United States Patent

[11] 3,627,458

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[21] Appl. No. 851,390
[22] Filed Aug. 19, 1969
[45] Patented Dec. 14, 1971
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[32] Priority Aug. 27, 1968
[33] Great Britain
[31] 40,958/68

[54] **FLAME DETECTION SYSTEM**
8 Claims, 3 Drawing Figs.

[52] U.S. Cl. **431/25,**
328/6, 431/48, 431/50, 431/78
[51] Int. Cl. **F23n**
[50] Field of Search 431/78, 25,
48, 50; 328/6; 340/228.1

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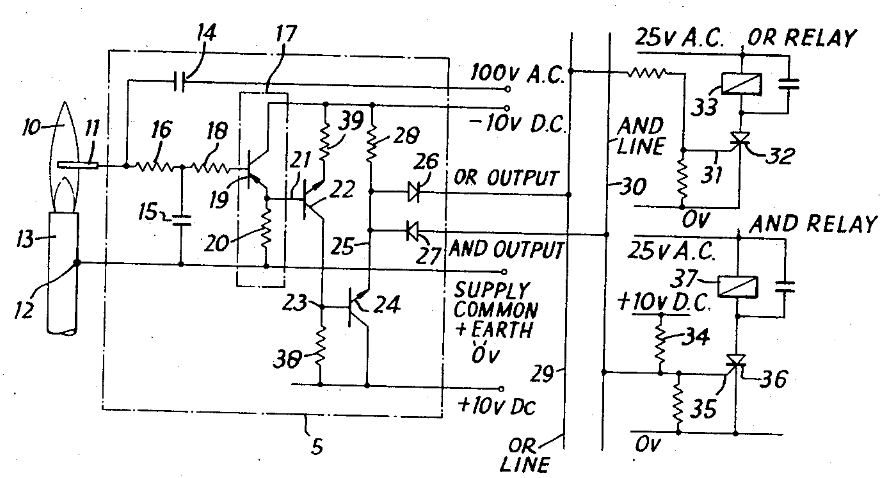
ABSTRACT: A flame detector, particularly for use in effecting automatic control of the fuel supply to burners, has a capacitor connected to an electrode which is disposed in the flame, when present at one of the burners or at a pilot burner, so that the capacitor charges up through the rectifying action of a said flame when an alternating current is supplied to the electrode.



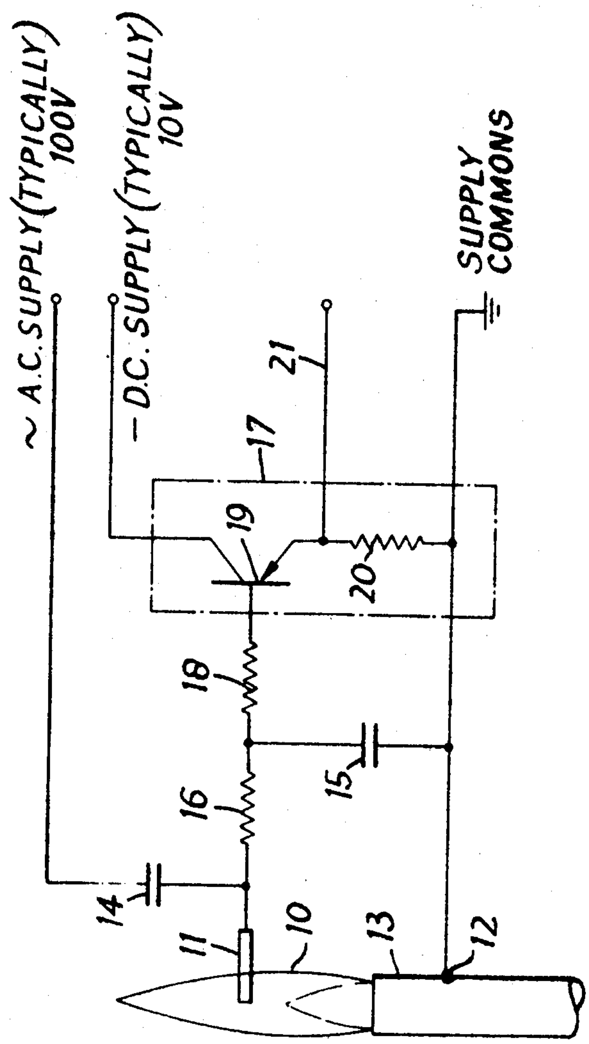

~ A.C. SUPPLY (TYPICALLY) 100V
− D.C. SUPPLY (TYPICALLY) 10V
SUPPLY COMMONS
21
17
19
20
18
15
16
14
11
10
13
12

FIG 1

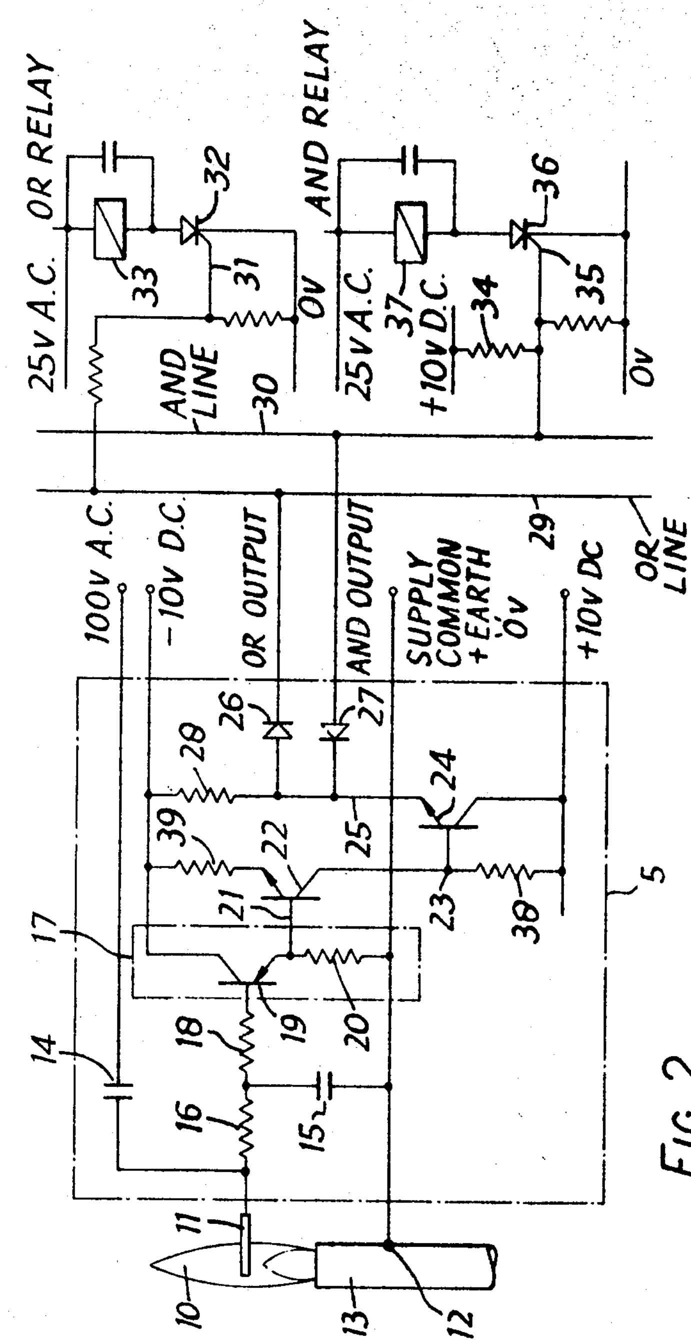

OR RELAY
25v A.C.
AND RELAY
25v A.C.
+10v D.C.
0v
0v
AND LINE
30
100v A.C.
-10v D.C.
OR OUTPUT
AND OUTPUT
SUPPLY COMMON + EARTH 0v
+10v DC
29
OR LINE
5
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
31
32
33
34
35
36
37
38
39

FIG. 2.

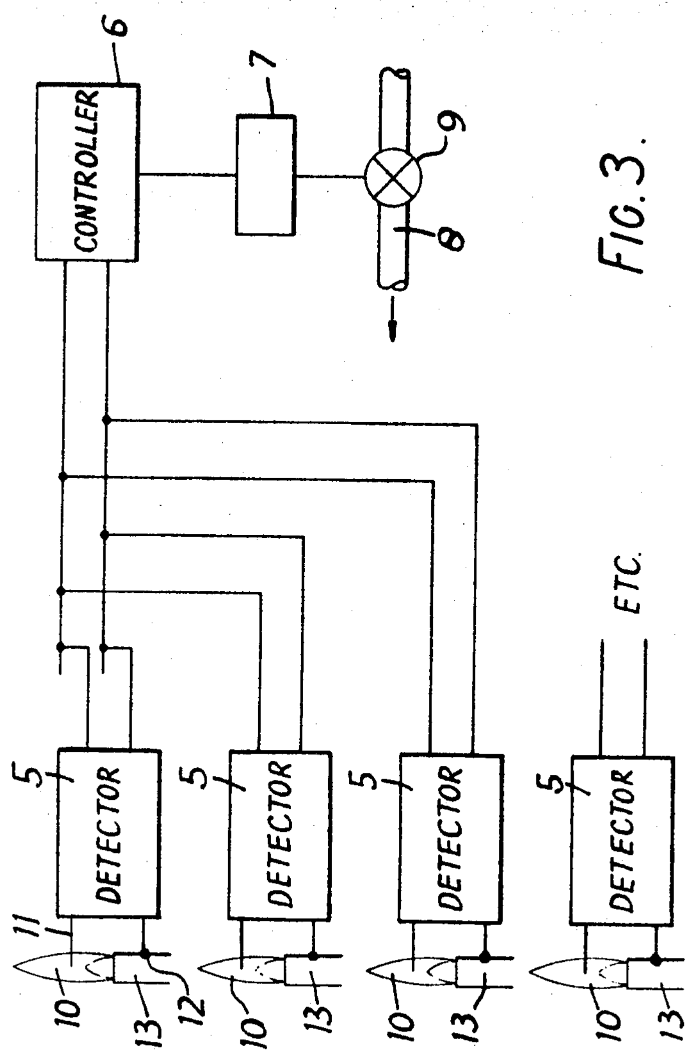

CONTROLLER
6
7
9
8
DETECTOR
DETECTOR
DETECTOR
DETECTOR
5
11
10
12
13
ETC.

FIG. 3.

FLAME DETECTION SYSTEM

This invention relates to systems for the detection of flames, and particularly, but not exclusively, the detection of flames in gas heating installations.

There is present, in all types of flame, a certain amount of ionization. As a consequence of the different mobilities of the ions formed in the relatively high and low temperature regions of the flame there is in general a space charge distribution in the flame, the effect of which may be observed as a difference in electrical potential between relatively high- and low-temperature regions of the flame. This potential difference may typically be of the order of 20 millivolts for a small methane flame, and may be measured by inserting two electrodes into different regions of the flame and measuring the potential difference therebetween by means of a high-impedance voltmeter.

If the electrodes in the flame were connected to an electrical supply rather than to a voltmeter, it would be observed that a larger current flow would take place between the electrodes for one polarity of the supply than for the opposite polarity thereof. That is, the flame acts in part as a rectifier or diode. The ratio between the effective resistance between two points in the flame to current flow in opposite respective directions typically ranges from 1:2 to 1:10, depending on the positions of the two points and the flame characteristics: the lower resistance of the flame, that is, its resistance in the "forward" direction of the effective diode, is typically of the order of 50 megohms.

The present invention makes use of the above-described rectifying action characteristic of a flame to detect the presence of a flame.

Accordingly the present invention provides a flame detector in which the presence of a flame is detected by means responsive to a charge developed on a capacitor from an alternating current source through the rectifying action of said flame.

Preferably the means responsive to the charge on said capacitor is effective to prevent the supply of fuel to said flame, and/or to another flame, upon extinction or partial extinction of said flame.

Where several burners are supplied from a common fuel supply, flame detectors according to the invention may be utilized to control the common fuel supply so as to shut off this supply in the event of any one of the flames being extinguished.

Thus the invention also provides a flame detection system including a plurality of said flame detectors, and means gating the outputs of the flame detectors together, said means being responsive both to the presence or absence of flames at all the detectors collectively and to the presence or absence of a flame at any one detector. Said gating means preferably include a first relay which is energized when a signal indicating the presence of a flame is received from any one flame detector, and a second relay which is energized when signals indicating the presence of a flame are received from all the flame detectors. The system may include a controller for controlling the supply of fuel to burners with which said flame detectors are associated, said controller being operatively associated with said relays so that fuel can be supplied to the burners for ignition only when both said relays are initially deenergized.

The present invention is of particular use for controlling the gas supply to large industrial gas burners. Here, a main gas feedpipe may supply several small gas burners which collectively form the overall burner installation. The method used to ignite the small burners has previously been to provide a pilot flame for lighting each of the small burners. One difficulty with this arrangement is that, should the supply of gas from the main gas feedpipe become temporarily disconnected and the small burners and their associated pilot flames extinguished, but subsequently the gas supply restored, there exists a danger of a gas explosion.

The flame detection system of the present invention allows the flames of individual burners to be continuously monitored, thus substantially reducing the risk of a gas explosion in the above-described circumstances.

The invention is further described by way of example with reference to the accompanying drawings, in which:

FIG. 1 is a circuit diagram showing means responsive to a charge developed on a capacitor, forming a simple flame detector according to the invention;

FIG. 2 is a circuit diagram of a flame detector according to a preferred embodiment of the invention, and

FIG. 3 is a schematic diagram which shows how a typical flame detection system including flame detectors according to the invention is used for controlling the supply of fuel to a series of burners.

FIG. 1 shows a fuel burner **13** substantially of metal having an electrode **11** arranged adjacent the burner so that one end of the electrode just enters a flame **10** formed at the burner **13**.

A capacitor **15** has one plate connected through a resistor **16** to the electrode **11** and its other plate connected to the metal burner **13** via a connection **12**. It is arranged for an alternating voltage to be applied between the electrode **11** and the connection **12** through a high-impedance direct-current blocking capacitor **14**.

The capacitor **15** is connected across the input terminals of a respective high-input impedance low-output impedance **17** through a resistor **18**.

The amplifier **17** in the embodiments of the invention illustrated in FIGS. **1** and **2** comprises a single transistor **19** connected in the common collector or emitter follower mode having a load resistor **20** in its emitter lead from across which the amplifier output is taken. This arrangement constitutes a simple flame detector according to the invention. In operation of this flame detector an alternating voltage, for example 100 volts AC, is applied through the capacitor **14** between the electrode **11** and the connection **12**. When a flame **10** is present at the burner **13** the rectifying action of the flame causes the capacitor **15** to be charged up through the resistor **16**. The potential difference across the capacitor **15** is applied to the input of the amplifier **17** through the resistor **18**. A direct voltage which is proportional to the potential difference across the capacitor **15** is developed across the load resistor **20** of the transistor **19** and can be used to provide an indication of the presence or absence of a flame at the burner **13**.

FIG. 2 shows a flame detector **5** according to the invention in which the output **21** from the transistor **19** of the amplifier **17** is fed to the base of a complementary transistor **22**. It is arranged that, with no flame present, the transistor **22** is biased into its conducting state by virtue of its base being connected to a supply which is more positive than that on its emitter. The collector and emitter of transistor **22** are connected to the positive (+10 volts) and negative (−10 volts) direct-current supply lines respectively, via resistors **38** and **39** respectively. The values of the resistors **38** and **39** are chosen such that when transistor **22** is fully conducting its collector **23** is at a voltage which is negative with respect to earth.

When a flame **10** is present direct current flows from the base of transistor **19**, causing a negative charge to appear at said base. This causes transistor **19** to conduct and hence its emitter **21** to become more negative.

This has the effect of reducing the conduction of the transistor **22** and in consequence the potential of the collector **23** of transistor **22** will become more positive. With a sufficiently strong flame the transistor **19** will become fully conducting and the transistor **22** will be completely nonconducting.

It will thus be seen that the collector **23** of the transistor **22** will be at a negative potential with respect to earth with no flame present and at a positive potential with respect to earth when a flame is present.

A further transistor **24** operating in the emitter follower mode has its base connected to the collector **23** of transistor **22** and its emitter **25** connected to the negative supply line (−10 volts) via a resistor **28**. The emitter **25** of transistor **24** will be at substantially the same potential as its base. Thus when no flame is present the emitter **25** of transistor **24** will be at a negative potential with respect to earth and when a flame is present the emitter 25 will be at a positive potential with respect to earth.

When it is required that several flames should be detected a respective detector 5 is provided for each burner and the emitter 25 of each transistor 24 is connected via a diode 26 to an OR-line 29 and via a diode to an AND-line 30.

A "flame present" indication on a detector 5 is given by the respective emitter 25 being at a positive potential. In this condition diode 26 is conducting and current will flow through the OR line into the trigger 31 of a thyristor 32 common to all the detectors 5, causing the thyristor 32 to conduct. The thyristor 32 is connected in series with a first relay 33 which is energized when the thyristor 32 conducts, in response to a "flame present" signal. Thus it will be seen that the presence of any one flame, or the existence of a fault in any detector 5 which simulates a flame, will cause the relay 33 to be energized.

The AND-line 30 is connected to the trigger 35 of a thyristor 36, which is in turn connected to a positive direct current supply via a resistor 34. When no flame is present emitter 25 of transistor 24 is at a negative potential and the diode 27 is conducting. The trigger 35 of the thyristor 36 is therefore also at a negative potential; hence the thyristor 36 is not conducting. If, however, a flame is present at each burner the emitter 25 of every detector 5 is at a positive potential and the diode 27 of every detector 5 is not conducting. Consequently the trigger 35 of the thyristor 36 becomes positive, causing the latter to conduct. A second relay 37 is connected in series with the thyristor 36 and is energized when the thyristor 36 conducts.

It will thus be seen that, where several detectors 5 are connected to the OR-line 29 and AND-line 30, if any one detector is giving a "flame present" signal the relay 33 will be energized and if all the detectors 5 are giving a "flame present" signal the second relay 37 will be energized.

In FIG. 3 there is shown a controller 6 which incorporates the relays 33 and 37 and their associated energizing circuits. Also incorporated in the controller 6 is a means for energizing an electrical actuator 7 of a fuel valve 9 included in a fuel supply line 8 leading to all the burners. The controller 6 is such that, prior to ignition, the actuator 7 can only be energized to open the valve 9 if both relays 33 and 37 are not energized. Thus should any one of the flame detectors 5 provide a "flame present" signal when the valve 9 is in fact closed prior to ignition, the controller 6 will prevent opening of the valve, indicating a fault in the integrity of the system.

The controller 6 is also such that, following ignition, both relays 33 and 37 must be energized, indicating that all burners are lit, before the system can be left unattended with the valve 9 maintained open.

The extinction of the flame on any one burner will cause the second relay 37 to become deenergized, causing deenergization of the actuator 7 to close the valve 9, shutting off the fuel supply to all the burners automatically.

I claim:

1. A flame detector comprising electrode means positioned at the site of a flame, a capacitor connected to said electrode means, means for supplying an alternating current to said electrode means, and means responsive to the presence of charge developed on said capacitor from said alternating current through the rectifying action of a flame when present at said site for producing a first output on a first output line which represents "flame present" and responsive to the absence of charge developed on said capacitor for producing a second output on a second output line which represents "flame absent," said means responsive to the presence and absence of charge on said capacitor including a first transistor having a base connected to said capacitor such that said first transistor becomes conducting when a flame is present, a second transistor having a base connected to the emitter of the first transistor such that the second transistor is turned off when a flame is present, a third transistor having a base connected to the collector of the second transistor such that the emitter of said third transistor is at a positive potential when a flame is present and at a negative potential when no flame is present, and first means connected between said third transistor emitter and one of the output lines which operates to conduct only when said emitter is positive and second means connected between said third transistor emitter and the other of the output lines which operates to conduct only when said emitter is negative.

2. A flame detector as claimed in claim 1, wherein said first and second means are diodes.

3. Flame detection system including a plurality of flame detectors, each comprising electrode means positioned at a respective flame site, a capacitor connected to said electrode means, means supplying an alternating current to said electrode means and means responsive to charge developed on said capacitor from said alternating current through the rectifying action of a flame for detecting the presence or absence of a flame at said site and for providing one or the other of two output signals representing respectively the presence of said flame and the absence of said flame; and controller means, responsive both to the flame present signals and to the flame absent signals, for producing a burner-enabling output.

4. Flame detection system as claimed in claim 3 which said controller means includes means for gating all of said "flame present" signals together and applying said "flame present" signals to operate a first relay when any one such signal is present and means for gating all of said "flame absent" signals together and applying said "flame absent" signals to operate a second relay when any one "flame absent" signal is present, and wherein said burner-enabling output is produced only when both said first and second relays are operated.

5. Flame detection system as claimed in claim 4, wherein said first relay is energized by the presence of any one of said "flame present" signals and said second relay is deenergized by the presence of any one of said "flame absent" signals.

6. Flame detection system as claimed in claim 5, said controller means further comprises a fuel supply valve supplying fuel to the said flame sites, said controller being controlled by said relays and being effective to open said valve initially only when both relays are initially deenergized.

7. Flame detection system as claimed in claim 6, in which the controller means is effective, after ignition of fuel has commenced, to maintain the fuel supply for unattended operation thereof only when both said relays are energized.

8. A flame detector comprising electrode means positioned at the site of a flame, a capacitor connected to said electrode means, means for supplying an alternating current to said electrode means and a solid-state circuit means responsive to the presence of charge developed on said capacitor from said alternating current through the rectifying action of a flame when present at said site for producing a first output on a first output line which represents "flame present" and responsive to the absence of charge developed on said capacitor for producing a second output on a second output line which represents "flame absent," said solid-state circuit means including at least one transistor the output of which is positive or negative according to whether or not a flame is present and a pair of diodes connecting the output of said transistor to one or other of the two output lines according to whether the said output is positive or negative.

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