A communication and data interpreting system for detecting and converting and combining multiple analog signals from flame detectors into a single analog signal and RS 485 for transmission. This system also uses an analog clamping circuit to generate the analog signal from flame rod sensors and a load resistor and a high voltage generator for generating the signal in an UV sensing tube. The input signals are then multiplexed and sent to a microcomputer. The microcomputer uses a diode and a solid state relay circuit to generate a compatible signal output to a burner control.
INDUSTRIAL FLAME SENSOR COMMUNICATION SYSTEM


ADDITIONAL REFERENCES

[0001] “Flame Worx”, brochure of Fireye, Inc in Derry N.H.


BACKGROUND OF THE INVENTION

[0004] Numerous industrial processes utilize combustion units, such as, for example, furnaces, ovens, incinerators, dryers, and boilers. Typically these types of equipment have more than one burner each operating with various fuels. Each of these burners is equipped with some type of flame sensor. The flame sensors are always mounted on the burner in such a way that the sensor is able to detect a flame when one is present in the burner. The sensor then generates a signal, which is detected by a burner control system. The flame control in turn governs the start up and shut down of the burner according to a prescribed sequence. The purpose of this is to avoid the possibility of explosions and other failure, which could result in damage or injury to equipment or personnel. There are different types of sensors in use in industrial burner applications. These include Flame rod and Ultra-violet sensors.

[0005] Flame rod sensors work on the principle of flame rectification. This principle is based on the fact that the flame in a burner is electrically conducive when a voltage is applied across two electrodes in the flame. Heat from the flame produces increased activity in the molecules between the electrodes. This increased molecular collisions, as a result of this activity, causes ions to be freed from the molecules. This principle is called flame ionization. The freed electrons are then capable of moving to the electrodes, which are electrically charged. The positive ions going to the negative electrode and the negative ions going to the positive electrode. If the electrodes in the flame have a different area the more ions will flow to one electrode that the other. In a flame rectification system the area of the grounded electrode is at least four times larger than that of the flame rod electrode which is connected to an alternating voltage source. Because of the differences in electrode areas more current flows in one direction than the other direction. This difference in current flow creates a pulsating direct current, which is detected as a flame present signal by the burner control.

[0006] Ultra-violet sensors do not actually come in contact with the flame in a burner as do flame rod electrodes. The Ultra violet flame detection system that employs a specialized sensor which detects the ultraviolet light radiated from a flame but is insensitive to other ranges of emitted light such as visible or infrared light. The typical ultraviolet flame sensor is a sealed quartz glass tube filled with a type of gas and containing two electrodes (anode and cathode).

A high voltage is applied across the electrodes by the burner control. When the sensing tube becomes exposed to ultraviolet light in the presence of the voltage, current will flow across the electrodes, electrons are emitted from the cathode. These electrons ionize the gas in the tube and the gas becomes conductive. Current then begins to flow across the electrodes and the voltage potential drops. When the voltage potential drops far enough the conduction stops. The flame sensor voltage to rise again. If ultraviolet light is still present from the flame the conduction process will start again when the voltage has risen far enough. This continual sequence results in a series of pulses emitted from the sensor when a flame is present. This series of pulses is then detected as a flame present signal by the burner control.

[0007] Because of the nature of the flame signal produced by the sensors described above the nature and method of connections between the sensor and the burner control has always been critical in the operation of the overall burner control system.

[0008] Each sensor is controlled and monitored by an individual circuit contained in the burner control unit. The wires used to carry the signal from the sensor to the control must be kept apart from any sources of electrical energy, which could disrupt the signal and cause an unwanted shutdown of the burner system.

[0009] This type of shut is not only inconvenient but can be costly in terms of lost production time and sometimes product.

[0010] In many installations of furnaces, ovens and other equipment using burners the burners are installed in an environmentally controlled control room. This control room could be as much as several hundred feet away from the physical location of the burners being controlled. This results in very long runs of expensive cabling and conduit to bring the signals from the sensors back to the control room. Even when such cabling and installation techniques are used to reduce the effects of electrical interference, the sensor signals themselves may attenuate to the point where the burners cannot run reliably. What is needed in industrial burner systems are means for communicating the flame sensor signal from the sensors to the burner controls, which improves the effectiveness and flexibility of burner control systems.

SUMMARY OF THE INVENTION

[0011] In view of the aforementioned discussion, the present invention provides a communication system and method which provide a reliable means through which the information contained in a flame sensor signal or many flame sensor signals can be reliably transmitted over long.
distance using a single pair of wires. This invention will also provide a system and method for combining several flame sensor signals into one signal, which can be interfaced to a burner control as a single sensor system.

[0012] This is done through a unique method of multiplexing the input sensor signals into the invention and capturing the relevant information required for the burner control. This information is then converted to a single or multiple sensor signals, which can be interfaced to a burner control for operation of the burner system. This information is also converted into a RS485 signal and transmitted over an effective distance of 3000 feet where in is converted by another module of the invention into multiple or single flame sensor signals which the burner control will recognize.

[0013] In addition to this, other objectives and advantages of the invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The accompanying drawings illustrate the aspects and concepts of the invention. In the drawings:

[0015] FIG. 1 is a block diagram of the invention concepts incorporating several new concepts in the process. The invention is made of several unique modules, which will be described in detail below.

[0016] While the invention will be described in connection with certain preferred embodiments, there is no intent to limit it to those embodiments. On the contrary, the intent is to cover all alternatives, modifications and equivalents as included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE PERFERRRED EMBODIMENTS

[0017] In the drawing labeled FIG. 1 the power supply 100 supplies the 5 volts and the 12 volts required to operate the electronics. The UV powers supply 102 provides power in the form of high voltage to energize the ultraviolet sensors connected to the system.

[0018] Flame Rod Sensing

[0019] The line voltage, which is supplied to the power supplies, is also supplying the capacitor C1 and the Analog Clamping Circuit 115.

[0020] The analog clamping circuit works with a unique principle. Rather than supply high voltage using a transformer, as current technology requires, this circuit uses 120 VAC (Line Voltage). The key principle is combining the diode effect of the flame upon the flame rod with C1 capacitor. This creates a clamping phenomenon and a partial direct current, which is detected by the comparator circuit contained in 115. The input multiplexer connects each of the sensor inputs to the signal generating circuitry. The output of the Analog clamping circuit 115 is connected to the Flame Rod analog to frequency module 105. This module changes the analog flame signal in to a frequency signal and sends it to the opto-isolater 106. This frequency signal is then sent to the microcomputer module 107 where it is interpreted as flame signal. Since the microcomputer controls which sensor is being looked at by the multiplexer, each sensor signal is individually identified.

[0021] Ultra-Violet Sensing

[0022] The Ultraviolet power supply 102 supplies the excitation voltage to each of the 16 UV sensors which in turn are connected one at a time by the multiplexer to the load R1. When a flame signal is present a frequency pulse occurs at R1 due to the UV sensing phenomenon explained above. This frequency pulse is then sent to the UV opto-isolator 104. This frequency signal is then sent to the microcomputer module 107 where it is interpreted as flame signal. Since the microcomputer controls which sensor is being looked at by the multiplexer, each sensor signal is individually identified.

[0023] The microcomputer 107 has several functions.

[0024] Firstly, the microcomputer module receives the frequency signals from the UV opto-isolator 104 and the Flame Rod opto-isolator 106. When a flame signal is present at all the connected sensors the microcomputer, the microcomputer creates a combination flame output signal using the circuit 110. The circuit in 110 is also a unique concept, which consisted of a solid state switch and a rectifier circuit. By modulating the solid state switch the microcomputer creates a frequency output signal with a direct current component. This output signal is compatible with both for UV and Flame rod type burner controls.

[0025] The microcomputer monitors all the components in the overall system. The circuit test line verifies the flame signal processing modules are functioning properly. In the event they are not then the entire system will shut down.

[0026] The microcomputer also converts the information in each of the sensor frequency signals into the RS485 communication format. This allows the transmission of this data over great distances (up to 3000 feet).

[0027] The DIP switch 109 is the operator interface, which indicates to the microcomputer the total number of sensors, connected (Flame rod, or Ultraviolet).

[0028] Turning now to the schematic drawing labeled Quanta-Max Logic board. The watchdog is comprised of U9-A, U9-B, U9-D, and four diodes. The Microcomputer sends pulses to the watchdog circuit through C22 while it is running. If the microcomputer should freeze or shut down and not send the pulses the output from U9-A would go high and send a reset signal to the microcomputer on the reset input. The DIP switches S3 and S2 set the configurable operational parameters. They are connected to the microcomputer through the parallel shift registers U17 and U16 and the SPI bus. U12 is the EEROM which stores the non-volatile information needed by the microcomputer U11. The circuit comprising U5 and U6 is the RS485 communication output device controlled by output PC7 of the microcomputer.

[0029] Turning now to the schematic drawing labeled Quanta-Max 5003-01 M.S01. The step down transformer T1 receives 115 volts on the primary. The secondary has two windings. One 5k6 is for supplying power (+5V) to the microcomputer. The voltage is rectified through U4 and filtered by C13. The second winding is used for the analog power to the flame rod circuit generating +12V and -12V through U20 and U19.

[0030] Turning now to the schematic drawing labeled Quanta-Max 5003-01 M.S02.
The circuit comprising D1, D3, D4, D5, D8, D9 and capacitors C2, C3, C7, and C8 comprise the voltage multiplier creating the voltage at UV (535VDC) ON THE SENSOR SELECT that supplies the voltage to the UV sensing tube. If there is a jumper between the center pin and the UV pin on SENSOR SELECT. The SENSOR line will connect to one of 16 inputted UV sensors. The frequency of negative pulses across C4 corresponds to the flame intensity. Through C4 the sensor is connected to an opto-isolator. The output UV5SIG connects to the microcomputer input Tcap. When the jumper is between the center pin and FR on SENSOR SELECT. The circuit comprising C29, D7, D2, R1, R3, R7, R9 R4, R8 and U1A is a voltage clamping circuit used in conjunction with the “flame diode” effect from the flame rod. The AC voltage is clamped through C29 and the “flame diode” with a negative bias. The amount of this bias is proportional to the amount of flame detected. The negative side of the bias is measured relative to the positive side through D2 and the divider R3 & R1. The positive side is measured through D2 and R7 & R9. The negative side is filtered by C6 and the positive side is filtered by C9. Negative and positive is combined and amplified by the op amp U1. The output of U1 goes to a voltage to frequency converter, which uses the formula shown at the bottom to determine the frequency. The output of the frequency converter goes to the microcomputer pin 2.

Turning now to the schematic drawing labeled Quanta-Max 5003-01M.S03. The switch SW1 determines the number of sensors connected through a parallel to serial converter U8 and connects to the microcomputer through the SDI bus. L1 and L2 are indicating LEDs. L1 indicates that the output circuit is active and L1 indicates the Flame signal is present. The circuit comprising D21, R68 and U15 is controlled from the microcomputer output Ttemp through U9. When pulsed by the microcomputer this circuit creates a pulsed DC output, which is equivalent to the DC current required by a flame rod type burner control. The DC pulses are also equivalent to the frequency pulse requirement of the Ultraviolet type burner controls. This allows a unique interface to various burner controls in the industry. The Fault Relay is a supervisory relay and will open the output circuit in the event of a failure. The Flame Relay is energized through Q2 in the event that a flame is detected. The relay contacts are supervised through the opto-coupler U3 and the rectifier U14.

Turning now to the schematic drawings labeled Quanta-Max 5003-01M.S04 and Quanta-Max 5003-01M.S05. OP3 through OP 16 are solid state switches each activated by an opto-coupler controlled by PAO-7 from the microcomputer. These are used to selectively connect one of 16 sensors, one at a time into the sensor signal processing circuit.

The entire system as described provided a level of flexibility and reliability over a long distance, which the industry does not have at present. This invention will receive the input of multiple flame sensors, process that information and produce a single or multiple output signals completely indistinguishable to the burner control. In addition it provides a communication means for transmitting the flame signal information into a format readily acceptable to computers and distributed control systems. The foregoing description of various preferred embodiments of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obvious modifications or variations are possible in the light of the above teachings. The embodiments discussed were chosen and described to provide the best illustration of the principles of the invention and its practical application to thereby enable one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the invention as determined by the appended claims when interpreted in accordance with the breadth to which they are fairly, legally, and equitably entitled.

What is claimed is:

1. A communication system for a plurality of flame sensors in a single or multiple burner system with a connection required between the sensors at a remote location and the burner control or controls, comprising in combination

   a transmitting module each having an input for connection to a flame sensing transducer exposed to a flame to be sensed, each having an output for producing an electronic level signal indicative of the sensed flame or group of sensed flames;

   a receiving module for receiving the information from the transmitting module upon detection of a flame or loss of a flame from a burner or extinguished burner and identifying the identity of the burner or extinguished burner and the time at which the burner is established or extinguished;

   a display module with memory means associated with the processor for displaying the signal status of each flame transducer and recording status information at the time of occurrence of loss of signal condition, the status information including the identity of any extinguished burner and the time at which said extinguished burner extinguished.

2. The combination as set forth in claim 1 wherein the electronic programmable processor includes manually settable means for specifying the number of flame sensors in a particular system.

3. The combination as set forth in claim 1 wherein the memory means includes non-volatile memory means for storing status information on the system, the nonvolatile memory means having sufficient capacity to store information on all burners and maintain said storage in the event of power failure upon system shutdown.

4. The combination as set forth in claim 1 in which each flame sensor input to the transmitting module includes an output signal at the receiving module associated with a sensing transducer when the sensing transducer detects a flame, the output signal corresponding to the output signal from the sensing transducer and capable of interfacing to the corresponding burner control for the sensing transducer.

5. The combination as set forth in claim 1 wherein the memory means includes a plurality of words of storage for storing information regarding system faults as they are detected for later scanning of the stored fault information to detect patterns therein.

6. The combination as set forth in claim 1 in which the control system includes a flame watchdog timer triggered by
the processor and having an output serving as an enabling signal for fault relay which enables the flame sensing output.

7. The combination as set forth in claim 6 in which a flame present signal generated by the transmitting module when polling the flame sensors is operatively associated with the flame watchdog timer to enable the flame watchdog timer to respond to trigger pulses from the processor only in the presence of the flame present signal.

8. The combination as set forth in claim 8 wherein the flame watchdog timer has a reset input, and means coupling the reset input to the processor for enabling the flame watchdog timer in a normal mode to sense the flame present signal and provide an output signal to the transmitting module.

9. The combination as set forth in claim 8 including a further watchdog timer having a trigger input connected to the microcomputer for being serviced periodically within the time constant of the further watchdog timer, an output from the further watchdog timer being connected to a fault relay for control thereof, the output of the watchdog timer serving to energize the fault relay and terminate the flame present signal in the event the further watchdog timer is not triggered by the processor.

10. The combination as set forth in claim 1 including an analog-to-digital converter associated with the processor and with the flame sensors, a multiplexer connected to an analog signal from the flame sensors indicative of flame quality, and having an output connected to the analog-to-digital converter for digitizing flame quality signals and passing them to the processor for storage.

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