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CHECKING APPARATUS FOR CONDITION RESPONSIVE-SYSTEM

Filed July 25, 1963

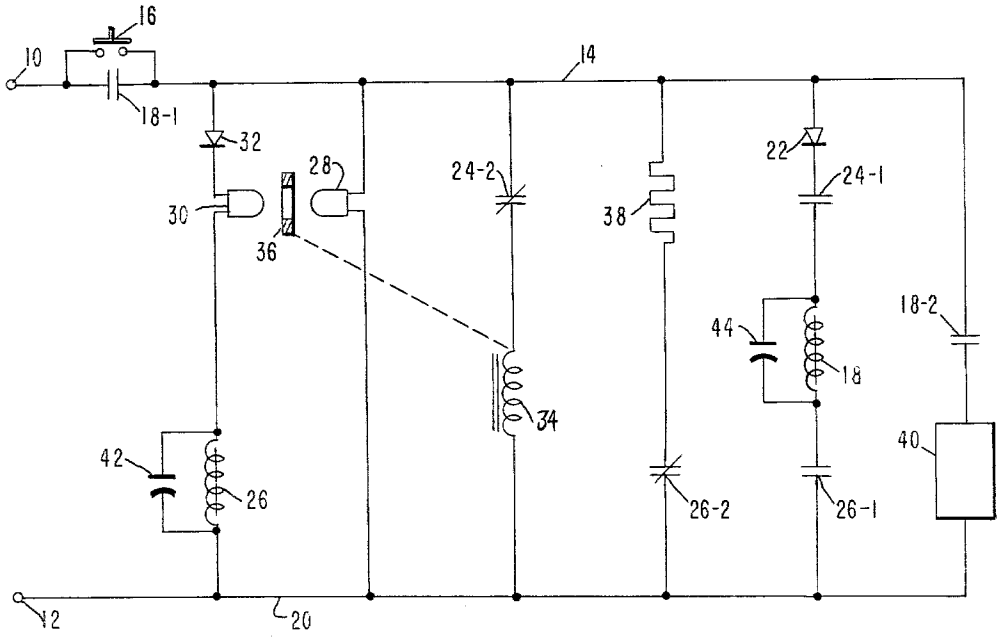


FIG.1

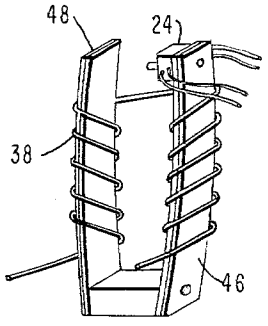


FIG.2

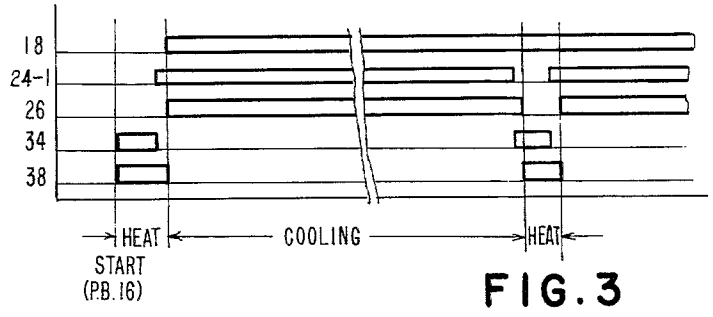


FIG.3

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CHECKING APPARATUS FOR CONDITION RESPONSIVE SYSTEM

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This invention relates to control apparatus and more particularly to condition responsive apparatus 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 apparatus.

In condition responsive systems, as for example those used for supervision of combustion established in a furnace chamber, it is desirable that the system react very quickly to the presence or absence of a flame so that excessive amounts of unburned fuel will not accumulate in the chamber in the absence of flames. Electronic flame sensing systems have the desirable rapid reaction to presence or absence of flame, but such systems are susceptible to malfunctions such as, for example, a continuously avalanching sensor of the gas-discharge type which falsely indicates flame presence or a runaway transistor which continuously passes substantial current to a flame responsive device in the absence of the flame signal normally required to initiate and sustain such current flow. Should such a failure occur, it would be an unsafe type as the sensing system would, in the event of flame failure, continue to react as if flame were present and would therefore permit continued fuel introduction. In such a case the chamber can accumulate an excessive charge of fuel or fuel vapor which might be ignited explosively by the hot refractory or upon an attempt to reignite the burner. If the sensing system through component failure erroneously indicates the absence of flame, however, fuel introduction will be terminated and the failure is of a safe type.

In order to check the integrity of such condition responsive systems, it has been proposed to employ a condition absence simulator which operates repetitively at intervals shorter than the deactuation time of the load control device. Failure of the condition responsive device to react properly to the simulated condition absence results in deactivation of the controlled loads. A major disadvantage of this system is the limited life of those mechanical portions thereof which, because of the rapid repetition rate, amass a large number of operations within a relatively short period of time.

Another proposal has been to utilize a timing motor to periodically initiate a condition absence simulation, with the interval between such simulations being appreciably longer than the response time of the load control device. Whereas the less frequent operation of the checking apparatus contributes to its longer life expectancy, there is no assurance against malfunctions of the checking apparatus itself, and when such occur there is no continuing check on the integrity of the condition responsive system.

Accordingly, it is an object of this invention to provide novel and improved control apparatus for checking condition responsive systems.

Another object of the invention is to provide novel and improved control apparatus for use with condition responsive systems which incorporate means to periodically simulate the absence of the condition being sensed and means to check the continued operation of the condition absence simulator.

Another object of this invention is to provide a self-checking condition responsive system in which the checking events are provided at intervals substantially longer than the predetermined delay provided in the system between loss of the sensed condition and operation of load devices in response to such loss.

Another object of the invention is to provide a simplified checking system for a condition responsive system in which the checking components alternate between a first position and a second position and return to the first position only once during each checking cycle, which cycle is substantially longer than the system delay provided between the loss of sensed condition and operation of load devices in response to such loss.

A further object of the invention is to provide a simplified control circuit particularly useful in combustion supervision systems in which the condition sensor will shut down the circuit in substantially immediate response to the sensing of the absence of the condition, and in which the operation of the condition sensor is checked at frequent and regular intervals, the sensor and the checking circuitry being interconnected so that they actuate each other automatically.

Still another object of the invention is to provide a novel and improved flame detection control circuit which utilizes inexpensive and reliable components which may be manufactured in a compact unit including means for regularly simulating a flame failure condition and means to check the operation of that simulator.

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

FIG. 1 is a schematic diagram of control circuitry constructed in accordance with the invention employed in a combustion supervision arrangement;

FIG. 2 is a diagrammatic view of mounting of thermally actuated time delay relay employed in the preferred embodiment of the invention; and

FIG. 3 is a timing diagram indicating the operating sequence of components in the control circuitry of FIG. 1.

With reference to FIG. 1, a 120 volt 60 cycle power source is applied at terminals **10**, **12** of the control circuitry. Connected in parallel between terminal **10** and line **14** is a normally open, momentarily operated push button **16** and holding contacts **18–1** of load control relay **18**. The load control relay **18** is connected between lines **14** and **20** through diode **22**, normally open timer relay switch contacts **24–1** and normally open condition indicating relay contacts **26–1**.

Condition source **28** is shown connected between the lines **14** and **20**. This source may be completely independent of the control circuit or a controlled source that is initially energized by the push button control **16** and may, for example, be the flame in the combustion chamber of a burner installation. Disposed adjacent source **28** is a condition sensor **30** which may be a photocell sensing visible radiation from the flame, an infra red radiation sensor or a Geiger-Muller type of ultraviolet sensor responsive to a particular frequency range of radiation from the flame, for example. This condition sensor **30** is connected across lines **14** and **20** in series with diode **32** and the condition indicating (flame) relay **26**. Normally, signal modifying and/or amplifying circuitry is employed between the sensor **30** and condition indicating device **26**, but such circuitry has been omitted to simplify the drawing.

Also connected across lines **14** and **20** is a simulator solenoid **34** which operates a shutter **36** for positioning between the condition source **28** and the sensor **30**. Solenoid **34** is controlled by normally closed timer controlled contacts **24–2**. Other types of simulators may also be employed, the illustrated arrangement merely being one suitable type.

The actuator 38 for the switch 24, which in the preferred embodiment is a heating coil wound about two bimetallic elements of the type shown in FIG. 2, is connected through normally closed contacts 26–2 operated by the condition indicating relay 26 across lines 14 and 20. Finally, also connected across lines 14 and 20 in series with normally open contacts 18–2 of load control relay 18 is a load generally indicated at 40 which may be a solenoid controlled fuel valve, for example, in a combustion supervision system.

The solenoid coil of relay 26 has a capacitor 42 connected across it which in combination with the impedance of the coil holds that relay in during the half cycles of line voltage blocked by diode 32, but does not substantially delay the drop out of the relay when an absence of the condition to be sensed is detected. Capacitor 44, connected across the solenoid coil of relay 18, holds that relay in for a period of three seconds after deenergization of its coil.

The timer delay relay in the illustrated embodiment includes a miniature mechanical switch unit 24 having normally open contacts 24–1 and normally closed contacts 24–2. In the preferred embodiment this unit is mounted on a first bimetallic strip 46 and in spaced relation from a second bimetallic strip 48. These strips are arranged so that they move toward each other under the influence of heat applied by the resistance heater element 38 wound about both of them. Improved operating characteristics of this relay are obtained through this mounting arrangement. This relay has an operating cycle of about one minute, which is initiated when the control circuit is energized and relay 26 is deenergized. Heat from the heater 38 causes the bimetal elements 46, 48 to move toward one another to operate switch 24, opening contacts 24–2 and closing contacts 24–1. When the heater 38 is de-energized a timing cycle is started and as the bimetal elements cool, they move apart and ultimately release the switch 24, normally in about one minute. Other timing devices, such as slow drop out relays having similar operating cycles, may also be used.

In operation the control circuit is initially energized by depressing push button 16 which applies electrical power to line 14. This energizes the condition source 28 (when connected as shown in FIG. 1), simulator solenoid 34 and heater 38. As soon as heater 38 has brought strips 46, 48 toward one another to operate switch 24, contacts 24–1 close and contacts 24–2 open, the latter de-energizing simulator solenoid 34. With the withdrawal of shutter 36, detector 30 can view the flame or other condition from source 28 and will energize the condition indicating relay 26, closing contacts 26–1 and opening contacts 26–2. The opening of contacts 26–2 de-energizes thermal element 38 and the strips 46, 48 start to cool. Load control relay 18 is energized with the closing of contacts 26–1 (switch contacts 24–1 already being closed) to close holding contacts 18–1 and load contacts 18–2.

The system now continuously senses flame or other condition from source 28 and should the sensor 30 detect absence of the condition, solenoid 26 will promptly be de-energized and open contacts 26–1, de-energizing the solenoid of load control relay 18 so that relay drops out in the three seconds time delay. With the drop out of relay 18 the load 40 is de-energized, and the holding contacts 18–1 are opened, de-energizing the entire control circuit.

Should no condition failure be detected, as is the usual case in a combustion supervision system, the bimetal elements 46, 48 gradually cool until they have moved apart sufficiently for the contacts 24–1 and 24–2 to return to their original states as shown in FIG. 1, de-energizing the load relay circuit and energizing the solenoid 34 to interpose shutter 36 between the sensor 30 and source 28. This simulated condition absence de-energizes the condition indicating relay 26, opening contacts 26–1 and closing contacts 26–2.

The circuit to the load control relay 18 is opened by contacts 26–1, but at the same time current flow, applied to heater 38 through closed contacts 26–2, moves the strips 46, 48 toward one another quickly. As soon as the time delay relay opens contacts 24–2 solenoid 34 is de-energized. Contacts 24–1 close and condition indicating relay 26 is again energized as soon as sensor 30 sees the flame for example so that the load control relay circuit is again complete with the closing of contacts 26–1, within a time substantially less than the drop out delay of relay 18. This cycle is repeated as determined by the cycle of the time delay relay to regularly simulate condition absence.

If the sensor 30 or its associated signal modifying circuitry should fail in condition indicating condition (unsafe failure), relay 26 would not drop out when the shutter 36 is positioned between the source and the sensor at the end of a control cycle. Contacts 26–2 remain open, preventing reheating of the timer control strips 46, 48, and, since contacts 24–1 are open, the load control relay 18 will shortly drop out for de-energization of the load and the checking circuit. Thus the sensor and its circuitry is checked regularly for failure. The timer relay switch 24 operating cycle is initiated by de-energization of the timer switch actuator (via contacts 26–2) and a cycle is completed after a preestablished period of de-energization of the heater. Should the switch actuator not be de-energized due to failure of solenoid 26 to open contacts 26–2, the load control circuit remains open (cross connected contacts 26–1) so that the load is de-energized in safe condition. In the preferred embodiment the actuator for contacts 24–1, 24–2 comprises two spaced juxtaposed bimetal strips 46, 48 which control the opening of contacts 24–1 as the result of a cooling process. Such process ensues if the bimetal heater 38 fails in a manner to discontinue heating with resulting safe de-energization of the load. The bimetal strips employ in their action no hinge, linkage or other mechanism which may bind to prevent their proper action. The actuator for safety contact 24–1 is thus an inherently fail-safe device.

Thus it will be seen that the invention provides a self-checking condition responsive system which utilizes a minimal number of components in a simple, economical and yet reliable arrangement. The circuit automatically checks itself regularly with minimum mechanical wear on its components. While a preferred embodiment of the invention has been shown and described, various modifications thereof will be obvious to those skilled in the art, and 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.

We claim:

1. A condition responsive system comprising a condition sensor,

a condition indicating device controlled by said senor to indicate the presence or absence of the sensed condition,

a load control device controlled by said condition indicating device, said load control device having a predetermined release delay after de-energization,

simulator means for allowing said condition indicating device to assume a first state independently of the presence or absence of the condition being sensed,

a timer operative independently of the presence or absence of the condition being sensed in a timing cycle of duration greater than the release delay of said load control device,

electrically operated timer control means coupled to said timer for initiating a timing cycle upon de-energization of said control means,

timer responsive means to actuate said simulator means at the end of said timing cycle,

means responsive to said condition indicating device in said first state to energize said timer control means and de-energize said load control device,

and means responsive to the energization of said timer control means to deactuate said simulator means.

2. A condition responsive system comprising a condition sensor,

a condition indicating device controlled by said sensor to indicate the presence or absence of the sensed condition,

a load control device controlled by said condition indicating device, said load control device having a predetermined release delay after de-energization,

simulator means for allowing said condition indicating device to assume a first state independently of the pressence or absence of the condition being sensed,

a thermally responsive timer operative independently of the presence or absence of the condition being sensed, which provides a timing cycle of duration greater than the release delay of said load control device, as a function of its cooling rate,

a timer responsive control element having first and second operative states,

means to apply heat to said timer to place said timer responsive control element in said first operative state,

means responsive to said timer responsive control element being in said second state to operate said simulator means,

means responsive to said condition indicating device in said first state to energize said heat applying means and de-energize said load control device,

and means responsive to said timer responsive control element in said first operative state to de-energize said heat applying means.

3. A combustion control system comprising a flame sensor,

a flame relay controlled by said flame sensor to indicate the presence or absence of flame in the supervised combustion chamber,

a load control device controlled by said flame relay, said load control device having a predetermined release delay after de-energization,

simulator means for allowing said flame relay to be de-energized independently of the presence of flame in said combustion chamber,

a timer operative independently of the presence or absence of the condition being sensed to provide a timing cycle of duration greater than the release delay of said load control device,

electrically operated timer control means coupled to said timer for causing said timer to initiate a timing cycle,

timer responsive means to actuate said simulator means at the end of said timing cycle,

means responsive to the de-energization of said flame relay to de-energize said load control device and to energize said timer control means,

and means responsive to the energization of said timer control means to deactuate said simulator means and permit re-energization of said flame relay.

4. The system as claimed in claim 3 wherein said timer control means includes a thermally responsive actuator,

said actuator providing said timing cycle as a function of its cooling rate.

5. A combustion control system comprising a flame sensor,

a flame relay responsive to said flame sensor,

a load control device responsive to said flame relay, said load control device having a predetermined release delay after de-energization,

simulator means to allow said flame relay to indicate the absence of flame,

a timer operative independently of the presence or absence of flame in a timing cycle of duration greater than the release delay of said load control device,

a time responsive simulator actuator,

said actuator adapted to actuate said simulator to allow said flame relay to indicate the absence of flame when in a first state and adapted to deactuate said simulator to permit the energization of said load control device when in a second state,

and means responsive to the de-energization of said flame relay to cause said timer to initiate a timing cycle.

6. The system as claimed in claim 5 wherein said timer includes a thermally responsive timing element and said actuator includes a circuit controlling switch responsive to said timing element,

said circuit controlling switch being connected to actuate said simulator when said actuator is in said first state and to energize said load control device when said actuator is in said second state.

7. The system as claimed in claim 6 wherein said thermally responsive element includes two bimetallic elements disposed in juxtaposed spaced relation and said circuit controlling switch is mounted on one of said bimetallic elements.

8. A condition supervision system comprising a condition sensor adapted to provide a signal indicating the presense of a supervised condition,

condition indicating means controlled by said condition sensor, said condition indicating means having a first state indicating the presence of the supervised condition and a second state indicating the absence of the supervised condition,

a load control device having a predetermined release delay after de-energization,

means responsive to said indicating means being in said first state to energize said load control device,

a timer having a timing cycle of substantially greater duration than said release delay, said timer having a first state during each said timing cycle and a second state at the end of each said timing cycle,

simulator means responsive to said timer in its second state for allowing said condition indicating means to be placed in its second state independently of the presence of the supervised condition,

and means responsive to said condition indicating means being in said second state for placing said timer in said first state.

9. A condition responsive system comprising means to supply energy to said system,

a condition sensor,

a condition indicating device controlled by said sensor to indicate the presence or absence of a sensed condition,

a load control device connected for energization directly from said supply means and controlled by said condition indicating device, said load control device having a predetermined release delay after de-energization,

simulator means for allowing said condition indicating device to assume a first state independently of the presence or absence of the condition being sensed,

a timer operative independently of the presence or absence of the condition being sensed in a timing cycle of duration greater than the release delay of said load control device,

timer responsive means to actuate said simulator means at the end of each timing cycle,

means responsive to said condition indicating device being in said first state for causing said timer to initiate a timing cycle and to de-energize said load control device,

and means responsive to the initiation of a timing cycle to de-actuate said simulator means.

10. A combustion control system comprising means to supply energy to said system,

a flame sensor,

a flame relay controlled by said sensor to indicate the presence or absence of flame in a supervised combustion area,

a load control device connected for energization directly from said supply means and controlled by said flame relay, said load control device having a predetermined release delay after de-energization,

simulator means for allowing said flame relay to assume a first state independently of the presence or absence of flame in the area being supervised,

a timer operative independently of the presence or absence of flame in a timing cycle of duration greater than the release delay of said load control device,

timer responsive means to actuate said simulator means at the end of each timing cycle,

means responsive to said flame relay being in said first state for causing said timer to initiate a timing cycle and to de-energize said load control device,

and means responsive to the initiation of a timing cycle to de-actuate said simulator means.

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NEIL C. READ, *Primary Examiner.*