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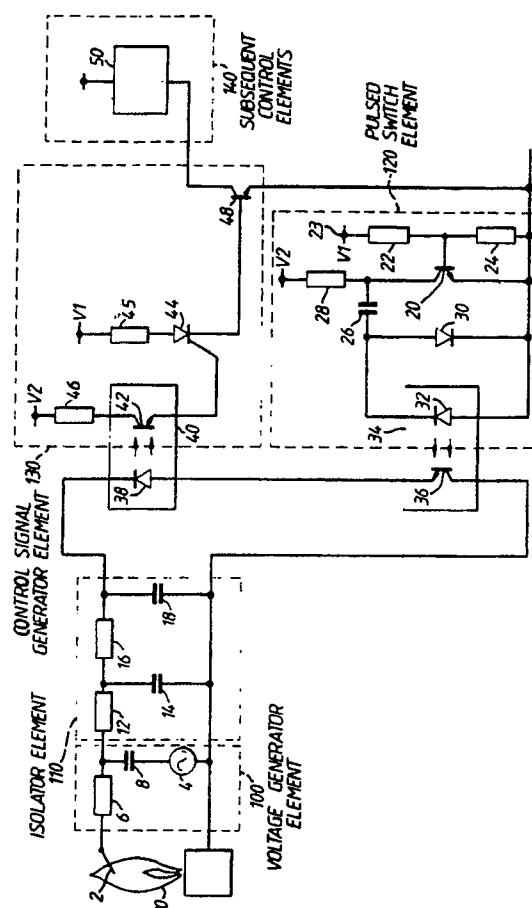
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54 **Flame detection apparatus and method.**

57 Apparatus and methods are described for the detection of the presence of a flame (10), the apparatus including circuit means for applying an alternating voltage to a flame probe (2) such that the alternating voltage is partially rectified in the presence of a flame (10) at the probe (2) resulting in the development of a DC voltage component. The DC voltage component causes the accumulation of a corresponding electrical charge in a storage element (18), the apparatus includes means (120,36) for periodically releasing the charge. An optical coupling means (40) is responsive to the released charge to initiate a control signal in a control signal generator (130), the control signal indicating detection of the flame (10).



FLAME DETECTION APPARATUS AND METHOD

The invention relates to apparatus and methods for the detection of the presence of a flame.

There are many domestic and industrial applications in which it is desirable to detect the presence of a flame and, as a result of that detection, to operate secondary control systems. Electronically controlled gas fired appliances, for example, require an adequate means of flame detection to ensure their safe operation. In the past, this has been achieved by exploiting the ionizing effect of a flame. In a typical arrangement, an alternating voltage is applied to a flame probe comprising two electrodes. The presence of a flame in the region of the probe causes the alternating voltage to be partially rectified. The DC component produced in this way is very small and requires high amplification before it can be used to control an appliance safety shut-off valve and, as a result, has given rise to a number of safety-related weaknesses.

In U.K. Patent No. 1,419,653 there is described a fuel flow control apparatus of the type described herebefore for monitoring a flame generated by a fuel burner. The apparatus described includes a flame probe to which an alternating voltage is applied, the DC component produced by the probe in the presence of a flame being used to charge up a capacitor so as to avoid the requirement for high amplification of the DC component. A sampling means is arranged to periodically discharge the capacitor to produce a periodic output signal indicative of the presence of the flame. A control means is responsive to the output signal to close a valve controlling the flow of fuel to the burner when the output signal indicates that the flame is not present.

Such an apparatus suffers the disadvantage however that there is an electrical path between the alternating voltage applied to the flame probe, and the valve which controls the flow of fuel to the burner. Thus, the circuit incorporated in the apparatus has to be relatively complex such that this electrical path does not constitute a safety hazard.

It is an object of the present invention to provide an apparatus and method for the detection of the presence of a flame of the type disclosed in U.K. Patent No. 1,419,653, but which contains relatively few electrical components and is thus relatively cheap to manufacture and wherein the difficulties inherent in the prior art arrangements are at least alleviated.

According to the invention, there is provided apparatus for the detection of the presence of a flame, comprising circuit means for applying an alternating voltage to a flame probe such that the alternating voltage is partially rectified in the pres-

ence of a flame at the probe resulting in the development of a DC voltage component, means responsive to the DC component to cause the accumulation of a corresponding electrical charge in a storage element, means for periodically releasing the charge, and optical coupling means responsive to the released charge to initiate a control signal in a control signal generator, the control signal indicating detection of the flame.

Thus, in an apparatus in accordance with the present invention, the means for applying an alternating voltage to the flame probe is electrically isolated from the control signal, together with any control systems which the control signal is arranged to operate. The alternating voltage may therefore be derived from any suitable source, for example directly from the mains supply or via a transformer.

According to the invention, there is also provided a method of detecting the presence of a flame, comprising the steps of applying an alternating voltage to a flame probe to produce a DC voltage component in the presence of a flame at the probe, producing an accumulation of electrical charge in response to the DC component, periodically releasing the accumulated charge, producing an optical signal representative of the released charge, and using the optical signal to initiate the generation of a control signal indicating detection of the flame.

Flame detecting apparatus and methods according to the invention will now be described, by way of example only, with reference to the accompanying sole figure of the drawings in which is shown a schematic representation of an electronic circuit of the apparatus.

As shown in the figure, a flame sensing probe 2, comprising a pair of electrodes, is connected across the terminals of a voltage generator element 100. Voltage generator element 100 provides an alternating high voltage by means of an AC voltage source 4, the alternating high voltage being applied to the flame sensing probe 2 via a resistor 6 and a capacitor 8. When a flame 10 is present in the region of probe 2 the alternating voltage applied to the probe is partially rectified as a result of the ionizing effect of the flame and a direct current flows between the electrodes of the probe 2. Thus the presence of a flame 10 within a region occupied by the flame sensing probe 2 causes a DC voltage to be developed across capacitor 8.

The rectified DC voltage component, together with the AC voltage component produced by AC source 4, is applied to isolator element 110 comprising a low pass filter assembly, in particular

resistors 12 and 16 and capacitors 14 and 18. In this way the DC voltage component is isolated from that produced by the AC source 4 so that the voltage developed at the output of isolator element 110, that is across capacitor 18, is predominantly DC in character and results from the presence of a flame 10 in the region of probe 2.

A pulsed switch element 120 is provided which, in the embodiment shown, includes a transistor 20 to the base of which is presented a periodically varying voltage V1 in such a way that transistor 20 assumes an off-state as voltage V1 approaches zero, the voltage V1 being presented to the base of transistor 20 via a resistor 22 from a source 23 which produces a varying voltage V1 falling to zero at for example 8.3 millisecond intervals where V1 is a 60 Hz mains voltage supply. Transistor 20 will resume an on-state as the voltage V1 rises and at a point determined by the ratio of the values of the resistors 22 and 24 and the peak value of V1. During the time that transistor 20 is off, a capacitor 26 will charge from a DC voltage supply V2 via resistor 28 and diode 30. When transistor 20 resumes an on-state, the charge stored in capacitor 26 is discharged through the light emitting diode 32 of opto-coupler 34 which in turn will cause the associated phototransistor 36 to assume an on-state. Thus pulsed switch element 120 causes phototransistor 36 to be pulsed on each time the voltage V1 approaches zero.

If a flame 10 is present in the region of probe 2, a DC voltage will exist across capacitor 18 as has been described. When phototransistor 36 is pulsed on, the capacitor 18 discharges through the light emitting diode 38 of opto-coupler 40. If the resultant current is above a certain threshold value, the associated phototransistor 42 of opto-coupler 40 will be pulsed on, causing an input voltage to be presented to control signal generator element 130.

Control signal generator element 130 includes a thyristor 44 energised via a resistor 45 from voltage V1, to the gate of which is presented the voltage pulse arising from the phototransistor 42, the voltage pulse being presented via resistor 46. As a result of the voltage pulse, the thyristor 44 will latch on and remain in an on-state until such time as the voltage V1 returns to zero and will cause transistor 48 to assume an on-state to operate subsequent control elements 140. The subsequent control elements 140 may comprise any elements whose operation is required to be dependent upon the presence of a flame 10 in the region of flame probe 2. In particular the subsequent control elements may contain a flame relay 50 or an appliance safety shut-off valve.

In a modification of the circuit shown in the figure, a capacitor (not shown) may be inserted in the signal path between the collector of the transis-

tor 48 and the subsequent control elements 140. Such a capacitor will prevent any short circuit occurring between the collector and emitter of the transistor 48 from leading to a permanent indication that a flame is present. However the inclusion of such a capacitor is not essential under present regulations as a permanent flame indication is allowed if this prevents the control elements from initiating an ignition cycle.

It will be appreciated that the intervals at which the varying voltage V1 falls to zero may be any suitable time interval sufficient to allow a sufficient amount of charge to build up on the capacitor 18.

It will also be appreciated that by the use of the opto-couplers 34,40 isolation between the pulsed switch element 120, voltage element 100 and associated isolator element 110, and the control signal generator element and associated subsequent control elements 140 is achieved. It is advantageous to the operation of the circuit that the operation of opto-coupler 40 is effectively checked by the operation of the opto-coupler 34 as the optical pulses emitted in each opto-coupler will be synchronised. In some flame detection apparatus in accordance with the invention however, the pulsed switch means for periodically releasing the charge on the charge storage element which has been accumulated due to the presence of a flame may form part of the circuit for applying an alternating voltage to the flame probe, the opto-coupler means linking the pulsed switch means to the charge storage element thus being omitted.

Claims

1. Apparatus for the detection of the presence of a flame (10), comprising circuit means (4,6,8) for applying an alternating voltage to a flame probe (2) such that the alternating voltage is partially rectified in the presence of a flame (10) at the probe (2) resulting in the development of a DC voltage component, means (110) responsive to the DC component to cause the accumulation of a corresponding electrical charge in a storage element (18), and means (120,36) for periodically releasing the charge, the apparatus being characterised in that it includes optical coupling means (40) responsive to the released charge to initiate a control signal in a control signal generator (130), the control signal indicating detection of the flame (10).

2. Apparatus according to claim 1, including low pass filter means (110) for substantially isolating the DC voltage component from the alternating voltage.

3. Apparatus according to claim 1 or claim 2, in which the means (120,36) for periodically releasing the charge comprises a pulsed switch means (120)

optically linked to the storage element (18) via a further optical coupling means (34).

4. Apparatus according to any one of the preceding claims in which the or each optical coupling means (34,40) comprises a phototransistor (36 or 42) which is triggered into conduction by light pulses emitted by a light emitting diode (32 or 38).

5. An apparatus according to claim 4 when dependent on claim 3 in which the pulsed switch means (120) comprises a transistor (20) and means for causing the transistor (20) to alternately charge and discharge a capacitor (26), discharge of the capacitor (26) causing the light emitting diode (32) to emit a light pulse.

6. An apparatus according to any one of the preceding claims in which the control signal generator (130) includes a thyristor (44) which is caused to switch into a conductive state in response to a signal indicative of the released charge.

7. An apparatus according to any one of the preceding claims including a control element (50) arranged to control the flame (10) in response to the control signal.

8. An apparatus according to claim 7 in which a capacitor is included in the signal path between the control element (50) and the control signal generator (130).

9. A method of detecting the presence of a flame (10), comprising the steps of applying an alternating voltage to a flame probe (2) to produce a DC voltage component in the presence of a flame (10) at the probe (2), producing an accumulation of electrical charge in response to the DC voltage component, and periodically releasing the accumulated charge, the method being characterised in that it includes the steps of producing an optical signal representative of the released charge, and using the optical signal to initiate the generation of a control signal indicating detection of the flame (10).

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