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2,870,329

FLAME SENSING CIRCUIT

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Fig. 1

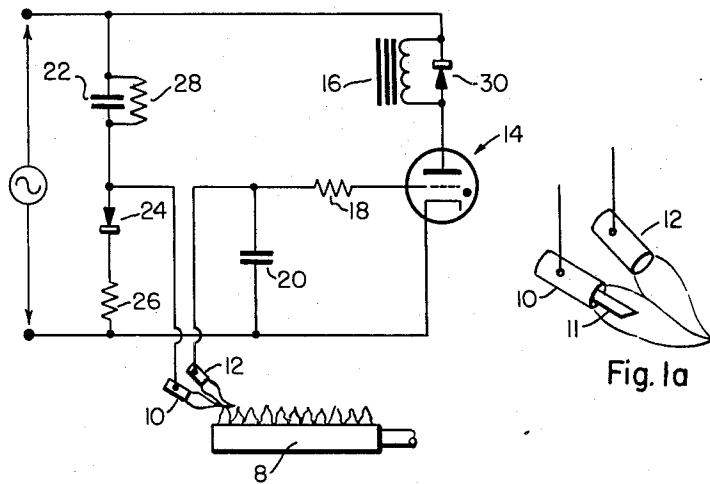


Fig. 1a

Fig. 2a

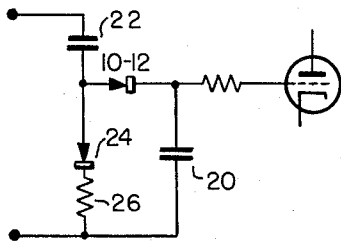


Fig. 2b

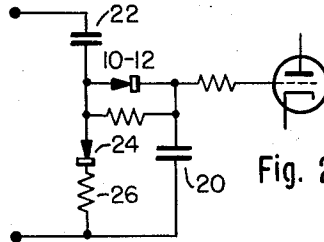


Fig. 2c

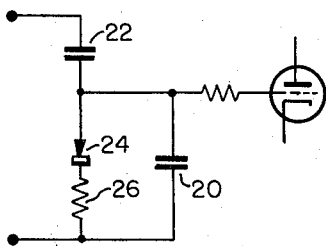
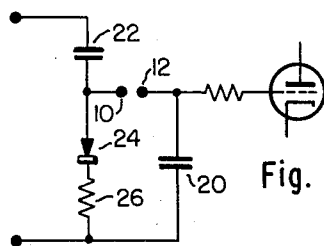


Fig. 2d



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2,870,329

FLAME SENSING CIRCUIT

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3 Claims. (Cl. 250—27)

This invention relates to combustion control systems and provides a novel flame sensing circuit by which such systems may be operated in response to the presence or absence of a flame at a burner.

An important safety feature of any combustion control system is its ability to respond to a flame failure in a manner causing the apparatus to shut down. Moreover, the system should also respond to any defect in its own functioning that might develop which would render it incapable of sensing a flame failure. It should, in other words, fail safe.

The circuit of this invention utilizes a flame as a component of an electronic circuit. The electrical characteristics of a flame are well appreciated in the art, and have been utilized heretofore in control systems as shown in U. S. Reissue Patent No. Re. 20,210 and in the copending application of applicant and Andrews, Ser. No. 368,708 filed July 17, 1953. A characteristic of circuits through flames is a lower resistance in one direction than in the other, by which a substantial degree of rectification is obtained when an A. C. potential is applied. In the circuit of the present invention the rectification characteristic of the flame is utilized in a manner such that a flame failure results in an open circuit while a shorting out of the flame path destroys the rectification characteristics of the normal flame path. In either case, the circuit causes a flame responsive relay to de-energize, and through it an appropriate program control system may be operated to cause the apparatus to shut down.

The flame sensing circuit of this invention utilizes a circuit in which the control electrode of an electronic tube circuit is maintained at a potential in excess of a threshold level through the rectification action of the flame path. This is conveniently achieved by biasing the control electrode by a condenser which is charged through the flame path from a circuit providing an alternating voltage generally below the threshold level.

In its preferred embodiment the electronic tube is an A. C. energized cold cathode gas-filled triode having a plate (anode) circuit which includes a relay energized when a flame is present. The starter anode, which functions as the control electrode, is biased by a condenser which is charged through the flame path from a control circuit. The control circuit provides pulses of magnitude and phase such that their application directly to the starter electrode (as would happen if the flame path were short circuited) would not permit the tube to fire, but which when rectified will charge the condenser to a firing potential.

The circuit is accordingly responsive to a flame failure through opening of the control electrode circuit by which firing of the tube is prevented, and is also responsive to a shorting of the flame circuit, which would indicate an abnormal condition during which operation should be prevented, by the control electrode having applied to it a voltage insufficient to permit firing of the tube.

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A preferred and representative embodiment of the invention is described in detail below with reference to the accompanying drawings in which:

Fig. 1 is a circuit diagram of the preferred embodiment of the flame detector circuit,

Fig. 1a shows the pilot burners by which the flame circuit is established,

Fig. 2a is a diagram of the equivalent control circuit to the control electrode of the electronic tube during normal operation,

Fig. 2b is a diagram of the equivalent control circuit when partial shorting of the flame circuit has occurred,

Fig. 2c is a diagram of the equivalent control circuit when the flame circuit is entirely shorted, and

Fig. 2d is a diagram of the equivalent circuit when no flame is present.

In the circuit shown in Fig. 1 the flame sensing means consists of a pair of pilot burners 10 and 12 directed toward a main burner 8, the flames from which impinge so that through them a circuit between the burners is established. Such a circuit will generally be found to have rectifying characteristics, that is a higher conductivity when current is passed between the burners in one direction than when the current is flowed in the opposite direction. Such rectifying action may be considerable as when a metallic fin 11 is placed in the flame of one of the burners, e. g. burner 10 as shown in Fig. 1a, such that a greater area of contact with the flame is made at one burner than at the other. Current will then be conducted in one direction with far less resistance than in the other direction, apparently by virtue of electrically charged bodies which are carried by the flame. Rectifying action may similarly be provided by placing a pair of electrodes displaced from each other in the stream of a single flame.

The flame path through the burners 10 and 12 connects the control electrode of an electronic tube with a control circuit. In the illustrated embodiment the tube is an A. C. energized cold cathode gas filled triode 14, such as one designated 1C21, having a relay coil 16 in the anode circuit. The control electrode is the starter electrode which connects through a current limiting resistor 18 to a biasing condenser 20.

The flame circuit leads to the condenser 20 and in normal operation provides a circuit for charging the condenser 20 to maintain the voltage on the starter electrode at above the firing potential necessary under the conditions of positive anode voltage prevailing in the circuit. The voltage applied to the flame circuit through the burners 10 and 12 is obtained from a control circuit which is in parallel with the anode-to-cathode circuit of the tube 14. This circuit is designed to provide an alternating control signal feeding the flame circuit but related to the anode voltage to be of phase and magnitude such that the firing potential of the starter electrode is not attained at pilot burner 10. When rectified, however, by the action of the flame circuit, a sufficiently high potential at the starter electrode is developed through the biasing condenser 20 to permit the tube to fire when the anode is sufficiently positive.

The control circuit includes a control condenser 22 between the anode side of the line and the burner 10 and a rectifier 24 and resistor 26 in series between the burner 10 and the cathode side of the line. The rectifier 24 is poled with its positive side at the burner 10, so that current may flow through the control circuit when the anode of the tube 30 is positive during which time the condenser 22 is charged with the side connecting the burner 10 negative. The rectifier 24 prevents the negative pulses from discharging the condenser 22. The charge on that condenser thus is maintained such that the potential at the burner 10 during positive pulses

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is limited to a desirably low value. A resistor 28 across the control condenser 22 may also be provided to permit gradual discharge of the control condenser. The control circuit functions largely as a voltage divider by which pulses of reduced magnitude phased with the anode potential may be provided to the starter electrode circuit, these pulses being out of phase such that the instantaneous pulse voltage never reaches the starter electrode firing potential at any instant when the anode potential is high enough to permit firing. Thus, at the peak of the anode pulse the voltage from the control circuit is too low to cause firing, and at the peak of the control voltage pulse the anode potential is too low for firing.

The flame circuit through the burners 10 and 12 is connected so that its rectifying action permits current flow to the starter electrode, and minimizes flow in the opposite direction. The equivalent circuit to the starter electrode during normal operation is shown in Fig. 2a, and will be seen to provide for charging of the biasing condenser 20 at a high level, while discharging of it is minimized by the substantial unidirectional conductivity of the flame circuit indicated at 10-12.

The circuit accordingly provides in normal operation a sustained high voltage at the control electrode which permits proper firing of the tube when the anode is positive. A flame failure opens the circuit to the control electrode such that a firing potential is never developed. A short in the flame circuit results in discharging of the biasing condenser 20 through the rectifier 24 and resistor 26, and the control electrode thereafter receives only pulses of magnitude and phase inoperative to permit firing of the tube.

In a typical embodiment the various circuit elements are of the following dimensions:

Condenser 20	.025 μ F.
Resistor 18	40 megohms.
Condenser 22	.025 μ F.
Resistor 28	10 megohms.
Resistor 26	2.5 megohms.
Applied voltage & freq.	120 v., 60 cycles.

In its operation, an A. C. voltage, e. g. 60 cycles, 120 volts, is applied across the terminals, as indicated in Fig. 1 and when normal conditions at burners 10 and 12 are established the tube conducts during positive half cycles such that the relay coil 16 is energized. A clamp rectifier 30 across the coil permits flow of the self-induced current in the relay coil during non-conducting period of the tube.

The relay coil may be utilized in numerous ways to control the combustion apparatus, as by opening or closing switches in appropriate control circuits, such as in the manner of the flame detector actuated relay in the combustion control system shown in applicant's copending application, Ser. No. 575,142, filed March 30, 1956, filed concurrently herewith, now Patent No. 2,851,095, or in the combustion control systems described in the copending application of Aubert and Andrews, Ser. No. 412,161 filed February 24, 1954, and in applicant's copending application, Ser. No. 512,541 filed June 1, 1955, now Patent No. 2,804,254.

The effect of different types of abnormal conditions in the flame detector are shown schematically in Figs. 2b, 2c and 2d.

Parallel resistance across the burners may frequently be present while the condition is not in any way defective or abnormal. As will be apparent from Fig. 2b, the effect of such resistance will depend on its magnitude and its effect on the time constant of its circuit with the biasing condenser 20. If very large, it will not prevent the build-up of firing potential at the starter electrode, while if larger, such build-up will not occur. A degree of control over the level at which the appear-

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ance of resistance in parallel with the flame path will shut down the system is accordingly provided. Since a high resistance will generally be present due to imperfect isolation of the flame circuit and to the increased conductivity at high temperatures of ceramic materials of which much apparatus of this type is built, such may be permitted while the appearance of lesser resistance will be effective to cause deenergization of the relay 16.

The condition of short circuiting of the flame path is shown in Fig. 2c from which it will be apparent that the control electrode potential will be maintained at the inoperative voltage of the control circuit. Sensing of a short circuit is important, since if not sensed, such a short would render the flame detector insensitive to flame failure, and it would then not be effective as a safety device.

The condition of the control circuit existing when no flame is present, as upon flame failure, is shown in Fig. 2d. Since the circuit to the control electrode is open, the biasing condenser 20 is substantially uncharged, and no firing potential can be established at the starter electrode. As a result, the tube remains non-conducting, and the relay 16 remains de-energized throughout.

From the foregoing it will be seen that the tube 14 conducts only in periods of normal operation, at which time the relay 16 is energized. When no flame is present or when the burners are short circuited, conduction of the tube and energization of the relay 16 do not occur.

Although this invention has been described in detail with reference to a preferred and representative embodiment, it is contemplated that modifications will readily occur to those skilled in the art and acquainted with the principles of the invention, and that such modifications may be made without departing from the scope of the invention.

Having thus disclosed my invention and described in detail a preferred embodiment thereof, I claim and desire to secure by Letters Patent:

1. A flame sensing circuit comprising an electronic tube having a plate circuit including means responsive to a plate current and having a control electrode, a condenser for biasing said control electrode at a level permitting conduction of said tube during half cycle of applied alternating voltage when said plate is positive, a control circuit in parallel with said tube for generating pulses of instantaneous phase and magnitude such that when applied directly to said control electrode conduction of said tube does not occur but the peak values of said pulses being above said level, and a flame sensing circuit feeding said pulses to said condenser, said flame sensing circuit including means forming a path through a flame having rectifying characteristics whereby through rectification of said pulses said condenser is maintained charged at said level.

2. A flame sensing circuit comprising an electronic tube having a plate circuit including means responsive to a plate current and having a control electrode, a condenser for biasing said control electrode at a level permitting conduction of said tube during half cycle of applied alternating voltage when said plate is positive, a control circuit in parallel with said tube including a condenser and rectifier in series with the juncture thereof providing control pulses phased with the plate circuit, said control pulses being of instantaneous phase and magnitude such that when applied directly to said control electrode conduction of said tube does not occur but the peak values of said pulses being above said level, and a flame sensing circuit feeding said pulses to said condenser, said flame sensing circuit including means forming a path through a flame having rectifying characteristics whereby through rectification of said pulses said condenser is maintained charged at said level.

3. A flame sensing circuit comprising an electronic

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tube having a plate circuit including means responsive to a plate current and having a control electrode, a condenser connecting with said control electrode for biasing said control electrode at a level permitting conduction of said tube during half cycles of applied alternating voltage when the plate is positive, a control circuit for generating pulses of instantaneous phase and magnitude such that when applied directly to said control electrode conduction of said tube does not occur but the peak values of said pulses being above said level, and a flame sensing circuit connecting said control circuit with said condenser, said flame sensing circuit including means

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forming a path through a flame having rectifying characteristics whereby through rectification of said pulses said condenser is maintained charged at said level in normal operation.

References Cited in the file of this patent

UNITED STATES PATENTS

2,640,920	Cairns	June 2, 1953
2,685,645	Wannamaker	Aug. 3, 1954
2,767,351	Gieseke	Oct. 16, 1956
2,817,758	Westbrook	Dec. 24, 1957