

[0016] Additionally, initial investment as well as maintenance requires a large amount of labor.

[0017] In addition, the burner 100J according to the prior art shown in FIG. 6 also has a problem that power consumption is large and running costs are expensive.

[0018] Here, various kinds of burners that perform proportional control have been conventionally proposed (see, e.g., Patent Literature 1).

[0019] However, a combustion apparatus according to the above-mentioned prior art (Patent Literature 1) is intended to effectively use a combustion unit having poorer user-friendliness in the combustion apparatus which includes two combustion units and has a restricted total combustion amount, and the above-mentioned prior art (Patent Literature 1) can not solve the above-described problem.

[0020] Further, in the combustion apparatus according to the above-mentioned prior art (Patent Literature 1), a large amount of oxygen is contained in a combustion gas for the purpose of preventing incomplete combustion, an exhaust amount discharged through a flue increases, and also, there is a problem that a large quantity of heat contained in exhaust air in the above-mentioned prior art

(Patent Literature 1).

CITATION LIST

PATENT LITERATURE

[0021] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2006-64301 (JPA2006-64301)

DISCLOSURE OF INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0022] In view of the above-mentioned problems in the prior art, the present invention has been proposed, and then, an object of the present invention is to provide a burner which can suppress power consumption, can decrease numbers of mechanical components in a proportional control type burner as much as possible and also can reduce a quantity of heat wasted through a flue as much as possible.

MEANS FOR SOLVING PROBLEMS

[0023] A burner (100) according to the present invention is characterized in that the burner comprises a fuel supply system (Lf) and an air supply system (La), the fuel supply system (Lf) includes a fuel supply pump (20) being disposed therein, a high-speed solenoid valve (11) is provided in a region (Lf2) on an injection side of the fuel supply pump (20) in the fuel supply system (Lf), the high-speed solenoid valve (11) has a function to open when a pulse signal input thereto is ON and a function to close when the signal is OFF, and an inverter (50) is disposed to a power supply circuit of a drive motor (30) which drives the fuel supply pump (20), and that the air supply system (La) has a blast fan (10) for air supply, and the inverter (50) is disposed to the power supply circuit of the drive motor (30) which drives the blast fan (10) for air supply.

[0024] In the present invention, it is preferable to be provided with a nozzle (12) on a discharge side of the high-speed solenoid valve (11) which is provided in the fuel supply system (Lf).

[0025] Further, in the present invention, it is preferable to be provided with an oxygen concentration sensor (80) which is provided in an exhaust pipe (E) and measures oxygen concentration in a combustion gas, and to be provided with a control apparatus (60) to which a measurement result of the oxygen concentration sensor (80) is supplied, said control apparatus has a function for changing a frequency of the inverter (50) in order to adjust a combustion air amount so that the oxygen concentration in the combustion gas being detected by the oxygen concentration sensor (80) becomes approximately zero.

[0026] In a method for operating a burner according to

the present invention, in an operation of a burner having said oxygen concentration sensor (80) and the control apparatus (60), characterized in that the method comprises

- 5 a step (S1) for measuring oxygen concentration in a combustion gas by the oxygen concentration sensor (80) arranged on a combustion exhaust side of an exhaust pipe (E); and
- a step (S3, S4) for changing a frequency of an inverter (50) and adjusting a combustion air amount so that the oxygen concentration in the combustion gas being detected by the oxygen concentration sensor (80) becomes approximately zero.

[0027] In the present invention, it is preferable that the fuel supply pump (20) and the blast fan (10) are driven by the single drive motor (30), and that the inverter (50) is disposed on a power supply circuit (Le) of the above-mentioned single drive motor (30).

[0028] However, it is possible that the fuel supply pump and the blast fan may be driven by different drive motors immediately, and that the inverters may be disposed on respective drive power supply circuits of the above-mentioned different drive motors immediately.

25 EFFECT OF THE INVENTION

[0029] According to the present invention having the above-described constructions, since a pulse width is controlled by the high-speed solenoid valve (11) to control a fuel injection amount, a control accuracy of the fuel injection amount can be improved, as compared with a proportional control type burner (e.g., FIG. 6) in the prior art which determines a fuel injection amount based on a difference between a supply fuel amount and a return fuel amount.

[0030] Furthermore, according to the present invention, due to control the number of revolutions of the drive motor (30) by means of the inverter (50), it is possible to change the number of revolutions of the supply fuel pump (20) which supplies the fuel to the high-speed solenoid valve (11) side (the injection side) and a rotation amount of the blast fan (10) which supplies air to the high-speed solenoid valve (11) side (the injection side) to appropriate numerical values. Consequently, wasteful power consumption can be suppressed.

[0031] In the present invention, even if the number of revolutions of the fuel supply pump (20) is not fixed, due to control a pulse width of a signal input to the high-speed solenoid valve (11) to highly accurately control, a fuel injection amount can be appropriately controlled. In other words, according to the present invention, even if a flow rate of the fuel which returns from the nozzle to the fuel supply source side is not controlled as different from the prior art, the fuel injection amount can be appropriately controlled.

[0032] Consequently, according to the present invention, it is not necessary to be provided fuel piping which communicates the nozzle (12) with the fuel supply source

(40) side. That is, in the present invention, a system which supplies the fuel is merely provided between the fuel supply pump (20) and the high-speed solenoid valve (11), it is not necessary to provide a circuit which supplies the fuel from the high-speed solenoid valve (11) to the fuel supply pump (20) side. Moreover, in the present invention, it is possible to be provided merely circuits (Lf1, LF3) which communicate with the pump (20) and the fuel supply source (40), as the circuits which return the fuel to the fuel supply source (40) side.

[0033] Thus, as compared with the prior art including a circuit which supplies the fuel to the nozzle and an other circuit returning the fuel to the fuel supply source side which fuel is not injected from the nozzle, the number of pipes in the fuel supply system can be decreased and labor required for maintenance can be reduced according to the present invention.

[0034] Additionally, in the present invention, since the number of revolutions of the drive motor (30) is controlled by the inverter (50) and then the number of revolutions of the fuel supply pump (20) which supplies the fuel to the high-speed solenoid valve (11) side (the injection side) can be controlled, it is not necessary to have to fix the fuel supply amount (an oil supply amount) supplied to the injection side, as different from the a proportional control type burner (100J) in the prior art. The fuel supply amount can be appropriately changed in accordance with an operation state.

[0035] Consequently, a flow rate of the fuel which returns to the fuel supply source (40) side can be reduced, and therefore, electric power required for fuel circulation can be cut back.

[0036] According to experiments carried out by the present inventor, as compared with the prior art burner (100J), a return flow rate of the fuel was reduced by approximately 70%, and approximately 60% of power consumption was successfully saved in the burner (100) entirely.

[0037] According to the present invention, the air supply amount required for combustion of the burner (100) can be controlled to an appropriate number of revolutions by means of the inverter (50) disposed to the power supply circuit (Le) of the drive motor (30) which drives the blast fan (10) for air supply.

[0038] Consequently, according to the present invention, air can be supplied a flow rate of which air is preferable for combustion conditions of the burner (100), and the combustion efficiency of the burner (100) can be improved.

[0039] Furthermore, unnecessary consumption of the fuel can be suppressed, and power consumption can be suppressed.

[0040] Moreover, according to the present invention, since a pulse width is controlled by the high-speed solenoid valve (11) to control a fuel injection amount and the number of revolutions of the drive motor (30) is controlled by the inverter (50), mechanical elements which are required in the prior art proportional control burner (100J),

e.g., an air damper (13), links (37, 38), an air control disk (36), and others are no longer necessary. Thus, the constructions of the burner can be simplified, and costs and labor of production and maintenance can be decreased.

[0041] In the present invention, it is preferable for the nozzle (12) to be provided on the discharge side of the high-speed solenoid valve (11).

[0042] According to experiments having been carried out by the present inventor, it is confirmed that combustibility is improved in a case that the nozzle (12) is provided on the discharge side of the high-speed solenoid valve (11).

[0043] In the present invention, in a case that burner comprises the oxygen concentration sensor (80) which is provided on the combustion exhaust side and measures oxygen concentration in a combustion gas and the control apparatus (60) to which a measurement result of the oxygen concentration sensor (80), and the control device (60) is constructed so as to have functions for changing a frequency of the inverter (50) and for adjusting the number of revolutions of the blast fan so that the oxygen concentration in the combustion gas being detected by the oxygen concentration sensor (80) becomes approximately zero,

an amount of air supplied in a situation of combustion can be reduced by changing a frequency of the inverter (50) and adjusting the combustion air amount so that the oxygen concentration in the combustion gas becomes approximately zero, thereby it is possible to minimize an amount of combustion gas. Also, energy can be saved corresponding to a quantity of heat contained in the exhaust gas.

[0044] Further, since the amount of combustion gas is minimized, an exhaust amount is reduced, and a quantity of heat being discharged through the flue is also decreased. Consequently, the fuel is effectively used, and thermal efficiency of the burner or a facility (e.g., a boiler) which uses the burner can be improved. Furthermore, a thermal influence which affects to a surrounding environment can be reduced.

BRIEF DESCRIPTION OF DRAWINGS

[0045]

FIG. 1 is a block diagram showing a first embodiment according to the present invention;

FIG. 2 is a characteristic diagram showing input signals to a high-speed solenoid valve used in the first embodiment;

FIG. 3 is a characteristic diagram showing a blast volume, a fuel supply amount to a pump, and a fuel injection amount in the first embodiment;

FIG. 4 is a block diagram showing a second embodiment according to the present invention;

FIG. 5 is a flowchart for explaining a control method according to a second embodiment;

FIG. 6 is a block diagram of a conventional propor-

tional control type burner; and

FIG. 7 is a characteristic diagram showing a blast volume, a fuel supply amount to a pump, and a fuel injection amount in the conventional proportional control type.

BEST MODE(S) FOR CARRYING OUT THE INVENTION

[0046] An embodiment according to the present invention will be described hereinafter with reference to the accompanying drawings.

[0047] First, a burner 100 according to the first embodiment will be described with reference to FIG. 1.

[0048] In FIG. 1, the burner 100 includes a fuel supply system Lf, an air supply system La, a motor 30 including two output shafts, an inverter 50, and a control unit 60 as controlling means.

[0049] The fuel supply system Lf has a high-speed solenoid valve 11, a fuel injection nozzle 12, a fuel pump 20, a fuel tank 40 as a fuel supply source, a fuel intake line Lf1 having an oil strainer 28 disposed thereto, a fuel supply line Lf2, and a fuel return line Lf3. Here, a solenoid valve 25 is disposed to the fuel supply line Lf2. Further, surplus fuel in the fuel pump 20 returns to the fuel tank 40 through the fuel return line Lf3.

[0050] The fuel intake line Lf1 having the oil strainer 28 disposed thereto connects the fuel tank 40 with an intake side 20i of the fuel pump 20. The fuel supply line Lf2 having the solenoid valve 25 disposed thereto connects a discharge side 20o of the fuel pump 20 with the high-speed solenoid valve 11.

[0051] The oil pump 20 is driven by an output shaft 31 of the motor 30.

[0052] The air supply system La has a blast fan 10, and the blast fan 10 is driven by said motor 30. Furthermore, the blast fan 10 is coupled with an output shaft 32 of said motor 30. The high-speed solenoid valve 11 and the fuel injection nozzle 12 are provided near a tip of the blast fan 10.

[0053] Here, said motor 30 includes the two output shafts, the oil pump 20 is connected to one output shaft 31, and the blast fan 10 is connected to the other output shaft 32. Two electric motors can be prepared in place of the motor having the two output shafts (31 and 32) as shown in the drawing so that one motor drives the oil pump 20 and the other motor drives the blast fan 10.

[0054] In the fuel supply line Lf2 (a region between the pump 20 and the fuel injection nozzle 12), the solenoid valve 25 arranged in series with the high-speed solenoid valve 11 is provided to prevent the fuel from leaking from the nozzle 12 after putting out the burner 100.

[0055] In other words, the solenoid valve 25 is a device provided as part of safety regulations.

[0056] The motor 30 is connected with an alternating-current power supply 70 through a power supply circuit Le having the inverter 50 disposed thereto.

[0057] The control unit 60 being controlling means is

connected with the inverter 50 via a control signal line So1. Furthermore, the control unit 60 is connected to the high-speed solenoid valve 11 through a control signal line So2.

[0058] The control unit 60 outputs a control signal to the inverter 50 through the control signal line So1 and outputs a control signal to the high-speed solenoid valve 11 through the control signal line So2.

[0059] The inverter 50 which receives the control signal from the control unit 60 adjusts a current and/or a voltage flowing through the power supply circuit Le to control a rotational speed of the motor 30. Moreover, controlling the number of revolutions of the motor 30 realizes control over a blast volume (an air supply amount) of the blast fan 10 and a fuel supply amount discharged from the fuel pump 20.

[0060] FIG. 2 exemplifies signal waveforms of pulse signals which are control signals output from the control unit 60 to the high-speed solenoid valve 11. FIG. 2 shows waveforms of two patterns.

[0061] In FIG. 2, an upper pattern and a lower pattern have the same cycle. The upper pattern shows a pulse signal when an opening time (an ON time) of the high-speed solenoid valve 11 is long and a fuel injection amount is relatively large. On the other hand, the lower pattern shows a pulse signal when the opening time of the high-speed solenoid valve 11 is short and the fuel injection amount is relative small.

[0062] In the first embodiment, adjusting the opening time (a pulse width: the ON time) of the high-speed solenoid valve enables highly accurately controlling the fuel injection amount.

[0063] In the burner 100, when an amount of fuel to be combusted (the fuel injection amount) is determined, an air amount required for combustion is necessarily determined.

[0064] In the first embodiment, after confirmation through, e.g., an experiment, control parameters for a supply current and/or a supply voltage from the inverter 50, a control pattern of the high-speed solenoid valve 11 (the ON time or the opening time in the pulse waveforms in FIG. 2), a ratio of the fuel injection amount and the supply air amount, and others are determined.

[0065] In FIG. 2, although one control cycle (one period) is set to, e.g., 10 msec, the period is not restricted thereto.

[0066] It is to be noted that, if one control cycle (one period) is shorter, control can be executed with a higher accuracy.

[0067] FIG. 3 shows characteristics of a fuel supply amount QA, a fuel supply amount QC supplied to the nozzle 12, an amount of fuel QR flowing through the fuel return line Lf3 (a pump fuel return amount), and an air supply amount Qa supplied by the blast fan 10.

[0068] Like FIG. 7, an axis of ordinate represents a fuel amount and an air amount in FIG. 3. In FIG. 3, reference character T-Qa indicates a characteristic of the air supply amount Qa, reference character T-QA indicates a char-

acteristic of the fuel supply amount QA supplied to the pump 20, reference character T-QC indicates a characteristic of the fuel injection amount QC, and reference character T-QR indicates a characteristic of the pump fuel return amount QR flowing through the fuel return line Lf3. Here, the fuel injection amount QC is a value obtained by subtracting the pump fuel return amount QR from the fuel supply amount QA supplied to the pump 20.

[0069] In FIG. 3, like FIG. 7, the burner performs maximum combustion in a region on the left side of a line LH extending in a vertical direction, and the combustion of the burner is adjusted and the fuel injection amount QC is reduced in a region on the right side of the line LH. Additionally, in FIG. 3, the air supply amount characteristic T-Qa and the fuel injection amount characteristic T-QC extend in parallel, and a ratio of the air amount and the fuel injection amount is fixed.

[0070] As described above, in the prior art shown in FIG. 7, a pump 20J always performs work corresponding to a fuel supply amount QAJ, a fuel return amount QBj, a fuel injection amount QC from a nozzle 12, and a pump fuel return amount QR.

[0071] On the other hand, in the first embodiment, the pump 20 does not have to perform work corresponding to the fuel return amount QBj in FIG. 7. Thus, power consumption of the pump 20 can be saved to that extent.

[0072] Further, as obvious from comparison between FIG. 3 and FIG. 7, in the first embodiment, the pump fuel return amount QR is far smaller than the pump fuel return amount QRj in the prior art, and hence the fuel supply amount QA is likewise smaller than a fuel supply amount in the prior art. Furthermore, the air supply amount Qa in the first embodiment is the same as the air supply amount Qaj shown in FIG. 7, but power consumption is far smaller.

[0073] Therefore, according to the first embodiment, the power consumption of the pump 20 and the power consumption of the motor 30 can be saved.

[0074] In other words, in the first embodiment, the number of revolutions of the pump 20 can be controlled by the inverter 50, the fuel supply amount can be adjusted in accordance with a combustion state of the burner 100, the fuel injection amount can be highly accurately controlled by the high-speed solenoid valve 11, and hence the power consumption in the burner operation can be reduced.

[0075] According to experiments carried out by the present inventor, in the entire system, as compared with the conventional burner 100J shown in FIG. 6 and FIG. 7, a return flow rate of the fuel is reduced by approximately 70% in the burner according to the embodiment shown in the drawings, and the power consumption of the entire burner 100 can be saved by approximately 60%.

[0076] Moreover, according to the first embodiment, since a pulse width is controlled by the high-speed solenoid valve 11 to control the fuel injection amount, the control accuracy of the fuel injection amount can be im-

proved, as compared with a burner being similar to the prior art burner (e.g., FIG. 6) which determines the fuel injection amount based on a difference between the supply fuel amount and the return fuel amount.

[0077] Additionally, according to the first embodiment, controlling the number of revolutions of the motor 30 by the inverter 50 enables changing the number of revolutions of the fuel supply pump 20 and a rotation amount of the blast fan 10 which supplies air to the high-speed solenoid valve 11 side (the injection side) to appropriate numerical values. Consequently, wasteful power consumption can be suppressed.

[0078] In the first embodiment, even if the number of revolutions of the fuel supply pump 20 is not fixed, due to control the fuel injection amount in highly accurately by controlling a pulse width of a signal which is input to the high-speed solenoid valve 11, the fuel injection amount from the nozzle 12 can be appropriately controlled without controlling a flow rate of the fuel which returns from the nozzle 12 to the fuel supply source side.

[0079] In the first embodiment, a difference between the fuel flow rate supplied to the pump 20 and the injection amount actually injected from the nozzle 12 is returned to the fuel tank 40 through the line Lf3 as a return amount from the pump 20.

[0080] According to the first embodiment, a fuel piping which connects the nozzle 12 to the fuel tank 40 side is no longer necessary. In other words, in the embodiment shown in the drawings, circuits in which the fuel flows in a direction to the fuel tank 40 side may be merely the circuits Lf1 and Lf3 which communicates the oil pump 20 to the fuel tank 40.

[0081] Thus, the number of pipes in the fuel supply system can be decreased and labor required for maintenance can be reduced, as compared with the prior art having a circuit Lf12 through which the fuel is supplied to the nozzle 12 (see FIG. 6) and a circuit Lf13 through which the fuel having not been injected from the nozzle 12 returns to the fuel supply source side.

[0082] Additionally, in the first embodiment, since controlling the number of revolutions of the motor 30 by the inverter 50 enables controlling the number of revolutions of the fuel supply pump 20 which supplies the fuel to the high-speed solenoid valve 11 side (the injection side), as different from the conventional proportional control type burner 100J, the fuel supply amount (an oil supply amount) supplied to the injection side does not have to be fixed. That is, the fuel supply amount can be appropriately changed in accordance with a state during the operation.

[0083] Consequently, a flow rate of the fuel which returns to the fuel tank 40 side through the fuel return line Lf3 can be reduced, and electric power required for fuel circulation can be cut back.

[0084] Further, according to the first embodiment, the air supply amount required for combustion of the burner 100 can be controlled to an appropriate number of revolutions by the inverter 50 disposed to the power supply

circuits Le of the motor 30 which drives the blast fan 10 for air supply.

[0085] Consequently, like the prior art shown in FIG. 6 and FIG. 7, air whose flow rate suitable for combustion conditions of the burner 100 can be supplied to improve the combustion efficiency of the burner 100 without need of constantly maximizing the number of revolutions of the blast fan 10 and narrowing a blast volume by the air damper 13. In addition, it is possible to suppress unnecessary consumption of the fuel or suppress power consumption.

[0086] According to the first embodiment, since a pulse width is controlled by the high-speed solenoid valve 11 to control the fuel injection amount and the number of revolutions of the motor 30 is controlled by the inverter 50, mechanical elements required in the conventional proportional control burner 100J, e.g., the air damper 13, the links 37 and 38, the air control disk 36, and others are no longer necessary. Thus, the constructions can be simplified, and costs and labors in production and maintenance can be decreased.

[0087] In the first embodiment, the nozzle 12 is provided on the discharge side of the high-speed solenoid valve 11.

[0088] According to experiments carried out by the inventor, it has been confirmed that providing the nozzle 12 on the discharge side of the high-speed solenoid valve 11 can improve combustibility as compared with a case where the nozzle 12 is not provided.

[0089] A second embodiment according to the present invention will now be described hereinafter with reference to FIG. 4 and subsequent drawings.

[0090] In the second embodiment, an oxygen concentration sensor (which will be referred to as an "O₂ sensor" hereinafter) 80 which measures oxygen concentration in a combustion gas is provided on a combustion exhaust side in an exhaust pipe E in addition to the constructions with reference to FIG. 1 to FIG. 3. Further, a control unit 60 has a function for changing a frequency of an inverter 50 based on a measurement result of the O₂ sensor 80 so that the oxygen concentration in the combustion gas being detected by the O₂ sensor 80 becomes approximately zero, and a function for adjusting the number of revolutions of a blast fan 10, thereby adjusting (changing) a combustion air amount.

[0091] The second embodiment according to the present invention will now be described hereinafter with reference to FIG. 4 and FIG. 5.

[0092] In the description of FIG. 4 and FIG. 5, structures, functions, and effects different from those of the first embodiment in FIG. 1 to FIG. 3 will be explained.

[0093] In FIG. 4, a burner 100A according to the second embodiment has the O₂ sensor 80 arranged on a combustion exhaust side (a left side in FIG. 4) in the exhaust pipe E.

[0094] The O₂ sensor 80 is connected to the control unit 60 as controlling means through an input signal line Li.

[0095] Like the first embodiment, the control unit 60 is connected with the inverter 50 through a control signal line line So1 and connected with a high-speed solenoid valve 11 through a control signal line So2.

[0096] Control of the burner 100A according to the second embodiment will now be described with reference to a control flowchart in FIG. 5.

[0097] At a step S1 in FIG. 5, O₂ concentration in a combustion gas in a region on a discharge side of a nozzle 12 is measured by the O₂ sensor 80.

[0098] At a step S2, the control unit 60 calculates an air-fuel ratio λ from the O₂ concentration measured by the O₂ sensor 80 and determines whether the air-fuel ratio λ is 1.0 or more. In a case that the air-fuel ratio λ is less than 1.0 ("NO" at the step S2), an air amount is determined to be small, and then, the control process advances to a step S3.

[0099] On the other hand, in a case that the air-fuel ratio λ is 1.0 or more, ("YES" at the step S2), the air amount is determined to be large, and the processing advances to a step S4.

[0100] At the step S3 (when the air amount is small: "NO" at the step S2), the control unit 60 outputs a control signal to the inverter 50, the number of revolutions of an electric motor 30 is increased by the inverter 50 to raise an air supply amount of the blast fan 10.

[0101] Here, a fuel injection amount is uniquely determined from a calorific value required for a device (a heated value: e.g., a boiler: not shown) heated by the burner 100A. Thus, the fuel injection amount of the burner 100A must be maintained constant unless the calorific value required for the non-illustrated heated device changes.

[0102] In the embodiment shown in the drawings, controlling an opening time of the high-speed solenoid valve 11 constant enables maintaining the fuel injection amount of the burner 100A constant unless the calorific value required for the heated device changes. Here, when the number of revolutions of the electric motor 30 increases, the number of revolutions of a fuel supply pump 20 increases, but surplus fuel is returned to a fuel tank 40 along a line Lf3 via a relief valve (not shown) installed in the fuel supply pump 20.

[0103] When the quantity of heat required for the heated device increases, a width of a pulse wave shown in FIG. 2 is expanded to increase the opening timing of the high-speed solenoid valve 11. On the other hand, when the quantity of heat required for the heated device decreases, the width of the pulse wave shown in FIG. 2 is narrowed to shorten the opening time of the high-speed solenoid valve 11.

[0104] At the step S3, when the air supply amount from the blast fan 10 is increased, the air-fuel ratio λ approximates 1.0. Furthermore, the processing advances to a step S5.

[0105] At the step S4 (when the air amount is large: "YES" at the step S2), a frequency of the inverter 50 is decreased to reduce the air supply amount from the blast fan 10. Consequently, the air-fuel ratio λ can approximate

1.0. Furthermore, the processing advances to a step S5.

[0106] At the step S5, whether the operation of the burner 100A is to be finished is determined. In a case that the operation of the burner 100A is to be finished ("YES" at the step S5), the control is terminated. On the other hand, in a case that the operation of the burner 100A is to continue ("NO" at the step S5), the processing returns to the step S1 to again repeat the step S1 and subsequent steps. Consequently, the air-fuel ratio λ approximates 1.0 every time a control cycle is repeated, and the oxygen concentration in the combustion gas approximates zero.

[0107] According to the second embodiment, the air-fuel ratio λ approximates 1.0, and the frequency of the inverter 50 is changed to adjust the combustion air amount so that the oxygen concentration in the combustion gas approximates zero, whereby the fuel to be injected can approach a complete combustion state.

[0108] When the fuel to be injected is allowed to approach the complete combustion state and an amount of the combustion gas is minimized, an exhaust amount is reduced, and a quantity of heat emitted through a flue is also decreased. Consequently, the fuel is effectively used, and thermal efficiency in the burner 100A or a facility such as a boiler using the burner 100A improves. Moreover, a thermal influence on a surrounding environment is reduced.

[0109] Structures, functions, and effects other than those in the second embodiment in FIG. 4 and FIG. 5 are the same as the first embodiment in FIG. 1 to FIG. 3.

[0110] It is to be noted that the embodiments shown in the drawings are just exemplifications and do not recognized as descriptions which restricts a technical range of the present invention.

REFERENCE CHARACTERS LIST

[0111]

10 ... blast fan	40
11 ... high-speed solenoid valve	
12 ... fuel injection nozzle	
20 ... oil pump	
25 ... solenoid valve	
30 ... motor	45
40 ... fuel tank	
50 ... inverter	
60 ... controlling means/control unit	
70 ... alternating-current power supply	
80 ... oxygen concentration sensor/O ₂ sensor	50

Claims

1. A burner comprising a fuel supply system and an air supply system, wherein the fuel supply system includes a fuel supply pump disposed thereto, a high-speed solenoid valve

is provided in a region on an injection side of the fuel supply pump in the fuel supply system, the high-speed solenoid valve has a function to open when a pulse signal input thereto is ON and a function to close when the signal is OFF, and an inverter is disposed to a power supply circuit of a drive motor which drives the fuel supply pump, and the air supply system has a blast fan for air supply, and the inverter is disposed to the power supply circuit of the drive motor which drives the blast fan for air supply.

2. The burner according to claim 1, wherein a nozzle is arranged on a discharge side of the high-speed solenoid valve provided in the fuel supply system.
3. The burner according to claim 1, wherein the burner comprises an oxygen concentration sensor which is arranged on the discharge side of the high-speed solenoid valve and measures oxygen concentration of a combustion gas and a control apparatus to which a measurement result of the oxygen concentration sensor is supplied, and said control apparatus has a function for changing a frequency of the inverter in order to adjust a combustion air amount so that the oxygen concentration in the combustion gas being detected by the oxygen concentration sensor becomes approximately zero.
4. A method for operating a burner according to claim 3 which burner comprises the oxygen concentration sensor and the control apparatus, the method comprising:

a step for measuring oxygen concentration in a combustion gas by the oxygen concentration sensor being provided on a combustion exhaust side of an exhaust pipe; and
a step for changing a frequency of an inverter and adjusting a combustion air amount so that the oxygen concentration in the combustion gas being detected by the oxygen concentration sensor becomes approximately zero.

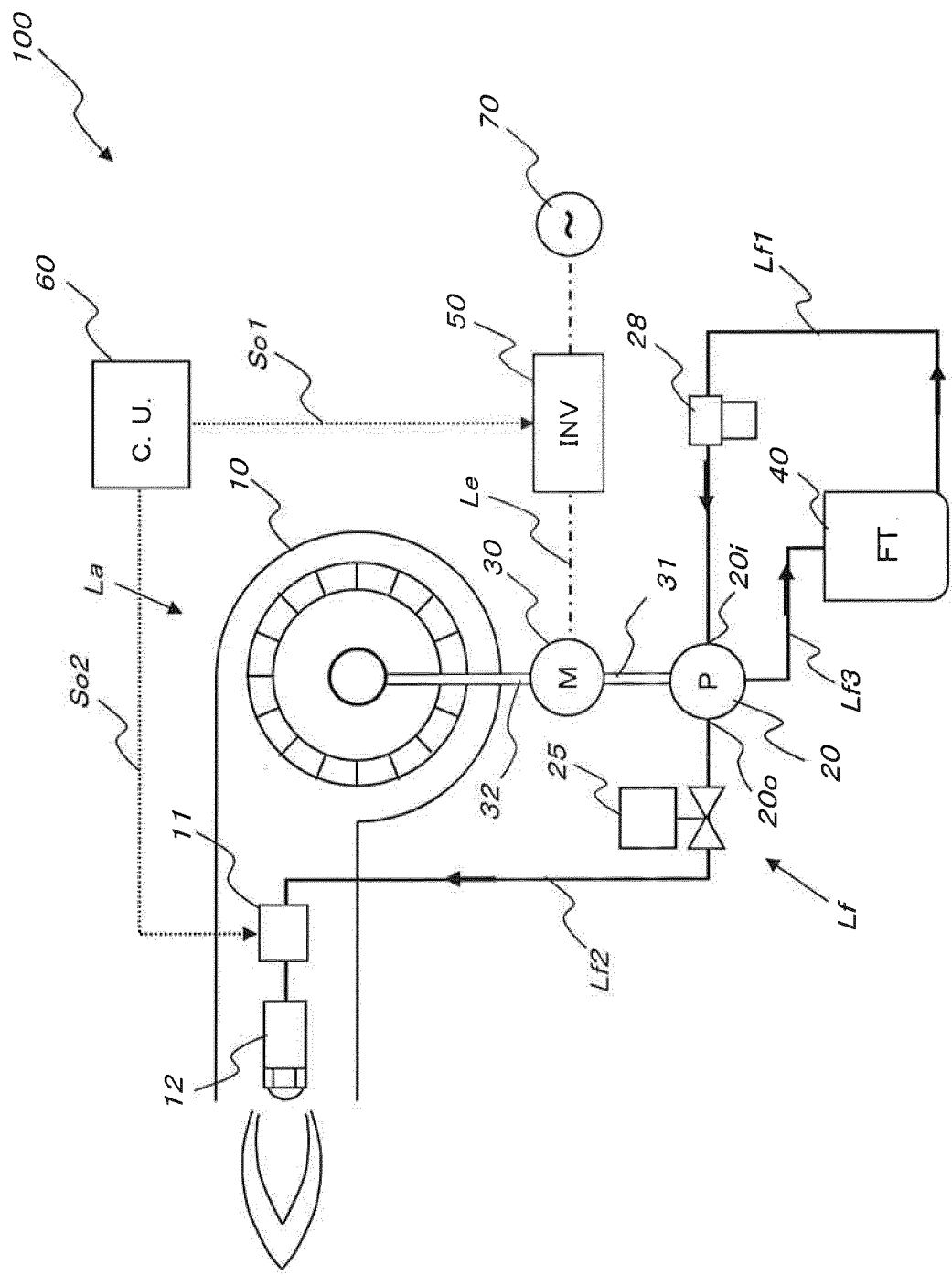


FIG.1

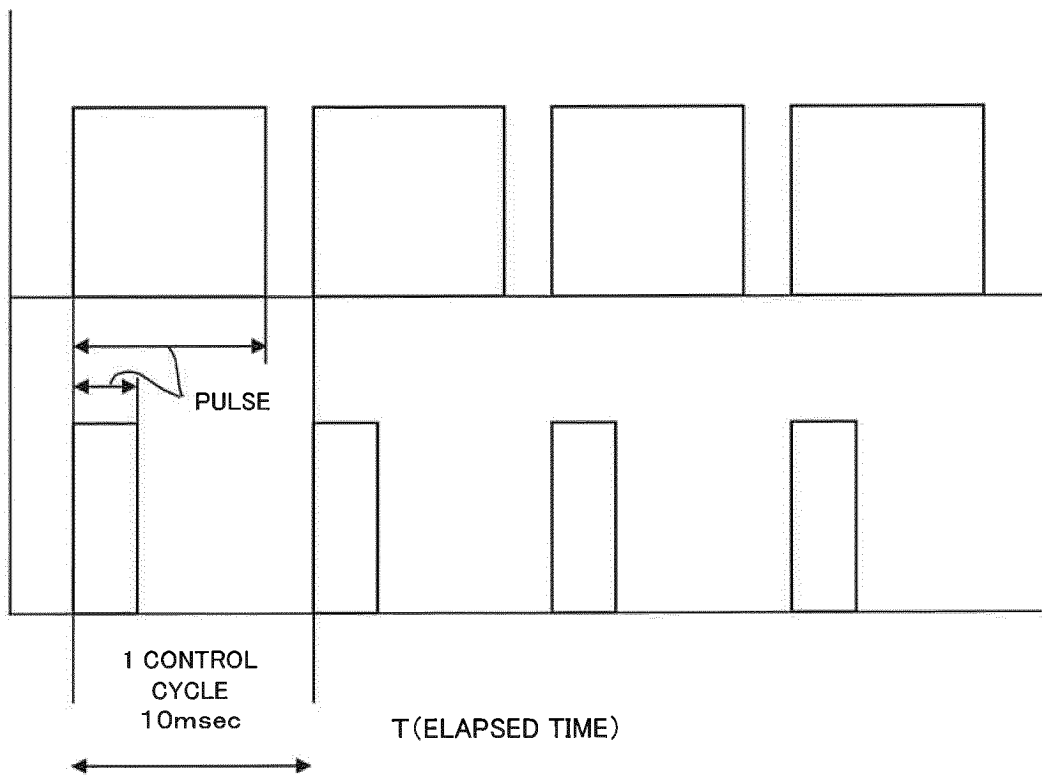


FIG. 2

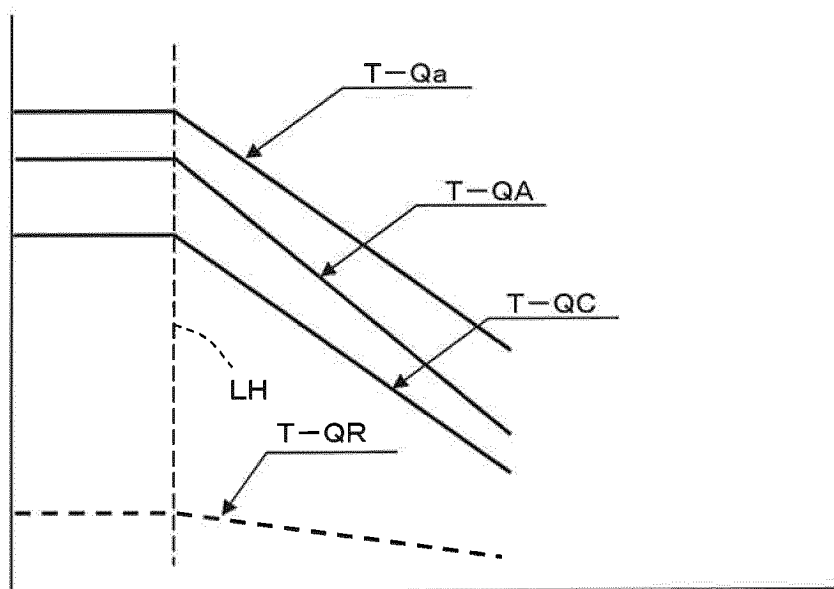


FIG.3

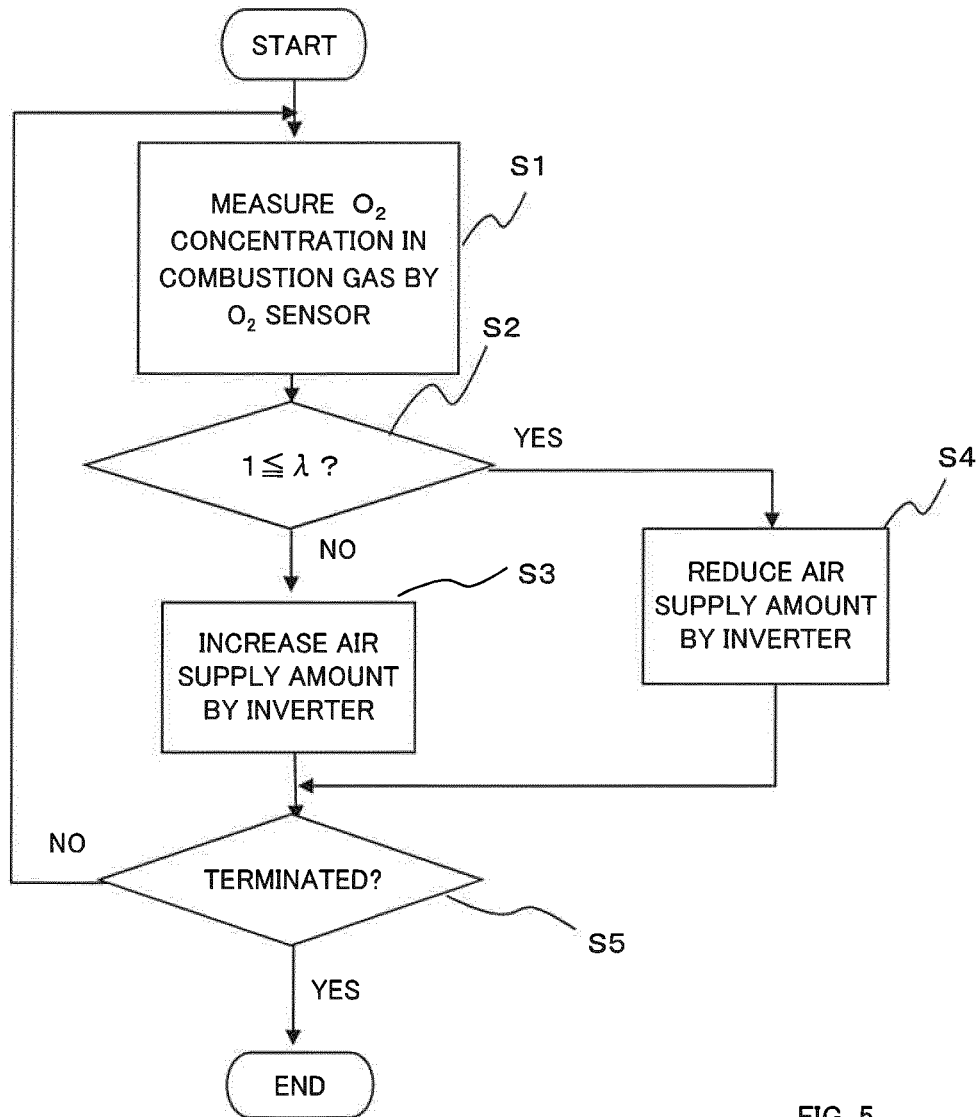


FIG. 5

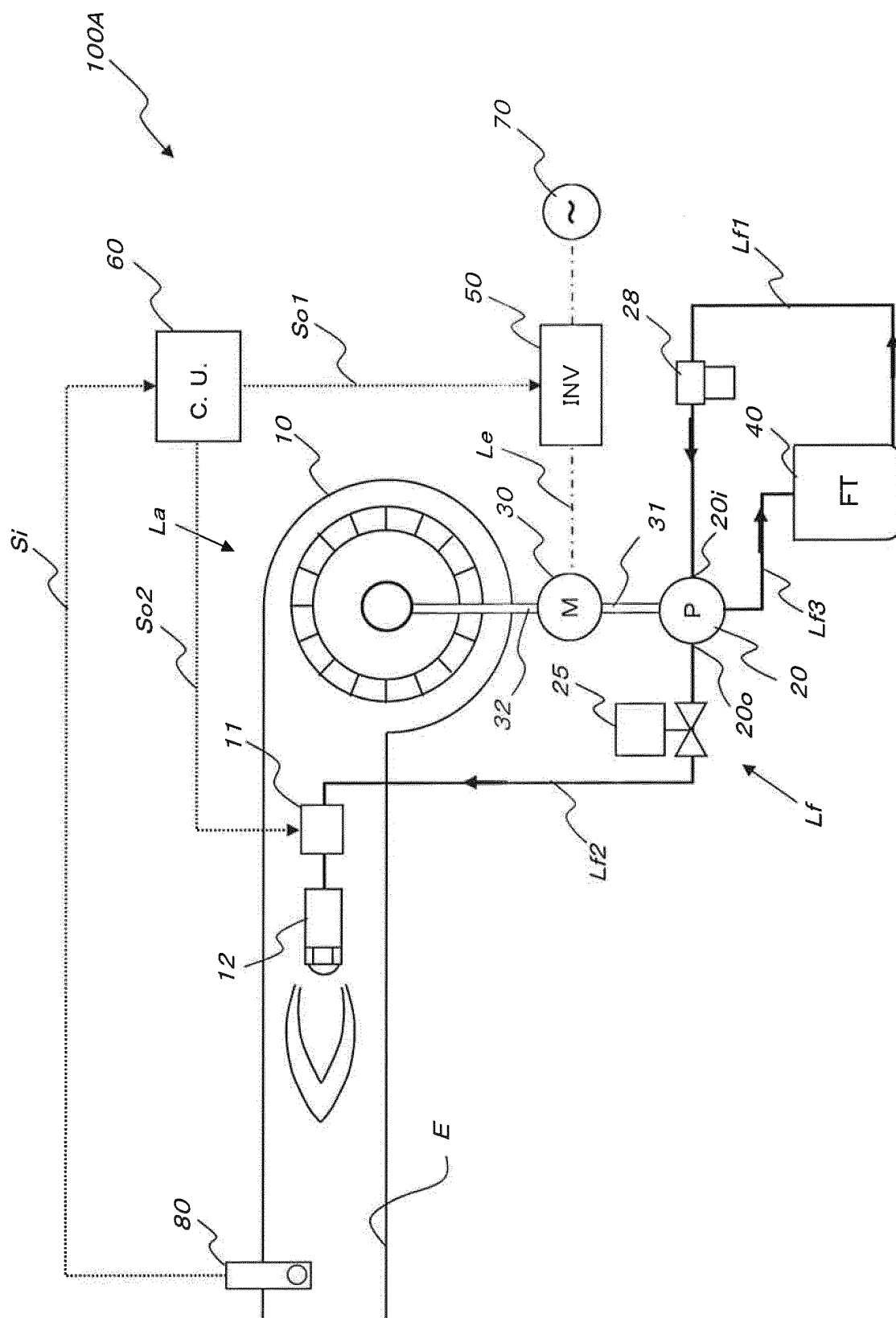


FIG. 4

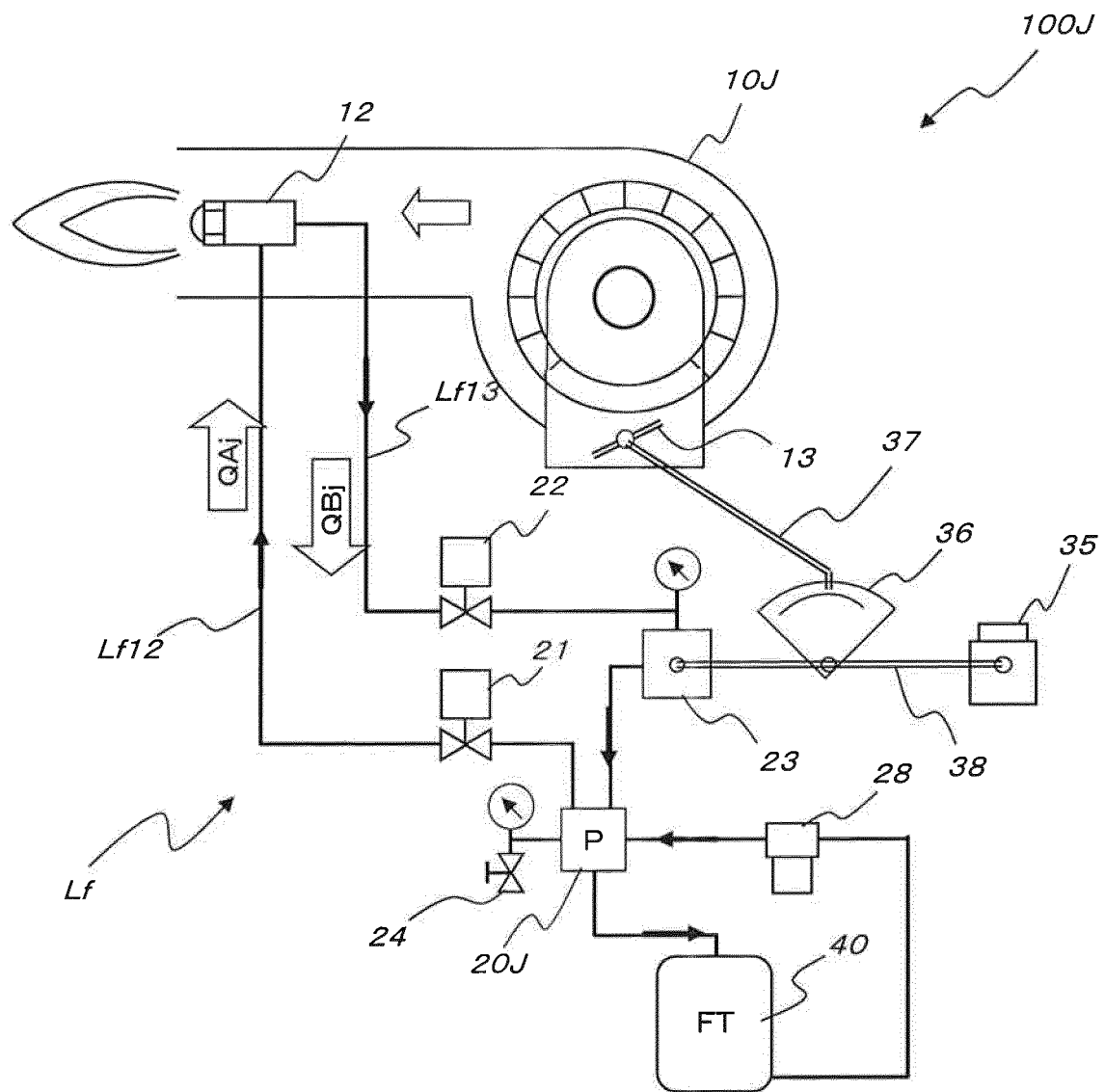


FIG.6

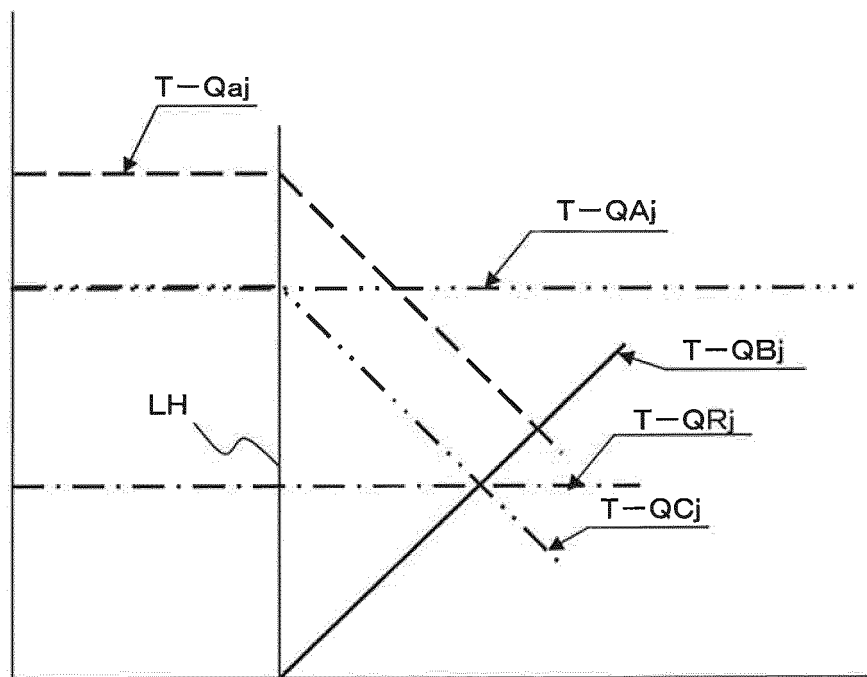


FIG.7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/064839

A. CLASSIFICATION OF SUBJECT MATTER

F23N1/00(2006.01)i, F23K5/04(2006.01)i, F23L5/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F23N1/00, F23K5/04, F23L5/02

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2013
 Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 61-31369 B2 (Toshiba Corp.), 19 July 1986 (19.07.1986), column 4, line 17 to column 6, line 19; fig. 5, 6 (Family: none)	1-4
Y	JP 2010-210176 A (Miura Co., Ltd.), 24 September 2010 (24.09.2010), paragraphs [0035] to [0040]; fig. 4, 5 (Family: none)	1-4
Y	JP 2004-69104 A (Kawasaki Thermal Engineering Co., Ltd., Asahi Breweries, Ltd.), 04 March 2004 (04.03.2004), paragraphs [0002], [0006] to [0008]; fig. 1 (Family: none)	3, 4



Further documents are listed in the continuation of Box C.



See patent family annex.

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document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"

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Date of the actual completion of the international search

09 July, 2013 (09.07.13)

Date of mailing of the international search report

16 July, 2013 (16.07.13)

Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/064839

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP 55-82226 A (Osaka Gas Co., Ltd.), 20 June 1980 (20.06.1980), entire text; all drawings (Family: none)	1-4
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A	JP 59-212620 A (Toshiba Corp.), 01 December 1984 (01.12.1984), entire text; all drawings & US 4516929 A & AU 2803884 A & KR 10-1989-0000341 B1 & AU 552938 B	1-4
A	JP 2012-163270 A (IHI Packaged Boiler Co., Ltd.), 30 August 2012 (30.08.2012), entire text; all drawings (Family: none)	1-4

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REFERENCES CITED IN THE DESCRIPTION

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