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(54) Flame detection and controlling the flow of fuel to a burner

(57) A flame detector comprises a flame rectification effect circuit (8, 9, 1, 2) receiving A.C and which charges a capacitor (10) in the presence of a flame between probes 1. (The flame is modelled (2) as a resistor (R1) and diode (D1). An oscillator (3) is powered solely by the capacitor (11) to produce a waveform indicative of a flame. In absence of a flame the capacitor (10) is not changed and the oscillator (3) is inoperative. The waveform produced by the oscillator (3) is applied to a transistor (4) to maintain a gas control valve open by energising its solenoid (5).

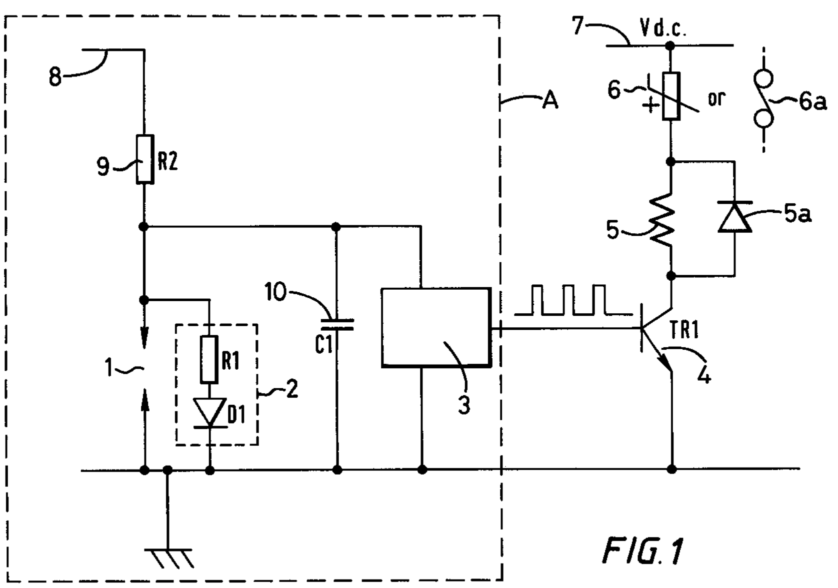

FIG. 1

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Description

The present invention relates to flame detection and also controlling the flow of fuel, such as gas, to a burner.

It is known to provide flame failure devices in a wide range of equipment which burns gas. Such devices detect the failure of a flame and cut-off the supply of gas to the burner producing the flame. Such devices are provided in domestic and industrial gas appliances such as cookers, heaters and boilers.

At present electro-mechanical devices are used especially in domestic gas-appliances. Whilst such devices are reasonably reliable, it is desired to provide a flame detector, and a flame failure device, which is more reliable and cheaper.

According to one aspect of the present invention, there is provided a flame detector comprising

a pair of spaced electrodes for applying a.c electrical energy to a flame when the flame is present between the electrodes,
capacitive means arranged to be charged, due to the rectification effect of the flame,
by the a.c. energy, the capacitive means being not charged in the absence of the flame, and
means energised solely by the said capacitive means for producing a signal indicative of the flame.

Because the means for producing the flame indicator signal is energised solely by the capacitive means, it is highly unlikely that a flame will be falsely indicated.

Because the flame detector is wholly electronic it is inherently more reliable than an electro-mechanical device. Also it can be manufactured in quantity more cheaply than an electro-mechanical device.

In a preferred embodiment, the capacitive means comprises a capacitor in parallel with the spaced electrodes, having one terminal connected to one of the said electrodes and another terminal connected to the other of the said electrodes and a resistor connected in series with the parallel arrangement of the capacitor and spaced electrodes. The simplicity of the embodiment and the well established failure modes of the resistor and capacitor result in a circuit which is reliable in operation but which also fails safe.

According to another aspect of the present invention, there is provided a flame detector in accordance with said one aspect of the invention, a fuel flow control valve which is electrically energisable to maintain a flow of fuel to the burner, and means responsive to the signal indicative of the flame to control the energisation of the valve. The fuel is preferably gas.

By using the flame detector of said one aspect, the flow control apparatus is more reliable and cheaper than an electro-mechanical device.

A preferred embodiment comprises means for responsive to electrical power greater than a predetermined threshold flowing to the valve for de-energising the valve. The responsive means may be a fuse or P.T.C resistor. If a fault condition develops whereby excessive current flows to the solenoid, the current is limited or cut-off to de-energise the valve.

The means for producing the flame indicative signal maybe an oscillator, the oscillator producing a mark-space waveform having a predetermined mark-space ratio for maintaining the valve open. If, due to a fault, the waveform tends more towards DC, the net current flowing to the valve will increase: the responsive means will then limit the current or cut it off.

In a most preferred embodiment the valve comprises a solenoid and the energisation control means comprises a control electrode connected to receive the flame indicative signal and a controlled path the controlled path, the solenoid, and responsive means being in series between terminals for receiving electrical energy for energising the valve. There is no separate power supply for the energisation control means which therefor cannot falsely maintain the valve open in the absence of the flame indicative signal.

For a better understanding of the present invention, reference will now be made, by way of example to the accompanying drawings in which:

Figure 1 is a circuit diagram of a flame failure device in accordance with the present invention; and
Figure 2 is an example of the low power oscillator used in the circuit of Figure 1.

The portion of Figure 1 within dashed box A is a flame detector.

Referring to Figure 1, in use a flame is produced by a gas burner (not shown) between a pair of electrodes 1 one of which is connected to an AC mains terminal 8 via a resistor 9 (R2). The equivalent circuit 2 of the flame is the series arrangement of a resistor R1 and diode D1 across the electrodes 1. Thus it will be appreciated that the contents of block 2 are not real components physically connected across the electrodes 1.

A capacitor 10 (C1) is connected in parallel with the electrodes 1 (and thus the flame) and in series with the resistor 9.

In the absence of a flame, when AC mains is applied between terminal 8 and ground, the circuit so far described effectively comprises only the resistor 9 and capacitor 10. No net charge is built up on the capacitor.

In the presence of a flame, because of the rectification effect of the flame, a net negative charge relative to ground accumulates on the capacitor 10.

The charge on the capacitor 10 is used to energise a low-power oscillator 3 an example of which is shown in Figure 2. The capacitor 3 is the sole power-supply for the oscillator. Thus in absence of a flame the oscillator does not function once the capacitor 3 discharges to a level too low to operate the oscillator.

The oscillator, in this example, produces a square wave having a mark: space ratio of 1:3. The square wave is a control signal, indicative of the presence of a flame, applied to the control electrode or base of a high gain transistor 4 (TR1). The transistor 4 may be replaced by, inter alia an FET, Darlington pair, an SCR, or a high gain current amplifier.

The collector-emitter path of transistor 4 is connected in series with a solenoid 5 and free-wheel diode 5a of a gas control valve and a positive temperature coefficient (PTC) resistor 6 or alternatively a fuse 6a between a +12V dc rail 7 and ground. (The rail 7 could be provided with e.g. 12V ac.) The transistor 4 has no power supply separate from the valve. It therefore has no source of power to falsely maintain the valve open.

When the solenoid 5 is energised the valve is maintained open and allows gas to flow to the burner. In this example, the energising current supplied to the solenoid is pulsed being controlled by the transistor 4 in response to the pulsed control signal produced by the oscillator 3. The pulsed energisation is sufficient to maintain the valve open.

The pulsed control signal is produced only if a flame is present between the electrodes 1. Thus if the flame fails, the control signal is not produced and the valve closes cutting off the gas supply to the burner.

The circuit of Figure 1 is arranged to minimise the risk of failing with the valve open. Because the oscillator 3 is energised solely by the capacitor 10, it is unable to produce a control signal indicative of a flame by false operation except in the unlikely presence of another fault which energises the oscillator. Resistors fail open-circuit so if resistor 9 fails, C1 will not charge and oscillator 3 will not operate so valve 10 will close.

If capacitor 10 fails as a short circuit, oscillator 3 will not operate. If capacitor 10 fails open-circuit then, an asymmetrical sine wave is produced in the presence of a flame. In the absence of a flame a sine wave is produced across the open-circuit. The oscillator may operate in short bursts but in either case insufficient to open the valve.

If, say due to a short circuit from the dc rail 7 or from terminal 8, or due to a malfunction in the oscillator the transistor 4 is held conductive for a prolonged period, the PTC 6 or fuse 6a will act to reduce or cut-off the current to the solenoid closing the valve and cutting off the gas supply to the burner.

Referring to Figure 2, the oscillator 3 which is energised only by the charge on the capacitor 10, may be a CMOS integrated circuit comprising two CMOS inverting amplifiers 20, 21 in series, and having capacitive (22) and resistive (23) feed back paths to cause the circuit to oscillate at the desired frequency and mark-space ratio.

Illustrative values for the components shown in Figure 1 are:

R1	50 - 120 Mohm
R2	22 Mohm
C1	33nF
TR1	e.g. ZVP4424
PTC6	116mA

The circuit of Figure 1 or Figures 1 and 2, may be provided in domestic and industrial gas appliances such as heaters, boilers, ovens and hobs.

Claims

1. A flame detector comprising

   a pair of spaced electrodes for applying a.c electrical energy to a flame when the flame is present between the electrodes,
   capacitive means arranged to be charged, due to the rectification effect of the flame,
   by the a.c. energy, the capacitive means being not charged in the absence of the flame, and
   means energised solely by the said capacitive means for producing a signal indicative of the flame.

2. A detector according to claim 1, wherein the signal producing means is a CMOS integrated circuit.

3. A detector according to claim 1 or 2, wherein the signal producing means is an oscillator.

4. A detector according to claim 1, 2 or 3, wherein the capacitive means comprises a capacitor in parallel with the spaced electrodes, having one terminal connected to one of the said electrodes and another terminal connected to the other of the said electrodes and a resistor connected in series with the parallel arrangement of the capacitor and spaced electrodes.

5. Apparatus for controlling the flow of gas to a gas burner, comprising a flame detector according to any preceding claim,

   a gas flow control valve which is electrically energisable to maintain a flow of gas to the burner, and
   means responsive to the signal indicative of the flame to control the energisation of the valve.

6. Apparatus according to claim 5, further comprising

   means for responsive to electrical power greater than a predetermined threshold flowing to the valve for de-energising the valve.

7. Apparatus according to claim 6, wherein the said responsive means comprises a fuse or positive temperature coefficient resistor.

8. Apparatus according to claim 6 or 7, wherein the valve comprises a solenoid, and the energisation control means comprises a control electrode connected to receive the flame indicative signal and a controlled path the controlled path, the solenoid, and responsive means being in series between terminals for receiving electrical energy for energising the valve.

9. Apparatus according to claim 5, 6, 7 or 8, comprising a current amplifier responsive to the flame detection signal to control the energisation of the valve.

10. Apparatus according to claim 9, wherein the amplifier is a bipolar transistor, Darlington pair or an FET.

11. Apparatus according to claim 5, 6, 7 or 8, comprising a switching device responsive to the flame detection signal to control the energisation of the valve.

12. Apparatus according to claim 11, wherein the switching device comprises a bipolar transistor, FET or SCR.

13. A gas appliance comprising a flame detector or gas flow-control apparatus according to any preceding claim.

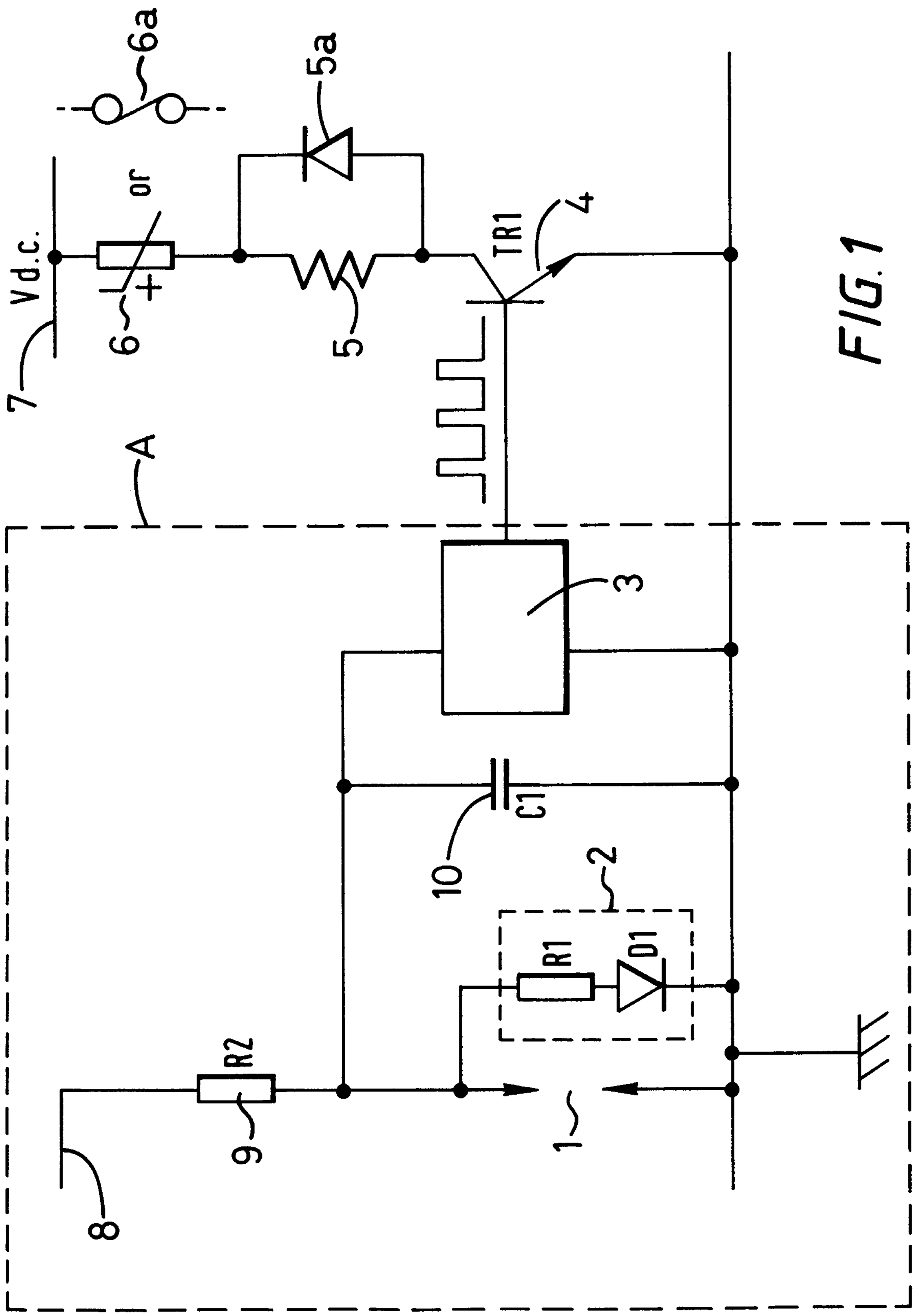

FIG.1

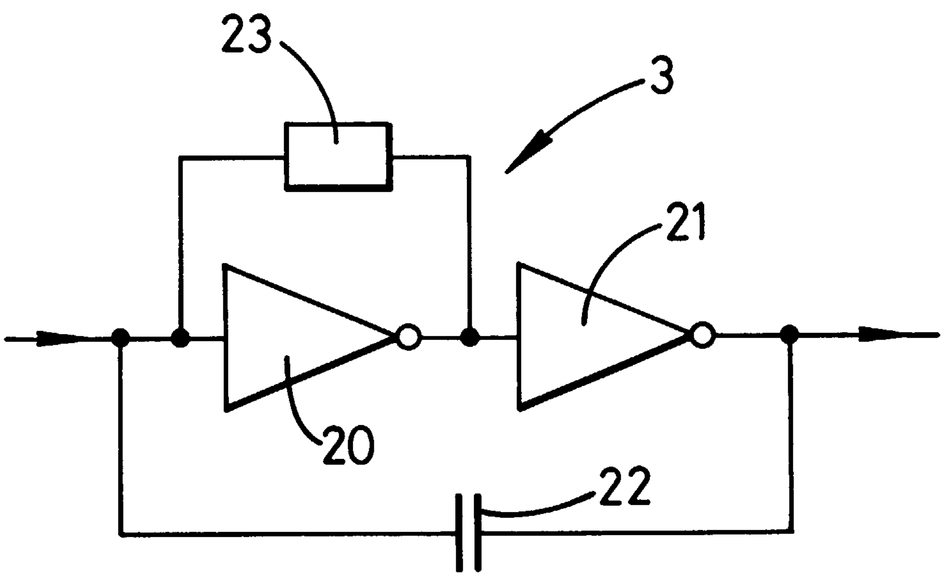

FIG. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 98 30 4553

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	DE 40 27 090 A (KROMSCHRÖDER) 5 March 1992 * column 3, line 19 - line 46; figures * ---	1,3,5,13	F23N5/12
X	US 3 853 455 A (RIORDAN ET AL.) 10 December 1974 * abstract; figures * ---	1-3,5,13	
A	US 4 019 854 A (CARLSON) 26 April 1977 * abstract; figures * ---	1,5,13	
A	PATENT ABSTRACTS OF JAPAN vol. 010, no. 275 (E-438), 18 September 1986 & JP 61 095601 A (HITACHI LTD), 14 May 1986 * abstract; figure * ---	2	
A	PATENT ABSTRACTS OF JAPAN vol. 005, no. 097 (M-075), 24 June 1981 & JP 56 042018 A (HITACHI HEATING APPLIANCE CO LTD), 20 April 1981 * abstract; figure * ---	1,5,9, 10,13	TECHNICAL FIELDS SEARCHED (Int.Cl.6) F23N
A	GB 1 509 705 A (WADE) 4 May 1978 * page 2, line 22 - line 33; figure 1 * -----	4	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10 September 1998	Kooijman, F

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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