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FLAME DETECTION APPARATUS

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Fig. 1.

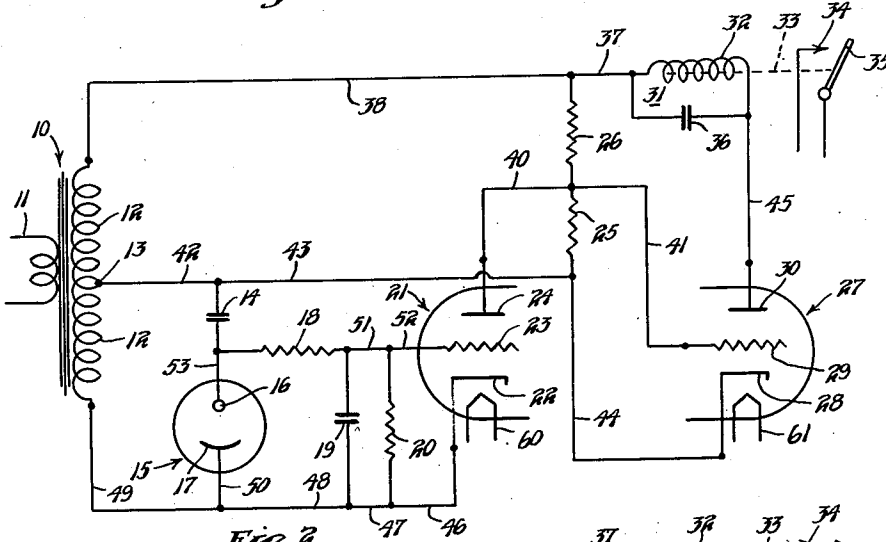
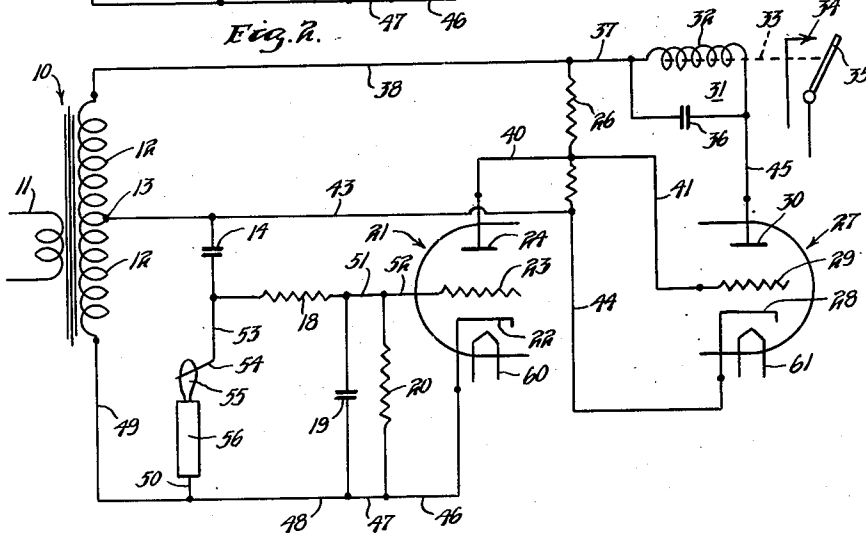


Fig. 2.



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FLAME DETECTION APPARATUS

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5 Claims. (Cl. 250—27)

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This invention relates to electronic flame detection apparatuses employing a flame sensitive device that may be either a photocell or a flame rod assembly. It is particularly related to the type of flame detector that utilizes the rectifying properties of the flame sensitive device to control the bias of a control amplifier.

In a copending application of Lawrence J. Dahline, Ser. No. 719,291, filed December 30, 1946, now Patent No. 2,478,373, there is shown a fire detection apparatus employing a single triode stage controlling a relay in accordance with the presence or absence of flame across a pair of flame electrodes. Since this system is primarily designed for an application where flame is not wanted, it is desirable to provide an output stage that is normally conducting to maintain a control relay energized on the absence of flame. When flame occurs the stage is cut off and the relay deenergized and thus closes a pair of control switch contacts. This system employs a filter network between the flame responsive device and the input to the control stage which gives additional stability to the circuit and makes it insensitive to flame fluctuations. The system also distinguishes between a short caused by a flame and any other type of short that may exist across the flame detection device.

The present invention is designed to utilize the characteristics of the apparatus described in the above mentioned application in the form of a two stage flame detection apparatus that will be conductive in the second stage when flame is detected by the flame detection device.

It is therefore an object of the present invention to provide a two stage flame detection apparatus which will distinguish between a condition of flame and a short condition of the flame detection device.

Another object of the present invention is to provide a two stage flame detection apparatus employing a flame sensitive device which will be insensitive to fluctuations of a flame.

Still another object of the present invention is to provide a two stage flame detection apparatus employing a flame sensitive device which will act as a non-linear impedance on the presence of a flame.

A further object of the present invention is to provide a simple two stage flame detection apparatus utilizing the rectifying properties of a flame detection device.

A still further object of the present invention is to provide a two stage flame detection apparatus employing a single tapped secondary trans-

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former winding for supplying operating voltages to the two stages, one half of the winding energizing one stage and the other half energizing the second stage.

A still further object of the present invention is to provide a two stage flame detection apparatus which will maintain a control relay energized on the presence of flame.

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

Figure 1 is a diagrammatical showing of my invention using a photocell; and

Figure 2 is another diagrammatical showing of my invention using flame electrodes as the flame detection device.

In the Figure 1, the numeral 10 is used to designate an input power transformer which consists of a primary winding 11 and a secondary winding 12 which is center tapped by a tap 13. Connected to the lower portion of the secondary winding 12 is a condenser 14 and a photocell 15, the latter of which consists of an anode 16 and cathode 17. A filter network consisting of resistor 18 and condenser 19 is connected to the input control element 23 of the amplifier stage 21.

The amplifier represented by the numeral 21 is preferably one half of a twin triode high vacuum tube. Included with the amplifier 21 are a cathode 22, a control element 23 and an anode 24. A heater 60, connected to any suitable power source, is used to energize the emitting surface of the cathode 22.

A biasing element 20 is connected between the control element 23 and the cathode 22. A load resistor 25 is connected in the output circuit of the amplifier 21. A second amplifier stage 27 consists of a cathode 28, a control element 29, and an anode and is preferably the other half of the twin triode of which amplifier 21 is a part. The cathode 28 is energized by a heater 61 which is connected to a suitable source. Connected in the anode circuit of the amplifier 27 is a relay 31 which consists of a winding 32, an armature 33, and a switch blade 35 and a contact 34. The switch blade 35 is biased open. A by-pass condenser 36 is connected across the relay winding 32.

While the various elements described may have a wide range of values, one embodiment of my invention uses a transformer having a high voltage secondary winding with 300 volts on both sides of the center tap. The vacuum tube employed is of the twin triode type, preferably a 12SN7. The condensers 14, 19 and 36 have ca-

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capacities of .002, .01 and 4 microfarads respectively. Resistors 18 and 20 both have resistances of 20 megohms, while the resistors 25 and 26 have resistances of 15,000 and 100,000 ohms respectively. The photocell 15 is preferably of the type known commercially as type 922. It is to be understood that these values are purely illustrative of those employed in one embodiment of my invention and that the invention is not in any way limited to the use of these particular values.

Operation of Figure 1

In discussing the operation of the apparatus shown in Figure 1, it will be assumed that the photocell 15 is not being energized by any light source which in one particular application would be a flame. When the photocell 15 is not energized there will be no current flow through the cell. With this condition it may be seen that an alternating current bias voltage is supplied to the control element 23 by a circuit that may be traced from the center tap 13, conductor 42, condenser 14, resistor 18, condenser 19, conductor 48, and conductor 49 back to the secondary winding 12. An energizing circuit is supplied to the amplifier 21 by way of conductor 42, conductor 43, resistor 25, conductor 40, anode 24, cathode 22, conductors 46, 47, 48 and 49 back to the secondary winding 12. It may now be seen that during the positive half cycles of the power supply, that is when the upper end of the transformer winding 12 is positive with respect to the lower, that the amplifier 21 will be conducting for the control element is slightly positive with respect to the cathode. With amplifier 21 conducting there will be a flow of current through the resistor 25 which will make the upper end negative with respect to the lower end. This current flow produces a bias voltage which is connected to the control element 29 of the amplifier 27 by way of conductor 41 and to the cathode 23 by way of conductor 44. The energizing circuit for amplifier 27 may be traced from the upper terminal of winding 12 through conductors 38 and 37, relay winding 32, conductor 45, anode 30, cathode 28, conductors 44, 43, and 42 back to the tap 13 of the secondary winding 12. As the polarity of anode 30 will correspond to that of the anode 24 of the amplifier 21, the current flow in the resistor 25 due to amplifier 21 will occur at the same time that anode 30 of amplifier 27 is positive. Since cathode 28 and the control element 29 are connected to the resistor 25, the voltage drop in the resistor 25 will be sufficient to bias the amplifier 27 to be effectively nonconducting.

As soon as flame is detected by the photocell 15 it will be possible for the photocell to pass current in such a direction as to charge the condenser 14 positive on the upper terminal and negative on the lower terminal since there is an alternating current applied to the photocell through the following circuit: tap 13, conductor 42, condenser 14, conductor 53, anode 16, cathode 17, conductor 50, and conductor 49 back to the secondary winding 12. Connected to the last named circuit between condenser 14 and photocell 15 is the filter network comprising the resistor 18 and the condenser 19 which acts to filter the D. C. charge on condenser 14 and apply a negative bias to the grid 23 to render the amplifier effectively non-conducting. The action of the resistor 20 is to form a load resistor for the filter condenser 19. The time delay of the resistor

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18 and the condenser 19 is sufficient to prevent any momentary fluctuation of the voltage on the condenser 14 due to a flame fluctuation from reaching the grid. With a negative bias on the amplifier 21 there will be a decrease in the amount of plate current flow through the resistor 25 which will mean that there will be a decrease in the negative biasing voltage applied to the grid 23 of the amplifier 27. Since the resistors 25 and 26 are connected across the section of the power supply common to amplifier 27, the control element 29 will tend to be positive with respect to the cathode 28 when there is no current flow through resistor 25 due to amplifier 21. This change in bias on the grid 29 will be sufficient to make the amplifier 27 conductive to the point where the relay 31 will be energized and will move the switch blades into engagement with contact 34 to indicate that there is a flame present at the photocell.

Should the flame be extinguished, the photocell 15 will be no longer conductive and the control element 23 of the amplifier 21 will again be biased to a voltage such as to allow the amplifier to conduct. The current flow through the amplifier 21 or through the load resistor 25 will be sufficient to bias the amplifier 27 to cut off and once again deenergize the relay 31 so that it is in the position as shown on the diagram.

Should a short condition exist at the photocell due to a tube short or a short between the conductors 53 and 50 leading to the photocell, the relay 31 will not be energized to indicate a flame. This may be seen since a short across the photocell 15 would not allow the photocell to rectify the alternating current flowing through it and condensers 14 would not be charged to bias the control grid 23 negative. Too, the control grid would be effectively tied to the same electrical point as the cathode and therefore the tube would conduct. With this conduction in amplifier 21, the resultant current flow through the resistor 25 will be sufficient to bias the amplifier 27 to be effectively nonconducting and relay 31 will not be energized. Therefore, the apparatus will not indicate a flame when a short occurs at the flame responsive device.

Figure 2

In Figure 2 is shown the invention used with a flame electrode associated with a flame and an electrical conductive burner apparatus. Components similar in Figures 1 and 2 carry the same reference numerals in both figures and will not be again described in connection with Figure 2. The only difference between Figures 1 and 2 is that portion that is connected between the conductors 27 and 53 which in the case of Figure 2 consist of a flame rod 54, a flame 55, and a conductive burner base 56.

The action of the apparatus shown in Figure 2 is practically identical to that of Figure 1 with the exception of the action of the flame detection device. It has long been recognized that a flame is a non-linear impedance and therefore has rectifying properties. This principle is utilized in this circuit by applying to the flame electrodes 54 and 56 an alternating current from the secondary winding of the transformer 12 by way of the center tap 13, conductor 42, condenser 14, conductor 53, electrode 54, flame 55, electrode 56, conductor 50, and conductor 46 back to the secondary winding. As the electronic current flow is in the direction of propagation of the flame it may be seen that the condenser 14 will be

charged positive on the upper terminal and negative on the lower terminal when there is a flame 55 bridging the flame electrodes 54 and 56. As in Figure 1, the charge on the condenser 14 biases the control element 23 through the filter network consisting of the resistor 18 and condenser 19 to bias the grid 23 negative and render the amplifier 21 effectively non-conductive. With the decrease in the current flow from the amplifier 21 flowing through the resistor 25 there will be less negative biasing action on the grid 29 of the amplifier 27 and therefore the amplifier 27 will be conductive and will energize the relay 31.

A short condition across the flame electrodes will produce the same effect as occurred when the photocell of Figure 1 was shorted out. Another condition often exists when using a flame rod and that is carbon from the flame will bridge the flame gap with a flame-like impedance. The action here is to remove the rectifying action of the flame and to not charge condenser 14 enough to bias the amplifier 21 to cut off. It is therefore easy to see that the relay 31 will not be energized to indicate a flame.

It may therefore be seen that a flame detection system has been provided which may be used with either a photocell or a pair of flame electrodes, the rectifying action of which controls the bias voltages on a two stage amplifier to effect energization of a control relay upon the presence of a flame. It may also be seen that this flame detection system provides for distinguishing between a flame condition and the condition of a short or bridging impedance at the flame detection device. It will also be seen that it is necessary to use only a single secondary winding with an intermediate tap to energize the apparatus.

While I have shown my invention in a flame detection apparatus and while it is particularly suitable for such an application, it is to be understood that it could be employed in any position where on-off action is desired from the action of a photocell or the like. It is therefore to be understood that my invention is to be limited solely by the scope of the appended claims.

I claim as my invention:

1. In combination, a source of alternating current comprising a transformer having a secondary winding with two end terminals and a tap thereon, a first electronic circuit operable from said source and comprising in part an electron discharge device whose current flow is controlled by the rectifying action of a condition responsive device, a second electronic circuit operable from said source and comprising an electron discharge device having an anode, a cathode, and control electrode, a current responsive device connected in the anode-cathode circuit of said last named discharge device, and means common to said first and second electronic circuits for controlling the operation of said second electronic circuit in accordance with the operation of said first electronic circuit, said means comprising a pair of series connected resistors connected across a portion of said source between one end terminal of said secondary and the tap of said secondary, means connecting the input of said second electronic circuit to said series connected resistors with the control electrode connected to the point of junction of said two series resistors and the cathode of the discharge device of said second electronic circuit connected to the top of said secondary.

2. In combination, a power transformer having a tapped secondary winding with two end terminals, a first electron discharge device having an anode and a cathode, the latter of which is connected to one end of said secondary winding, flame responsive means, a filter network, means connecting said flame responsive means and said filter network in a parallel relation, means connecting said filter network to said discharge device to control the current flow there-through, a pair of series connected resistors, means connecting said resistors between the other end and the tap of said secondary winding, means connecting the anode of said first discharge device directly to the junction of said resistors, a second electron discharge device having an anode, cathode, and control electrode, means connecting said control electrode directly to said junction of said resistors, means connecting said cathode of said second discharge device to said transformer, means connecting said anode of said second discharge device to said other end of said secondary winding, and flame responsive means connected in said last named anode connection.

3. In combination, a power transformer having a secondary winding with end terminals and a tap thereon, an electron discharge device having an anode, a cathode, and control element, condition responsive means, a condenser, means connecting said condenser and said condition responsive means in a closed series circuit between one of said end terminals and said tap, a filter network having input and output terminals, means connecting the input terminals of said filter network in parallel with said condition responsive means, means connecting the output terminals of said filter network between the control element and cathode of said electron discharge device to control the biasing thereof, means connecting said cathode to the end terminal of said secondary common to said closed series circuit, a pair of series connected resistors connected between said tap and the other end terminal of said secondary winding, means connecting said anode directly to the junction of said resistors, a second electron discharge device having an anode, cathode, and control element, a current responsive device, means connecting said current responsive device between said other end terminal of said secondary winding and the anode of said second electron discharge device, means connecting the cathode of said second discharge device to said tap, and means connecting said control element of said second discharge device directly to the junction to said series connected resistors.

4. In combination, a power transformer, a first electron discharge device having an anode, cathode and control element, means connecting the anode and cathode of said electron discharge device to said power transformer, a condenser, means indicative of a condition connected in circuit with said power transformer and adapted to charge said condenser on the presence of a condition, means connecting said last named means to the control element of said electron discharge device to render said electron discharge device non-conductive on the presence of a condition, a voltage divider comprising a pair of series connected resistors, means connecting the anode of said first discharge device directly to the point of connection between said resistors, a second discharge device having at least an anode, cathode and control element, means connecting the anode

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and cathode of said last named discharge device to the ends of said voltage divider, means connecting the junction of the resistors of said voltage divider directly to the control element of said second discharge device to control the conductivity of said second discharge device in accordance with the current flowing through said resistors due to said first discharge device and the voltage of said transformer, and control means connected in circuit with said second discharge device responsive to the conductivity thereof.

5. In combination, a power transformer having a center tapped secondary winding, a flame responsive device having rectifying properties, a condenser, means connecting said condenser and said flame responsive device in series between the center tap and one end of said secondary winding, an electron discharge device having an anode, cathode and control element, means including an output resistor connecting the anode and cathode of said discharge device in parallel with said condenser and said flame responsive device in series, a filter network, means connecting said filter network in parallel with said flame responsive means, means connecting the control element of said discharge device to said filter network at a point whose phase corresponds to that of the anode of said discharge device, a second electron discharge device having an anode, cath-

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ode and control element, a pair of series connected resistors one of which is said output resistor connected between said tap and the other end of said secondary winding, means connecting the anode and cathode of said second discharge device to said other end and said tap of said secondary winding respectively with a phase relation that corresponds to that of said first named discharge device, and means connecting the control element of said second discharge device directly to the junction of said resistors so that current flow through said resistors due to said first discharge device will affect the current flow in said second discharge device in one manner and when said first discharge device is non-conducting the voltage from said secondary upon said resistors will maintain the current flow in said second discharge device in a second manner.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,352,143	Wills	June 20, 1944
2,379,872	Gille	July 10, 1945
2,413,020	Wolfner	Dec. 24, 1946
2,422,574	MacLaren et al.	June 17, 1947