

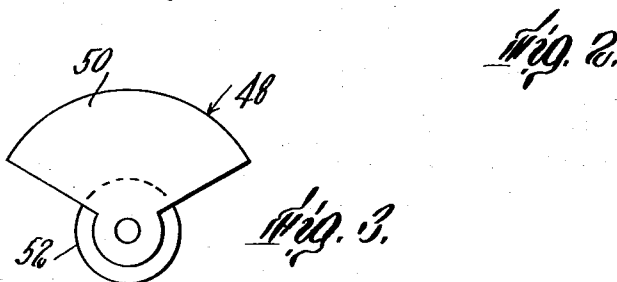
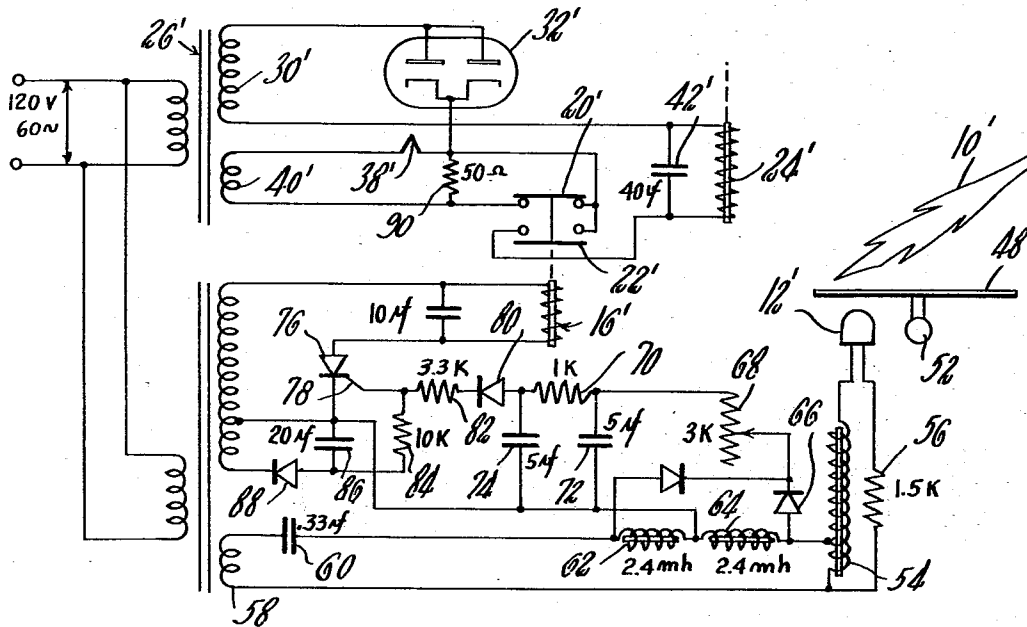
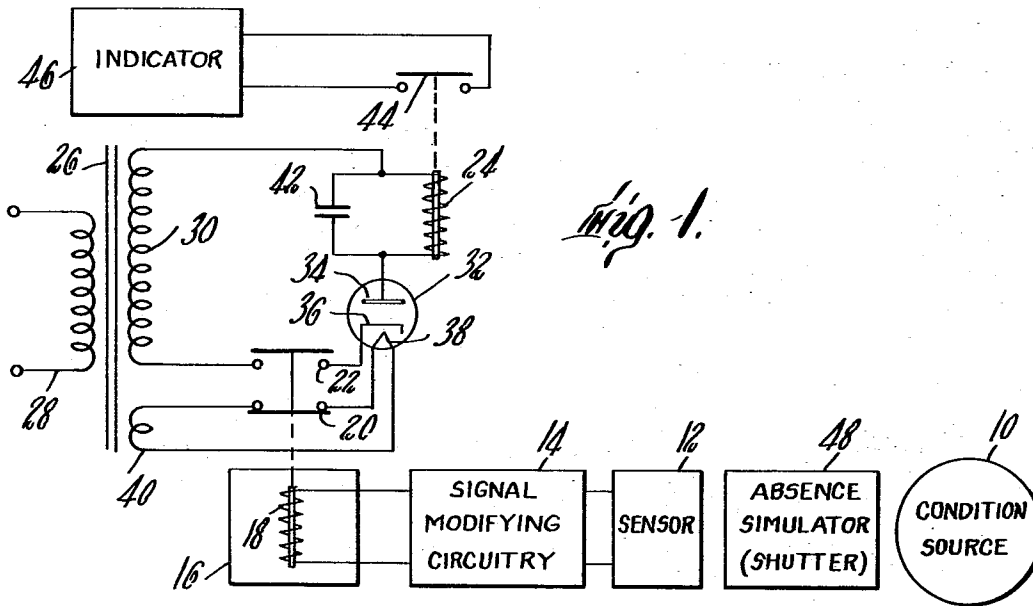
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**P. GIUFFRIDA**

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## CONTROL APPARATUS WITH TIME DELAY USING RECTIFIER

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## CONTROL APPARATUS WITH TIME DELAY USING RECTIFIER

Philip Giuffrida, North Andover, Mass., assignor to Electronics Corporation of America, Cambridge, Mass., a corporation of Massachusetts

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The present invention relates to improved control apparatus and more particularly to condition responsive systems such as those useful in supervising fuel burning systems, and to means for insuring reliable operation of the sensory and signal modifying portions of such systems.

In condition responsive systems of the type employed for the supervision of flame established in a combustion chamber, it is desirable that the supervising system react very quickly to the presence or absence of flame so that the fuel valve may be closed quickly and prevent an excessive amount of unburned fuel from accumulating in the combustion chamber in the absence of flame. Flame sensing systems which have the desirable rapid response to the presence or absence of flame are well known, but such systems are susceptible to component malfunction and may cause the flame detecting system to falsely indicate the presence of flame. Should such a malfunction occur in a system supervising flame in a combustion chamber, an unsafe condition might arise as the system, in the event of flame failure, would continue to react as if flame was present and permit the continued introduction of raw fuel into the furnace chamber. The accumulated raw fuel could be ignited explosively, either by the hot refractory or upon an attempt to reignite the burner for example, with disastrous results.

Industry standards specify that approved combustion control systems must operate with a maximum time delay of four seconds between flame failure and shut down of the fuel flow to the supervised combustion chamber. Component checking arrangements which check the operability of the system by simulating flame failure therefore must complete their cycle through flame relay drop out and flame relay pickup within that time.

Accordingly, it is an object of this invention to provide novel and improved condition sensing systems incorporating a component checking arrangement whereby the operation of the condition sensing system is checked at regular intervals to insure the system or system components have not failed in a manner enabling the system to falsely indicate the presence of the condition to be sensed.

A further object of the invention is to provide a novel and improved flame detecting system particularly useful with combustion supervision systems.

In accordance with the invention there is provided a condition sensing system employing a condition sensor and signal modifying circuitry which operates an output device to control an indicator device of the DC type. Connected in circuit with this indicator device is a rectifier of the thermionic type. The output device conditions the rectifier by applying energy to its heater circuit when the condition is not sensed by the sensor. When the condition is sensed by the sensor, the output device first interrupts the heater circuit and then completes an indicator device energizing circuit. Due to the fact that the rectifier retains its rectifying characteristics for a short period of time after its heater circuit has been opened, a DC signal is applied by the rectifier to the indicator device when the indicator energizing circuit is completed. The indicator device then provides an indication that the condition to be detected has been sensed.

Also included in the system is a means to periodically simulate a condition absence. Typically, such device may

be a shutter which is interposed between the condition source and the sensor. When the sensor fails to detect the condition presence, it releases the output device to interrupt the circuit to the indicator device and then re-energizes the heater circuit of the rectifier. Through suitably chosen simulator timing increments the system will continue to indicate the presence of the condition being sensed as long as that condition is present. Should the condition be absent, the output device will open the indicator circuit, and the indicating device will drop out within the period of its time delay as a function of the absence of the condition. However, should a system failure occur independently of the condition in which the sensing circuitry and output device continues in a position indicating the presence of the condition (an unsafe failure condition), the heater circuitry would not be energized in response to the simulator, and within a short time the rectifier's characteristics would become inadequate to maintain the indicator device energized, and it will drop out, indicating a condition absence (a safe failure condition).

Where such a system is employed in a combustion supervision system, the sensor is responsive to flame within the combustion chamber, and typically the indicating device is a relay. The relay is timed so that in condition failure it will drop out within a period of less than four seconds, and a thermionic rectifier is selected so that it will cease to have adequate rectifying properties if its heater circuit remains open more than about thirty seconds. Thus, should any of the system components from the flame sensor to the output relay fail in unsafe condition, the thermionic emission will decrease so that the rectifier will be placed in non-rectifying condition and the indicator relay will drop out.

This monitoring system provides a reliable check on system operability through the simple mechanism of controlling the enabling of a rectifier as a function of the sensor response. The only components, in addition to those needed for the basic combustion supervision system, are a shutter or other periodically operative condition absence simulator and a flame relay contact connected in the heater circuit of a thermionic emission type of device employed in the indicator relay circuit.

Other features, objects and advantages of the invention will be seen as the following description of a preferred embodiment of the invention progresses in conjunction with the drawing in which:

FIG. 1 is a diagram of a condition sensing system, partly in schematic form and partly in block diagram form, of the invention;

FIG. 2 is a schematic diagram of a preferred embodiment of a combustion supervision system constructed in accordance with the principles of the invention; and

FIG. 3 is a diagram of the shutter blade employed in the system shown in FIG. 2.

With reference to FIG. 1 there is shown in diagrammatic form a condition source 10 and a condition sensor 12 that is typically disposed in optically coupled relation to the condition source 10. The condition sensor 12 may be a photocell, for example, which, in response to radiation from source 10, produces an output signal, and that signal via suitable signal modifying and/or amplifying circuitry 14 operates an output device 16. For convenience that device is illustrated as a relay having solenoid 18, a set of normally closed contacts 20, and a set of normally open contacts 22. The relay contacts 20 are connected in series circuit with a load relay 24 which is energized from a transformer 26 having a primary winding 28 and a secondary winding 30. Connected in series with the load relay 24 is a rectifier 32 including an anode 34, a cathode 36, and a heater element 38. The heater element 38 is connected through normally closed

contacts 20 to the heater energizing winding 40 of transformer 26. The cathode of the rectifier is connected to normally open contacts 22. A capacitor 42 is connected across the load relay 24 and in a combustion supervision system provides a delay in release of the load relay contacts 44 of less than four seconds in accord with Underwriters Laboratory requirements. This delay may be different in other applications. The load relay contacts 44 are connected to a suitable indicating device 46 which may be an alarm or may control the solenoid of a fuel valve in a combustion supervision system.

Also included in circuit is an absence simulator 48 which may be a shutter or other device which causes the system periodically to respond as if the sensor has not seen the condition from the source 10.

In operation, with the circuit components in the position shown in FIG. 1 and the absence simulator deactivated, the rectifier 32 had been placed in rectifying condition through energization of its heater 38. When sensor 12 sees a condition sensed from source 10 which causes the output device (relay 16) to be energized, opening contacts 20 and closing contacts 22. Due to the thermionic lag characteristic of the rectifier even though its heater circuit has been opened and no more power is supplied to the heater, it continues to function as a rectifier.

When contacts 22 close, the rectifier is connected in circuit with the transformer winding 30 and load relay 24, and direct current is applied to close contacts 44. The load relay will drop out as soon as the rectifier ceases to have adequate rectifying properties, plus the time delay provided by capacitor 42 unless a checking function occurs.

This checking function is provided by the absence simulator 48 which causes the system to respond as if the sensed condition is not present. If all the circuit components are operating properly, the output device 16 will drop out in response to condition absence produced by simulator 48 to open contacts 22 and close contacts 20. In this manner the rectifier heater circuit will be re-energized recreating the rectification properties of the rectifier 32. The capacitor 42 holds the load relay 24 in energized condition for the predetermined period, and the simulator, within that period, allows the system to respond to the condition source. If the system operates properly, the output device 16 then responds to open contacts 20 and close contacts 22 to again complete the circuit to the load device. Thus, the system is regularly cycled to check its operability in a manner which maintains the system loads in energized state as a function of the sensed condition.

A failure of any component in a manner to cause output device 16 to respond in a condition absence manner will open relay contacts 22 and the load device will be de-energized within the delay time of that device. Other types of failures in which the output device 16 remains in energized position (indicating that the condition is present) cause the rectifier characteristics to become inadequate within a period determined by the rectifier design and the load relay 24 will then drop out. Should the anode-cathode circuit of the rectifier short, the direct current load relay 24 will not receive DC but rather AC, and again it will drop out.

A specific embodiment of circuitry suitable for use in a flame sensing system is shown in FIG. 2. In that figure, the condition corresponds to the flame 10', the simulator is a shutter 48' which has one blade 50 (FIG. 3)—an opaque sector of about 120°. A motor 52 is provided to drive the shutter 48' at a six r.p.m. rate. An ultraviolet radiation sensing tube 12' of the avalanche discharge type acts as the condition sensor and is disposed in optically coupled relation to the flame 10' in the combustion chamber, for example. The output device is a flame relay 16' which controls contacts 20' and 22'. Connected in the circuit is a load relay 24' with a capacitor 42' parallel

with the relay solenoid. A thermionic diode 32' (e.g. type 6X4) is connected in circuit across the secondary of transformer winding 30'. The filament 38' for the diode is energized by a 6.3 volt winding 40'.

The sensor 12' is connected across the secondary of auto-transformer 54 in series with a suitable current limiting resistor 56. The primary of the autotransformer is energized by transformer winding 58 and connected in series in the energizing circuit are capacitor 60 and two readout inductors 62, 64. The capacitor is sized in proportion to the transformer to simulate a resonant circuit to present a relatively low input impedance when the sensor tube 12' does not see the radiation to be sensed. Upon breakdown of the sensor tube, a relatively high frequency signal is coupled from the secondary back into the primary, and one of the inductors 62, 64, depending on the polarity of the signal, couples a pulse through a diode 66 and input pulse shaping and integrating circuit including resistors 68, 70 and capacitors 72, 74. When a sufficient charge has accumulated on capacitor 74, silicon controlled switch 76 is turned on via control electrode 78 which is connected to capacitor 74 through diode 80 and voltage dividing network 82, 84. The switch circuitry includes biasing network of capacitor 86 and diode 88. Connected to the switch is flame relay 16', and when that relay is energized in response to the UV tube sensing flame, it operates to connect diode 32' in circuit to energize the load 24'.

When the condition is sensed and the shutter 48' is operating properly, the circuitry will sequence through one check cycle every ten seconds. Due to the configuration of the shutter blade 50, the sensor 12' does not see flame (even though it is present) for about 2.2 seconds out of each ten second cycle (the period when the shutter totally obscures the sensor 12'). Thus, in this embodiment the sensor ordinarily sees flame about seventy-eight percent of the time.

When the sensor does not see flame, the flame relay 16' drops out, opening the circuit to the load relay. The circuit is designed so that the load relay remains held in for a period of three seconds. In the event of proper system operation, the UV tube 12' will see flame again after 2.2 seconds and cause the flame relay to pick up again well within the three second timing period delay afforded by capacitor 42' so that the load relay remains held in. Should that cycle not occur, the flame relay will drop out after the three second period and shut down the system safely.

However, should a component of the checking or monitoring system fail, as, for example, should the shutter 48' bind so that the flame absence is not periodically simulated, the load relay energizing circuit will remain completed, but the rectifying characteristics of diode 32' will dissipate as its cathode cools off, and after a period in the order of fifteen-thirty seconds, that device will cease its rectifying properties and an open load relay circuit will result. It will be noted that the check cycle time (ten seconds) is substantially less than the diode rectifying time (fifteen-thirty seconds) so that normally the cathode is regularly reheated so that it remains hot and is not poisoned under normal operating conditions.

It has been found preferable to apply current to the heater at rated voltage for at least about 20 percent of each cycle to maintain uniform thermionic emission response of the vacuum tube. If desired, a resistor 90 may be connected in parallel with the heater to reduce the cycling shock on that element.

It will be seen that the checking cycle of this system has a duration substantially longer than the drop out delay of the load relay—ten seconds as against three seconds in the described embodiment. The nature of the checking cycle is principally determined by the drop out time of the load relay and the length of time the heater of the thermionic emission device must be energized in each cycle. These two factors control the effective length of the

absence simulation in the checking cycle, and thus in the described embodiment it should not be substantially less than two seconds (20 percent of ten seconds) nor greater than three seconds (the load relay drop out delay).

While a preferred embodiment of the invention and modifications thereof have been shown and described, it will be understood that other modifications may be made there. For example, a multi-element heater-type vacuum tube may be used instead of a diode in the checking circuitry. A variety of condition absence simulators may be employed, including those that effectively disable the sensor by opening its circuit, for example. Therefore, it is not intended that the invention be limited to the disclosed embodiment or to details thereof, and departures may be made therefrom within the spirit and scope of the invention as defined in the claims.

What is claimed is:

1. A condition sensing system comprising a condition sensor,

signal modifying circuitry connected to said sensor, an output device responsive to signal from said signal modifying circuitry when said sensor senses a condition,

a load device,

thermionic rectifying means connected in series with said load device,

said thermionic rectifying means including a heater, and means responsive to said output device to energize said heater and to connect said thermionic rectifying means and said load device in energized circuit relationship alternately as a function of the output signal from said condition sensor.

2. In a condition sensing system having a condition sensor,

an output device responsive to the signal from said sensor and a load device responsive to said output device,

checking circuitry including means to simulate a condition absence,

thermionic rectifying means connected in series with said load device,

said thermionic rectifying means including heater means, and

means responsive to said output device to energize said heater means and to disconnect said thermionic rectifying means from said load device when the sensor produces a condition absent signal, and to de-energize said heater means and connect said thermionic rectifying means in energized circuit relationship to said load device when said condition sensor produces a condition present signal.

3. Apparatus for continually checking a detector system that is to detect a predetermined event and a load, coupled to said system, said system being in one condition when said predetermined event is detected and in a second condition at other times, comprising

means for repetitively subjecting said detector system to a simulation of said predetermined event,

control means adapted to be connected in circuit relation to said load to define a load-control means circuit,

said control means including an element having thermionic emission characteristics and element heating means,

means to energize said element heating means to place said control means in a state of thermionic emission and to disable said load-control means circuit when said system is in a first condition, and to deenergize said element heating means and to enable said load-control means circuit when said system is in the other condition.

4. A condition sensing system comprising a condition sensor for producing an output signal as a function of the presence of the condition to be sensed,

a load device,

thermionic emission means, and

means responsive to a first output signal condition from said sensor to energize said thermionic emission means and responsive to a second output signal condition alternate to said first output signal condition to connect said thermionic emission means and said load device in energized circuit relationship.

5. In a condition sensing system having a condition sensor,

an output device responsive to the signal from said sensor and having first and second conditions, and a load device responsive to said output device and having a predetermined release delay,

checking circuitry including means to simulate a condition absence,

means to operate said absence simulator to simulate a condition absence for an interval shorter than said predetermined release delay,

rectifying means connected in energizing series circuit with said load device,

said rectifying means including an electrode element and heater means for heating said electrode element to produce thermionic emission,

means responsive to said output device in said first condition to energize said heater means and to de-energize said series circuit, and

means responsive to said output device in said second condition to deenergize said heater means and to energize said series circuit.

6. The checking circuitry as claimed in claim 5 wherein said absence simulator is a shutter and said simulator operating means interposes said shutter between said sensor and the condition to be sensed.

7. The checking circuitry as claimed in claim 6 wherein said simulator operating means operates said simulator at intervals substantially greater than said predetermined release delay.

8. A combustion supervision system comprising a flame sensor adapted to be disposed to sense flame in a combustion chambers and to produce an output signal as a function of sensed flame,

an output device responsive to said output signal and having first and second conditions,

a load device,

thermionic emission means,

means to periodically simulate absence of flame,

means responsive to said output device in said first condition to energize said thermionic emission means, and

means responsive to said output device in said second condition to connect said thermionic emission means and said load device in energized circuit relationship.

9. In a combustion supervision system having a flame sensor arranged for sensing flame in a combustion chamber,

a flame relay responsive to the signal from said flame sensor and having first and second conditions, and

a load relay responsive to said flame relay and having a predetermined release delay,

checking circuitry including means to simulate absence of flame,

means to operate said absence simulator to simulate a flame absence for an interval shorter than said predetermined release delay,

rectifying means connected in energizing series circuit with said load relay,

said rectifying means including an electrode element and heater means for heating said electrode element to produce thermionic emission,

means responsive to said flame relay in said first condition to energize said heater means and to de-energize said series circuit, and

means responsive to said flame relay in said second con-

dition to deenergize said heater means and to energize said series circuit.

10. The checking circuitry as claimed in claim 9 wherein said absence simulator is a shutter and said simulator operating means interposes said shutter between said sensor and the flame in said combustion chamber.

11. The checking circuitry as claimed in claim 10 wherein said simulator operating means operates said simulator at intervals substantially greater than said predetermined release delay.

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RALPH G. NILSON, *Primary Examiner*.

M. ABRAMSON, *Assistant Examiner*.