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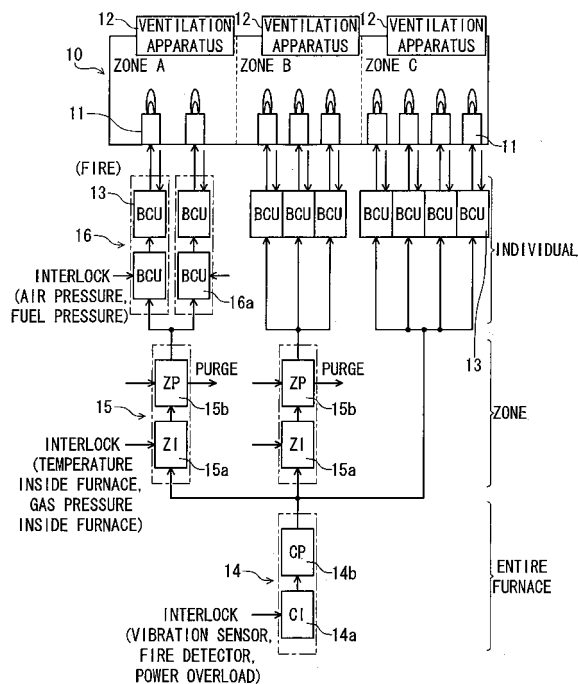
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(54) **Combustion furnace controller**

(57) There is provided a combustion furnace controller. The controller includes: a common control module (14) configured to control an overall operation of a combustion furnace (10) by verifying the state of a first interlock for a safe operation of the combustion furnace and then generating common control signals required for the safe operation of the combustion furnace; and combustion zone control modules (15) each provided for a corresponding one of combustion zones (A,B,C) of the combustion furnace and being configured to control an operation of one or more burners (11) provided in the corresponding combustion zone by verifying the state of a second interlock for a combustion environment in the corresponding combustion zone and a corresponding one of the common control signals, wherein the combustion zone control modules and the common control module are provided in a hierarchical manner.

FIG. 1



Description

BACKGROUND OF THE INVENTION

Technical Field

[0001] The present invention relates to a combustion furnace controller. More particularly, the present invention relates to a combustion furnace capable of securing the combustion safety of a combustion control system, which conforms to the combustion furnace specifications (safe operation) and that can be constructed easily.

Related Art

[0002] The operation control (combustion control) of a combustion furnace is basically carried out by monitoring the flame of a burner provided in the combustion furnace, the temperature inside the furnace and the composition of exhaust gas from the combustion furnace while using a combustion controller (burner control unit) to control the amount of fuel and the amount of air supplied to the burner (see e.g., JP-A-11-118150 and JP-A-10-332143). Also, when operating the combustion furnace, operation control that ensures (guarantees) the safety of the burner combustion as well as the safety of the combustion furnace operation is implemented by pre-ventilating the inside of the furnace (purge control) and then igniting the burner (ignition control).

[0003] In a medium and large size combustion furnaces, however, a plurality of burners are provided inside the furnace, and the inside of the furnace is separated into multiple combustion zones, with one or a plurality of burners provided for each of these combustion zones. Even in such a case, in order to ensure the combustion safety of the combustion furnace, it is important that various interlock, purge completion and other such signals be fed reliably to a plurality of burner control units (burner control units) for controlling the combustion (flame) of each burner. For this reason, in an operation control system constructed according to the combustion furnace specifications, measures must be implemented to enable the reliable transmission of the aforementioned interlock, purge completion and other such signals to the burner control units (burner control units) that are provided in correspondence to the burners.

[0004] Incidentally, typical operation control can be realized easily with sequence control using a programmable logic controller (PLC), for example. In the case of the operation control of a combustion furnace, however, in order to guarantee combustion safety, such usage of a PLC is permitted only if, for example, a general-purpose PLC is configured with custom software for an interlock for combustion safety. In other words, it is prohibited to configure an interlock for combustion safety and control a plurality of burner control units (burner control units), without an interlock device other than the aforementioned PLC that has been configured with custom software.

[0005] Accordingly, when controlling the operation of a combustion furnace, signals for combustion safety, particularly the interlock and purge completion signals, must be transmitted via safety devices that guarantee the safety. For this reason, the configuration of an operation control system constructed according to the combustion furnace specifications typically becomes complex and expensive.

10 SUMMARY OF THE INVENTION

[0006] Accordingly, it is an illustrative aspect of the present invention to provide a combustion furnace controller capable of securing the combustion safety (safe operation) of an operation control system that conforms to the combustion furnace specifications and also that can be constructed easily.

[0007] According to one or more illustrative aspects of the present invention, there is provided a combustion furnace controller. The controller includes: a common control module configured to control an overall operation of a combustion furnace by verifying the state of a first interlock for a safe operation of the combustion furnace and then generating common control signals required for the safe operation of the combustion furnace; and combustion zone control modules each provided for a corresponding one of combustion zones of the combustion furnace and being configured to control an operation of one or more burners provided in the corresponding combustion zone by verifying the state of a second interlock for a combustion environment in the corresponding combustion zone and a corresponding one of the common control signals, wherein the combustion zone control modules and the common control module are provided in a hierarchical manner.

[0008] According to the present invention, the combustion control system can be constructed easily since each control module simply verifies the state of the corresponding 1st to 3rd interlock of that hierarchical level, performs its operation, and then transmits a control signal to the control module of the next hierarchical level. Furthermore, interlock signals are not transmitted among the modules, but instead acknowledge signals, such as a purge complete signal, for example, are simply transmitted directly. Therefore, the combustion safety (safe operation) can be guaranteed without fail. Accordingly, a combustion control system conforming to the specifications of the combustion furnace can be constructed at an inexpensive cost while ensuring the combustion safety.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 shows a schematic diagram of a combustion control system in a combustion furnace controller according to an embodiment of the present inven-

tion;

Fig. 2 shows the configuration of signal transmission between modules;

Fig. 3 is a timing diagram of the operating state during normal operation;

Fig. 4 is a timing diagram of the operating state during an abnormality when the common contact and normally-open contact of a relay are fused together; and Fig. 5 is a timing diagram of the operating state during an abnormality when the common contact, normally-open contact and normally-closed contact of a relay are fused together.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0010] The combustion furnace controller according to exemplary embodiments of the present invention will be now described with reference to drawings.

Fig. 1 shows a schematic diagram of an operation control system in a combustion furnace controller for controlling the operation of the combustion furnace. The combustion furnace basically has a furnace divided into plural combustion zones. Each of the combustion zones is provided with one or more burners. Furthermore, depending on the combustion furnace specifications, the interior of the furnace is partitioned into a plurality of combustion zones, and each combustion zone may be provided with one or more burners. Also, provided in each combustion zone is a ventilation apparatus for ventilating (purging) the interior of the furnace.

Fig. 1 shows a combustion furnace 10, whose interior is portioned into three combustion zones, A, B and C. A plurality of burners (combustion devices) 11 and a ventilation apparatus 12 is provided in each combustion zone A, B and C. Moreover, although not expressly shown in Fig. 1, in the combustion furnace 10 is provided a flame sensor for each burner 11 for sensing the flame of the burner 11, and in each combustion zone A, B, C is provided a temperature sensor for sensing the temperature inside the furnace and a pressure sensor for sensing the gas pressure inside the furnace.

[0011] A combustion furnace controller for controlling operation of this type of combustion furnace is basically configured to control the combustion of each burner 11 while monitoring various types of interlocks for the safe operation of the combustion furnace. Moreover, the combustion control for burner 11, as disclosed in JP-A-11-118150 and JP-A-10-332143, is implemented by means of a burner control unit (BCU) 13. The BCU 13 is provided for each burner 11, and controls the amount of fuel and the amount of air supplied to the burner 11 while monitoring the flame of each burner 11, the temperature inside the furnace, and the composition of exhaust gas

from the furnace.

[0012] Namely, the combustion controller of the present invention implements combustion control for each burner 11 while monitoring each interlock, and in particular, the modularization of such basic functions as the determination of an interlock for the combustion safety of burner 11 and the monitoring of purge time. The hierarchically combination of these modules in accordance with the specifications of the combustion furnace 10 enable the construction of an operation control system for combustion furnaces 10 of various specifications. In particular, the interlock signals required for operation of each module are provided directly to the respective module and, among the modules, control signals (acknowledge signals) such as signals indicating purge completion, for example, are provided directly and reliably with their safety guaranteed so that signals for combustion safety can be handled without passing through a non-safety device.

[0013] Thus, in the present invention, the interlocks for safe operation of the combustion furnace 10 are classified as a 1st interlock for safe operation of the entire combustion furnace, a 2nd interlock for the combustion environment of each of the combustion zones A, B and C, and a 3rd interlock for operation of each of the burners 11. Namely, each interlock is classified hierarchically as either a 1st interlock for operation of the entire combustion furnace, a 2nd interlock for operation of individual combustion zones, or a 3rd interlock for operation of the individual burners.

[0014] Specifically, the 1st interlock indicates whether the operating conditions of the combustion furnace 10 meet given conditions such as a vibration sensor output, a fire detector output, a power overload output that indicates the results of the monitored power usage, and the like. The 2nd interlock indicates whether the combustion environment of the burner 11 in each combustion zone A, B and C meets given conditions such as a furnace interior high temperature limit interlock whose operation is determined based on the furnace interior temperature, a furnace interior gas pressure interlock, and the like. The 3rd interlock indicates whether the combustion (ignition) conditions for each burner 11 meet given conditions such as a fuel pressure build-up interlock, a fuel-air pressure low limit interlock, and the like.

[0015] Meanwhile, in the operation control system that controls the operation of each burner 11, respective modules are hierarchically connected to each other. Namely, there is a common control module 14 for determining the state of the aforementioned 1st interlock and controlling the overall operation of the combustion furnace, combustion zone control modules 15 for determining the state of the 2nd interlock for each combustion zone and controlling the combustion environment (operation conditions) of the respective combustion zones, and burner control modules 16 for determining the state of the 3rd interlock for each burner and controlling the combustion (operation) of the respective burners.

[0016] The common control module 14 forms the root of the combustion control system, and includes: an interlock determining unit 14a that determines the state of the 1st interlock; and a purge control unit 14b that receives the output (combustion furnace operation enable signal) from the interlock determining unit 14a, designates the initial purge process for the interior of the combustion furnace 10, implements timer control of the initial purge process and outputs a purge completion acknowledge signal (common control signal). In the common control module 14, if a portion of the 1st interlock disappears, then operating conditions of the combustion furnace is satisfied, of course, and the outputting of the acknowledge signal (common control signal) is halted.

[0017] Specifically, when the interlock determining unit 14a receives an activation signal, the interlock determining unit 14a verifies that all interlock signals for the entire furnace are normal and then outputs a global purge start enable signal. If an abnormality occurs in the interlock signal, the interlock determining unit 14a halts the outputting of the global purge start enable signal. Then, the purge control unit 14b receives the global purge start enable signal and begins the purging process for all of the zones A, B and C (the entire furnace), implements timer control for a preset purge process time, and after a certain purge process time has elapsed, outputs a zone activation signal to each zone A, B and C. Moreover, in the case where the inputting of the global purge start enable signal has been halted, the purge control unit 14b halts the outputting of a zone activation signal to each of the zones A, B and C, and as a result, the purge process for the entire combustion furnace and the operation of the combustion furnace are halted.

[0018] Also, the combustion zone control modules 15 are provided for each of the combustion zones, and are configured so as to operate only when receiving an acknowledge signal (common control signal) from the common control module 14, or more specifically, the zone activation signal). In particular, the combustion zone control module 15 includes: an interlock determining unit 15a that determines the state of the 2nd interlock when receiving the zone activation signal; and a purge control unit 15b that receives the output (combustion furnace operation enable signal) from the interlock determining unit 15a and designates a purge process in the combustion zone, and that implements timer control of the purge process and outputs a purge completion acknowledge signal (combustion zone control signal). In the combustion zone control module 15, if the acknowledge signal (common control signal) from the common control module 14 disappears or a portion of the 2nd interlock disappears, then operating conditions of the combustion furnace is satisfied, of course, and the outputting of the acknowledge signal (combustion zone control signal) is halted.

[0019] Specifically, when the interlock determining unit 15a receives a zone activation signal, the interlock determining unit 15a verifies that all 2nd interlock signals for

the relevant zone are normal, and outputs a purge start enable signal for that combustion zone. If an abnormality occurs in a 2nd interlock signal, the interlock determining unit 15a halts the outputting of the purge start enable signal. Then, the purge control unit 15b receives the zone purge start enable signal and begins the purging process for the relevant combustion zone, implements timer control for a preset purge process time, and after a certain purge process time has elapsed, outputs a combustion activation signal to the burner in the relevant combustion zone. Moreover, in the case where the inputting of the zone purge start enable signal has been halted, the purge control unit 15b halts the outputting of the combustion activation signal, and as a result, the burner operation is halted.

[0020] Also, a burner control module 16 is provided for each burner 11, and is configured so as to operate only when receiving an acknowledge signal (control signal), i.e., the combustion activation signal, from the combustion zone control module 14. Specifically, the burner control module 16 includes: an interlock determining unit 16a that determines the state of the 3rd interlock; and the burner control unit (BCU) 13 that receives the output (combustion furnace operation enable signal) from the interlock determining unit 16a and controls the burner combustion. Also in the burner control module 16, if the acknowledge signal (combustion zone control signal) from the combustion zone control module 15 disappears or a portion of the 3rd interlock disappears, the operation conditions for the combustion furnace is satisfied, of course, and the burner control module 16 halts operation (combustion) of the burner 11.

[0021] Specifically, when the interlock determining unit 16a receives a combustion activation signal, the interlock determining unit 16a verifies that all 3rd interlock signals for the burner are normal and outputs an ignition signal for the respective burners 11. However, if an abnormality occurs in the interlock signal, the outputting of the ignition signal is halted. The burner control unit 13 receives the ignition signal from the interlock determining unit 16a, ignites the burner and controls that combustion while monitoring the combustion status. Moreover, if the ignition signal is disrupted, the burner control unit 13 halts the burner combustion.

[0022] Moreover, Fig. 1 only shows the operation control system for combustion zone A as being configured by a hierarchical connection of control modules 14, 15 and 16, but a similar operation control system having a hierarchical relationship may also be configured, of course, for combustion zones B and C. Also, in the case of a simple type of combustion furnace without a 3rd interlock, as shown in combustion zone B, the operation control system may also be configured with only the common control module 14 and the combustion zone control module 15 connected hierarchically, and using the acknowledge signal (combustion zone control signal) from the combustion zone control module 15 so as to control directly the operation of the burner control unit (burner

control unit: BCU) 13 provided for each burner 11. In this case, the purge control unit 15b of the combustion zone control module 15 may be configured to output the burner ignition signal instead of the combustion activation signal. Also, as shown in the combustion zone C of Fig. 1, in the case where there is no zone purge, the operation control system may also be configured such that each burner control unit 13 receives the zone activation signal, ignites the respective burner, and controls the combustion thereof while monitoring the combustion status.

[0023] As described above, with a combustion furnace controller in which the operation control system is configured by connecting a plurality of control modules 14, 15 and 16 hierarchically, the operation control in each control module 14, 15 and 16 may be implemented by directly providing only the required interlock signals and simply making determination based thereon, without transmitting the interlock signals to another control module. Moreover, among the hierarchically connected control modules 14, 15 and 16, it is sufficient to transmit directly only the acknowledge signals (common control signals/ combustion zone control signals) that indicate operation completion, and therefore, for example, it is not necessary to control sequentially the operation of the combustion furnace with software using a programmable logic controller (PLC). In other words, while control signals are provided directly among the control modules 14, 15 and 16 that have been constructed using safety devices, the combustion furnace operation can be controlled by determining the state of the interlock at each hierarchical level, and therefore the operational safety of the combustion furnace can be guaranteed easily and efficiently without the use of a general-purpose programmable logic controller (PLC).

[0024] Also, since a PLC is not required in the controller of the present invention, there is no need to consider abnormalities that may occur in the PLC itself. Also, if an abnormality occurs in any one of the interlocks, because the control module that determines the state of that interlock can quickly and reliably detect the abnormality, this embodiment provides the effect, among others, of enabling measures to be taken quickly according to the type of abnormality. Moreover, since there is no need to develop custom software for using a PLC, this embodiment has the advantage in that the combustion furnace controller can be constructed easily.

[0025] Hereinafter, the transmission of acknowledge signals among the aforementioned control modules will be described with reference to Fig. 2. Fig. 2 shows example configurations of the transmission module (common control module) 14 and reception module (combustion zone control module) 15 that accomplish the transmission of acknowledge signals among the control modules. In this embodiment, the transmission module corresponds to the common control module 14, and the reception module corresponds to the combustion zone control module 15.

[0026] The common control module (transmission

module) 14 includes two parallel CPUs 1a and 1b that generate pulses of a certain fixed period and enhance the reliability of the acknowledge signals (pulse signals) by generating multiple (doubly redundant) information (pulse signals) indicating the presence of the acknowledge signals (common control signals) or interlock signals. Incidentally, the CPUs 1a and 1b usually operate in synchronization with each other and function as signal generators for generating time division pulse signals. Specifically, the CPUs 1a and 1b are configured so as to generate alternately at 100 ms intervals, for example, pulse signals having a 20 ms cycle and forming a square wave with a 50% duty cycle. Then, the respective pulse signals outputted from each of the CPUs 1a and 1b pass through a logical OR circuit (pulse signal synthesis unit) including transistors 2a and 2b and are combined into a single signal which, as a pulse signal (pulse signal string) that is continuous with a certain fixed cycle in a time-series, is output through an output transistor 3 to the combustion zone control module (reception module) 15.

[0027] Moreover, a relay (switch) 4 for controlling the output of the pulse signals outputted from the output transistor 3 is provided in series into the output stage of the common control module 14, and pulse signals (acknowledge signals) are provided to the reception module 15 via a normally-open contact NO only when this relay 4 is turned on (when in a driving state). Specifically, the relay 4 is a switching type relay, and when an electromagnetic coil L thereof is in a non-conducting (off) state, a common terminal C is connected to a normally-closed contact NC side. Meanwhile, when the electromagnetic coil L is in a conduction driving (on) state, the common terminal C is connected to the normally-open contact NO side. In this embodiment, the common contact C of the relay 4 is connected to the output terminal of the output transistor 3 (the collector of the emitter-grounded pnp transistor 3), and the normally-closed contact NC is connected to an external output terminal 5. Accordingly, by operating the relay 4 in a conduction driving state, the time-series pulse signal, formed by passing the pulse signals outputted from control devices 1a and 1b through the logical OR circuit (transistors 2a and 2b) to combine them into a single signal, is provided from the output transistor 3 through the normally-open contact NO of relay 4 to the combustion zone control module (reception module) 15.

[0028] In addition, the conduction of the electromagnetic coil L of relay 4 is controlled by a relay driving circuit, including two transistors 6 and 7 that receive a relay driving signal from CPUs 1a and 1b and are driven in a conducting state. Accordingly, the relay 4 is driven via the relay driving circuit (transistors 6 and 7) only when the CPUs 1a and 1b output relay driving signals simultaneously. Also, if at least one of CPUs 1a and 1b halts outputting the relay driving signal, the driving of the relay 4 will be halted.

[0029] The common control module 14 further includes a transistor 9 for monitoring pulse signals outputted externally through the normally-open contact NO of relay

4, and a transistor 8 for monitoring the pulse signals outputted to the normally-closed contact NC of relay 4 when the relay 4 is in a non-driven state. Then, the detected pulse signals that pass through transistors 8 and 9 (monitoring circuits) are provided as output monitoring results in1 and in2 to each CPU 1a and 1b, and are used in the self-diagnostic functions of the common control module 14.

[0030] Moreover, the combustion zone control module (reception module) 15 is configured so as to detect pulse signals (acknowledge signals) that are sent, as described above, from the transmission module 14 via a photocoupler that includes a light emitting element 21 and a light receiving element 22 that is optically coupled to the light emitting element 21. Also, the output from the photocoupler is provided to two CPUs 23 and 24 provided in a parallel configuration to double-check the reception of the pulse signals (acknowledge signals). Each CPU 23 and 24 is configured so as to recognize pulse signals having durations equal to or longer than a certain fixed interval (such as 500 ms, for example) as acknowledge signals. In other words, if the duration of the pulse signal is less than a certain fixed interval (such as 500 ms, for example), the CPUs 23, 24 determine that the acknowledge signal has disappeared or that, due to some sort of abnormality in the transmission module A, the acknowledge signal has not been sent.

[0031] In a transmission system for control signals configured as described above, if the relay 4 and all other elements in the common control module 14 are in a normal state, the CPUs 1 and 2 provided in a parallel will alternately output pulse signals of a certain fixed duration as shown in Fig. 3, for example, in response to interlock signals. However, unless the confirmation that the common control module 14 is in a normal state, the CPUs 1 and 2 do not activate the relay 4. Accordingly, after the pulse signals outputted from each control device 1 and 2 pass through the logical OR circuit (transistors 2a and 2b) and are combined into a single time-series pulse signal as described above, that signal is simply provided from the output transistor 3 to the relay 4.

[0032] However, if the relay 4 is in a normal state, when the relay 4 is not being driven, pulse signals will be provided to the normally-closed contact NC side of relay 4, not to the normally-open contact NO side. The result, as shown in Fig. 2, is that pulse signals detected from the normally-closed contact NC side of the relay 4 are provided to the 1st monitoring input port in1 of the CPUs 1 and 2, and no pulse signals are provided to the 2nd monitoring input port in2. Based on such monitoring results, the CPUs 1 and 2 determine that the relay 4 is in a normal state, and at this time, provides a drive signal to the relay 4.

[0033] Then, when transistors 6 and 7 of the relay drive circuit that receives these relay drive signals enter into conduction mode operation, the relay 4 is driven and the output contact is switched. Thus, as shown in Fig. 3, the time-series pulse signal combined into a single signal is

sent from the normally-open contact NO side of the relay 4, via an external contact terminal 5, to the reception module B side. At this time, there is no pulse signal output from the normally-closed contact NC side of the relay 4. In other words, the inputting of a pulse signal to the 1st monitoring input port in1 in each of the control devices 1 and 2 is discontinued, and instead, a pulse signal is provided to the 2nd monitoring input port in2. The control devices 1 and 2, based on this type of monitoring results, determine that the relay 4 is in a normal state.

[0034] Then, at this time, because the pulse signal outputted via the external connection terminal 5 to the combustion zone control module 15 has been formed by combining the pulse signals generated alternately by the CPUs 1 and 2 into a single continuous pulse signal string, this pulse signal takes on the significance of the aforementioned control signal (common control signal). Accordingly, a common control signal will not be unintentionally output from the common control module 14.

[0035] Furthermore, in the case where either CPU 1 or 2 does not generate a pulse signal normally, or in the case of an abnormality in transistors 2a and 2b, which function as a pulse signal combining unit, a single combined time-series pulse signal string will not be generated as described above. Accordingly, in such a case, the system will determine that an abnormality has occurred at one of the CPUs 1 and 2, and then the generation of pulse signals will be halted. Similarly, in the case where a pulse signal is not detected, regardless of whether the control devices 1 and 2 have been activated, the system will determine that some abnormality has occurred.

[0036] However, contact failures in the relay 4 are caused by electrical discharges that cause the contacts to fuse together when the relay 4 is being driven. Accordingly, to detect a failure of the relay 4, the driving of relay 4 is halted, and at that time, the monitored status of the 1st and 2nd monitoring input ports in1 and in2 may be checked. Specifically, in the case where the common contact C and the normally-open contact NO of the relay 4 are fused together, even if the driving of relay 4 has been halted, the moveable armature thereof will not return to the normally-closed contact NC side. Accordingly, in this case, as shown in Fig. 4, even if the driving of relay 4 is halted, pulse signals continue to be provided to the normally-open contact NO side of relay 4 (1st monitoring input port in2) and meanwhile, no pulse signals are provided to the normally-closed contact NC side of relay 4 (1st monitoring input port in1).

[0037] Accordingly, as monitoring results, each of the CPUs 1 and 2, determines that an abnormality has occurred in the relay 4, and then halts the generation of pulse signals. Thus, the transmission of pulse signals to the combustion zone control module 15 is forcibly terminated. In particular, even in the case where the driving of the relay 4 has been halted in order to terminate the outputting of pulse signals, if there is an abnormality in the relay 4, the termination of the generation of pulse signals by the control devices 1 and 2 will prohibit the

subsequent outputting of pulse signals to the combustion zone control module 15.

[0038] Furthermore, in one example of failure of the relay 4, in addition to the fusing together of the common contact C and the normally-open contact NO, the normally-closed contact NC may also become fused at the same time. When this type of situation arises, regardless of whether the relay 4 is being driven or has been halted, as shown in Fig. 5, pulse signals continue to be provided to the normally-open contact NO side (monitoring input port in2) of relay 4 and pulse signals also are provided to the normally-closed contact NC side (monitoring input port in1) of relay 4. Accordingly, even when these types of monitoring results are obtained, each CPU 1 and 2 may be configured to determine that an abnormality has occurred in the relay 4, halt the generation of the pulse signals, and to terminate forcibly the transmission of pulse signals to the combustion zone control module 15.

[0039] Namely, as described above, with the common control module 14 including an output section for control signals, in the state where two CPUs 1 and 2 alternately generate pulse signals, by controlling the driving of the relay 4 so as to enable or disable operation of the burner, during normal operation, while the burner operation is enabled, pulse signals are detected only at the normally-open contact NO side (monitoring input port in2) of relay 4, but while the burner operation is disabled, pulse signals are detected only at the normally-closed contact NC side (monitoring input port in1). Therefore, the common control module 14 is able to detect the occurrence of other states as the occurrence of an abnormality. Thus, when an abnormality is detected, the CPUs 1 and 2 disable the generation of pulse signals so that there is no transmission of mistaken control signals to the combustion zone control module 15.

[0040] Furthermore, in the case where an abnormality has occurred in either one of the two CPUs 1 and 2, the outputting of pulse signals is discontinued from the control device side where the abnormality occurred. Accordingly, even if a time-series string of pulse signals is provided by a logical OR circuit (transistors 2a and 2b), the output thereof will consist only of the pulse signals outputted from the one control device. Accordingly, the abnormal condition of the other control device can be detected based on the occurrence of intermittent interruptions of a certain fixed period in the pulse signal. Thus, in this case, prohibiting the generation of pulse signals by the normally functioning control device enables the outputting of mistaken pulse signals from the common control module 14 to be prevented reliably.

[0041] Also, in the aforementioned configuration, a single continuous time-series pulse signal cannot be obtained if the transistors 2a and 2b are broken. Also, the relay 4 cannot be switched on and off if the transistors 6 and 7 are broken. Accordingly, by monitoring the signal detected at the monitoring input ports in1 and in2, the above-described abnormalities can also be detected. Therefore, only when the common control module 14 is

in a normal state, common control signals that are continuous pulse signals having durations equal to or longer than a certain fixed interval can be reliably provided to the combustion zone control module 15. Moreover, the transmission of acknowledge signals (zone control signals) from the combustion zone control module 15 to the burner control module 16 may be implemented similarly.

[0042] Furthermore, the present invention is not limited to the above-described embodiment. For example, the interlock may be configured in accordance with the specifications of the combustion furnace, or an appropriate interlock can be added. Also, in the above-described embodiment and Fig. 1, a combustion controller (BCU) 13 is provided for each burner 11, but the present invention is not limited to this configuration. For example, the combustion controller (BCU) 13 may be provided for two or more burners 11. In this case, all burners 11 associated with a single combustion controller 13 are provided in the same zone, that is to say, the burners 11 are preferably limited to the same operating conditions. Even in this type of situation, it is sufficient to determine the interlock at each hierarchical level classified as described above. Also, in order to ensure operational reliability of the transmission of signals among modules, it goes without saying that various measures may be implemented. Additionally, the present invention, without departing from the gist thereof, may be modified variously and implemented.

[0043] Constituent components disclosed in the aforementioned embodiments may be combined suitably to form various modifications. For example, some of all constituent components disclosed in one of the embodiments may be removed or the constituent components disclosed in different embodiments may be appropriately combined.

Claims

1. A combustion furnace controller, comprising:

a common control module (14) configured to control an overall operation of a combustion furnace (10) by verifying the state of a first interlock for a safe operation of the combustion furnace and then generating common control signals required for the safe operation of the combustion furnace; and

combustion zone control modules (15) each provided for a corresponding one of combustion zones (A,B,C) of the combustion furnace and being configured to control an operation of one or more burners (11) provided in the corresponding combustion zone by verifying the state of a second interlock for a combustion environment in the corresponding combustion zone and a corresponding one of the common control signals, wherein the combustion zone control modules and the common control module are pro-

vided in a hierarchical manner.

2. The controller according to Claim 1, wherein the combustion furnace is partitioned into the plurality of combustion zones. 5
3. The controller according to claim 1, wherein each of the combustion zone control modules generates combustion zone control signals required for an operation of the burners, wherein the controller further comprises: 10

burner control modules (16) each provided for a corresponding one of the burners and being configured to control the operation of the corresponding burner by verifying the state of a third interlock for a safe operation of the corresponding burner and a corresponding one of the combustion zone control signals, and 15

wherein the common control module, the combustion zone control modules and the burner control modules are provided in a hierarchical manner. 20
4. The controller according to Claim 3, wherein the combustion furnace is partitioned into the plurality of combustion zones. 25
5. The controller according to Claim 1 or 3, wherein the common control signals are signals for enabling or disabling the operation of the burners. 30
6. The controller according to Claim 1 or 3, wherein when the operation of the burners is enabled, each of the combustion zone control modules ventilates the corresponding combustion zone so as to ensure a safe operating environment for the burners provided in the corresponding combustion zone, and then generates the combustion zone control signals. 35 40
7. The controller according to Claim 1, further comprising:

burner control units (13) each provided for a corresponding one of the burners, and performing combustion control on the corresponding burner, only when the operation of the burners is enabled after the burner control units receive combustion zone control signals from the combustion zone control modules. 45 50
8. The controller according to Claim 3, further comprising: 55

burner control units (13) each provided for a corresponding one of the burners, and performing combustion control on the corresponding burn-

er, only when the operation of the burners is enabled by the burner control modules.

9. The controller according to Claim 3, wherein the common control signals are signals for enabling or disabling the operation of the burners.
10. The controller as cited in Claim 3, wherein when the operation of the burners is enabled, each of the combustion zone control modules ventilates the corresponding combustion zone so as to ensure a safe operating environment for the burners provided in the corresponding combustion zone, and then generates the combustion zone control signals.

FIG. 1

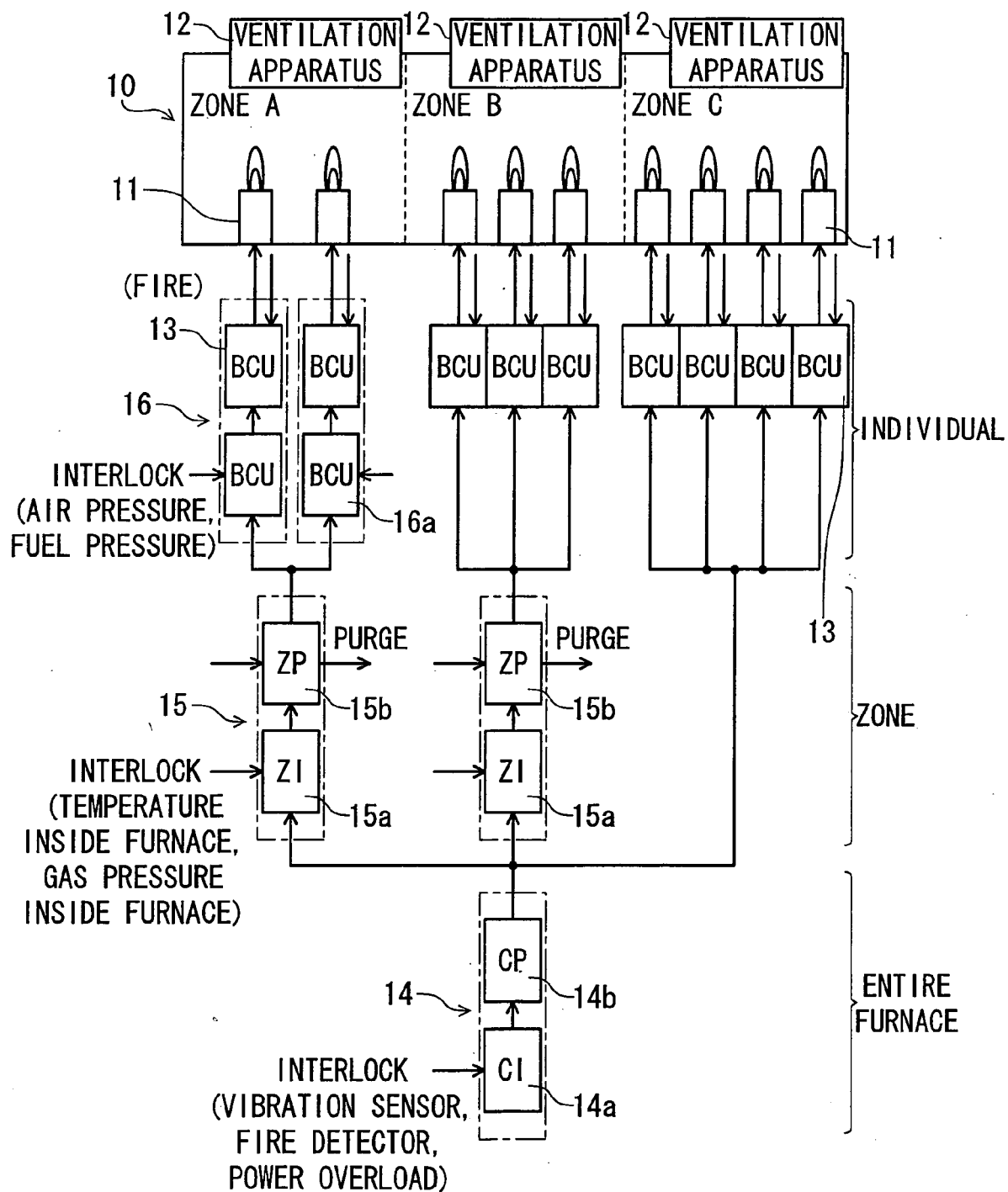


FIG. 2

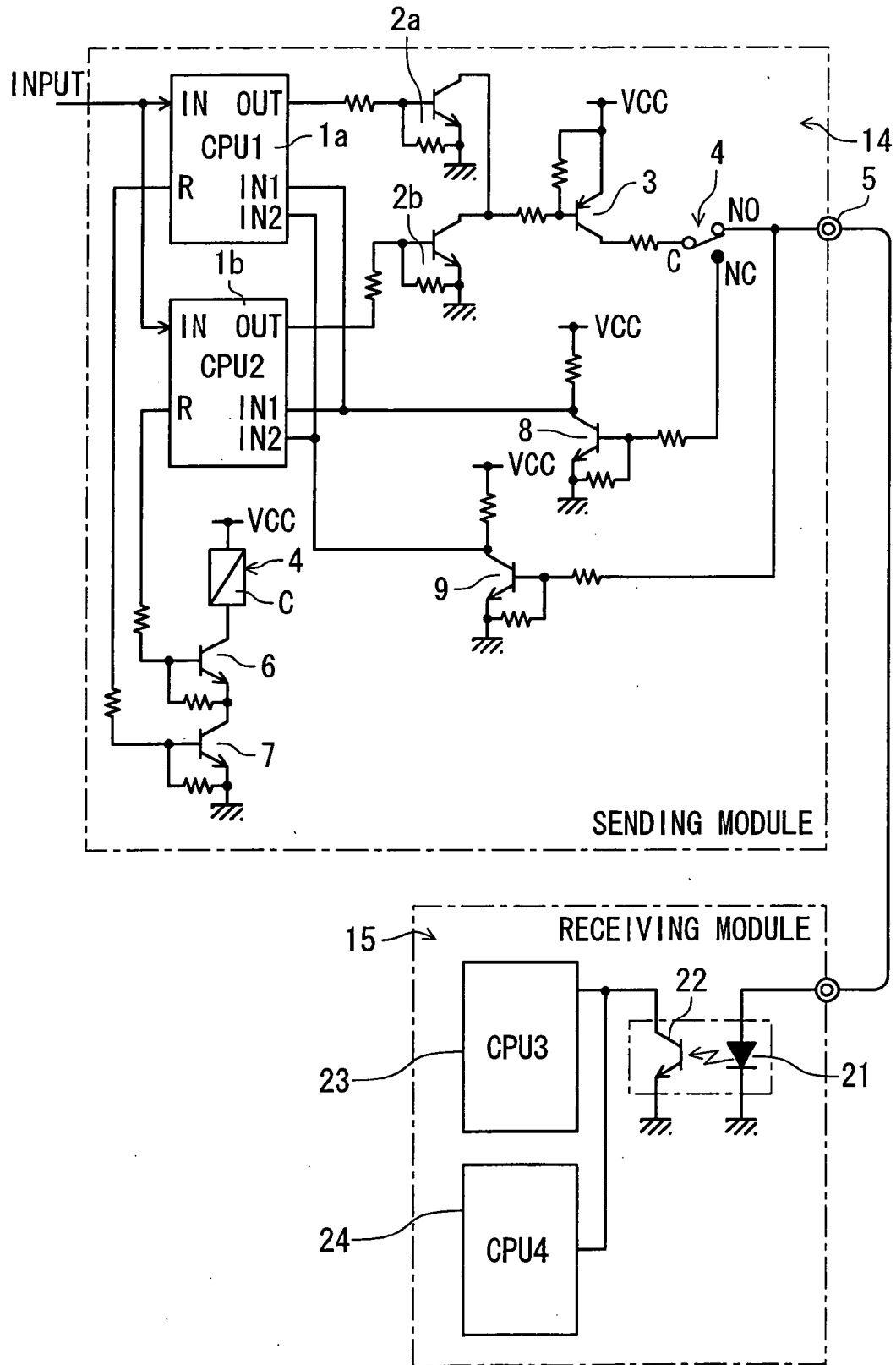


FIG. 3

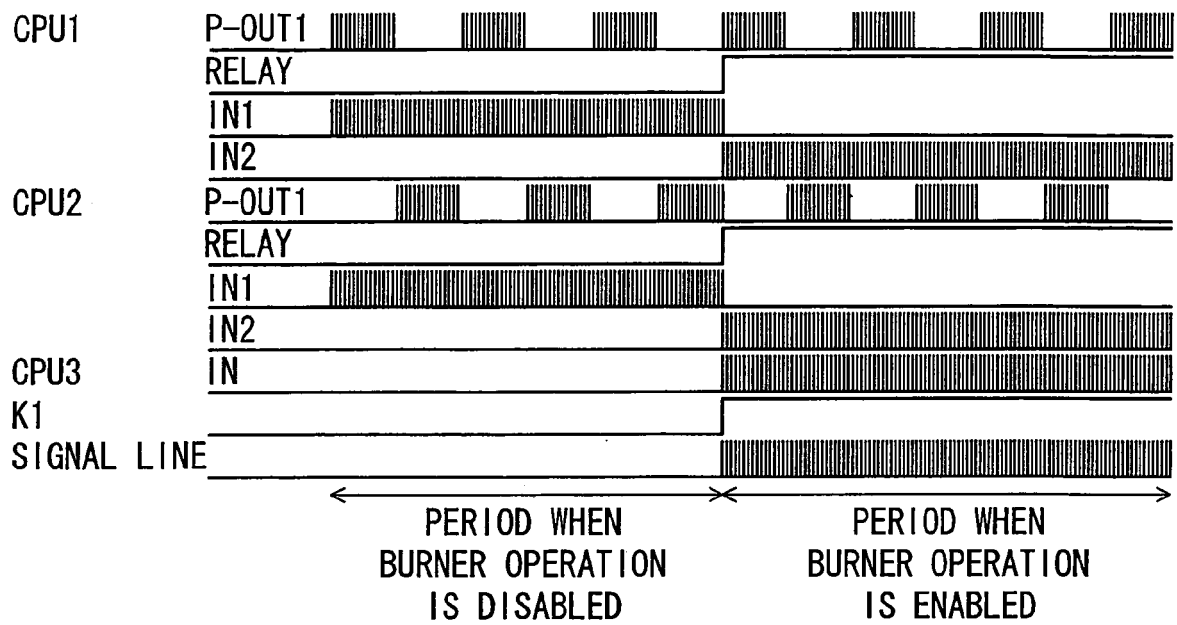


FIG. 4

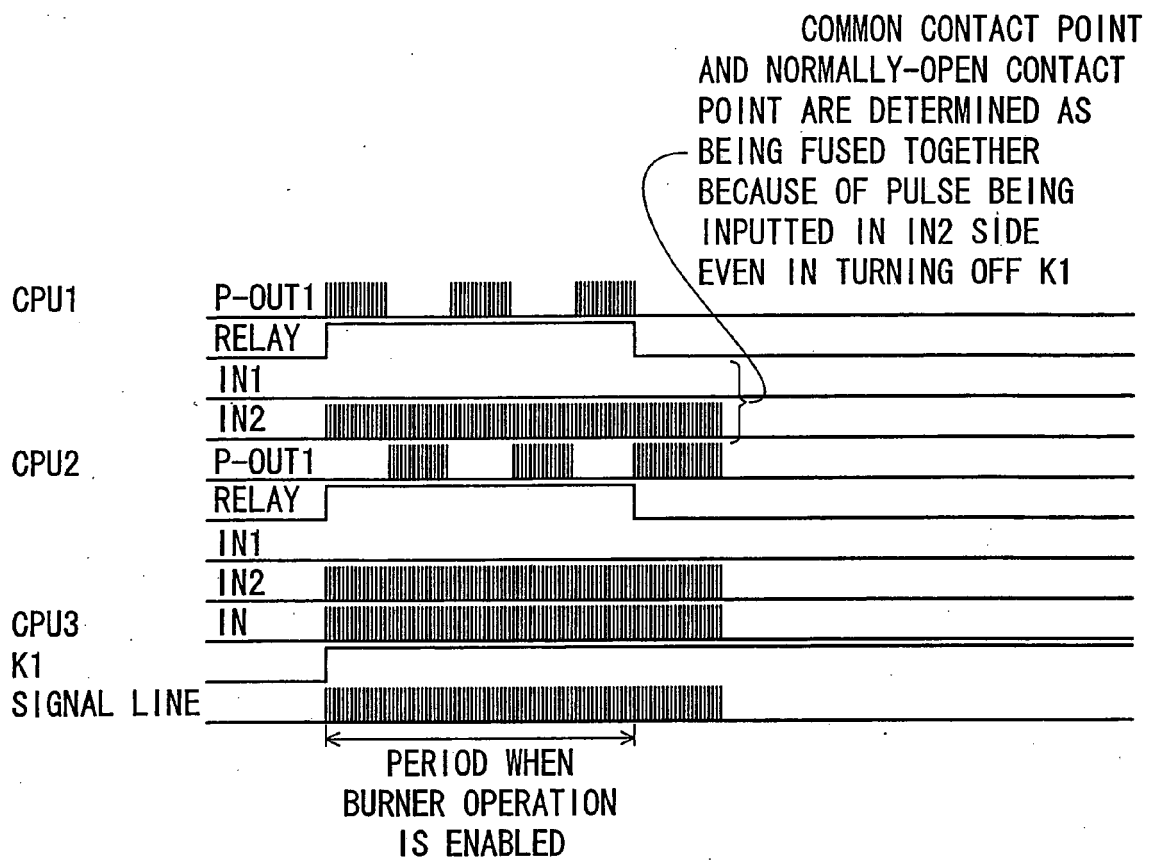
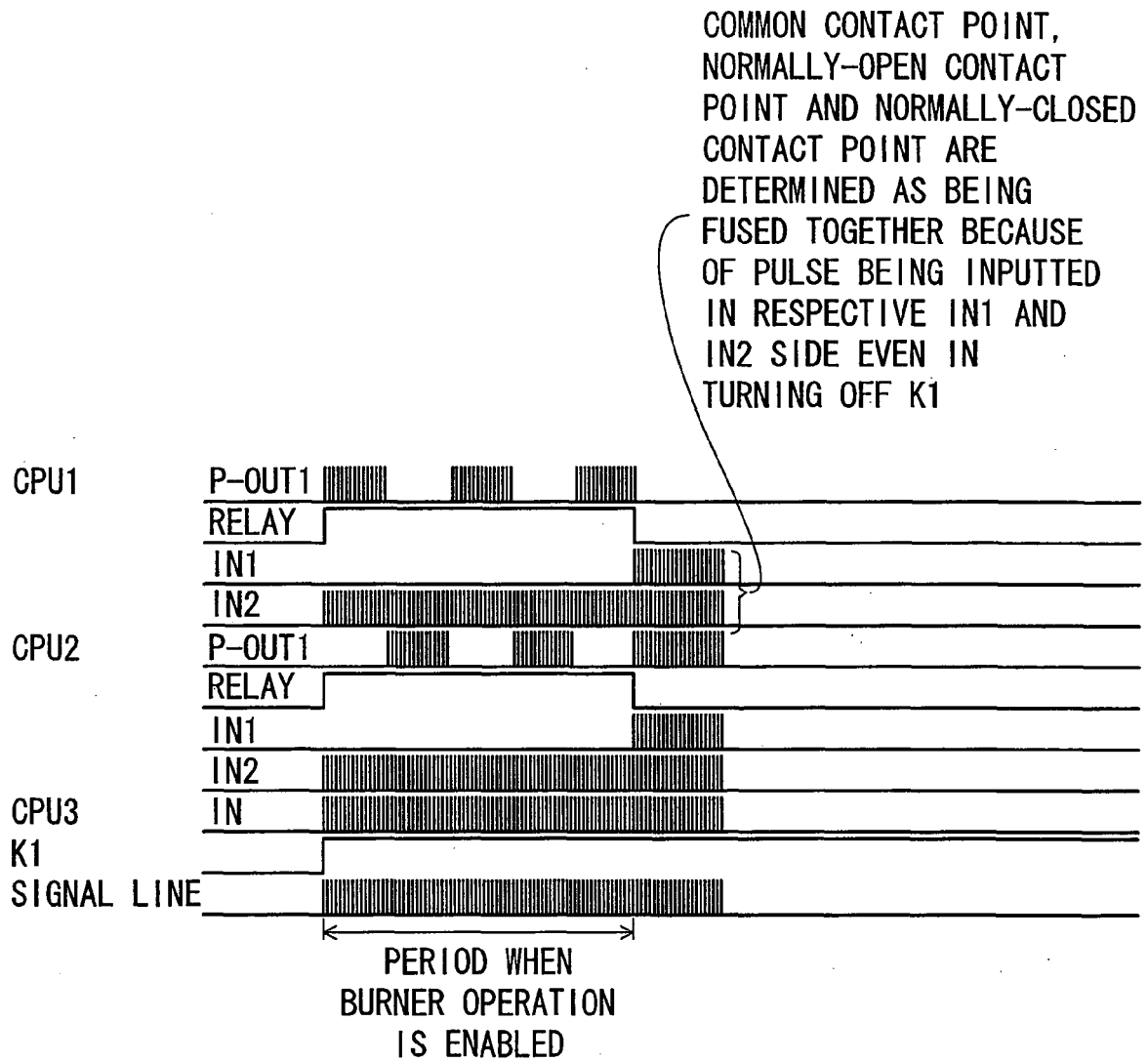


FIG. 5



REFERENCES CITED IN THE DESCRIPTION

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