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COMBUSTIBLE GAS DETECTOR

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1 Claim. (Cl. 23—255)

The present invention relates to a thermally responsive device for detecting the presence of flammable gases, particularly to a heated catalytic device having a resistor element which varies in resistance according to temperature changes produced by combustion of the flammable components of gas.

It has been proposed to connect a coil of resistor wire in a resistance measuring circuit such as a Wheatstone bridge, heat the coil to the temperature required for catalytically induced combustion of the gas to be detected, and expose the resistor wire to a current of air containing the flammable gas. Variation in the amount of gas in the air current will change the heat of combustion and produce a corresponding variation in the resistance of the wire. Variations in the wire resistance indicate the amount of flammable gas present. While previous thermally responsive devices have operated satisfactorily for limited periods, they have proved to be inefficient and subject to rapid deterioration. If high current is applied to the relatively fragile resistor it consumes power excessively when operated at a temperature high enough to insure sensitivity and has a relatively short useful life, while if operated at low temperature it is insufficiently sensitive to detect low concentrations of certain flammable gases and is more susceptible to catalytic poisoning. Devices of the character referred to are also useful as fire detectors because the smoke and other products of combustion resulting from a fire contain unoxidized gas.

One object of the present invention is to afford a way of increasing the sensitivity of the thermally responsive device while reducing its consumption of power. Another object is to provide a simple, economically manufactured device which is physically more durable and catalytically less susceptible to deterioration.

In one aspect the invention relates to a temperature responsive device for use in apparatus for detecting flammable gas, the device comprising an electrical heating element for raising the gas to combustion temperature, a separate thermo-sensitive element which changes value in response to combustion of flammable gas, means for electrically insulating the aforesaid elements from each other and holding them in spaced relation, and terminals associated with the respective elements for connecting them in different circuits so that the thermo-sensitive element is electrically as well as physically separated from the heating resistance, thus allowing the heating element to be operated at optimum power or current, while the sensitive element may be operated at high voltage for maximum sensitivity but at relatively low current and temperature to reduce power consumption and deterioration.

Preferably the aforesaid insulating means includes a hollow support, one of the elements being mounted outside and one inside the support. The heating element may be a relatively thick durable wire mounted outside the support, while the thermo-sensitive element may be a relatively fine wire enclosed within and protected by the support. In one embodiment the insulating means com-

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prises a multi-threaded tubular support, the support having two or more parallel threads, the aforesaid heating and thermo-sensitive elements comprising wires of different sizes lying in different threads.

In a more specific aspect the temperature responsive device is associated with a heating circuit carrying low-voltage, high-amperage alternating current and another circuit carrying alternating or preferably direct current of higher voltage and lower current than aforesaid, said heating and thermo-sensitive elements being connected in said circuits respectively, allowing the heating element to be operated at optimum power and the sensitive element at maximum sensitivity.

In another aspect the invention involves apparatus comprising two resistance units, each unit including a thermo-sensitive element and a heating element, the thermo-sensitive element of each unit being in heat-transfer relation to the heating element, one unit having greater catalytic activity on flammable gas so that the resistance of its thermo-sensitive element is affected by heat more than that of the thermo-sensitive element of the other unit, together with an indicator circuit, an indicator interconnected with the thermo-sensitive elements through said circuit to indicate change in the ratio of the resistances of the elements in response to combustion of flammable gas, and a circuit independent of said circuit for energizing each of said heating elements, whereby the heating elements may be operated at optimum power while the thermo-sensitive elements are operated at maximum sensitivity. The catalytic activity of one unit may be made greater than that of the other either by forming the heating elements of materials which differ in their catalytic activity or by applying more catalytic material to one unit than the other, making the two units substantially identical in all physical and electrical characteristics except in respect to the amount of catalytic material, or partly one way and partly the other way.

For the purpose of illustration typical embodiments of the invention are shown in the attached drawing in which—

Fig. 1 is a schematic diagram of gas analyzing apparatus employing the present temperature responsive device; and

Figs. 2 and 3 are side elevations, partly in section, showing various embodiments of the device.

The gas analyzing apparatus chosen for the purpose of illustration in Fig. 1 comprises a Wheatstone bridge with terminals 11 and 12 for connection to a source of current, terminal 13 to which a galvanometer G is connected, and resistances 6, 8, 9 and 10 in the four legs of the bridge. Resistances 9 and 10 are fixed resistances while resistance 8 is a potentiometer for balancing the bridge. The resistance units 2 and 3 each comprises a supporting core 4 on which is mounted a heating element 5 and a thermo-sensitive element 6. The supporting core may be formed of any suitable porous ceramic, electrically-insulating material which is resistant to heat deterioration and is heat conductive, or may be formed of a braided asbestos tube having like properties. As indicated by broken lines 1, the two units 2 and 3 may be located in a flow chamber having its inlet connected to a source of gas to be tested or analyzed. For fire detection purposes the two units 2 and 3 may be located directly in the room or compartment to be protected so that the device will respond to unoxidized or partial products of combustion of the smoke as soon as a fire starts. Whether or not the two units are enclosed in a flow chamber they should be close together so as to be subjected to like conditions of surrounding temperature, draft, etc.

The potentiometer 8 is set so that the galvanometer reads zero when units 2 and 3 are exposed to gas having no flammable component. Current flowing through the

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heating element 5 heats the elements 5 and the supports 4 to the point where the flammable component of the gas is oxidized as it passes the heated wire. By making the catalytic activity of one of the units 2 and 3 greater than that of the other, the temperature of its heating element 5 and the resistance of its thermo-sensitive element 6 is raised more than that of the other unit by the oxidation of contacting gas. Consequently the bridge is unbalanced and the galvanometer G indicates the proportion of flammable material in the gas. Instead of the galvanometer the device may of course comprise a signal or relay for actuating any chosen protective apparatus.

In the drawings the catalytic activity of unit 3 is made greater than that of unit 2 by a deposit of catalytic material on the core as indicated at 7, 7a and 7c. Unit 2 may also have a catalytic deposit, but if the two units are otherwise identical the deposit should be much less than that on unit 3. While any suitable catalyst may be used, platinum or platinum-rhodium is recommended. Instead of applying different amounts of catalyst to the two units, or in addition to this difference, the heating element 5 of unit 3 may be formed of material having greater catalytic activity than that of the heater element of unit 2. For example, the heater element of units 2 and 3 may be formed of nickel-chromium alloy wire and platinum-iridium wire, respectively. Another way of obtaining a difference in activity between the two units is to make the heating elements of different sizes, as, for example, with wire of different diameters. The different ways may be employed individually or in any combination of two or more.

By using different materials or wires of different diameters for the two heating elements, instead of a difference in catalytic coating on the two units, it is easier to obtain uniformity in production because it is difficult to gauge the amount of catalytic coating with precision. By making the compensating unit 2 with little or no catalytic deposit and its heating element of material having low catalytic activity, while making the heating element of the active unit 3 of material having high catalytic activity, either with or without a deposit of catalyst, high sensitivity can be obtained because of wide difference between the responsiveness of the two units.

According to the present invention the heating elements 5 and the thermo-sensitive elements 6 comprise separate resistor elements. The heating elements 5 have their own terminals 14 to 17, inclusive, and may therefore be connected in a heating circuit including an alternating current transformer 18. The thermo-sensitive elements 6 have terminals 11 to 13, inclusive, which may be connected in a direct current circuit including a rectifying device 19 for rectifying alternating current supplied from an alternating current transformer 20.

Accordingly, the transformer 18 may furnish to the heating element 5 high-amperage, low-voltage, alternating current which affords optimum wattage with low power loss since the transformer 18 operates on alternating current with high efficiency. The thermo-sensitive elements 6, on the other hand, may be operated at relatively higher voltage and lower current supplied by the rectifying device 19, thus affording a greater electrical voltage unbalance as the result of temperature change and at the same time minimizing the cost of alternating current rectification equipment which depends on the amount of current.

As shown in Fig 2 the insulating core 4a comprises a tube. Deposited on the outside of the tube is a coating of oxidizing catalyst 7a, although it should be understood the deposit may be in the form of an impregnated layer at the surface of the porous tube. The heating wire 5a having terminals 14 and 15 is wound around the outside of the tube. The heating wire may be selected without regard to its value as a temperature indicator, and may consist of a metal alloy such as Nichrome or platinum-iridium in proportion of 80 to 20. The platinum-iridium

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alloy is particularly well suited because it has a resistivity approximately three times as much as pure platinum so that its cross section may be three times as great for the same heating effect, and thus a more rugged and serviceable heating wire is available. The thermo-sensitive element 6a may be a semi-conductor such as a sintered mixture of the oxides of manganese and nickel, or a fine platinum wire too delicate for heater wire but highly satisfactory as a temperature indicator. The semi-conductor element may be enclosed in its own protective case fitting within the tube 4a, or a delicate platinum wire may be sealed within the tubular core.

In the embodiment as shown in Fig. 3 the supporting core 4c comprises a cylindrical body provided with two threads 21 and 22 disposed in parallel along the surface of the cylinder, the heating wire 5c being wound in one of the threads, and the thermo-sensitive resistance 6c being wound in the adjacent thread and the two wires being separated by the apex between the two threads. The deposit of oxidizing catalyst 7c may be applied as in Fig. 2.

It can be seen that because of the electrical and physical separation of the heating and sensitive resistances these resistances, respectively, may be selected from the most favorable materials for heating and for temperature indicating, respectively. The heating wire preferably, but not necessarily being exposed on the outside of the core, may be a relatively thick and durable wire, while the thermo-sensitive resistance is preferably protected within the supporting core.

I claim:

In apparatus for detecting flammable gas, a temperature responsive device comprising an electrical heating resistance for raising the gas combustion temperature, a thermo-sensitive resistance responsive to combustion of flammable gas, electrically-insulating means for holding said resistances in spaced relation including a multi-threaded support, said resistances comprising wires differently constructed to have different catalytic activity and lying in different threads respectively, means for connecting said resistances in different circuits, and catalytic material for catalytically inducing combustion of the gas, the catalytic material being disposed on the threaded surface of the core.

References Cited in the file of this patent

UNITED STATES PATENTS

1,143,473	Williams	June 15, 1915
1,506,003	Kambayashi	Aug. 26, 1924
1,559,461	Ruben	Oct. 27, 1925
1,779,569	Thompson	Oct. 28, 1930
1,860,541	Hebler	May 31, 1932
1,902,427	Sawyer	Mar. 21, 1933
2,099,548	Vayda et al.	Nov. 16, 1937
2,285,633	Venable	June 9, 1942
2,329,840	Keinath	Sept. 21, 1943
2,369,811	Stuart	Feb. 20, 1945
2,535,950	Page	Dec. 26, 1950
2,541,857	Besselman et al.	Feb. 13, 1951
2,581,812	Page	Jan. 8, 1952
2,583,930	Cotton	Jan. 29, 1952
2,643,316	Glassow	June 23, 1953

FOREIGN PATENTS

290,581	Germany	Mar. 7, 1916
418,399	Germany	Sept. 4, 1925
539,562	Germany	Dec. 10, 1931
21,714	Great Britain	Oct. 27, 1900
of 1889		
238,531	Great Britain	Sept. 9, 1926
466,391	Great Britain	May 27, 1937