March 29, 1938. W. D. COCKRELL 2,112,736

FLAME DETECTOR

Filed Dec. 18, 1935

Fig. 1.

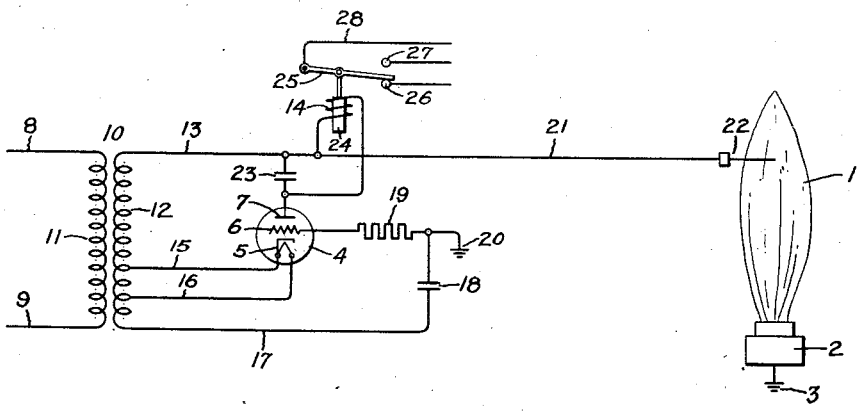
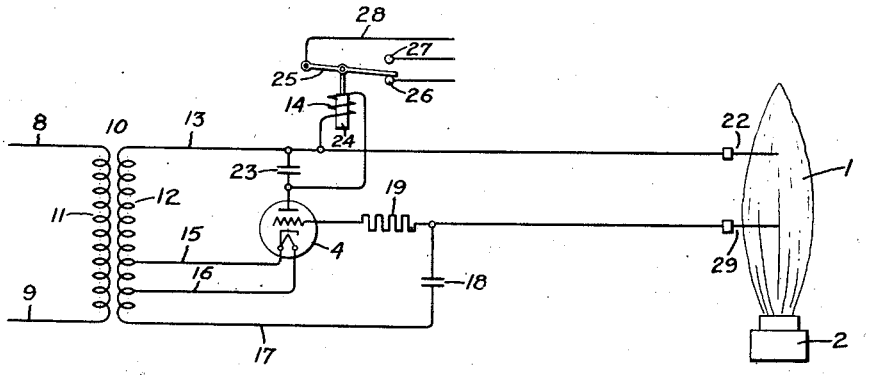


Fig. 2.



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FLAME DETECTOR

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7 Claims. (Cl. 175—320)

My invention relates to flame detectors and more particularly to flame detectors using electric discharge devices.

An object of my invention is to provide a simplified, highly efficient, and quickly responsive flame detector.

Another object of my invention is to provide an improved flame detector that may be used with any of the existing conventional burner control systems to control the system in response to the presence of flame.

A further object of my invention is to provide a flame detector utilizing an electric discharge device which is rendered conductive substantially immediately upon the presence of flame by utilizing the rectifying property of the flame.

Another object of my invention is to provide a flame detector utilizing a three element electric discharge device which requires but a single source of potential to energize the anode-cathode circuit and to apply a positive bias on the control electrode under certain conditions, and thus make the detector simpler and more efficient in its operation.

More particularly it is an object of my invention to provide a source of potential for the cathode-anode circuit of the electric discharge device and to provide means whereby the same source of potential may be utilized to bias the control electrode either positively or negatively in response to and in the absence of flame.

My invention may be utilized with any control apparatus in which a controlling function is to be exerted in response to the presence or absence of flame. In automatic control systems for fuel burners the system is usually provided with a flame responsive device operable from one controlling position to another in response to the presence of flame. My invention is particularly adapted for use with such systems.

It is known that a flame is a conductor of electricity and that the conduction through flames and hot gases is due to the motion of charged ions distributed through the gases. In addition to being a simple conductor of electricity, the flame possesses a rectifying property, that is, it conducts electricity better when the current flows in one direction, as compared to the direction of flame propagation, than in the other, the better conduction occurring when the electron flow is in the direction of flame propagation. By direction of flame propagation, I mean the general direction in which the flame and the hot gases of the flame move. Generally, this is in a direction outwardly from the nozzle or source of supply of fuel. The distinction between current flow and electron flow must, however, be kept in mind because of the fact that current, or positive current as it is sometimes called, flows in a direction opposite to the electron flow and consequently current is conducted better in a direction opposite to flame propagation.

Considering the above in relation to a flame propagated outwardly from any suitable nozzle, then, with electrical connections from the nozzle and some point in the path of the flame and with a source of alternating current potential impressed across these connections, the current will flow better in a direction opposite to the direction of flame propagation.

Accordingly, I have taken advantage of this property of the flame to provide a substantially immediately responsive flame detector employing an electric discharge device. I apply the biasing potential to the control electrode of the electric discharge device in such a direction as to take advantage of the better conductivity of the flame in that direction to make the control electrode more positive in a shorter length of time and thus render the device conductive more rapidly. The positive bias, according to one form of my invention, is applied to the control electrode through a conductive path formed by the flame, an electrical connection from the anode of the electric discharge device to the flame and an electrical connection from the nozzle, or source of fuel, to an interconnected cathode and control electrode.

My invention will be pointed out with greater particularity in the appended claims and for a complete understanding of my invention reference may be had to the accompanying drawing taken in connection with the following description. In the drawing:

Fig. 1 is a diagrammatic illustration of an embodiment of my invention as it may be applied to control a circuit in response to the presence of flame.

Fig. 2 discloses a modification of my invention.

My invention may be used, as stated above, with any of the well-known control systems wherein a control member is moved from one position to another in response to the presence of flame. In my preferred embodiment, the flame is illustrated by reference numeral 1 and this flame may be one produced by any means whatever such, for instance, as gas, oil, and the like. The flame is propagated upwardly from any suitable point such, for instance, as a nozzle 2 which is grounded at 3. While I have illustrated the flame as being propagated upwardly my invention may be ap-

plied irrespective of direction of flame propagation and it has been applied in actual practice more particularly to detect flames propagated in a downward direction.

To detect the presence of the flame I have provided an electric discharge device 4 which is of the usual three-element type having a cathode 5, a control electrode or grid 6, and an anode 7. The electric discharge device is adapted to be rendered conductive in response to the presence of flame, as will be described later. It may be supplied with electrical energy from any suitable source of alternating current potential 8, 9 through a transformer 10 whose primary winding 11 is connected to the source of supply. I have shown the source of potential as an alternating current source, but it is evident to those skilled in the art that a suitable source of direct current could be used by modifying the circuit so as to make it a direct current circuit. The secondary winding 12 of the transformer has one terminal connected to the anode 7 through an electrical connection 13 and control means such as a relay 14 of any suitable type. The cathode or filament 5 is provided with energy to heat the same by tapping the secondary winding at any suitable points by connections 15 and 16, the heating circuit thus consisting of electrical connections 15, 16 and part of the secondary winding. I provide means for applying a negative bias to the control electrode 6 in the absence of a flame by connecting the remaining terminal of the transformer secondary winding to the control electrode through conductor 17, condenser 18, and resistance 19, in a manner well known to those skilled in the art. The resistance 19, in addition, acts as a protective device to limit the rate of discharge of the discharge device and control the sensitivity thereof. The control electrode circuit is grounded at 20 in order to provide a connection therefrom to the nozzle 2 through the ground connection 3 of the latter. To complete a conductive path from the anode to the cathode and control electrode through the flame, I provide a connection 21 leading from the anode to a flame electrode 22 positioned in the flame at some distance from the nozzle in the direction of flame propagation.

The relay, being positioned in the anode-cathode circuit, is energized whenever the electric discharge device is rendered conductive. In order that the relay will not chatter or flutter, as a result of the fact that the electric discharge device conducts only during the positive half cycles, I have placed a condenser 23 across the relay. This condenser acts to smooth out pulsations of direct current which flow through the relay and will maintain the relay energized at all times while the electric discharge remains conductive. The relay is provided with an armature 24 and associated with the latter is a contact carrying control member 25 movable in response to energization of the relay from its lower controlling position wherein it engages contact 26 to an upper controlling position wherein it engages contact 27. In each of the control positions, an electric circuit leading from a conductor 28 through the movable control member 25 to the contact member engaged by the latter is closed.

The operation of my invention will now be described. Assuming first that there is no flame present, it will be evident to those skilled in the art that with the primary of the transformer connected to a suitable source of alternating current a negative bias will be imposed on the control electrode 6 through a circuit including conductor 17, condenser 18, and resistance 19, thus rendering the electric discharge device 4 nonconductive. The filament or cathode 5 of the electric discharge device will be heated to a suitable temperature by means of a local circuit consisting of connections 15, 16 and a portion of the secondary winding 12. The relay 14 will remain de-energized because the electric discharge device is nonconductive and the control element 25 will remain in the position indicated in the figure, that is, in engagement with contact 26. Assuming that combustion is initiated and a flame produced, then a positive bias will be imposed upon the control electrode to render the discharge device conductive each half cycle that the anode is positive. The biasing potential is derived from the flame electrode 22, connected to the anode 7 and electrical connection 13 leading to the secondary winding 12, through a path leading from the flame electrode through the flame to the nozzle 2 and thence through ground 3 to ground 20 and from there to the control electrode through resistor 19. Due to the fact that the flame is a better conductor of electricity in a direction opposite to flame propagation, it is evident that the control electrode will be rendered positive more rapidly and that the device will respond more quickly to the presence of flame.

Upon the disappearance of the flame, the positive bias will be removed from the control electrode and the discharge device will be again rendered nonconductive, causing the de-energization of the relay 14 and the consequent operation of the movable contact member 25 from its upper to its lower control position.

The modification just described is applicable to systems in which the fuel is projected from a nozzle or the like which is grounded. This is the case with most systems but in some systems, it may be that the nozzle remains ungrounded. In such cases, it is necessary to provide a second electrode positioned in the flame in order to provide a conductive path from anode to the control electrode. Such a modification is disclosed in Fig. 2.

The apparatus is identical with that shown in Fig. 1, with the exception of the fact that the ground connection 3 leading from the nozzle has been removed and a second flame electrode 29 has been connected to a point intermediate condenser 18 and resistance 19, replacing the ground connection 20 of Fig. 1. The operation of this modification is identical with that of the modification shown in Fig. 1 and, consequently, it will be unnecessary to describe it in detail. It may be noted that the direction of current flow in the flame is the same as in Fig. 1 so that the device will be immediately responsive to the presence of flame.

It may be seen that my invention provides a simple and efficient means for detecting the presence of flame and one which may be used merely to detect the presence of flame or to control any apparatus whatever in response to its presence.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a flame detector, the combination including an electric discharge device having an anode, a cathode, and a control electrode, means for normally applying a negative bias to said control electrode to render said device nonconductive, and means for applying a positive bias to said control electrode to render said device conductive

in response to presence of flame, said last named means including a pair of flame electrodes having an alternating potential impressed thereon and electrically connected respectively to the anode and control electrode of said device and so positioned in the flame that the rectifying current conducting path established thereacross is in a direction to positively bias said control electrode.

2. In a flame detector, the combination including an electric discharge device having an anode, a cathode, and a control electrode, means for energizing said device from an alternating current source including means normally applying a negative bias to said control electrode to render said device nonconductive in the absence of flame, and means for rendering said device conductive upon the presence of flame, said last mentioned means including electrical connections from said control electrode and anode to points in the path of the flame, the point to which said anode is connected being spaced from the point to which said control electrode is connected in the direction of flame propagation.

3. In a flame detector, the combination including an electric discharge device having an anode, a cathode, and a control electrode, an alternating current transformer having windings connected for applying an alternating potential between said anode and cathode and for normally applying a negative bias to said control electrode and means including a first flame electrode adapted to be positioned in the flame and connected to the anode and a second flame electrode spaced from the first in a direction opposite the flame propagation having an electrical connection with said control electrode for rendering said device conductive in the presence of flame.

4. In a flame detector, the combination of an electric discharge device having an anode, a cathode, and a control electrode for selectively controlling the conductivity of said device in response to presence and absence of flame, means including an alternating current transformer for applying an alternating potential between said anode and cathode and for normally applying a negative bias to said control electrode to render said device nonconductive in the absence of flame, and connections for establishing a current conductive path through the flame between said anode and said control electrode in a direction opposite the flame propagation for rendering said device conductive in response to the presence of flame.

5. In a flame detector, the combination including an electrical relay adapted to be energized from an alternating current source in response to the presence of flame, means for controlling the energization of said relay including an electric discharge device having an anode, a cathode and a control electrode connected with the alternating current source to provide normally a negative bias rendering the device nonconducting, and connections establishing a current conducting path from the alternating current source to said control electrode through the flame in a direction corresponding to its greatest conductivity for energizing said control electrode positively to render said device conductive upon the presence of flame.

6. In a flame detector, the combination of an electric discharge device having an anode, a cathode and a control electrode, means including an alternating current transformer for applying an alternating potential between said anode and cathode, means including a resistor and a condenser connected in series circuit between said control electrode and said transformer to provide normally a negative bias rendering the discharge device nonconducting, and connections establishing a current conducting path from said anode to a point between said resistor and condenser through the flame in a direction opposite to flame propagation for energizing said control electrode positively to render said device conductive upon the presence of flame.

7. In a flame detector, the combination including a space discharge device having an anode, a cathode, and a control electrode, means including a resistance and a condenser connected respectively in series circuit with said control electrode for rendering the space between said anode and cathode non-conductive in the absence of flame, and means establishing a separate current conductive path through said resistance and through the flame in a direction opposite to flame propagation for rendering the space between said cathode and anode conductive in response to presence of flame.

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