

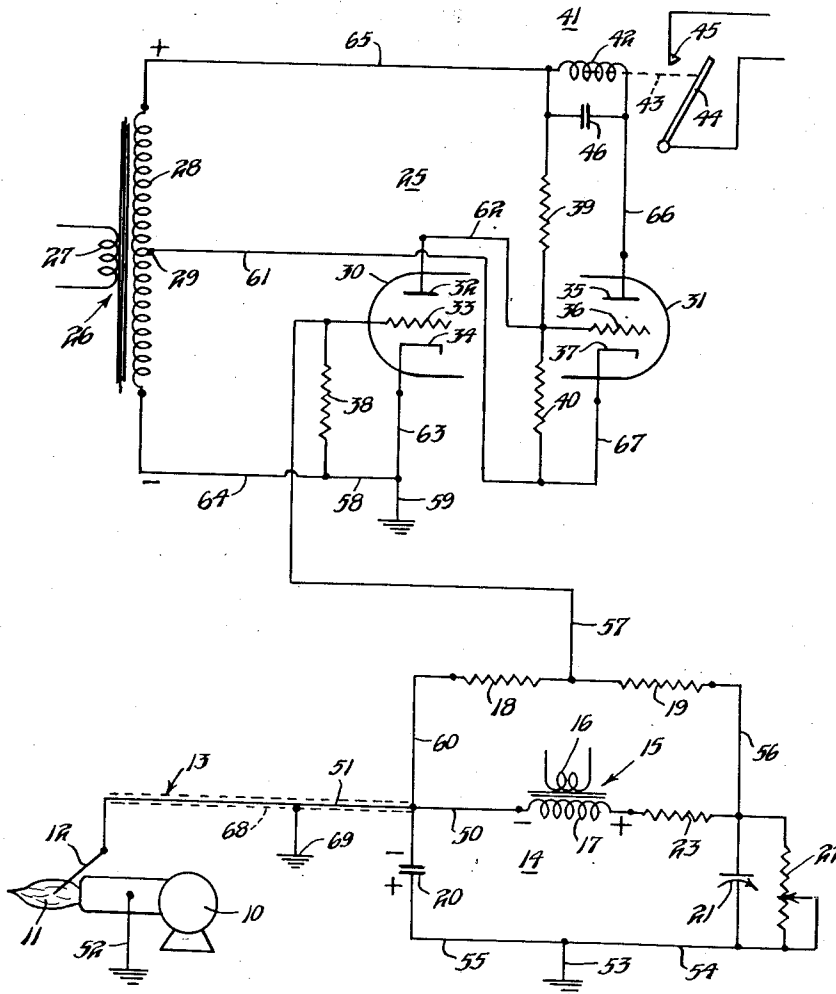
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FLAME DETECTION APPARATUS

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FLAME DETECTION APPARATUS

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The present invention relates to an improved type of electronic flame detection apparatus of the type adapted to respond in one manner when flame is present and in another manner in the absence of flame or in the event that the flame detection circuit is not functioning properly. It is particularly related to the type of flame detector that utilizes the rectifying properties of a flame detecting device to control the operation of appropriate indicating means.

In present day applications of flame detecting apparatus to various types of burner installations, it is sometimes desirable to use a flame detector employing a pair of flame electrodes which when positioned in the path of a flame form electrodes of a rectifier. A rectifier is formed since a flame has electrical conducting properties which, as far as the electrons in the flame are concerned, are greater in the direction of propagation of the flame. This rectifier is utilized to bias an electron discharge device which in turn operates an appropriate indicating device such as a relay to indicate the presence of flame. As the electrodes of the flame detecting device may gradually become coated with the products of combustion, they tend to act less and less as a rectifier and are apt to upset the operation of the apparatus. Further, the electrodes are generally coupled to the detecting apparatus by some appropriate shield and cable, the presence of which introduces capacity effects into the control apparatus that may also upset the operation of the apparatus.

The present invention proposes a flame detector circuit in which the capacity of the coupling cable and the leakage resistance between the flame electrodes may be compensated for. The detecting apparatus further provides with the above provision a flame detector that will respond in a flame indicating manner only when flame is present at the flame electrodes.

It is therefore an object of the present invention to provide a flame detection apparatus which will compensate for the impedances in the flame detection circuit.

Another object of the present invention is to provide an improved flame detection apparatus of the type which will be rendered operative in one sense when the flame bridges a pair of flame electrodes and in another sense when the electrodes are open circuited or short circuited.

Still another object of the present invention is to provide an improved flame detection apparatus of the type which utilizes the rectifying action of a flame bridging a pair of flame electrodes to bias an electron discharge device into and out of con-

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duction in accordance with the presence or absence of flame across the electrodes.

A still further object of the present invention is to provide a flame detection apparatus having as a flame detection circuit a balanceable bridge by which it is possible to balance out the capacity effects on the electric circuit coupled to a pair of electrodes and the leakage resistance of the cable and the electrodes.

A still further object of the present invention is to provide a flame detection apparatus by which it is possible to determine when the flame electrodes of the flame detection circuit will require cleaning.

Other objections of the invention will be apparent from a consideration of the accompanying specification, claims and drawing in which:

The single figure represents a diagrammatic showing of my flame detection apparatus associated with a flame emitting from an oil burner.

The numeral 10 represents an oil burner of any appropriate design having a flame 11 emitting from the nozzle thereof. Detecting the presence of flame is an electrode 12 which is operatively connected through a shielded cable 13 to a bridge network 14. The shield 68 is grounded at 69 and provides a protective covering for conductor 51. The bridge network 14 may be seen to consist of an input power transformer 15 having a primary winding 16, connected to a suitable source of alternating current power, and a secondary winding 17. A pair of resistors 18 and 19 form two legs of the bridge while condensers 20 and 21 form two further legs of the bridge. Connected in parallel with the condenser 21 is a potentiometer 22. A resistor 23 is connected in series with secondary 17 for current limiting purposes.

An appropriate electronic indicating device is indicated by the numeral 25. The indicating device may be seen to consist of an input power transformer 26 having a primary winding 27 connected to a suitable source of power and a secondary winding 28 having a tap at 29. Operatively connected to the power transformer 26 are a pair of electron discharge devices 30 and 31. The electron discharge device 30 is a triode tube having an anode 32, a control electrode 33, and a cathode 34. The electron discharge device 31 is also a triode tube having an anode 35, a control electrode 36 and a cathode 37. A resistor 38 is connected in biasing relation to the input of triode 30 while a pair of resistors 39 and 40 are connected in biasing relation to the input of triode 31. A relay 41 is connected in the output circuit of the triode 31 and may be seen to consist

of a relay winding 42, an armature 43, and a switch blade 44 normally biased out of engagement with its associated switch contact 45. A condenser 46 is connected across relay winding 42 to function in the normal manner to by-pass alternating current in the anode circuit of triode 31.

In one particular embodiment of my invention it was found that operation was satisfactory with the secondary 17 having a voltage of 300 volts. Resistors 18 and 19 each had a resistance of 20 megohms while the limiting resistor 23 had a resistance of 5 megohms. Grid resistor 38 had a resistance of 30 megohms while the resistors 39 and 40 had resistances of 100,000 and 15,000 ohms respectively. The voltage on the secondary winding 28 was 600 volts and was tapped at the center at tap 29. The vacuum tubes 30 and 31 are preferably included within a single envelope and may be of the type known commercially as a 12SN7. The condenser 20 was 100 micromicrofarads and the condenser 21 was a 150 micromicrofarad variable condenser. Potentiometer 22 had a resistance of 100 megohms. It is to be understood these values are merely illustrative of one particular embodiment and are in no way to be considered limiting on the scope of my invention.

Operation

In discussing the operation of the present invention, it is important to note that when a flame bridges a pair of flame electrodes, as occurs in the present invention when flame 11 bridges the gap between burner 10 and the electrode 12, an electrical circuit may be completed through the flame and the conductivity of that circuit is more in one direction than in the other. The direction of greatest electron conductivity is in the direction of propagation of flame, or in other words, the conventional current flow will be greatest in a direction opposite the direction of flame propagation. Just how this rectifying action is utilized in the subject control apparatus, will be understood in the discussion that follows. In the present apparatus when flame is present at burner 10 it is desirable to have relay 41 become energized so that switch blade 44 may move into engagement with its associated contact 45 to complete its electrical circuit which may be utilized in any desirable manner for controlling the operation of the burner or for indicating the presence of flame. When flame 11 is present and intersecting the electrode 12, it is possible to complete an electrical circuit from the left-hand terminal of the secondary 17 through conductor 50, conductor 51 of shielded cable 13, electrode 12, flame 11, burner 10, ground 52, ground 53, conductor 54, condenser 21, and resistor 23 back to the right-hand terminal of the secondary 17. Since the flame 11 in bridging the gap between the burner 10 and the electrode 12 forms a rectifier the alternating current from the transformer 17 will be effectively rectified and the direct current component will place a charge on condenser 21 so that it will be positive on the lower terminal and negative on the upper terminal. The condenser 20 will also be charged so that its upper terminal is negative and its lower terminal is positive since condenser 20 and condenser 21 are effectively connected in series opposition or in parallel in a discharge path through the resistor 38. The electron current discharge path for the charge on condenser 21 may be traced from the upper terminal of

the condenser 21 through conductor 56, resistor 19, conductor 57, resistor 38, conductor 58, ground 59, ground 53 and conductor 54 back to the lower terminal of the condenser 21. The resistor 22, which is connected in parallel with the condenser 21, is relatively large when compared with the resistance of the last traced circuit so that the discharge of condenser 21 through resistor 22 has negligible effect upon the operation of the control apparatus. Since the condensers 20 and 21 are effectively in parallel in the discharge circuit through resistor 38, the electron current discharge path for condenser 20 may be traced from the upper terminal of the condenser through conductor 60, resistor 18, conductor 57, resistor 38, conductor 58, ground 59, ground 53, conductor 55 back to the lower terminal of condenser 20. With condensers 20 and 21 discharging through the last traced circuits there will be a current flow through the resistor 38 such that its upper terminal will be negative and its lower terminal will be positive. This voltage drop from resistor 38 is utilized to bias an electronic amplifier system in accordance with the current flow through the resistors.

In the absence of current flow through the resistor 38 the control electrode 33 and cathode 34 of the triode 30 will be effectively operating at the same potential so that the current flow through triode 30 will be quite large, during each half cycle when the anode 32 is positive with respect to the cathode 34 as shown on the diagram. The circuit for this current flow may be traced from the secondary 28 at tap 29 through conductor 61, resistor 40, conductor 62, anode 32, cathode 34, and conductors 33, 58 and 54 back to the lower terminal of the secondary 28. With the large amount of current flowing in the last traced circuit there will be a biasing voltage applied to the input of triode 31 since it is directly connected across the resistor 40 by direct connections at the upper terminal of resistor 40 to the control electrode 36 and a direct connection to the lower terminal of the resistor 40 to the cathode 37. This biasing voltage will be such that the upper terminal of the resistor 40 will be negative and a lower terminal will be positive so that the triode 31 will be biased to be effectively non-conducting. The conducting circuit for the triode 31 may be traced from the upper terminal of the secondary 28 through conductor 65, relay winding 42, conductor 66, anode 35, cathode 37, conductors 67 and 61 back to the tap 29 of the secondary 28. With a large amount of current flowing through the triode 30 energizing circuit the triode 31 will be biased below the point of current flow necessary to energize the relay 41.

As soon as the condensers 20 and 21 start to discharge through the resistor 38, such that the upper terminal of the resistor becomes negative and the lower terminal becomes positive, the triode 30 will be biased to be effectively non-conducting. With the decrease in current flow in the energizing circuit for the triode 30, there will be a decrease in the voltage drop across the resistor 40 so that the triode 31 will now be biased to a potential that will permit sufficient current flow to pass through the energizing circuit of triode 31 to energize relay 41. When relay 41 becomes energized the switch blade 44 is moved into engagement with its associated switch contact 45 by the armature 43 so that an electrical circuit may be completed to indicate the presence of flame.

Should the flame 11 be extinguished, it would

be impossible to complete an electrical circuit from the electrode 12 to the burner 10 so that as soon as the condensers 20 and 21 have discharged through the resistor 38 there will be no further current flow through the resistor 38 to bias the triode 30. With triode 30 once again having its control electrode 33 and cathode 34 at the same potential, it will be conducting a large amount of current which will, when passing through the resistor 40, bias the triode 31 to be effectively nonconducting so that the relay 41 will be deenergized.

In the event that there is a ground out condition, as occurs when electrode 12 shorts with burner 10, it is desirable to see that the relay 41 does not become energized to indicate the presence of flame. This is accomplished in the present invention by the connection of the flame detection circuit to the bridge 14. Bridge 14 has as the upper two legs resistors 18 and 19 with a junction point acting as an output terminal of the bridge. The lower two legs of the bridge consist primarily of condensers 20 and 21 whose point of junction forms the other output terminal of the bridge. Connected in parallel with the condenser 20 is the flame detection circuit which may be traced from the upper terminal of condenser 20 through conductor 51, electrode 12, flame 11, burner 10, ground 52, ground 53, and conductor 55 back to the lower terminal of condenser 20. Connected in parallel with the condenser 21 is the potentiometer 22. The tap on the potentiometer 22 is normally adjusted to counterbalance the leakage resistance present in the flame detection circuit which is in parallel with the condenser 20. The condenser 21 is made variable so that the circuit capacities of the flame detection circuit in parallel with condenser 20 may be counter balanced. Thus, under normal operating conditions, the bridge 14 is balanced so that there will be no output between its output terminals at conductor 57 and ground 53. However, in the event that the electrode 12 should short to the burner 10 or be connected to the burner 10 by some low impedance shorting element, the bridge 14 will become unbalanced so that there will be an alternating current voltage on the output terminal of the bridge. Connected across the output terminals of the bridge 14 is the resistor 38 and this connection may be traced from conductor 57 through resistor 38, conductor 58, ground 59, back to the other ground terminal 53 of the bridge 14.

As explained above, the triodes 30 and 31 form an alternating current amplifier which operates on alternate half cycles of the power supply. Since it is desirable not to have relay 41 energized when there is a shorted condition between the electrode 12 and burner 10 it may be seen that it is desirable to have triode 31 effectively nonconducting and the triode 30 conducting. To have triode 30 conducting it will be necessary to maintain the control electrode 33 at an effectively positive potential. This must be accomplished by the unbalance voltage of the network 14 and this unbalance voltage, since it is alternating voltage, must be phased so that the control electrode 33 is positive when the triode 30 is on its conducting half cycle. By phasing the secondary 17 to be negative on its left hand terminal and positive on its right hand terminal when triode 30 is on its conducting cycle, or when secondary 28 is positive on its upper end and negative on its lower terminal as shown, the control electrode 33 will be biased

by the alternating current unbalance on the bridge so that triode 30 will pass a large amount of current. With a large amount of current flowing through the triode 30 it will be impossible to energize the relay 41 since the triode 31 is effectively biased below the relay energizing point by reason of the voltage drop on the biasing resistor 40.

As it is possible to build up a shorting condition between the electrode 12 and burner 10 by the continual depositing of the products of combustion on them, it is desirable to not have that shorting condition cause malfunctioning of the control apparatus. This is accomplished in the present invention by the bridge 14 with a potentiometer 22 acting in one arm thereof. As explained above, the potentiometer 22 is connected in the arm opposite the connection of the flame detection circuit so that it may be used to balance up the leakage resistance of the flame detection circuit. This balance may be accomplished by connecting any suitable voltage measuring device across the output terminals of the bridge and then adjusting the potentiometer 22 until a balance point is reached. As the leakage resistance of the flame detection circuit decreases, it will be obvious that less resistance will be required at potentiometer 22 to maintain the network balance. When the leakage resistance between the electrode 12 and the burner 10 becomes too small, the direct current component of the current flowing in the flame detection circuit becomes insufficient to charge condensers 20 and 21 and keep them charged to bias triode 30. By calibrating the movement of the tap of potentiometer 22, it is possible to anticipate when this point is about to be reached so that the apparatus can be disassembled and the electrode 12 on burner 10 may be cleaned.

The potentiometer 22 may also be used for a sensitivity adjustment. This may be seen when it is noted that the balance of the bridge 14 is adjustable so that if the potentiometer 22 is adjusted to unbalance the bridge in a direction to maintain 30 conducting the rectifying action of the flame detection circuit will have a greater voltage to work against in rendering triode 30 nonconducting on the presence of flame.

For various installations it may be necessary to vary the length of cable 13 which is used to connect the flame electrode 12 to the bridge network 14 which will mean the cable capacity for different installations will cause the bridge balance to be affected by varying amounts. By making condenser 21 variable the change in the capacity of the flame detection circuit may be counterbalanced so that the bridge 14 will remain balanced.

From the foregoing it may be seen that I have provided a flame detecting apparatus which distinguishes between a flame and a short circuiting impedance in the flame detection circuit and in which it is possible to determine the leakage impedance of a flame detection circuit and counter balance the same. It may also be seen that I have provided a flame detection apparatus where it is possible to adjust the sensitivity with which the flame detection circuit will respond to the presence of flame.

Although I have described my invention in connection with an oil burner, and while it is well suited for use there, it is to be understood that it could receive application in many ways which will be obvious to those skilled in the art.

I therefore intend to be limited solely by the scope of the appended claims in which I claim:

1. A flame detection apparatus comprising in combination, a source of power, electrical signal responsive means adapted to operate in one manner on the presence of flame and in another manner when no flame is present, an electrical bridge network including therein a chargeable element, means connecting said source of power to said responsive means and said bridge network, an electrical circuit adapted to act as a rectifier when bridged by a flame, means connecting said electrical circuit in parallel with a portion of said network so that said electrical circuit will place a charge on said chargeable element on the presence of flame on said circuit, and means connecting said responsive means to said network so that said network will control said responsive means in accordance with the presence or absence of a flame bridging said electrical circuit.

2. A flame detection apparatus comprising in combination, a source of power, electrical signal responsive means adapted to operate in one manner on the presence of flame and in another manner when no flame is present, an electrical bridge network including therein a chargeable element, means connecting said source of power to said responsive means and said bridge network, an electrical circuit adapted to act as a rectifier when bridged by a flame, means connecting said electrical circuit in parallel with a portion of said network so that said electrical circuit will place a charge on said chargeable element on the presence of flame on said circuit, and means connecting said responsive means to said network so that when said electrical circuit is bridged by a flame said responsive means will be operative in said one manner and when said electrical circuit is bridged by an impedance of less than a predetermined value said network will be unbalanced in a direction to maintain said responsive means operative in said other manner.

3. A flame detection apparatus comprising in combination, a source of power, electrical signal responsive means adapted to operate in one manner on the presence of flame and in another manner when no flame is present, a balanceable electrical network having a chargeable element therein and having input and output terminals, means connecting said source of power to said responsive means and the input terminals of said network, an electrical circuit adapted to act as a rectifier when bridged by a flame, means connecting said electrical circuit in parallel with a portion of said network so that said network will have a charge placed thereon when a flame is present at said electrical circuit and will be unbalanced when said circuit is bridged by an impedance of less than a predetermined value, and means connecting said responsive means to the output terminals of said network so that said responsive means will be operative in said one manner when said electrical circuit is bridged by a flame and in said other manner when said circuit is open circuited or bridged by an impedance of less than a predetermined value.

4. A flame detection apparatus comprising in combination, a source of power, electrical signal responsive means adapted to operate in one manner on the presence of flame and in another manner when no flame is present, means connecting said source of power to said responsive means, and an electrical network adapted to

render said responsive means operative in said one manner on the presence of flame across a portion of said network, said network comprising a balanceable electrical bridge having input and output terminals and a chargeable element therein, means connecting said output terminals to said responsive means, means connecting said input terminals to said source of power, an electrical circuit connected to a portion of said bridge and adapted to act as a rectifier when bridged by a flame and to place a charge on the output terminals of said bridge, and adjustable impedance means in a further portion of said bridge network for balancing the impedance added to said bridge by said electrical circuit to prevent the impedance of said electrical circuit from rendering said responsive means operative in said other manner.

5. A flame detection apparatus comprising in combination, a source of power, electrical signal responsive means adapted to operate in one manner on the presence of flame and in another manner when no flame is present, comprising an electron discharge device, an input circuit for said discharge device comprising a balanceable electrical network and operable to cause deenergization of said discharge device when unbalanced, an electrical circuit adapted to act as a rectifier when bridged by a flame and bias said discharge device to operate in said one manner, means connecting said electrical circuit to a portion of said network so that the impedance of said circuit tends to unbalance said network, adjustable impedance means, means connecting said adjustable impedance means to a further portion of said network so that said network will be balanced in the absence of a shorting impedance in said electrical circuit.

6. A flame detection apparatus comprising in combination, a pair of flame electrodes adapted when in an electrical circuit and bridged by a flame to act as a rectifier, a balanceable bridge network having output terminals and comprising an adjustable impedance and a condenser, an electrical circuit connected to said flame electrodes, means connecting said circuit in parallel with said condenser so that said condenser is charged when flame bridges said electrodes, means connecting said adjustable impedance in counterbalancing relation to said condenser and electrical circuit so that said bridge is normally balanced in the absence of a shorting impedance bridging said electrodes, electrical signal responsive means adapted to operate in one manner on the presence of flame and in another manner when no flame is present, and means connecting said responsive means to the output terminals of said bridge so that said responsive means will be rendered operative in said one manner when said bridge is balanced and said condenser is charged and rendered operative in said other manner when said bridge is unbalanced.

7. A flame detection apparatus comprising in combination, a pair of flame electrodes adapted when connected in an electrical circuit and bridged by a flame to act as a rectifier, a balanceable bridge network having output terminals and comprising a pair of condensers and a resistor, an electrical circuit connected to said flame electrodes, means connecting said circuit in parallel with one of said condensers so that said one condenser is charged when flame bridges said electrodes, means connecting the other of said condensers in counterbalancing relation to said one condenser and the capacity of said elec-

trical circuit, means connecting said resistor in counterbalancing relation to the leakage resistance of said flame electrodes and said electrical circuit so that said bridge will be balanced in the absence of a shorting impedance across said electrodes, electrical signal responsive means adapted to operate in one manner on the presence of flame and in another manner when no flame is present, and means connecting said responsive means to the output terminals of said bridge so that said responsive means will be rendered operative in said one manner when said bridge is balanced and said condensers are charged and rendered operative in said other manner when said bridge is unbalanced or said condensers are not charged.

8. A flame detection apparatus comprising in combination, an alternating current source of power, an electron discharge device having an anode, cathode and control electrode, means connecting the anode and cathode of said discharge device to said source of power so that said discharge device is conductive on alternate half cycles of said power supply, a balanceable bridge network having input and output terminals, a flame detection circuit adapted to act as a rectifier when bridged by a flame, a resistor, means connecting said source of power to the input terminals of said bridge, means connecting a portion of said flame detection circuit to said bridge so that said bridge will become unbalanced when said circuit is bridged by an impedance of less than a predetermined value, a condenser, means connecting said condenser as an element of said bridge so that said condenser will be charged by said flame detection circuit on the presence of flame, means connecting said resistor across the output terminals of said bridge in discharging relation to said condenser, means connecting said resistor in biasing relation to the control electrode and cathode of said discharge device so that said discharge device will be rendered operative in one range of values when said condenser is discharging through said resistor and operative in a second range of values when said condenser is not discharging or said bridge is unbalanced in a direction indicative of the presence of a shorting impedance in said flame detection circuit.

9. In combination; an electron discharge device having an anode, a cathode and a control electrode, a source of power having a plurality of points for connection, means connecting said anode to a first point on said source, means connecting said cathode to a second point on said source, a resistor, means connecting said resistor between said cathode and said control electrode, a condenser, a condition responsive impedance means which is rectifying only on the presence of a condition, means connecting said condenser in circuit with said impedance so that said condenser is charged on the presence of a condition, means connecting said resistor in discharging relation to said condenser so that when said condenser is discharging said resistor will have a voltage thereon biasing said discharge device into a first range of operation, electrical means including said condenser and said impedance means responsive to the nonrectifying impedance of said impedance means, and means connecting said electrical means to said resistor to apply a voltage thereto which will bias said discharge device into a second range of operation when the nonrectifying impedance of said im-

pedance means becomes less than a predetermined value.

10. In combination, an electron discharge device having an anode, a cathode and a control electrode, an alternating source of power having a plurality of points for connection, means connecting said anode to a first point on said source, means connecting said cathode to a second point on said source, a resistor, means connecting said resistor between said cathode and said control electrode, a condenser, a condition responsive impedance means which is rectifying only on the presence of a condition, means connecting said condenser in circuit with said impedance so that said condenser is charged on the presence of a condition, means connecting said resistor in discharging relation to said condenser so that when said condenser is discharging said resistor will have a voltage thereon biasing said discharge device into a first range of operation, electrical means having connected thereto said responsive impedance means and said condenser responsive to the nonrectifying impedance of said impedance means, and means connecting said electrical means to said resistor to apply a voltage thereto having an electrical phase which will bias said discharge device into a second range of operation when the nonrectifying impedance of said impedance means becomes less than a predetermined value.

11. A flame detection apparatus comprising in combination; a source of power; a flame detection circuit, said circuit comprising a pair of electrodes adapted to act as a rectifier when bridged by a flame, a condenser, and a resistor; means interconnecting said source of power, said electrodes, said resistor and said condenser in an electrical circuit so that said condenser is charged on the presence of a flame at said electrode and discharged through said resistor; electrical signal responsive means adapted to operate in one manner on the presence of flame and in another manner when no flame is present; means connecting said responsive means to said resistor so that said responsive means will be rendered operative in said one manner by the presence of discharge current flowing through said resistor; a balanceable network, said network including as elements thereof said flame detection circuit; and means including said network for effecting a predetermined current flow through said resistor when said electrodes are bridged by an impedance of less than a predetermined value to render said responsive means operative in said other manner.

12. A flame detection apparatus comprising in combination; a source of power; a flame detection circuit, said circuit comprising a pair of electrodes adapted to act as a rectifier when bridged by a flame, a condenser, and a resistor; means interconnecting said source of power, said electrodes, said resistor and said condenser in an electrical circuit so that said condenser is charged on the presence of flame at said electrodes and discharged through said resistor; an electron discharge device having an anode, cathode and control electrode; electrical signal responsive means; means connecting said responsive means in operational responsive relation in the anode circuit of said discharge device; means connecting said resistor between the cathode and control electrode of said discharge device so that said discharge device will be operative in one range only when said resistor has discharging currents flowing therethrough; a balanceable network,

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said network including as a portion thereof said flame detection circuit; means including said flame detection circuit for unbalancing said network when a portion of said flame detection circuit is bridged by an impedance of less than a predetermined value; and means including said resistor for interconnecting said discharge device and said network so that when unbalanced said network will cause said discharge device to operate in a further range which corresponds to a range of operation when said condenser is not being charged.

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12**REFERENCES CITED**

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,012,573	Long	Aug. 27, 1935
2,231,420	Gille	Feb. 11, 1941
2,379,872	Gille	July 10, 1945