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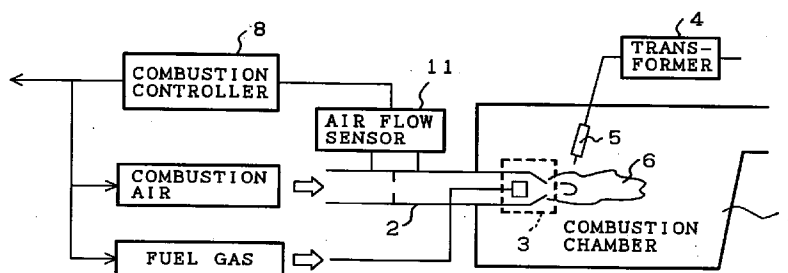
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(54) **Combustion control system**

(57) A prior art combustion control system fails to accurately detect firing by deterioration of an ultraviolet sensor and to decide a suitable maintenance/checking timing. According to a combustion control system of the present invention, a flow velocity detector detects a flow velocity of a combustion air or a fuel gas supplied into a

combustion chamber and a combustion controller decides whether a firing state is normal or abnormal on the basis of a decelerated state of the flow velocity detected by the flow velocity detector upon ignition operation of the combustion chamber.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a combustion control system for controlling a combustion device used for a water heater, a boiler, or the like.

2. Description of the Prior Art

FIG. 9 is a configuration diagram showing a prior art combustion control system, in which reference numeral 1 denotes a combustion chamber; 2 is a fuel gas pipe for supplying a mixed gas of a combustion air and a fuel gas into the combustion chamber 1; 3 is a burner; 4 is a transformer for supplying an electric power to an ignition plug 5; 6 is a flame discharged from the burner 3; 7 is an ultraviolet sensor for detecting the flame 6 using ultraviolet rays; and 8 is a combustion controller for controlling a burning operation on the basis of the result of detecting a firing state upon ignition operation by means of the ultraviolet sensor 7 in such a manner as to allow continuation of the burning operation when the firing state is decided as normal firing or to stop the burning operation when the firing state is decided as abnormal firing.

The operation of the prior art combustion control system will be described below.

The prior art combustion control system is so configured that the flame 6 is detected by means of the ultraviolet sensor 7 upon ignition operation of the burner 3, and the combustion controller 8 decides whether a firing state is normal or abnormal on the basis of the detection result obtained by the ultraviolet sensor 7 and controls a burning operation in such a manner as to allow continuation of the burning operation when the firing state is decided as normal firing or to stop the burning operation by cutting off the supply of the combustion air and the fuel gas when the firing state is decided as abnormal firing.

The prior art combustion control system having the above-described configuration has a disadvantage that the ultraviolet sensor 7 provided in the vicinity of the flame in the combustion chamber tends to be deteriorated by a secular change, contamination and the like, thereby to reduce the magnitude of a flame detection signal, making it difficult to accurately detect actual firing, resulting in an inconvenience that normal firing is erroneously decided as abnormal firing.

In the prior art combustion control system, a detector of a type in which flame of a burner is partially detected, for example, a flame rod may, in some cases, be used in place of the ultraviolet sensor. The flame rod, however, presents another disadvantage that it will output a detection signal even when only a portion of the flame in the vicinity of the flame rod fires the burner, that is, it cannot detect such an abnormal firing state, causing faulty burning operation.

The prior art combustion control system has a further disadvantage that it cannot measure such a time delay between starting of ignition operation and firing that becomes larger as a burner and an ignition plug are deteriorated by secular change, and consequently it is unable to decide suitable maintenance/checking timings of the burner and the ignition plug, thereby allowing each of the burner and the ignition plug to be continuously used in a state in which its performance has been already deteriorated or reversely allowing each of the burner and the ignition plug usable still to be replaced with a new one.

SUMMARY OF THE INVENTION

The present invention has been made to solve the above-described disadvantages, and an object of the present invention is to provide a combustion control system capable of exactly detecting whether a firing state is normal or abnormal, and deciding a suitable maintenance/checking timing.

A combustion control system according to a first configuration of the present invention has a feature that a flow velocity detector detects a flow velocity of a combustion air or a fuel gas supplied to a combustion chamber, and a combustion controller decides whether a firing state is normal or abnormal on the basis of a decelerated state of the flow velocity detected by the flow velocity detector upon ignition operation of the combustion chamber.

A combustion control system according to a second configuration of the present invention has a feature that the combustion controller decides the firing state as normal firing when the flow velocity of the combustion air or the fuel gas is decelerated to a predetermined value or less.

A combustion control system according to a third configuration of the present invention has a feature that the combustion controller measures a time spent from starting of ignition operation to deceleration of the flow velocity of the combustion air or the fuel gas and it decides the firing state as abnormal firing when the measured time reaches a predetermined value or more.

A combustion control system according to a fourth configuration of the present invention has a feature that the flow velocity detector is an air flow sensor using a micro flow sensor chip in which a heater unit and a temperature sensor unit are formed on a silicon substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a configuration diagram showing a combustion control system according to a first embodiment of the present invention;

FIG. 2 is a diagram illustrating a method of determining a set value (absolute value) for normal firing;

FIG. 3 is a diagram illustrating a method of determining a set value (relative value) for normal firing;

FIG. 4 is a diagram illustrating a method of deter-

mining a set value (time) for normal firing;

FIG. 5 is a flow chart showing an operation of a combustion controller according to a second embodiment of the present invention;

FIG. 6 is a configuration diagram showing an air flow sensor according to a third embodiment of the present invention;

FIG. 7 is a plan view showing the details of a micro flow sensor chip;

FIG. 8(a) is a characteristic diagram showing a flow velocity output in the case of using a differential pressure sensor as a flow velocity detector and FIG. 8(b) is a characteristic diagram showing a flow velocity output in the case of using an air flow sensor as the flow velocity detector; and

FIG. 9 is a configuration diagram showing a prior art combustion control system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, preferred embodiments of the present invention will be described.

Embodiment 1

FIG. 1 is a configuration diagram showing a combustion control system according to the first embodiment of the present invention, in which reference numeral 1 denotes a combustion chamber; 2 is a fuel gas supply pipe for supplying a mixed gas of a combustion air and a fuel gas into the combustion chamber 1; 3 is a burner; 4 is a transformer for supplying an electric power to an ignition plug 5; 6 is a flame discharged from the burner 3; 8 is a combustion controller; and 11 is an air flow sensor as a flow velocity detector for detecting a flow velocity of a combustion air or a fuel gas supplied to the combustion chamber 1. The combustion controller 8 decides a firing state as normal firing when a flow velocity of a combustion air or a fuel gas detected by the air flow sensor 11 upon ignition operation is decelerated to a specified value or less and it allows continuation of the burning operation of the combustion chamber 1; while the combustion controller 8 decides the firing state as abnormal firing when the above flow velocity is not decelerated to the specified value or less and it stops the burning operation of the combustion chamber 1.

The operation of the combustion control system in this embodiment will be described below.

FIG. 2 is a diagram illustrating a method of determining a set value (absolute value) for normal firing. As shown in this diagram, in the case of normal firing, a mixed gas in the burner 3 is exploded after starting of ignition operation by means of the ignition plug 5 and then fired. In this case, an impulse wave due to explosion of the mixed gas reaches the upstream side of the fuel gas pipe 2, and a rapidly decelerated state of the flow velocity is detected by means of the air flow sensor 11.

In the method shown in FIG. 2, a flow velocity upper limit I_{max} and a flow velocity lower limit I_{min} in the rapidly decelerated state produced after starting of ignition operation are set in the combustion controller 8 on the basis of flow velocity characteristics specified in accordance with the combustion control system. The combustion controller 8 decides the firing state as normal firing and allows continuation of the burning operation when the air flow sensor 11 detects a flow velocity within a range of from the flow velocity upper limit I_{max} and the flow velocity lower limit I_{min} ; while the combustion controller 8 decides the firing state as abnormal firing and outputs a maintenance/checking signal indicating the fact that maintenance/checking is required for the burning operation when the air flow sensor 11 does not detect a flow velocity within the range of from the flow velocity upper limit I_{max} to the flow velocity lower limit I_{min} .

FIG. 3 is a diagram illustrating a method of determining a set value (relative value) for normal firing. In this method shown in this diagram, a rapidly decelerated amount I produced upon normal firing is rendered constant, and a flow velocity upper limit $I_{max} = I_a - L1$ and a flow velocity lower limit $I_{min} = I_a - L2$ (where I_a is a flow velocity upon starting of ignition operation and $L1$, $L2$ are specified values) are set in the combustion controller 8. The combustion controller 8 decides a firing state as normal firing and allows continuation of the burning operation when the air flow sensor 11 detects a flow velocity within a range of from the flow velocity upper limit I_{max} to the flow velocity lower limit I_{min} ; while the combustion controller 8 decides the firing state as abnormal firing and outputs a maintenance/checking signal indicating the fact that maintenance/checking is required for the burning operation when the air flow sensor 11 does not detect a flow velocity within the range of from the flow velocity upper limit I_{max} to the flow velocity lower limit I_{min} .

According to this embodiment, as described above, normal firing of the burner 3 is decided on the basis of the flow velocity of the combustion air or the fuel gas supplied to the combustion chamber 1 which is detected by the air flow sensor 11 provided in the fuel gas pipe 2, so that the air flow sensor 11 is not required to be provided in the vicinity of the flame 6 and thereby it can be prevented from being deteriorated. As a result, the air flow sensor 11 can positively effect the firing detection.

The first embodiment is also advantageous in that partial firing can be distinguished from the entire firing because the firing state is decided as normal firing when the flow velocity is decelerated to a value within the specified range, to thereby prevent faulty burning operation, and in that abnormal firing can be checked even when a decelerated amount of the flow velocity is increased by a large explosion.

Although the air flow sensor 11 is provided in the fuel gas pipe 2 in this embodiment, it may be provided in a combustion air pipe or in the vicinity of the combustion chamber 1, and further it may be provided on the

exhaust gas side if it is made of a corrosion resisting material.

Embodiment 2

FIG. 4 is a diagram illustrating a method of determining a set value (time) for normal firing. In this method shown in this diagram, an alarm set time t_1 and a burning operation stopping set time t_2 are set in a combustion controller 8. The combustion controller 8 compares a time t_x spent from starting of ignition operation to detection of a rapid deceleration I (produced upon normal firing) by means of an air flow sensor 11 with the alarm set time t_1 and the burning operation stopping set time t_2 , and it outputs an alarm or stops the burning operation.

The operation of the combustion control system in this embodiment will be described below.

FIG. 5 is a flow chart showing the operation of the combustion controller 8 in this embodiment. The combustion controller 8 receives an ignition starting time of an ignition plug 5 (step ST1), and also receives from the air flow sensor 11 a time point at which a rapid deceleration I of the flow velocity produced upon ignition operation is detected (step ST2), to calculate the time t_x spent from starting of the ignition operation to detection of the rapid deceleration I of the flow velocity (step ST3). The combustion controller 8 also compares the time t_x with the alarm set time t_1 and the burning operation stopping set time t_2 predetermined at step ST4 (step ST5). When the time t_x is after the alarm set time t_1 and before the burning operation stopping set time t_2 , the combustion controller 8 decides the firing state as abnormal but satisfactory firing and allows continuation of the burning operation, and at the same time, it decides that the burner 3 and the ignition plug 5 are required to be subjected to maintenance/checking and outputs an alarm. The combustion controller 8 also stops the ignition operation (step ST6) when the time t_x exceeds the burning operation stopping set time t_2 and the air flow sensor 11 does not detect the rapid deceleration I of the flow velocity until the burning operation stopping set time t_2 .

According to this embodiment, as described above, it becomes possible to decide the firing state as abnormal firing and hence to output an alarm of informing an operator of a suitable maintenance/checking timing or stop the burning operation by comparing the time t_x with the predetermined alarm set time t_1 and the burning operation stopping set time t_2 .

Additionally, in this embodiment, the burning operation stopping set time t_2 must be set with a high reliability and thereby it is preferably set using a discharge circuit composed of a capacitor and a resistor; while for setting the alarm set time t_1 , which is used for decision of a suitable maintenance/checking timing, there is not required a high reliability as compared with the burning operation stopping set time t_2 and thereby it is preferably set by a timer operated by a microcomputer using a software.

Embodiment 3

FIG. 6 is a configuration diagram showing an air flow sensor according to a third embodiment, in which reference numeral 2a denotes an orifice plate provided in a fuel gas pipe 2; 11 is an air flow sensor; and 12 is a micro flow sensor chip as a detecting element.

FIG. 7 is a plan view showing the details of the micro flow sensor chip 12, in which reference numeral 12a denotes a silicon substrate; 12b is a heater unit; 12c is an upstream side temperature sensor unit (temperature sensor unit); and 12d is a downstream side temperature sensor (temperature sensor unit). In addition, a blacken portion indicates an electrode.

The operation of the combustion control system in the third embodiment will be described below.

The air flow sensor 11 is a flow velocity sensor having a high sensitivity and a high reliability, which uses the micro flow sensor chip 12 (shown in FIG. 7) as a detecting element. As shown in FIG. 6, the air flow sensor 11 is connected across the orifice plate 2a of the fuel gas pipe 2. In this case, an air flow ΔF corresponding to a differential pressure ΔP which is generated in accordance with a flow velocity F at the orifice plate 2a, is shunted in the air flow sensor 11. The micro flow sensor chip 12 provided in the air flow sensor 11 outputs an electric signal corresponding to the air flow ΔF .

The air flow sensor 11 is assumed to be used in an environment exposed to dust, oil smoke, steam, and the like and it contains a trap structure for trapping dust, oil smoke, steam, and the like permeating in the air flow sensor 11, thereby protecting the micro flow sensor chip 12 therefrom. Namely, the sensor 11 is improved in resistance against environment and thereby it is prevented in its characteristic change.

Next, the detection principle of the micro flow sensor chip 12 as the detecting element will be described in detail with reference to FIG. 7. A combustion air and a fuel gas flowing in an air passage are brought in contact with the heater unit 12b on the silicon substrate 12a to be heated, and the temperatures of each of the combustion air and the fuel gas before and after heating are detected by the upstream side temperature sensor 12c and the downstream side temperature sensor 12d, respectively. Subsequently, the differential temperature of each of the combustion air and the fuel gas between before and after heating is converted into an electric output, to thus detect the flow velocity of each of the combustion air and the fuel gas.

FIG. 8(a) is a characteristic diagram showing a flow velocity output in the case of using a differential pressure sensor as a flow velocity detector; and FIG. 8(b) is a characteristic diagram showing a flow velocity output in the case of using an air flow sensor as a flow velocity detector.

As can be seen from these diagrams, the air flow sensor can detect the peak of a flow velocity pulse upon firing at a higher sensitivity as compared with the differential pressure sensor, and consequently, the air flow

sensor is more preferable for detecting a flow velocity pulse rapidly changed as shown in the first and second embodiments as compared with the differential pressure sensor.

The air flow sensor 11, which is used as a flow velocity detector in this embodiment, can trap dust, oil smoke, steam, and the like permeating therein with the aid of the trap structure, and accordingly it can protect the micro flow sensor chip 12 and carry out high accuracy detection. Moreover, the air flow sensor 11 can detect the peak of a flow velocity pulse upon firing at a high sensitivity and a high accuracy.

Although the detection of a flow velocity by the air flow sensor 11 is used for deciding whether a firing state is normal or abnormal in the first, second and third embodiments, the detection of a flow rate may be used for deciding whether a firing state is normal or abnormal.

As described above, according to the first configuration of the present invention, a flow velocity detector detects a flow velocity of a combustion air or a fuel gas supplied into a combustion chamber, and a combustion controller decides whether a firing state is normal or abnormal on the basis of a decelerated state of the flow velocity, so that the flow velocity detector is not affected by combustion and exhaust gas so much, thereby to be little deteriorated, thus making it possible to positively carry out firing detection.

According to the second configuration of the present invention, the combustion controller decides a firing state as normal firing when the flow velocity of the combustion air or the fuel gas is decelerated to a predetermined value or less, so that partial firing can be distinguished from the entire firing, thus preventing faulty burning operation.

According to the third configuration of the present invention, the combustion controller measures a time spent from starting of ignition operation to deceleration of a flow velocity of a combustion air or a fuel gas, and decides a firing state as abnormal firing when the measured time reaches a predetermined value or more, so that it is possible to easily carry out maintenance/checking by informing an operator of a suitable maintenance/checking timing.

According to the fourth configuration of the present invention, the flow velocity detector is an air flow sensor using a micro flow sensor chip in which a heater unit and a temperature sensor unit are formed on a silicon substrate, so that the flow velocity detector can detect the flow velocity at a high sensitivity and a high accuracy.

Claims

1. A combustion control system comprising:

a flow velocity detector for detecting a flow velocity of a combustion air or a fuel gas supplied into a combustion chamber; and

a combustion controller for deciding whether a firing state is normal or abnormal on the basis of a decelerated state of a flow velocity of the combustion air or the fuel gas detected by said flow velocity detector upon ignition operation of the combustion chamber.

2. A combustion control system according to claim 1, wherein said combustion controller decides a firing state as normal firing when a flow velocity of the combustion air or the fuel gas is decelerated to a predetermined value or less.
3. A combustion control system according to claim 1, wherein said combustion controller measures a time spent from starting of ignition operation to deceleration of a flow velocity of the combustion air or the fuel gas, and decides a firing state as abnormal firing when the measured time reaches a predetermined value or more.
4. A combustion control system according to any one of claims 1 to 3, wherein said flow velocity detector is an air flow sensor using a micro flow sensor chip in which a heater unit and a temperature sensor unit are formed on a silicon substrate.

FIG. 1

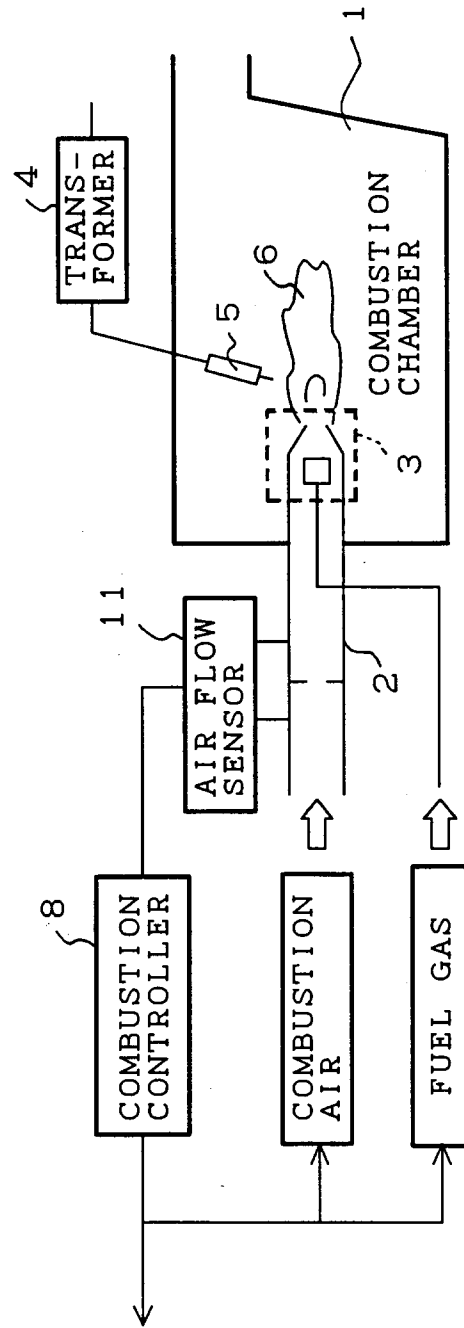


FIG. 2

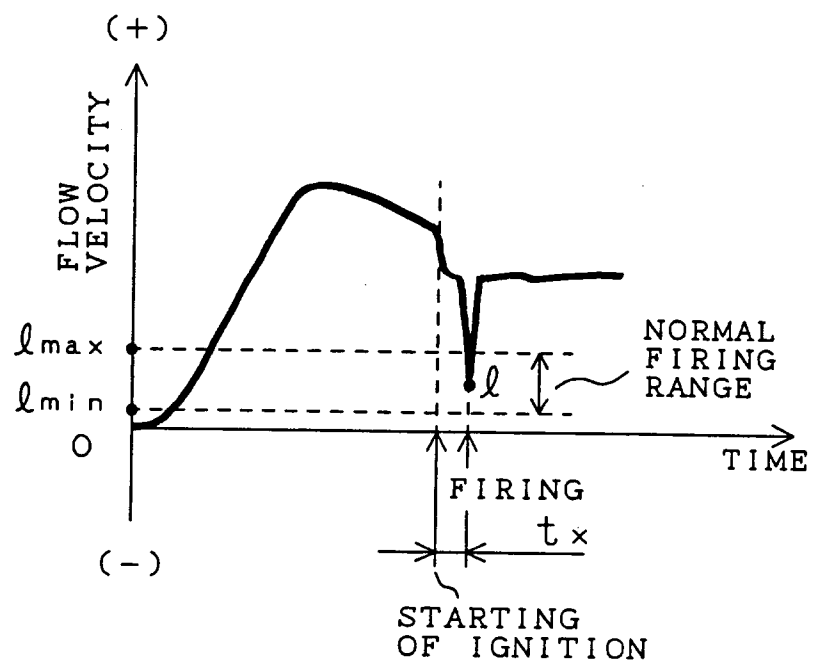


FIG. 3

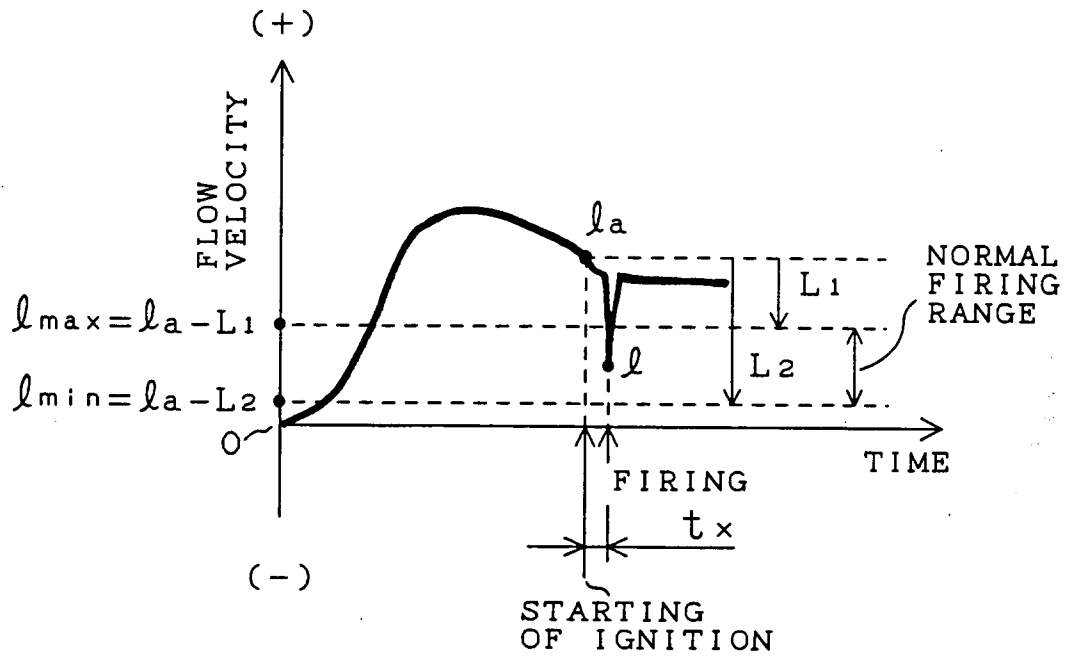


FIG. 4

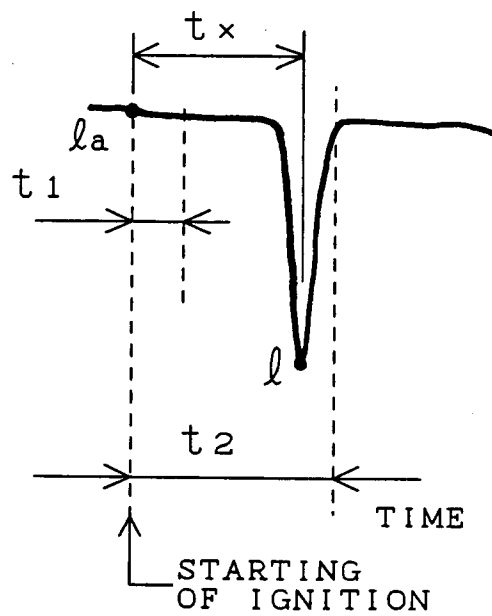


FIG. 5

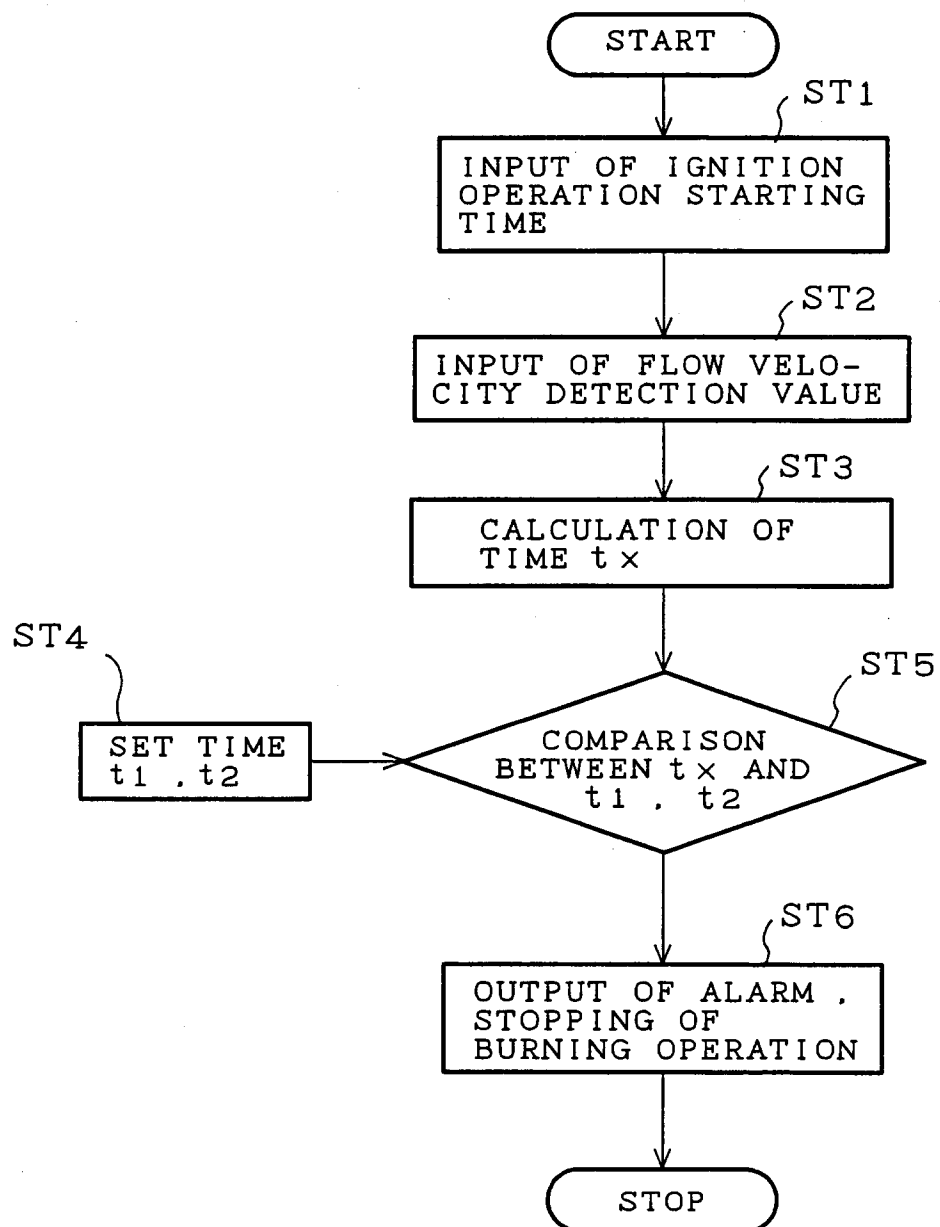


FIG. 6

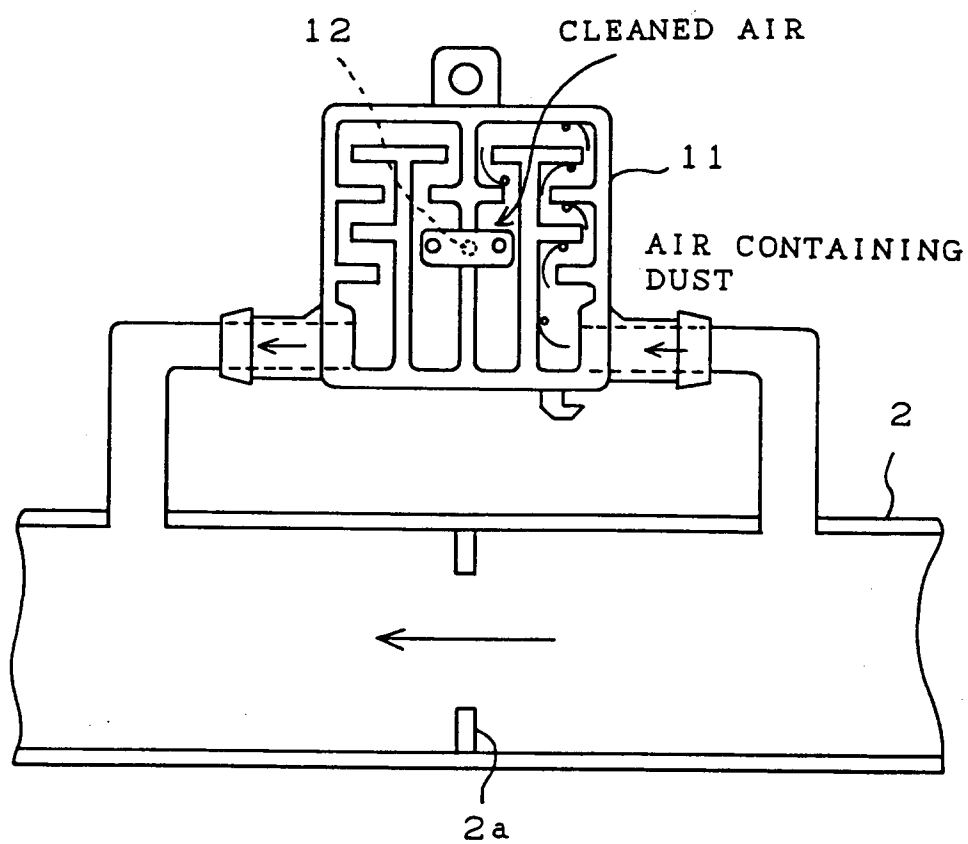


FIG. 7

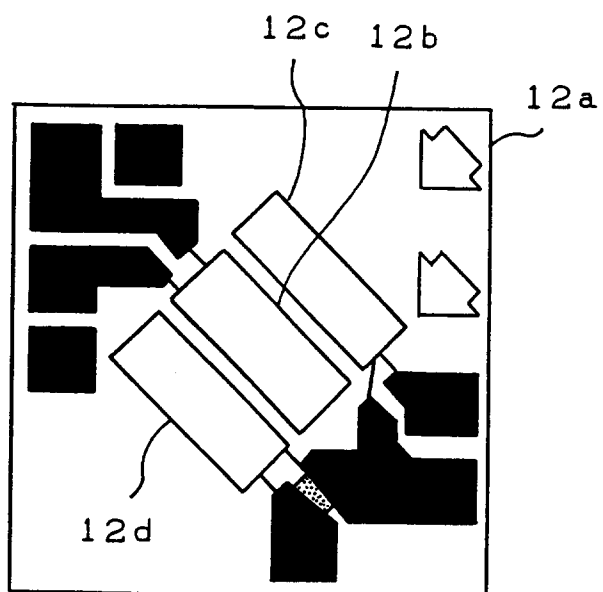


FIG. 8 (a)

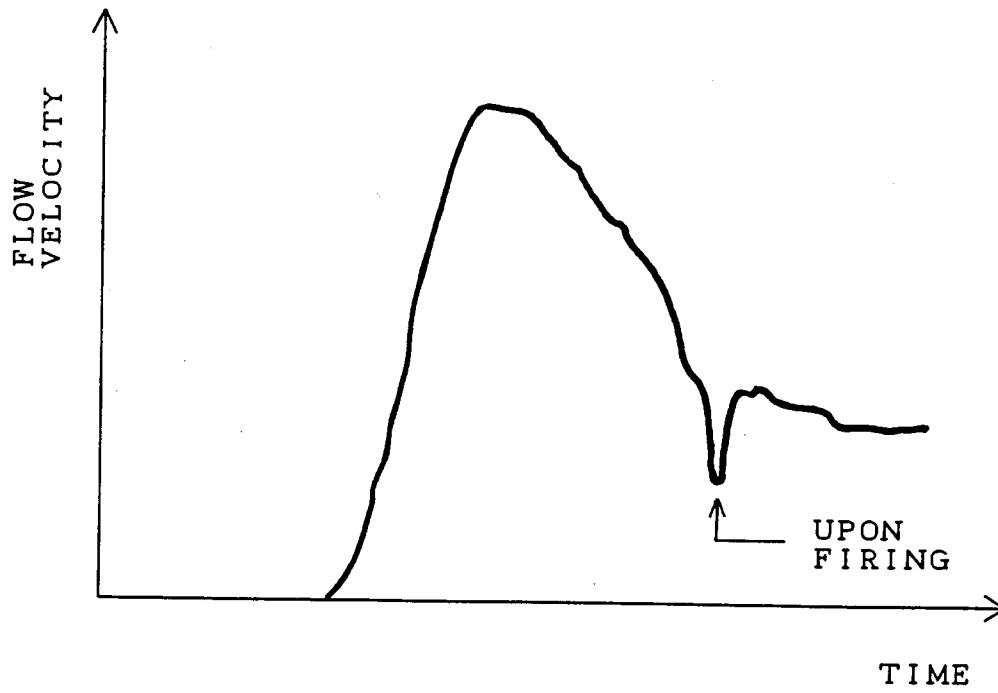


FIG. 8 (b)

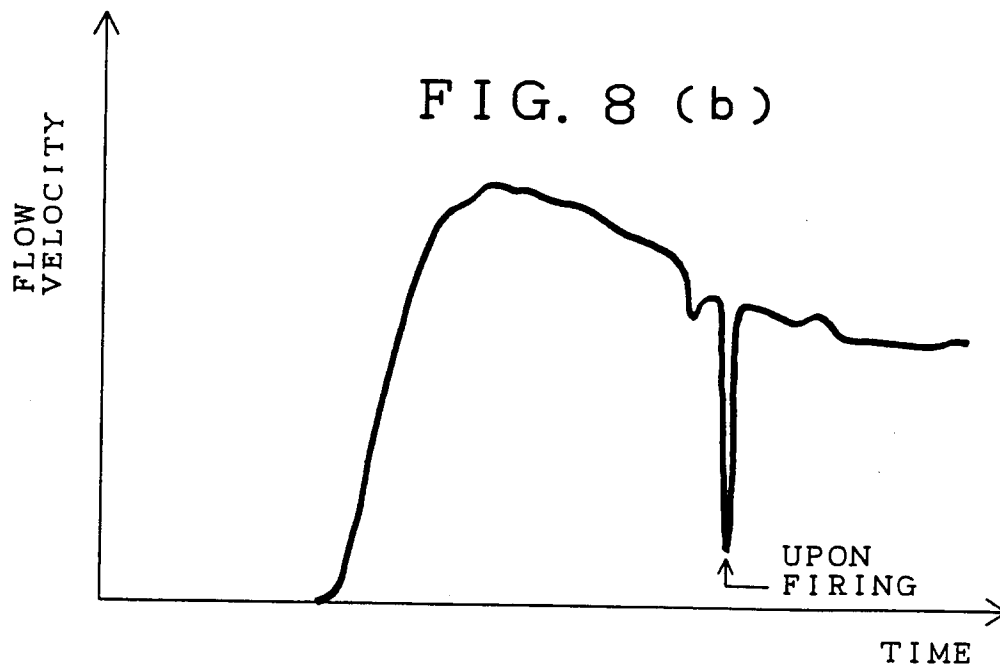


FIG. 9
(PRIOR ART)

