

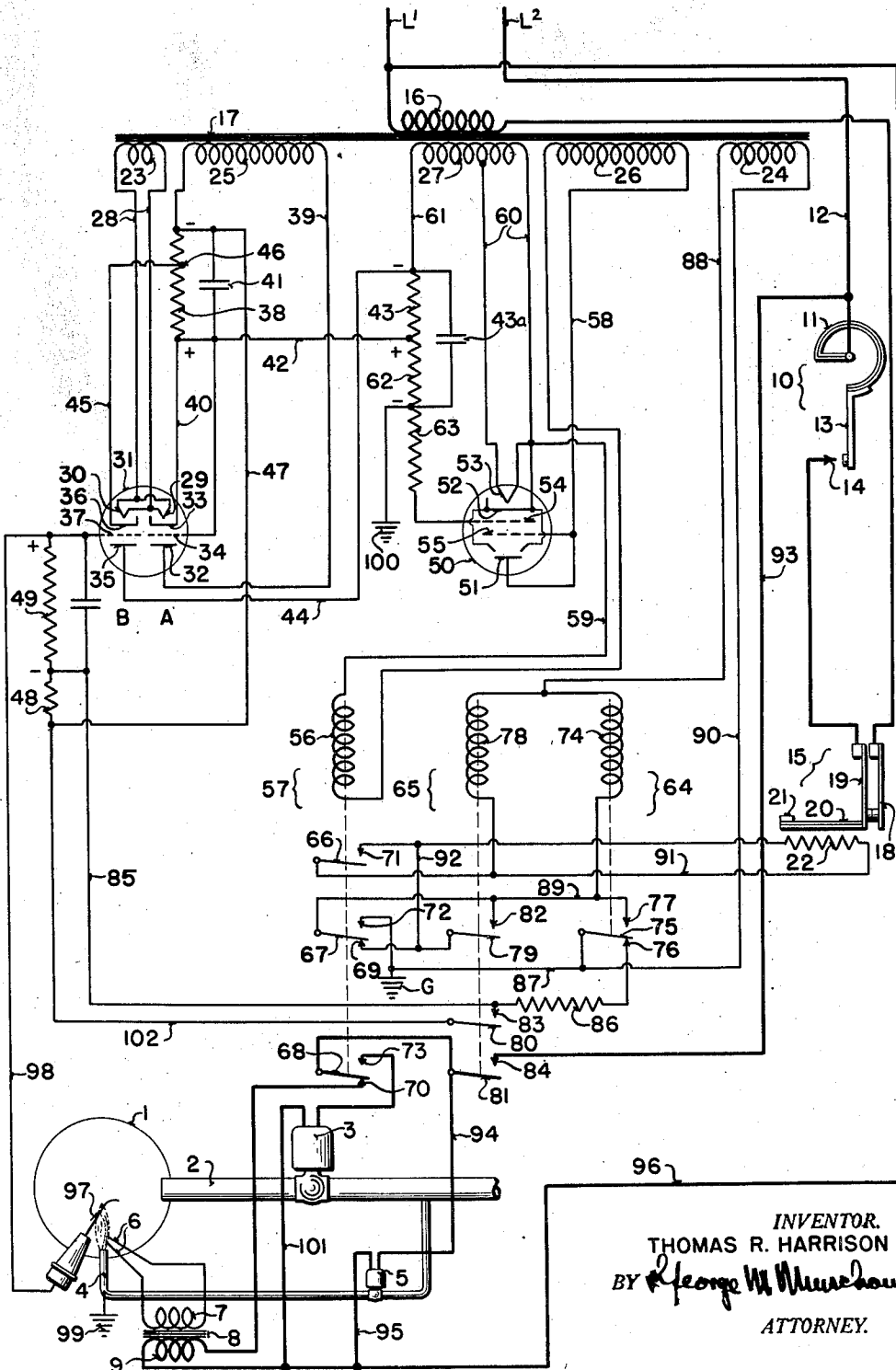
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CONTROL SYSTEM

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CONTROL SYSTEM

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The present invention relates to safety control systems for fuel burners and more particularly to safety control systems having means for distinguishing between normal and abnormal conditions of combustion.

A general object of the invention is to provide an improved safety control system for a fuel burner that shall operate in accordance with the conductivity of a flame of the burner fuel.

Another object of the invention is to provide a safety control system of the flame responsive type which utilizes an electric discharge device the conductivity of which is changed substantially immediately upon the presence of a flame by utilizing the conductive property of the flame.

A further object of the invention is to provide a safety control system of the flame responsive type which employs a pair of electrodes, one of which may be the burner itself, in engagement with the flame for measuring the flame conductivity, and wherein means are provided for distinguishing between normal flame conductivities and apparent conductivities of the path between the electrodes that may be set up due to accidental engagement of the electrodes or established by virtue of carbonization thereof.

In combustion control systems which have been proposed heretofore, various means have been employed for determining if combustion conditions are proper, and whether combustion actually takes place, one such means comprising an electrode which extends into the flame of the burner and which is so connected in the system as to provide a conductive path of relatively low resistance to ground through the flame. The variation in the electrical conductivity of this path to ground when a flame is present and when a flame is not present is commonly employed to change the bias on the control grid of an electronic valve for controlling a thermal safety switch. Since there is a possibility that a low resistance path may be set up from the electrode to ground through other agencies than by means of the flame, for example, a low resistance path which may be established between the flame electrode and ground by reason of carbonization, by accidental touching of the electrode to ground, or by other abnormal conditions simulating combustion, provisions have been made in devices of the prior art for preventing the fuel supply and ignition from being turned on when such abnormal conditions exist.

Since an abnormal condition of this character simulating combustion may arise after the system is already in operation, it is desirable to

provide means for distinguishing between such abnormal conditions and natural combustion while the system is in operation. For example, in a thermostatically controlled house heating system, if the control system is insensitive to the presence of the flame after initial ignition of the flame, the fuel feeding means will be operated continuously as long as the room thermostat is closed. If the flame should then be extinguished, the furnace will be flooded with atomized fuel and a highly explosive mixture of the latter will be permitted to accumulate.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, its advantages and specific objects attained with its use, reference should be had to the accompanying drawing and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

The figure of the drawing shows a gas burner 1 supplied with gas through conduit 2 and the flow of gas to the burner is controlled by an electrically operated or other suitable valve 3. A pilot burner 4 is provided which is controlled by an electrically operated or other suitable valve 5, and means are provided for igniting the pilot flame including a pair of electrodes 6 which are connected to the terminals of a secondary winding 7 of an ignition transformer 8 having a primary winding 9 which is adapted to be energized from the alternating current supply lines L¹ and L².

The fuel valve operating circuit of my control system is controlled by means of a thermostat 10 which may be located in a room or space to be heated. The thermostat 10 may be of any suitable construction and includes a bimetallic element 11 connected by means of conductor 12 to line L², and a contact blade 13 adapted to engage a stationary contact 14 which is connected to line L¹ through a thermal switch 15 and winding 16 of a transformer 17.

The thermal switch 15 is preferably of the form disclosed in the Patent 1,958,081 issued to F. S. Dennison May 8, 1934. As shown more or less diagrammatically in the drawing, this switch comprises a stationary arm 18 and a movable arm 19 biased for movement away from arm 18 but normally held in engagement with the latter by means of a bimetallic element 20. Element 20 is rigidly secured at one end to a block 21 and is arranged to be heated by a coil 22 when

the latter is energized through a circuit which will later be described. Upon energization of coil 22 for a predetermined period of time, element 20 will be warped sufficiently in the clockwise direction to permit arm 19 acting under spring or other bias to separate from switch arm 18 thereby interrupting the circuit including thermostat 10. The switch 15 will remain locked in this position until manually returned to its normal closed position.

The transformer 17 which supplies power for the control system is a combination step-up and step-down transformer and comprises the line voltage primary winding 16, low voltage secondary windings 23 and 24, and high voltage secondary windings 25, 26 and 27. The low voltage secondary winding 23 is connected by conductors 28 to the heater filaments 29 and 30 of an electronic valve 31 and supplies energizing current thereto. The electronic valve 31 is a twin type amplifier valve, for example, an R. C. A. type 6C8, and includes two triodes in one envelope. One triode of valve 31 functions as a rectifier to supply a source of direct current voltage for the second triode and the latter functions as an amplifier. For convenience, the first mentioned triode will hereinafter be referred to as triode A and the second mentioned triode as triode B. The triode A includes an anode 32, a cathode 33, the heater filament 29, and a control electrode 34 which, as shown, is connected directly to the cathode 33, and the triode B includes an anode 35, a cathode 36, the heater filament 30, and a control electrode 37. The transformer secondary winding 25 is connected in a circuit including the triode A and a voltage divider resistance 38 which may be traced from one terminal of the transformer secondary winding 25 to a conductor 39, anode 32 of triode A, cathode 33, and a conductor 40 in which the resistance 38 is inserted to the other terminal of the winding. A condenser 41 is desirably connected across resistance 38 for filtering out the pulsations in the direct current flows therethrough. A substantially smooth direct current is thus established across the voltage divider resistance 38 by the half wave rectifying action of triode A.

Direct current anode voltage is supplied the triode B from the voltage divider 38 through a circuit which may be traced from the positive terminal of divider 38 to a conductor 42, a resistance 43, a conductor 44, anode 35 of triode B, cathode 36, and a conductor 45 to a tap 46 on the divider. Negative bias voltage is impressed on the control electrode 37 of triode B by the voltage divider 38 through a circuit which may be traced from the negative terminal of the divider to a conductor 47 in which a pair of resistances 48 and 49 are inserted, the control electrode 37, cathode 36 and conductor 45 to the tap 46 on the divider. This negative bias voltage is adjusted to such a value that, when it is the only potential impressed between the control electrode and cathode of triode B the latter will be rendered substantially non-conductive. A circuit including the resistance of the path of the pilot flame of the burner and described in detail hereinafter is provided for reducing the negative bias on the control electrode 37 so that the conductivity of the triode B is adapted to be controlled in accordance with the resistance of the said path.

The triode B operates to control the conductivity of a second electronic valve 50 which may be of the type known commercially as beam power

amplifier valves, for example, an R. C. A. type 6L6. Valve 50 includes an anode 51, a cathode 52, a heater filament 53, a control electrode 54, and a screen electrode 55 which, as shown, is connected directly to the anode 51. Anode voltage is supplied the valve 50 from the transformer secondary winding 26 through a circuit which includes the winding 56 of a relay 57 and may be traced from one terminal of winding 26 to a conductor 58, anode 51, cathode 52, and a conductor 59 in which the winding 56 is inserted, to the other terminal of the transformer winding. Energizing voltage is supplied the heater filament 53 from an end portion of the transformer secondary winding 27 through conductors 60. The terminal at this end of the winding 27 is also connected to the cathode 52 of valve 50 and the other terminal is connected by a conductor 61 in which the resistance 43 and resistances 62 and 63 are inserted to the control electrode 54. Winding 27 thus tends to impress an alternating potential between the cathode 52 and control electrode 54 and is so wound relatively to the winding 26 as to render the control electrode 54 negative with respect to the cathode 52 during the half cycles when the anode 51 is positive. It will be noted, however, that the direct current potential drop produced across resistance 43 by the flow of anode current from triode B continuously tends to render the control electrode 54 positive with respect to the cathode 52 so that the conductivity of valve 50 is adapted to be controlled in accordance with the conductivity of the triode B.

As illustrated in the drawing a plurality of relays designated by the reference numerals 57, 64, and 65 are employed in the control system. The main function of the relay 64, which is controlled by the relay 57 is to check the operation of the system before the fuel igniting and fuel feeding means are permitted to operate, and after combustion has been established to bring about the desired operating conditions. Energization of the relay 57 will result in the closing of an energizing circuit to the relay 64 and, only if normal conditions of combustion are present, the relay 57 will be deenergized and a combustion producing condition of the system will be established. Deenergization of the relay 57 then results in the closure of an energizing circuit to the relay 65 which functions to establish the conditions necessary for combustion.

The relays 64 and 65 are alternating current relays and receive energizing current from the transformer secondary winding 24. The relay 57 is a direct current relay and, as noted hereinbefore, is connected in the output circuit of the electronic valve 50. Winding 56 of relay 57 is operatively associated with three switch blades, 66, 67 and 68 which are gravity or spring biased in a downward direction and when the winding 56 is deenergized, the blades 67 and 68 engage contacts 69 and 70, respectively. When the relay is energized, the blades 66, 67 and 68 move upward into engagement with contacts 71, 72 and 73 respectively.

The relay 64 comprises a winding 74 which is operatively associated with a switch blade 75. This blade is biased by gravity or spring means in a downward direction into engagement with a contact 76, and when the winding is energized moves upward out of engagement with contact 76 and into engagement with a contact 77.

The third relay 65 comprises a winding 78 which is operatively associated with three switch

blades 79, 80 and 81. These blades are similarly biased in a downward direction and are adapted to be moved into engagement with contacts 82, 83 and 84, respectively, upon energization of the relay winding 78.

When the temperature of the room or space to be controlled falls below the value it is desired to maintain, the thermostat 10 operates to move the switch blade 13 into engagement with the contact 14 resulting in closure of an energizing circuit to the transformer primary winding 16 and thereby energization of the transformer secondary windings. As soon as cathode 33 of valve 31 becomes heated, a direct current voltage appears across the voltage divider 38, which, because of the connections previously described, causes a negative bias voltage to be applied between the control electrode 37 and the cathode 36. As noted hereinbefore, however, circuit connections are provided for reducing the negative bias in response to the presence of a flame of the pilot burner, which circuit connections will now be described.

When the system is initially energized, the various relays are in the positions shown in the drawing and the control electrode 37 is connected to the positive terminal of the voltage divider 38 through a circuit including the control electrode 37, resistance 49, a conductor 85 in which a resistance 86 is inserted, contact 76, switch arm 75, a conductor 87 to ground G, from ground G to ground 100 and thence to the point of engagement of resistances 62 and 63, through resistance 62 and conductor 42 to the positive terminal of the divider 38. The result of this connection of the control electrode 37 to the positive terminal of divider 38 is that the control electrode 37 is subjected to a positive voltage which reduces the negative biasing circuit described sufficiently to cause a current to flow between anode 35 and cathode 36. As noted hereinbefore, the anode circuit of triode B includes the resistance 43 and when the triode B is thus rendered conductive a potential drop is produced across resistance 43 which operates to reduce the negative bias maintained between the control electrode 54 and cathode 52 of valve 50 by the transformer secondary winding 27 and thereby causes a current to flow between the anode 51 and cathode 52.

The flow of this anode current through the relay winding 56 is effective to cause the switch arms 66, 67 and 68 to move upward into engagement with contacts 71, 72 and 73, respectively, and to close the previously mentioned energizing circuit to the relay 64. The movement of arm 67 into engagement with contact 72 establishes an energizing circuit through the relay winding 74 which may be traced from the left end terminal of the transformer secondary winding 24 to a conductor 88, relay winding 74, a conductor 89, switch arm 67, contact 72, conductor 87, and a conductor 90, to the other terminal of the winding 24. The establishment of this energizing circuit for relay 64 causes the switch blade 75 to be moved into engagement with the contact 77 and such engagement establishes a holding circuit for the relay 64 which may be traced from conductor 88, relay winding 74, contact 77, switch blade 75, conductor 90, and the transformer secondary winding 24, to the conductor 88.

At the same time that the switch blade 75 moves into engagement with contact 77 it moves out of engagement with contact 76, and since the previously traced connection between the control electrode 37 of valve 31 and the positive

terminal of voltage divider 38 depended upon the engagement of switch arm 75 and contact 76, the control electrode 37 is now subjected only to the negative biasing voltage between the tap 46 and the negative end of the voltage divider 38. The result is that the grid potential is now sufficiently negative to render the triode B non-conductive and since no current then flows through the resistance 43, the potential on the control electrode 54 of valve 50 is increased in the negative direction and the latter is rendered non-conductive thereby deenergizing the relay winding 56.

It will be noted that subsequent engagement between switch blade 67 and contact 69 establishes an energizing circuit to the relay winding 78 which may be traced from the conductor 88, relay winding 78, conductor 91 in which the heater winding 22 of the thermal safety switch 15 is inserted, a conductor 92, contact 69 switch blade 67, conductor 89, contact 77, switch blade 75, conductor 90, and the transformer secondary winding 24, to the conductor 88. This circuit is energized only because the previously mentioned holding circuit for the relay winding 74 has been closed. The energization of winding 78 causes the relay arms 79, 80 and 81 to be moved into engagement with the contacts 82, 83 and 84, respectively. The engagement of switch blade 79 with contact 82 closes a holding circuit for the relay winding 78 from one end of the transformer secondary winding 24, conductor 88, relay winding 78, conductor 91, heating element 22, conductor 92, contact 79, contact 82, conductor 89, contact 77, switch blade 75, and conductor 90, and the other terminal of the transformer secondary winding. The establishment of the holding circuit just traced functions to render the energization of relay winding 78 independent of relay 57 so that when the relay 57 becomes reenergized, as subsequently takes place, the relay 65 will remain energized. It is pointed out, however, that the energizing and holding circuit for relay winding 78 includes the heating element 22 of the thermal safety switch 15 so that as soon as the winding 78 is energized, the heating element of the thermal safety switch begins to heat the bimetallic element 20.

When the relay 65 is energized, the resulting movement of the switch blade 81 into engagement with the contact 84 results in the establishment of the following circuit through the operating means for the valve 5 which controls the supply of fuel to the pilot burner:—from supply line L², conductor 93, contact 84, switch blade 81, conductor 94, the pilot valve actuating means 5, conductors 95 and 96 to the supply line L¹. The establishment of this circuit causes the valve controlling the pilot to be opened with the result that fuel is fed thereto. At the same time, the ignition transformer 8 is energized through a circuit including supply line L², conductor 93, contact 84, switch blade 81, conductor 94, switch blade 68, contact 70, the ignition transformer primary winding 9 and conductor 96 to the supply line L¹. This energization of the primary winding of the ignition transformer 8 causes a high voltage to be induced across the terminals of the secondary winding 7 which is applied to produce a spark across the electrodes 6.

Combustion will now take place if combustion conditions are proper and the control system will subsequently operate to open the main fuel valve and to deenergize the ignition transformer. As soon as a flame appears at the pilot

burner, a circuit is established through the flame which circuit operates to reduce the negative bias on the control electrode 37 and to render the triode B conductive. The plate current conducted by the latter then operates to render the valve 50 conductive and thereby to reenergize the relay 57. As will be described hereinafter, reenergization of the relay 57 results in operation of the main fuel valve and deenergization of the ignition means.

The means for reducing the negative bias on the control electrode 37 for rendering the triode B conductive and subsequently causing opening of the main gas valve 3 includes an electrode 97 which is insulated from the burner and is suitably positioned in the pilot flame. This electrode is connected through a conductor 98 to the control electrode 37. The pilot burner is connected to ground as indicated at 99 and the positive terminal of the voltage divider 38 is connected to ground through conductor 42 and resistance 62 as indicated at 100. When a flame of lower resistance than the air gap appears at the pilot burner by reason of the same being lighted, an electrically conductive path is established between the control electrode 37 and the positive terminal of the divider 38. The resistance 62 is provided to prevent the control electrode 37 from being subjected to too high a voltage if the electrode should accidentally be connected directly to ground, and also operates in a manner to be described to reduce the conductivity of valve 50 on such an occurrence and to thereby cause deenergization of the system. A condenser 43a may desirably be connected across the resistances 43 and 62 as shown in the drawing to filter out any alternating components in the current flow through resistance 43 from triode B and which may be introduced as a result of any stray E. M. F.'s induced in the conductor or the flame electrode 97.

When the triode B is thus rendered conductive, the resulting energization of relay 57 operates to move the switch arms 66, 67 and 68 into engagement with the contacts 71, 72 and 73, respectively. Movement of the arm 68 out of engagement with contact 70 causes the previously traced circuit through the primary winding 9 of the ignition transformer 8 to be interrupted with the result that the ignition means is deenergized. At the same time movement of the arm 68 into engagement with contact 73 establishes an energizing circuit to the valve actuating means 3 from supply line L², conductor 12, conductor 93, contact 84, switch blade 81, conductor 94, switch blade 68, contact 73, the control valve 3, a conductor 101, and conductor 96 to the supply line L¹. The main fuel valve 3 is then opened and fuel is admitted to the burner, 1, which fuel is subsequently ignited by the pilot flame.

The system is not permitted to open the main fuel valve, however, until a check has been made on the insulation resistance of the system. Referring to the drawing it will be noted that until the relay 65 is energized, the negative biasing circuit for the triode B includes resistances 48 and 49. As soon as the relay is energized, however, with the resultant moving of switch blade 80 into engagement with contact 83, the resistance 48 is shunted out by a circuit which may be traced from one end of resistance 48, conductor 85, contact 83, switch blade 80, and a conductor 102 to the other terminal of resistance 48. It is thus seen that until relay 65 is

energized the resistance between the control electrode 37 and the negative terminal of divider 38 is greater than after energization so that during the initial stages of operation of the system the control electrode is biased less negatively.

The advantage obtained in so biasing the grid less negatively during the initial stages of operation and increasing this bias later on is that if, through insulation leakage or due to accidental connection of the flame electrode 97 with the burner, a resistance path of the order of the flame resistance exists between the flame electrode and ground, the bias on the control electrode 37 will remain sufficiently low so that the triode B will be conductive. Since it is necessary for the triode B to be non-conductive before the relay 65 can be energized, the latter will not be energized in the event of the occurrence of such a leakage resistance between the flame electrode and ground.

In this manner a check is made on the insulation resistance of the system while at the same time provision is made against a faulty check of the presence of a flame being made by virtue of the bias on the control electrode 37 not being sufficiently negative that the system is too sensitive. By cutting out resistance 48 it is necessary that there be a material reduction in the resistance in the circuit between the control electrode 37 and the positive side of divider 38, such as that occurring when a flame bridges the gap between the pilot burner and the flame electrode 97, before the triode B will be again rendered conductive.

The reenergization of relay 57 with the resultant movement of switch blades 66 and 67 into engagement with their respective contacts 71 and 72 establishes a new holding circuit for relay winding 78 which does not include the heating resistance 22 of the thermal safety switch 15, but which shunts that resistance. This circuit may be traced from conductor 88, winding 78, conductor 91, switch blade 66, contact 71, conductor 92, switch blade 79, contact 82, conductor 89, contact 77, switch blade 75, conductor 90, and the transformer secondary winding 24 to the conductor 88. Short circuiting of the resistance 22 in this manner operates to render the thermal safety switch 15 inoperative and the system will then remain in operation as long as normal combustion conditions exist and the thermostat 10 is in closed position.

If, for any reason, the pilot burner should not become lighted, the potential of the control electrode 37 will not be raised sufficiently to cause reenergization of relay 57. The result will be that the last traced holding circuit for the relay winding 78 will not be established and the current flowing therethrough must pass through the heating element 22 of the thermal safety switch. After a predetermined period, this will cause the bimetallic element 20 to be heated sufficiently to result in separation of the switch blades 18 and 19. The separation of the latter opens the circuit to the primary winding 16 of transformer 17 and deenergizes the entire system. As was previously noted, the switch blades 18 and 19 cannot be automatically reset so that it is necessary for an attendant to investigate the condition which prevents ignition of the pilot burner before the system can again be put into operation.

As was mentioned hereinbefore, if a low resistance path is established between the flame

electrode 97 and the pilot burner 4 after the system is in operation, for example, due to carbonization of the flame electrode, or direct engagement of the latter with the burner, the system will immediately operate to close the main fuel valve. Referring to the drawing, it will be noted that when a flame is present, a closed circuit exists from the positive terminal of the voltage divider 38 to conductor 42, resistance 62, to ground 100, ground 99, the flame electrode 97, conductor 98, resistance 49, the shunt circuit about resistance 48, and conductor 47, to the negative terminal of the divider. The current which flows in this circuit produces a potential drop across resistance 62 which is in a direction to impress a negative potential on the control electrode 54 of valve 50 but which due to the high resistance of the flame is normally ineffective to render the valve 50 non-conductive. On the occurrence of a low resistance connection between the flame electrode 97 and the burner, however, an increased current will flow in the circuit to produce a potential drop across resistance 62 of a magnitude sufficient to render the valve 50 non-conductive and thereby to cause deenergization of relay 57. The circuit shunting the heating element 22 of the thermal safety switch 15 will then be opened and the energizing-current for relay winding 78 will flow through said element and subsequently the thermal safety switch will operate to deenergize the system.

Thus means have been provided for avoiding the disadvantages of certain devices of the prior art wherein the establishment of a low resistance path between the flame electrode 97 and ground while the system is in operation remains undetected. It is noted that if carbonization of the electrode 97 occurs to a sufficient degree to reduce the resistance between the electrode and ground to a predetermined low value, the system will operate to close the fuel supply valve. The presence of other abnormal conditions producing the same low resistance path from the flame electrode to ground will operate in a similar manner to deenergize the system. It is thus seen that the system may be so proportioned that slight variations in the conductivity of the flame will not cause the system to be deenergized but if the resistance of the path from the flame electrode to ground decreases to an abnormally small value, the system will be deenergized.

While in accordance with the provisions of the statutes I have illustrated and described the best form of embodiment of my invention now known to me, it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit of my invention as set forth in the appended claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A safety control system including in combination, a burner, means for supplying fuel to said burner, means for igniting said fuel to establish a flame, a device to control said fuel supplying means and having a position in which it causes said fuel supplying means to assume a fuel supplying condition and a position in which it causes said fuel supplying means to assume a

condition preventing the supply of fuel, an electric discharge device having an anode, a cathode, and a control electrode, a circuit including said anode and cathode and said control device, a flame electrode insulated from burner and positioned in the path of said flame, and a circuit between said cathode and control electrode to control the potential of said control electrode and thereby the operation of said control device, said last mentioned circuit including means effective in the absence of flame to maintain said control device in its second mentioned position, means connected to said flame electrode and burner tending to apply a positive potential to said control electrode in response to the presence of flame and normally effective to cause said control device to assume its first mentioned position, and a connection which is normally closed by said flame including means operative in the event of the closure thereof by a conductive path lower in resistance than that of a flame to apply a second negative potential to said control electrode and thereby cause said control device to assume its second mentioned position.

2. A safety control system including in combination, a burner, means for supplying fuel to said burner, means for igniting said fuel to establish a flame, a device to control said fuel supplying means and having a position in which it causes said fuel supplying means to assume a fuel supplying condition and a position in which it causes said fuel supplying means to assume a condition preventing the supply of fuel, an electric discharge device having an anode, a cathode, and a control electrode, a circuit including said anode and cathode and said control device, a flame electrode insulated from burner and positioned in the path of said flame, and a circuit between said cathode and control electrode to control the potential of said control electrode and thereby the operation of said control device, said last mentioned circuit including means effective in the absence of flame to maintain said control device in its second mentioned position, means connected to said flame electrode and burner tending to apply a positive potential to said control electrode in response to the presence of flame and normally effective to cause said control device to assume its first mentioned position, said last mentioned means including a second electric discharge device the conductivity of which is controlled in accordance with the resistance of the path between said flame electrode and burner, and a connection which is normally closed by said flame including means operative in the event of the closure thereof by a conductive path lower in resistance than that of a flame to apply a second negative potential to said control electrode and thereby cause said control device to assume its second mentioned position.

3. Safety means for a combustion control system including in combination, combustion producing means to establish a flame, a device to control said second mentioned means and having a first position in which it causes said second mentioned means to produce a flame and a second position in which it prevents said second mentioned means from producing a flame, a pair of spaced electrodes insulated from each other and located in the path of said flame, an electric discharge device having an anode, a cathode and a control electrode, a circuit including said anode and cathode and said control device, and a circuit between said cathode and control electrode to control the potential of said control electrode

and thereby the operation of said control device, said last mentioned circuit including means effective in the absence of flame to apply a negative potential to said control electrode and thereby to maintain said control device in its second mentioned position, means connected to said flame electrodes tending to apply a positive potential to said control electrode in response to the presence of flame and normally effective to cause said control device to assume its first mentioned position, and a connection which is normally closed by said flame and including means operative in the event of the closure thereof by a path lower in resistance than that of a flame to apply a second negative potential to said control electrode and thereby cause said control device to assume its second mentioned position.

4. Safety means for a combustion control system including in combination, combustion producing means to establish a flame, a device to control said second mentioned means having a first position in which it causes said second mentioned means to produce a flame and a second position in which it prevents said second mentioned means from producing a flame, a pair of spaced electrodes insulated from each other and located in the path of said flame, an electric discharge device having an anode, a cathode and a control electrode, a circuit including said anode and cathode and said control device, and a circuit between said cathode and control electrode to control the potential of said control electrode and thereby the operation of said control device, said last mentioned circuit including means effective in the absence of flame to apply a negative potential to said control electrode and thereby to maintain said control device in its second mentioned position, means connected to said flame electrodes tending to apply a positive potential to said control electrode in response to the presence of flame and normally effective to cause said control device to assume its first mentioned position, and a connection which is normally closed by said flame and including means operative in the event of abnormal operation of said last mentioned means to increase the negative potential on said control electrode and thereby cause said control device to assume its second mentioned position.

5. A safety control system including in combination, combustion producing means to establish a flame, a device to control said first mentioned means and having a first operative condition in which it causes said first mentioned means to produce a flame and a second operative condition in which it prevents said first mentioned means from producing a flame, a pair of spaced electrodes insulated from each other and positioned in the path of said flame, an electric discharge device having an anode, a cathode and a control electrode, a source of voltage, a connection between said anode, said cathode, and said source of voltage including said control device, a connection between said cathode and control electrode to control the potential of said control electrode and thereby the operation of said control device, said last mentioned connection including a second source of voltage which is effective in the absence of flame to maintain said control device in its second mentioned operative condition, a first impedance and a second impedance also included in said last mentioned connection, a third source of voltage, a third impedance, a connection from said last mentioned voltage source to said second and third impedances which is effective on the establish-

ment of an impedance between said flame electrodes substantially lower than that of a flame to cause said control device to assume its second mentioned operative condition, said last mentioned connection including a first conductor from said second impedance to one of said flame electrodes and a second conductor from said third impedance to the other of said flame electrodes, and means including said flame electrode connections to control the current flow through said first impedance in accordance with that through said third impedance and normally effective in response to the presence of a flame to cause said control device to assume its first mentioned condition.

6. The combination of claim 5 wherein said last mentioned means includes an electric discharge device having an anode, a cathode, and a control electrode, a connection from said third source of voltage to the anode and cathode of said last mentioned electric discharge device, and a connection from the control electrode of said last mentioned device to said second conductor.

7. A safety control system including in combination, combustion producing means to establish a flame, a device to control said first mentioned means and having a first operative condition in which it causes said first mentioned means to produce a flame and a second operative condition in which it prevents said first mentioned means from producing a flame, a pair of spaced electrodes insulated from each other and positioned in the path of said flame, an electric discharge device having an anode, a cathode and a control electrode, a source of voltage, a connection between said anode, said cathode, and said source of voltage including said control device, a connection between said cathode and control electrode to control the potential of said control electrode and thereby the operation of said control device, said last mentioned connection including a second source of voltage which is effective in the absence of flame to maintain said control device in its second mentioned operative condition, a first resistance and a second resistance also included in said last mentioned connection, a third source of voltage, a third resistance, a connection from said last mentioned voltage source to said second and third resistance which is effective on the establishment of a resistance between said flame electrodes lower than that of a flame to cause said control device assume its second mentioned operative condition, said last mentioned connection including a first conductor from said second resistance to one of said flame electrodes and a second conductor from said third resistance to the other of said flame electrodes, and means including said flame electrode connections to control the current flow through said first resistance in accordance with that through said third resistance and normally effective in response to the presence of a flame to cause said control device to assume its first mentioned condition.

8. A safety control system including in combination, a burner, means for supplying fuel to said burner, means for igniting said fuel to establish a flame, a pair of spaced electrodes insulated from each other and positioned in the path of said flame, an electric discharge device having an anode, a cathode and a control electrode, current responsive means for causing a flow of fuel to said burner when the current between said anode and cathode is a predetermined value, a source of voltage, a connection between said an-

ode, said cathode, and said source of voltage including said current responsive device, a connection between said cathode and control electrode to control the potential of said control electrode and thereby the flow of current between said anode and cathode, said last mentioned connection including a second source of voltage which is effective in the absence of flame to maintain the current between said anode and cathode lower than said predetermined value, a first resistance and a second resistance also included in said last mentioned connection, a condenser connected in shunt to at least one of said resistances, a third source of voltage, a third resistance, a connection from said last mentioned voltage source to said second and third resistances which is effective on the establishment of a resistance between said flame electrodes lower than that of a flame to cause the current flow between said anode and cathode to assume a value lower than said predetermined value, said last mentioned connection including a first conductor from said second resistance to one of said flame electrodes and a second conductor from said third resistance to the other of said flame electrodes, and means including said flame electrode connections to control the current flow through said first resistance in accordance with that through said third resistance and normally effective in response to the presence of a flame to cause the current between said anode and cathode to assume said predetermined value.

9. In a flame responsive device, the combination including a pair of spaced electrodes insulated from each other and adapted to be positioned in the path of said flame, an electric discharge device having an anode, a cathode, and a control electrode, a source of voltage to apply a negative potential to said control electrode for maintaining said electric discharge device non-conductive in the absence of flame, means controlled by the resistance of the path between said flame electrodes for rendering said electric discharge device conductive and tending to apply a positive potential to said control electrode responsively to the presence of flame, and a connection which is normally closed by said flame and including means operative to apply a second negative potential to said control electrode for rendering said electric discharge device non-conductive when said resistance is lower than that of a flame.

10. In a flame responsive device, the combination including a pair of spaced electrodes insulated from each other and adapted to be positioned in the path of said flame, an electric discharge device having an anode, a cathode, and a control electrode, a source of voltage to apply a negative potential to said control electrode for maintaining said electric discharge device non-conductive in the absence of flame, means for rendering said electric discharge device conductive and tending to apply a positive potential to said control electrode responsively to the presence of flame, said last mentioned means including a second electric discharge device having an impedance in its output circuit connected between said cathode and control electrode and having its input circuit controlled by the resistance of the path between said flame electrodes, and a connection which is normally closed by said flame and including means operative to apply a second negative potential to said control

electrode for rendering said first mentioned electric discharge device non-conductive when said resistance is substantially lower than that of a flame.

11. In a flame responsive device, the combination including a pair of spaced electrodes insulated from each other and the impedance between which is adapted to be controlled responsively to the presence of flame, said impedance being one value when a flame is present and a higher value in the absence of flame, an electric discharge device having an anode, a cathode, and a control electrode, a source of voltage to apply a negative potential to said control electrode for maintaining said electric discharge device non-conductive in the absence of flame, means controlled by the impedance of the path between said electrodes for rendering said electric discharge device conductive and tending to apply a positive potential to said control electrode responsively to the presence of flame, and a connection which is normally closed by the impedance between said electrodes and including means operative to apply a second negative potential to said control electrode for rendering said device non-conductive when said impedance is lower than said first mentioned value.

12. In a flame responsive device, the combination including a pair of spaced electrodes insulated from each other and the impedance between which is adapted to be controlled responsively to the presence of flame, said impedance being one value when a flame is present and a higher value in the absence of flame, an electric discharge device having an anode, a cathode and a control electrode, means to apply a negative potential to said control electrode for maintaining said electrode discharge device non-conductive in the absence of flame, means controlled by the impedance of the path between said electrodes for rendering said electric discharge device conductive and tending to apply a positive potential to said control electrode responsively to the presence of flame, and a connection including means tending normally to apply a negative potential to said control electrode and operative when the impedance between said electrodes is substantially lower than said first mentioned value to increase that negative potential for rendering said electric discharge device non-conductive.

13. In a flame responsive device, the combination including two spaced electrodes insulated from each other and adapted to be positioned in the path of said flame, an electric discharge device having an anode, a cathode, and a control electrode, a source of voltage to apply a negative potential to said control electrode for maintaining said electric discharge device non-conductive in the absence of flame, means controlled by the resistance of the path between said flame electrodes for rendering said electric discharge device conductive and tending to apply a positive potential to said control electrode responsively to the presence of flame, and means responsive to the impedance of the space between said electrodes which normally includes said flame to apply a second negative potential to said control electrode for rendering said electric discharge device non-conductive when said impedance is lower than that of a flame.

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