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(54) **COMBUSTION CONTROLLING DEVICE**

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(57) **ABSTRACT**

Two controlling devices, namely a combustion controlling device controlling the combustion of a combustion furnace, and a safety controlling device checking the operation of the devices wherein the operations are controlled by the combustion controlling device. This enables safer control of combustion because if there is a fault in either the combustion controlling device or the safety controlling device, a process can be performed by the other device to stop the combustion. Additionally, because the controlling device for controlling the structural elements that control the combustion in the boiler system and the controlling device for operational checks of the outputs from those structural elements are separate, if there is a failure in any of the structural elements or controlling devices, that failure can be detected reliably, enabling safer control of the combustion.

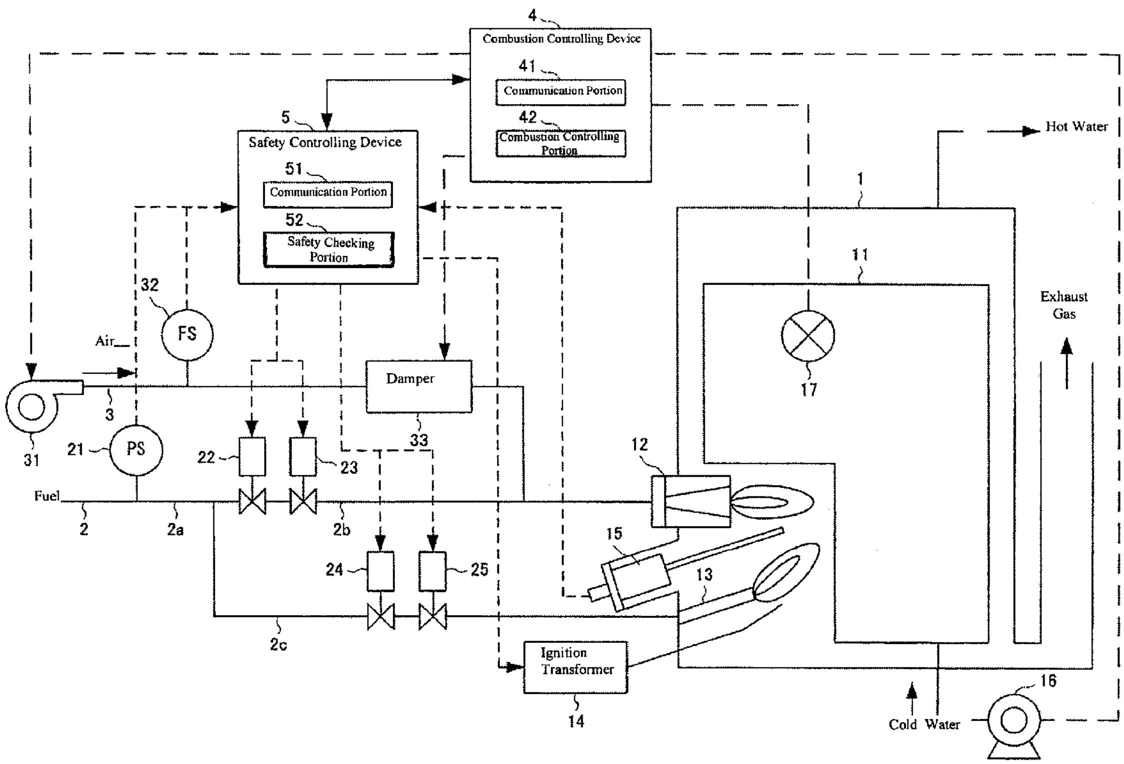


FIG. 1

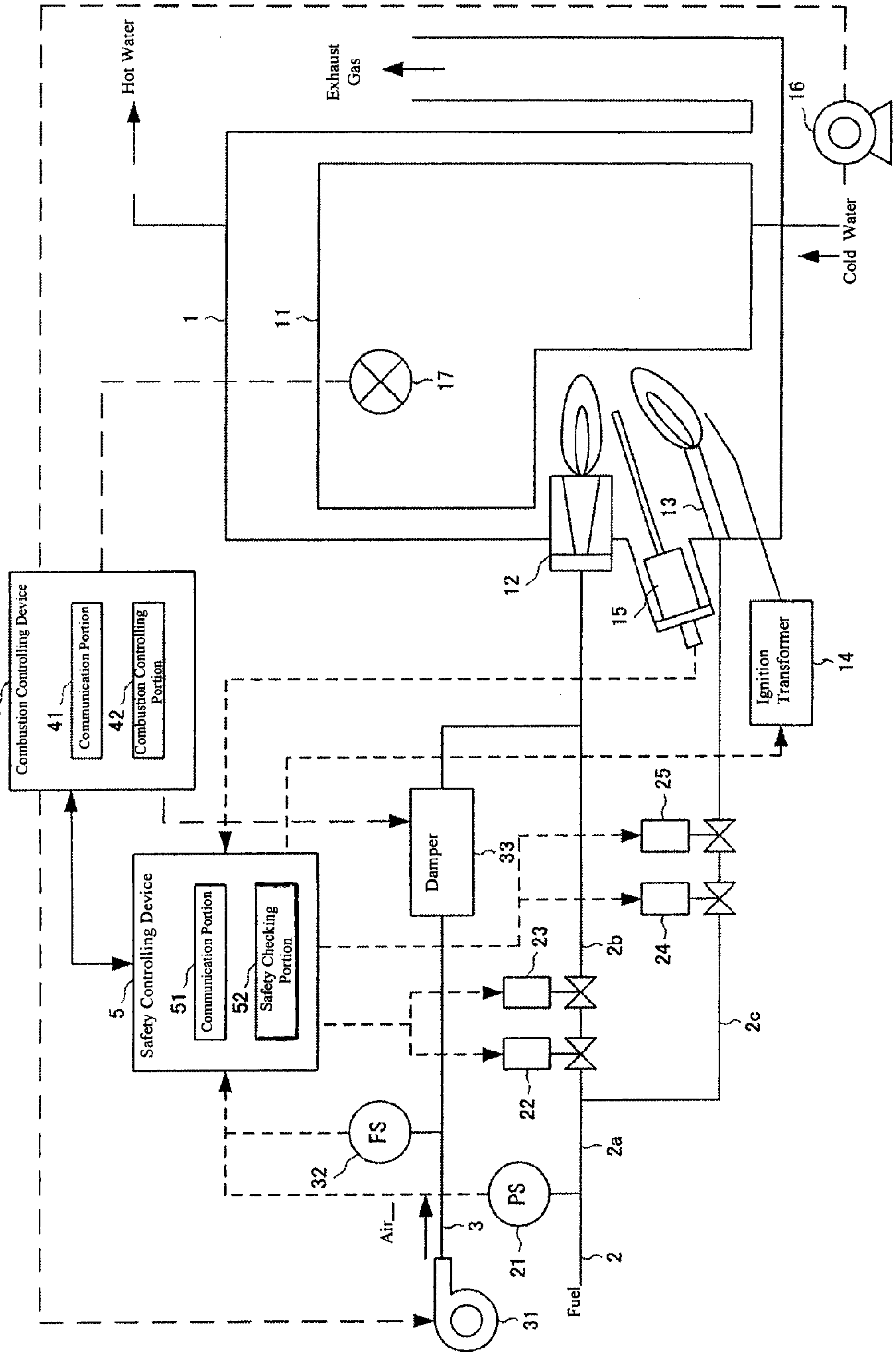

Hot Water
Exhaust Gas
Cold Water
Combustion Controlling Device
Communication Portion
Combustion Controlling Portion
Safety Controlling Device
Communication Portion
Safety Checking Portion
Damper
Ignition Transformer
FS
PS
Air
Fuel
1
11
12
13
14
15
16
17
2
2a
2b
2c
21
22
23
24
25
3
31
32
33
4
41
42
5
51
52

FIG. 2

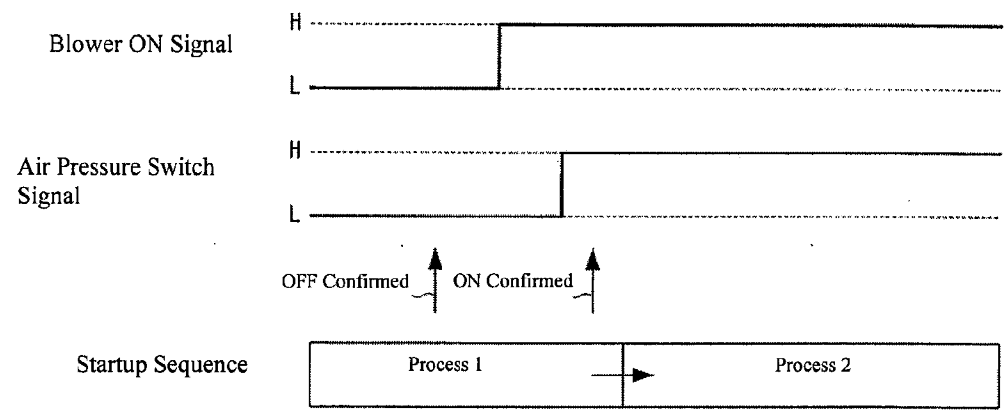

Blower ON Signal
H
L
Air Pressure Switch Signal
H
L
OFF Confirmed
ON Confirmed
Startup Sequence
Process 1
Process 2

FIG. 3

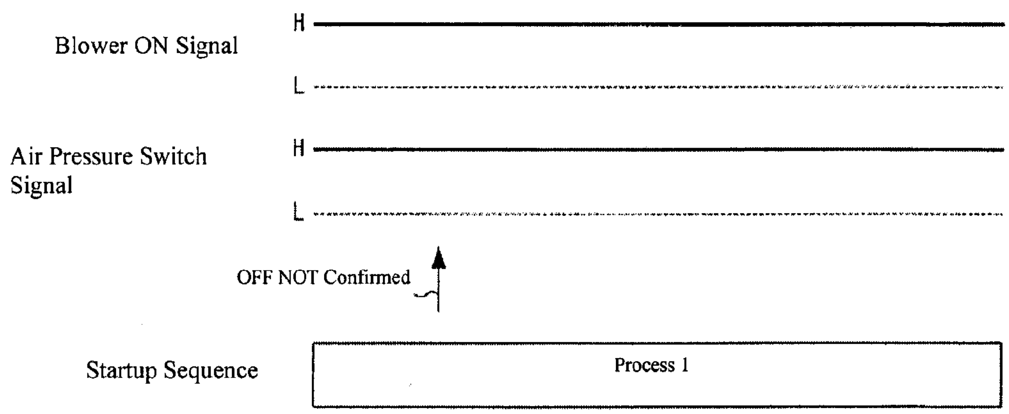
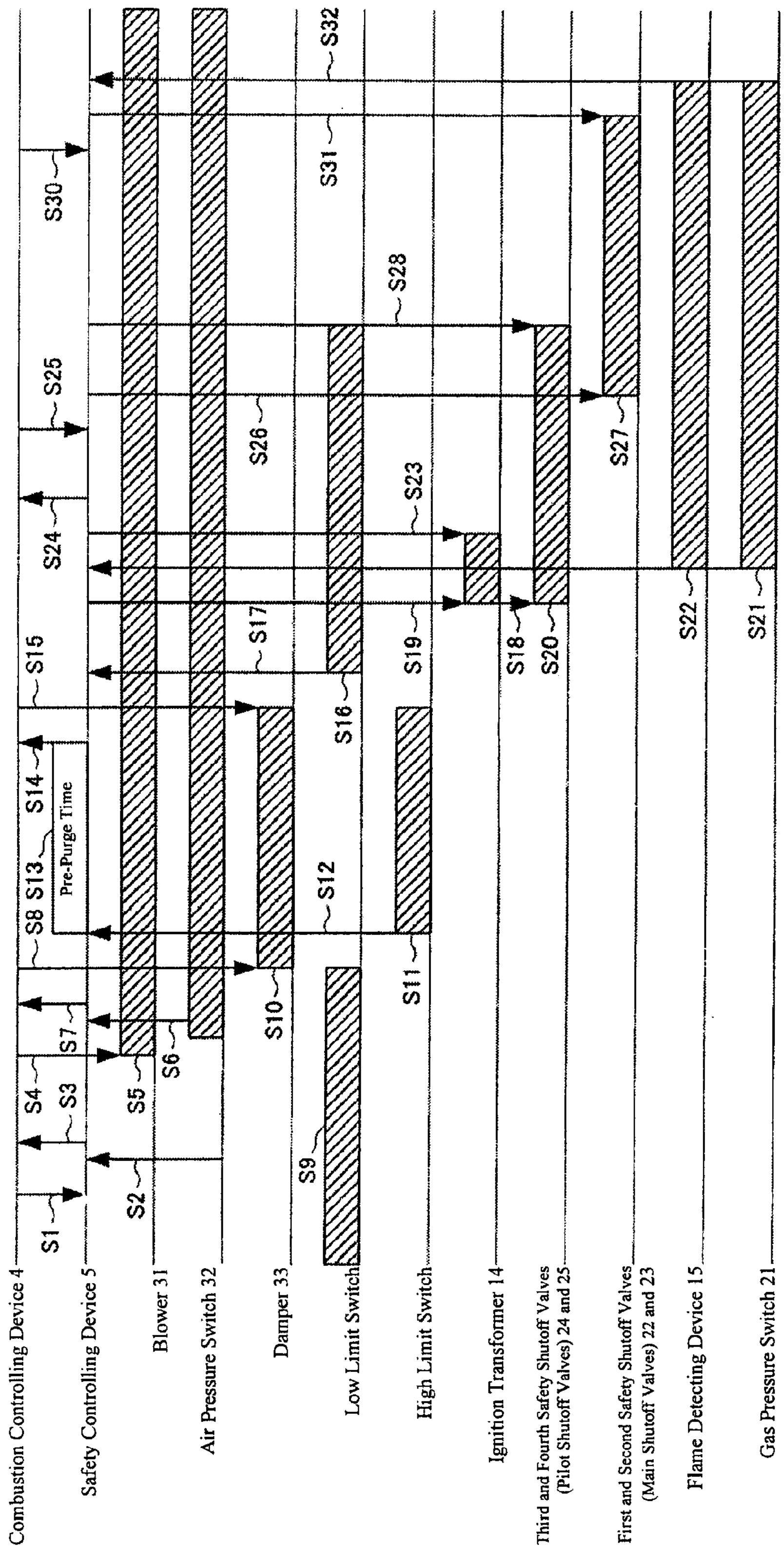

Blower ON Signal
H
L
Air Pressure Switch Signal
H
L
OFF NOT Confirmed
Startup Sequence
Process 1

FIG. 4


Combustion Controlling Device 4
Safety Controlling Device 5
Blower 31
Air Pressure Switch 32
Damper 33
Low Limit Switch
High Limit Switch
Ignition Transformer 14
Third and Fourth Safety Shutoff Valves (Pilot Shutoff Valves) 24 and 25
First and Second Safety Shutoff Valves (Main Shutoff Valves) 22 and 23
Flame Detecting Device 15
Gas Pressure Switch 21
Pre-Purge Time
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
S17
S18
S19
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S21
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S24
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S28
S30
S31
S32

COMBUSTION CONTROLLING DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority under 35 U.S.C. §119 to Japanese Patent Application No. 2010-079498, filed Mar. 30, 2010, which is incorporated herein by reference.

FIELD OF TECHNOLOGY

[0002] The present invention relates to a combustion controlling device for controlling the combustion of a combustion furnace.

BACKGROUND OF THE INVENTION

[0003] Conventionally, in a combustion controlling device a gas flow path shutoff valve, a gas flow path flow rate controlling damper, an air flow path air supply damper, an air flow rate controlling damper, and the like are controlled based on the gas pressure within the gas flow path, the flow rate of the air within the air flow path, the temperature within the combustion furnace, and the like, in order to control the combustion within the combustion furnace while maintaining a desirable air/fuel ratio (See, for example, Japanese Unexamined Patent Application Publication 2001-235146).

[0004] However, conventionally control and monitoring of all of the structural elements have been performed by a single combustion controlling device, and thus there has been the risk that it may become impossible to stop the combustion safely if a fault were to occur within the combustion controlling device itself. Typically control and monitoring has been performed for a plurality of devices by a single combustion controlling device, wherein there has been a. relationship such as, for example, between a. blower and an air pressure switch for measuring the result of the operation of the blower, that is, a relationship between a controlled device (the blower) and a. sensor instrument (the air pressure switch) wherein a measured value is changed by the operation of the controlled device. For convenience, in the below the explanation uses a blower and an air pressure switch as an example. As described above, when a fault occurs in the combustion controlling device in the control system, it becomes impossible to control the blower properly, or impossible to detect the output of the air pressure switch properly, and, as a result, there has been the risk that it may become impossible to stop the combustion.

[0005] Given this, the object of the present invention is to provide a combustion controlling device able to control combustion more safely.

SUMMARY OF THE INVENTION

[0006] In order to solve the problem set forth above, the combustion controlling device according to the present invention has a first controlling portion for outputting, to a first device that controls the combustion in a combustion furnace, a control signal for controlling the operation of the first device; and a second controlling portion for not only checking the operation of the first device, but also for controlling a second device for stopping the combustion; wherein: the first controlling portion outputs a control signal to the second controlling portion; the second controlling portion outputs, to the first controlling portion, an operation check result for the first device; and the first controlling portion and the second controlling portion perform a process to stop the combustion when it is confirmed, based on the control signal and on the operation check result, that there is a fault in the first device.

[0007] In the combustion controlling device set forth above, the second controlling portion may stop the combustion through controlling the second device. Moreover, in the combustion controlling device set forth above, the first controlling portion may stop the combustion through controlling the first device.

[0008] Given the present example, the provision of two controlling portions, namely a first controlling portion, for outputting, to a first device for controlling the combustion of the combustion furnace, a control signal for controlling the operation of the first device, and a second controlling portion for not only checking the operation of the first device, but also for controlling a second device for stopping the combustion, enables the combustion to be controlled more safely because if a fault were to occur in one of the controlling portions, a process can be performed by the other controlling portion to stop the combustion. Furthermore, because the controlling portion for controlling the first device and the controlling portion for checking the operation of the first device are separate, even if a fault were to occur in either the device or the controlling portion it would still be possible to detect the fault reliably, enabling the control of the combustion to be performed more safely.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a diagram illustrating schematically a structure for a combustion furnace system according to the present invention.

[0010] FIG. **2** is a diagram for explaining an operating sequence if operating properly.

[0011] FIG. **3** is a diagram for explaining an operating sequence if a fault has occurred.

[0012] FIG. **4** is a diagram for explaining a sequence that illustrates one example from actuation to stopping.

DETAILED DESCRIPTION OF THE INVENTION

[0013] An example according to the present invention will be explained in detail below in reference to the drawings. Note that in the below the explanation is an example applied to a boiler system, as a system that uses the combustion controlling device according to the present example.

[0014] As illustrated in FIG. **1**, the boiler system according to the present example has a combustion device **1** for producing hot water within a tank **11**; a fuel flow path **2** for providing fuel to the combustion device **1**; an air flow path **3** for providing air from a blower **31** to a main burner **12** of the combustion device **1**; a combustion controlling device **4**; and a safety controlling device **5**.

[0015] The combustion device **1** has a tank **11** for storing water; a main burner **12** for heating the tank **11**; a pilot burner **13** for igniting the main burner **12**; an ignition transformer **14** for igniting the pilot burner **13**; a flame detecting device **15** for detecting the ignition status of the main burner **12**; a pump **16** for supplying water to the tank **11**; and a temperature sensor **17** for detecting the temperature of the water in the tank **11**.

[0016] The fuel flow path **2** comprises: a main flow path **2*a*** for supplying fuel from the outside, and a first flow path **2*b*** and a second flow path **2*c*** that branch from the main flow path **2*a***, where the first flow path **2*b*** is connected to the main burner **12** and the second flow path **2*c*** is connected to the pilot burner **13**. As a result, the fuel that is supplied to the main flow path **2***a* is sent to the main burner **12** and the pilot burner **13**. Here the main flow path **2***a* is provided with a gas pressure switch **21**, the first flow path **2***b* is provided with first and second safety shutoff valves **22** and **23**, and the second flow path **2***c* is provided with third and fourth safety shutoff valves **24** and **25**.

[0017] The air flow path **3** is connected on one end to a blower **31**, and connected on the other end to the first flow path **2***b*, where the air that is expelled by the blower **31** is supplied through the first flow path **2***b* to be supplied to the main burner **12** together with the fuel. This type of air flow path **3** is provided with an air pressure switch **32** and a damper **33**.

[0018] The combustion controlling device **4** is structured from an electric circuit such as a programmable logic controller (PLC), and controls structural elements for controlling the combustion in the combustion device **1**, such as the pump **16**, the blower **31**, and the damper **33**. This type of combustion controlling device **4** is provided with a communication portion **41** and a combustion controlling portion **42**.

[0019] Here the communication portion **41** not only inputs the respective detection results from the temperature sensors **17**, hut also outputs control signals to the pump **16**, the blower **31**, and the damper **33**. Additionally, the communication portion **41** not only outputs the control signals to the safety controlling device **5**, but also inputs control signals and detection results, described below, from the safety controlling device **5**.

[0020] Additionally, the combustion controlling portion **42** controls various types of operations of the boiler system, including the combustion sequence, described below. Specifically, it controls the sequence of various operations of the boiler system, such as starting and stopping the main burner **12** and adjusting the power of the main burner **12**, by generating control signals to the blower **31**, the damper **33**, and the safety controlling device **5**, based on the detection results of the temperature sensors **17** and on various types of information from the safety controlling device **5**, and the like.

[0021] The safety controlling device **5** is structured from electric circuits such as a burner controlling module and an interlock module, and checks the operations of the structural elements controlled by the combustion controlling device **4**. Here the interlock module sends, to the burner controlling module, commands such as for starting and stopping the main burner **12** and for adjusting the power of the main burner **12**, based on the control signals from the combustion controlling portion **42**. The interlock module also ensures safety by checking the status of the combustion, based on signals from the flame detecting device **15**, and stopping the fuel supply if there is an irregular event such as incomplete combustion. Additionally, the burner controlling module follows the instructions from the interlock module to ignite the pilot burner **13** and ignite the main burner **12**. Moreover, although not illustrated, a plurality of main burners **12** may be provided, and a plurality of burner controlling modules may be provided corresponding thereto, while, additionally, the structure may be one wherein the plurality of burner controlling modules, and the like, is controlled by a single interlock module. This type of safety controlling device **5** comprises a communication portion **51** and a safety checking portion **52**.

[0022] Here the communication portion **51** not only inputs the detection results from the flame detecting device **15**, the gas pressure switch **21**, and the air pressure switch **32**, along with the control signals from the combustion controlling device **4**, but also outputs control signals to the ignition transformer **14** and the first through fourth safety shutoff valves **22** through **25**. Moreover, the communication portion **51** not only outputs the control signals and the detection results to the combustion controlling device **4**, but also inputs the aforementioned control signals from the combustion controlling device **4**.

[0023] The safety checking portion **52**, based on the detection results from the flame detecting device **15**, the gas pressure switch **21**, and the air pressure switch **32**, and on the control signals generated by the combustion controlling device **4**, checks whether or not the various operations can be performed safely by the combustion controlling device **4** that performs one or more steps of the various steps that structure the combustion sequence, described below. If safe performance is confirmed, then the safety checking portion **52** allows the deployment of the various combustion operations, such as causing the process corresponding to the next step to be performed by the combustion controlling device **4**. On the other hand, if it is confirmed that there can be no safe operation, the safety checking portion **52** stops the various combustion operations, for example not allowing the combustion controlling device **4** to advance to the next process.

Startup Sequence

[0024] The combustion sequence by the combustion controlling device **4** will be explained in reference to FIG. **2** and FIG. **3**. In the below, the startup sequence for starting up the boiler system is explained as an example. This startup sequence is structured from a plurality of processes; however, the explanation will be for a case wherein there is a transition from an initial process **1** to the next process **2**.

[0025] In the case of starting up a boiler system, the following operations are performed as a process **1**. First the ignition controlling portion **42** of the combustion controlling device **4** outputs a control signal to the safety controlling device **5** indicating that the boiler system is to be started up.

[0026] When the control signal indicating that the boiler system is to be started up is received from the combustion controlling device **4**, the safety checking portion **52** of the safety controlling device **5** checks whether or not the signal from the air pressure switch **32** is OFF, and outputs the check result to the combustion controlling device **4**.

[0027] In this step, the combustion controlling portion **42** does not output a control signal, to the blower **31**, requesting driving. Consequently, if the combustion controlling device **4**, the safety controlling device **5**, the blower **31**, and the air pressure switch **32** are all operating properly, then the blower **31** is stopped, and thus no air is supplied into the air flow path **3**, and so the air pressure switch **32** that is provided in the air flow path **3** should be in the OFF state. However, if a fault were to occur in the combustion controlling device **4**, the safety controlling device **5**, the blower **31**, or the air pressure switch **32**, then the signal from the air pressure switch **32** may turn ON, or the check result may not be outputted to the combustion controlling device **4**. For example, as illustrated in FIG. **3**, if a fault were to occur in the combustion controlling device **4** so as to output, to the blower **31**, a control signal requesting driving, then the signal for the air pressure switch **32** would go ON.

[0028] If the signal from the air pressure switch **32** is ON without the control signal indicating the actuation of the boiler system being inputted from the combustion controlling device **4**, the safety checking portion **52** determines that a fault has occurred in the combustion controlling device **4**, the blower **31**, or the air pressure switch **32**. Given this, the safety checking portion **52** outputs control signals for stopping the combustion, such as not only preventing the actuation of the ignition transformer **14**, but also maintaining the first through fourth safety shutoff valves **22** through **25** in the closed state.

[0029] If the checking result of the air pressure switch **32** is not inputted into the combustion controlling device **4**, or if a checking result that indicates that the signal from the air pressure switch **32** is ON is inputted, then the combustion controlling portion **42** determines that a fault has occurred in the safety controlling device **5**, and outputs a control signal so as to stop the combustion, such as shutting the damper **33**.

[0030] This can prevent the hazards in the boiler system, because the combustion operation will not be performed in the boiler system.

[0031] On the other hand, if, after the control signal indicating that the boiler system is to be started up is outputted, a check result indicating that the signal for the air pressure switch **32** is OFF is inputted, then the combustion controlling portion **42** would not only output a control signal, to the blower **31**, requesting driving, but would also output this control signal to the safety controlling device **5** as well.

[0032] When the control signal indicating that the blower **31** is being driven is received from the combustion controlling device **4**, the safety checking portion **52** of the safety controlling device **5** checks whether or not the signal from the air pressure switch **32** is ON, and outputs the check result to the combustion controlling device **4**.

[0033] In this step, if the combustion controlling device **4**, the safety controlling device **5**, the blower **31**, and the air pressure switch **32** are all operating properly, then the blower **31** is driven, and thus air will be supplied into the air flow path **3**, and so the air pressure switch **32** that is provided in the air flow path **3** should be in the ON state. However, if there is a fault in any of these structural elements, then the signal from the wind pressure switch may be OFF, or the check result for the air pressure switch **32** may not be inputted into the combustion controlling device **4**.

[0034] If the signal from the air pressure switch **32** is OFF despite the control signal indicating the driving of the blower **31** being inputted from the combustion controlling device **4**, the safety checking portion **52** determines that a fault has occurred in the combustion controlling device **4**, the blower **31**, or the air pressure switch **32**. Given this, the safety checking portion **52** outputs control signals for stopping the combustion, such as not only preventing the actuation of the ignition transformer **14**, but also maintaining the first through fourth safety shutoff valves **22** through **25** in the closed state.

[0035] If the checking result of the air pressure switch **32** is not inputted into the combustion controlling device **4**, or if a checking result that indicates that the signal from the air pressure switch **32** is OFF is inputted, then the combustion controlling portion **42** determines that a fault has occurred in the safety controlling device **5**, and outputs a control signal so as to stop the combustion, such as shutting the damper **33**.

[0036] This can prevent the hazards in the boiler system, because the combustion operation will not be performed in the boiler system.

[0037] When it is confirmed that the air pressure switch **32** signal indicates as ON, then the combustion controlling portion **42** of the combustion controlling device **4** advances to the next process **2** in the boiler system startup sequence.

[0038] As explained above, in the present example the provision of two controlling devices, namely the combustion controlling device **4** for controlling the combustion of the combustion furnace and the safety controlling device **5** for not only checking the operation of the device is controlled by the combustion controlling device **4** enables the combustion to be controlled more safely because if a fault were to occur in either the combustion controlling device **4** or the safety controlling device **5**, a process can be performed by the other device to stop the combustion. Additionally, because the controlling device for controlling the structural elements that control the combustion in the boiler system (the combustion controlling device **4**) and the controlling device for operational checks of the outputs from those structural elements (the safety controlling device **5**) are separate, if there is a failure in any of the structural elements or controlling devices, that failure can be detected reliably, enabling safer control of the combustion.

[0039] Note that in the present example, a case was explained wherein the occurrence of a fault was confirmed within structural elements having the relationship of a blower **31** and an air pressure switch **32** that checks the output from the blower **31**, that for which the check is performed is not limited to the blower **31** and the air pressure switch **32**, insofar as it is among structural elements having a relationship of a structural element that performs some sort of operation and a structural element that can confirm an output that derives from the operation of that structural element, and can be set freely as appropriate between the various structural elements that are included in the various sequences, such as checking for the occurrence of a fault in, for example, a damper **33** and a sensor for detecting the position of the damper **33**. Given this, with reference to FIG. **4**, the entirety of the sequence from startup to shut down in a case wherein the system is operating properly is explained.

[0040] As described above, when starting up the boiler system, first the combustion controlling device **4** outputs a control signal to the safety controlling device **5** that the boiler system is to be started up (Step S**1**). When the control signal for starting up the boiler system is received, the safety controlling device **5** checks the signal from the air pressure switch **32** (Step S**2**). If it is confirmed that the signal from the air pressure switch **32** is OFF, then the safety controlling device **5** outputs to the combustion controlling device **4** a control signal indicating that the air pressure switch **32** is in the OFF state (Step S**3**). When the control signal indicating that the air pressure. switch **32** is in the OFF state is inputted, the combustion controlling device **4** outputs, to the blower **31**, a control signal for causing the blower **31** to be driven (Step S**4**).

[0041] The inputting of the control signal requesting that the blower **31** be driven causes the blower **31** to be driven (Step S**5**), and when the air pressure switch **32** detects that there is an airflow in the airflow path **3** (Step S**6**), the safety controlling device **5** outputs, to the combustion controlling device **4**, a control signal indicating that there is air flowing in the airflow path **3** (Step S**7**).

[0042] When the control signal indicating that air is flowing in the airflow path **3** is inputted, the combustion controlling device **4** outputs, to the damper **33**, a control signal indicating that it is to go to the fully open state (Step S**8**). Here let us assume that the damper **33** has a low limit switch and a high limit switch.

[0043] The damper **33** is in the closed state until inputting the control signal directing the damper **33** to go to the fully open state. Consequently, the low limit switch, which detects whether or not the damper **33** is in the closed state, is in the ON state, that the damper **33** is in the closed state, until the inputting of this control signal **33** (Step S**9**).

[0044] When the control signal instructing the fully open state is inputted, the damper **33** puts the damper to the fully open state (Step S**10**). As a result, the high limit switch, which detects whether or not the damper **33** is in the fully open state, goes to the ON state, that the damper **33** is in the fully open state (Step S**11**). At this time, the low limit switch goes to the OFF state because the damper **33** is in the fully open state.

[0045] When the damper **33** being in the fully open state is confirmed (Step S**12**), the safety controlling device **5**, in order to maintain the pre-purge, maintains, for a specific amount of time (the pre-purge time) the driving of the blower **31** and the fully open state of the damper **33** (Step S**13**). Once this specific amount of time has elapsed, then the safety controlling device **5** outputs, to the combustion controlling device **4**, a control signal indicating that the specific amount of time has elapsed (Step S**14**).

[0046] When the control signal indicating that the specific amount of time has elapsed has been inputted, the combustion controlling device **4** outputs, to the damper **33**, a control signal indicating that the damper **33** is to be closed (Step S**15**).

[0047] When the control signal instructing the closed state is received, the damper **33** puts the damper into the closed state. When the damper **33** goes to the closed state, the high limit switch goes into the OFF state and the low limit switch goes into the ON state (Step S**16**). When the low limit switch is confirmed to be in the ON state (Step S**17**), the safety controlling device **5** outputs control signals to open the third and fourth safety shutoff valves **24** and **25** (Step S**18**) and outputs a control signal to start up the ignition transformer **14** (Step S**19**).

[0048] The third and fourth safety shutoff valves **24** and **25** go to the open state (Step S**20**), and when it is confirmed, by the gas pressure switch **21**, that gas is flowing in the fuel flow path **2** (Step S**21**) and confirmed by the flame detecting device **15** that the pilot burner **13** has been ignited (Step S**22**), the safety controlling device **5** outputs a control signal to stop the ignition transformer **14** (Step S**23**), When this control signal is inputted, the ignition transformer **14** stops its operation.

[0049] Additionally, when the control signal indicating that the pilot burner **13** has ignited is inputted from the safety controlling device **5** (Step S**24**), the combustion controlling device **4** outputs, to the safety controlling device **5**, a control signal indicating that the main burner **12** is to be ignited (Step S**25**). When this is done, the safety controlling device **5** outputs control signals to place the first and second safety shutoff valves **22** and **23** into the open state (Step S**26**). When the first and second safety shutoff valves **22** and **23** go to the open state (Step S**27**) and the ignition of the main burner **12** is confirmed by the flame detecting device **15**, then the safety controlling device **5** outputs a control signal indicating that the third and fourth safety shutoff valves **24** and **25** are to be put into the closed state (Step S**28**), to close the third and fourth safety shutoff valves **24** and **25**. The boiler system is started up through these processes.

[0050] In stopping the boiler system from the state wherein the boiler system has been started up in this way, when a control signal indicating that the boiler system is to be shut down is received from the combustion controlling device **4** (Step S**30**), the safety controlling device **5** outputs a control signal indicating that the first and second safety shutoff valves **22** and **23** are to be closed (Step S**31**), to place the first and second safety shutoff valves **22** and **23** into the closed state. When it is confirmed by the gas pressure switch **21** that there is no flow of gas in the fuel flow path **2** (Step S**21**) and confirmed by the flame detecting device **15** that there is no flame in the main burner **12**, the safety controlling device **5** then stops operating.

[0051] In the sequence from startup to shutdown in this way, it is possible to check for the occurrence of faults among the low limit switch and the high limit switch and the damper **33**, among the ignition transformer **14** and the flame detecting device **15**, among the first through fourth safety shutoff valves **22** and **25** and the gas pressure switches, and the like, to check for faults between structural elements wherein there is a relationship between structural elements that perform some type of operation and structural elements that check an output that is derived from the operation of those structural elements.

[0052] The present invention can be applied to combustion controlling devices for controlling combustion in combustion furnaces that are used in boiler systems, and the like.

1. A combustion controlling device comprising:

a first controller outputting, to a first device controlling the combustion in a combustion furnace, a control signal controlling the operation of the first device; and

a second controller checking the operation of the first device, and controlling a second device that stops the combustion;

wherein the first controller outputs a control signal to the second control;

wherein the second controller outputs, to the first controller, an operation check result for the first device; and

wherein the first controller and the second controller perform a process to stop the combustion when it is confirmed, based on the control signal and on the operation check result, that there is a fault in the first device.

2. A combustion controlling device as set forth in claim **1**, wherein the second controller stops the combustion by controlling the second device.

3. A combustion controlling device as set forth in claim **1**, wherein the first controller stops the combustion by controlling the first device.

* * * * *