Nov. 13, 1962 J. E. LINDBERG, JR 3,064,245

HEAT DETECTION DEVICE

Original Filed May 25, 1959

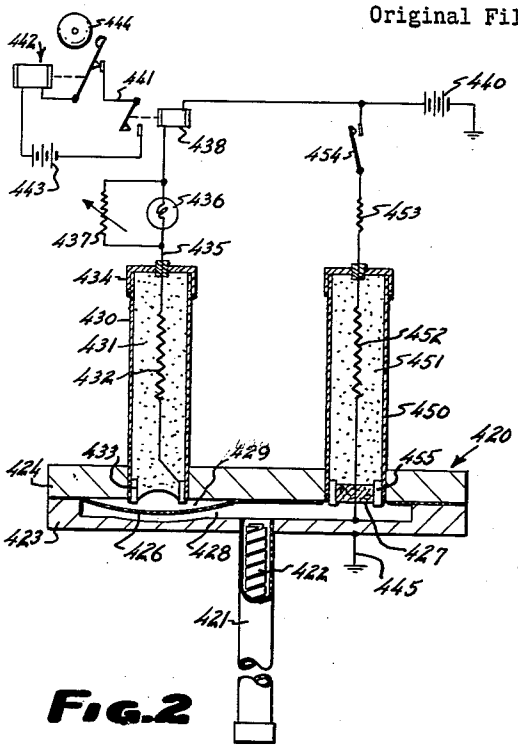


FIG. 2

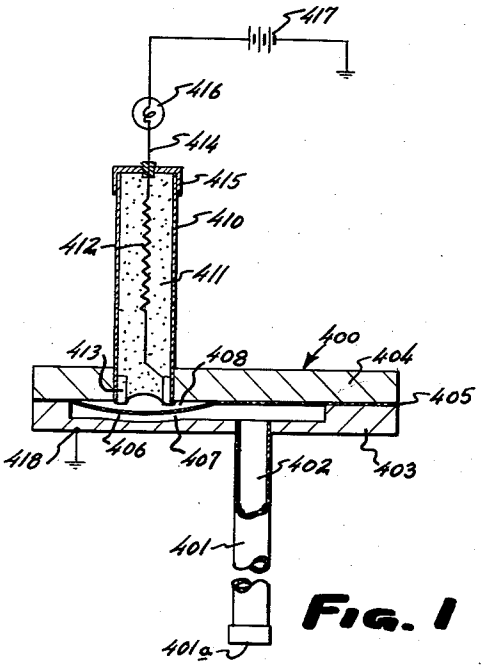


FIG. 1

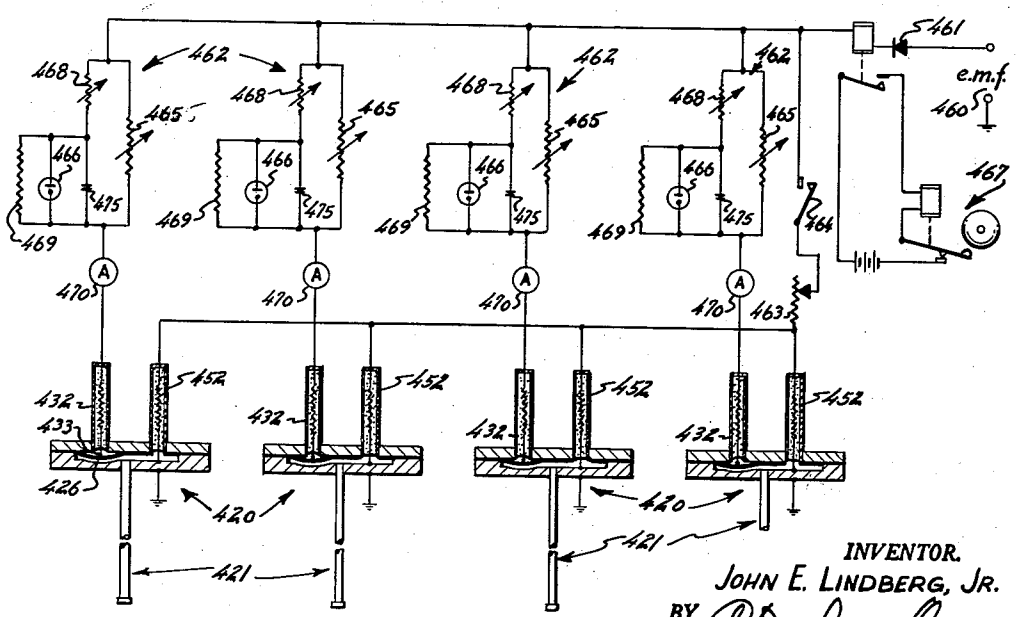


FIG. 3

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HEAT DETECTION DEVICE

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Original application May 25, 1959, Ser. No. 815,406. Divided and this application Jan. 18, 1961, Ser. No. 83,399

15 Claims. (Cl. 340—227)

This invention relates to heat detection devices. This application is a division of application Serial No. 815,406 filed May 25, 1959.

An important object of the invention is to measure a plurality of different temperatures with a single detecting instrument.

Another object is to provide a flashing-lamp type of temperature indicator.

Another object is to provide a single device that can indicate two different average temperatures.

Another object is to provide a single circuit for a plurality of such detecting devices.

Other objects and advantages of the invention will appear from the following description of some embodiments thereof.

In the drawings:

FIG. 1 is a view in elevation and in section of a device embodying one form of the invention and connected to a circuit, shown diagrammatically. The sensor is broken in the middle to conserve space.

FIG. 2 is a similar view of a modified form of the invention.

FIG. 3 is a similar view of a plurality of the devices of FIG. 2 joined in a single circuit.

(1) *Indication of Two Different Average Temperatures by a Single-Blister Type of Responder, and a Single Gas-Filled Sensor (FIG. 1)*

Indication of two different temperatures can be obtained from a single-blister responder **400** (a type of gas pressure-actuated switch fully described in the parent application) and an associated alarm circuit. A sensor tube **401** is sealed gas-tight at the end **401***a* away from the responder **400** with a gas **402** inside. Preferably a gas **402** which does not react chemically with the tube **401** is used; e.g., one or more of the noble gases such as argon or neon.

The responder **400** has two metal housing plates **403** and **404** and a metal diaphragm **405** sealed to the plates **403** and **404** except for a single blister **406**, an integral metal portion formed to a generally spherical segment. The blister **406** divides a sensor chamber **407** from an anti-sensor chamber **408**. A ceramic or other electrically insulating non-porous tube **410** connected to the anti-sensor chamber **408** is filled with a solid which liberates gas when heated and takes it back up when cooled. This material **411**, for example, may be fully ingassed calcium hydride or other hydride of an alkaline or alkaline earth metal or of any other metal of the type that liberates hydrogen when heated, as mentioned in the parent application. In the material **411** (preferably pretreated as described in a co-pending application Serial No. 65,891 filed October 31, 1960) is embedded a filament **412**, at one end of which is an electrode **413** extending into the chamber **408** below the tube **410**. A lead **414** from the filament **412** goes through the top of a sealing cap **415** and goes directly to an alarm circuit comprising a lamp **416** and a current source **417**. The electrode **413** may be annular and may be specially designed to retain the hydride **411** within the ceramic tube **410** while yet allowing gas released from the hydride **411** to pass into the anti-sensor chamber **408**.

Thus, the sensor chamber **407** and the inside of the

sensor tube **401** enjoy a common gas-filled atmosphere to the exclusion of any other, while the anti-sensor chamber **408** and the inside of the tube **410** enjoy a separate atmosphere to the exclusion of any other. The gas **402** in the tube **401** expands when the tube **401** is subjected to heat, the pressure within the sensor chamber **407** and the tube **401** corresponding to the average temperature to which the sensor tube **401** is exposed. When the sensor tube **401** is exposed to heat at a sufficient level to deflect the blister **406** against the electrode **413**, the electrical circuit is closed, and current passes from the current source **417** to the lamp **416** and thence to the filament **412**, the electrode **413**, and the diaphragm **405**, returning to the current source **417** via a ground **418**.

The passage of current through the filament **412** heats the hydride **411**, and as a consequence hydrogen is liberated. This gas is confined to the region on the anti-sensor side of the blister **406** and exerts pressure on the blister **406** which soon redeflects the blister **406** away from the electrode **413**, thereby breaking the electrical circuit and causing the lamp **416** to go out. Then the hydride **411** cools and reabsorbs some or all of the previously released gas, thereby lowering pressure in the anti-sensor chamber **408**. If the sensor tube **401** is still exposed to the original source of heat, the pressure in the sensor chamber **407** will then deflect the blister **406** against the electrode **413**, completing the circuit again.

Under these conditions, the blister **406** performs cyclically to make and break contact with the electrode **413**. This results in the lamp **416** flashing on and off. This alternating illumination of the lamp **416** indicates that the sensor tube **401** is exposed to an average temperature at or above a certain level.

As the temperature to which the sensor tube **401** is exposed is elevated, the pressure on the sensor chamber **407** becomes increasingly greater, and the effect on the cycle can be calibrated to indicate temperature. Finally a point is reached at which the pressure in the chamber **407** holds the blister **406** in contact with electrode **413** regardless of the gas-liberating effect of the hydride **411** on the blister **406**. Contact between the blister **406** and the electrode **413** will then be maintained until the pressure within the sensor tube **401** is reduced below a certain critical value, due to a drop of the average temperature below a certain critical value. One can select design parameters of the system, i.e., the deflecting force of the blister **406**, the amount and type of hydride **411** (or other gas-releasing material of similar characteristics) contained within the tube **410**, so as to differentiate between any two temperatures.

When the pressure in the sensor chamber **407** holds the blister **406** constantly against the electrode **413**, the lamp **416** stays lighted. Thus the two types of temperature conditions applied to the sensor **401** are readily distinguished by the alarm circuit C. For a "fire" temperature, the lamp **416** is steadily illuminated, while for the lower temperature which may represent overheating below fire, the lamp **416** flashes on and off. As a particular example of design, flashing may be obtained at 600° F. and a steady illumination at 1500° F.

(2) *Indication of Two Different Average Temperatures by a Single Blister Type of Responder and a Single Sensor Containing a Gas-Liberating Solid (FIG. 2)*

FIG. 2 shows a responder **420** like the responder **400** except that a testing device is included, along with an alarm circuit and a sensor that contains a gas-liberating solid. Thus, a sensor tube **421** contains a solid transducing agent **422** such as a compound like zirconium hydride. This compound retains its gas until heated to or above a certain threshold temperature, at which tem-

perature release of hydrogen begins. The amount of gas released increases as the temperature is increased above the threshold temperature. The elaborated gas obeys the gas laws, and the pressure effects are augmented as temperatures are increased by a further release of gas. The quantity of such evolved gas, once the threshold point has been reached, and the resulting pressure, are proportional to the responsible temperature. This phenomenon is useful for discriminatory temperature sensing.

The responder **420** has plates **423**, **424**, a diaphragm **425** with a blister **426** and a hole **427**, a sensor chamber **428**, and an anti-sensor chamber **429**. An insulating tube **430** is filled with material **431** such as calcium or zirconium hydride. A filament **432**, an electrode **433**, and a cap **434** are like the corresponding elements in FIG. 1, A circuit lead **435** extends from the filament **432** to a parallel arrangement of a lamp **436** and variable resistor **437** and from there proceeds to a relay **438** and up to a current source **440**. A supplementary circuit **441**, operated by the relay **438**, includes a bell circuit **442** in series with a battery **443** to ring a bell **444**. The responder **420** is grounded at **445**.

When the sensor **421** of FIG. 2 is heated to a particular temperature level, for example 600° F., where its outgassing threshold is reached and somewhat exceeded, gas is evolved to exert pressure against the diaphragm blister **426**. Sufficient pressure causes the blister **426** to deflect and make contact with the electrode **433**, closing the electrical circuit C. This lights the lamp **436**, energizes the relay **438**, and heats the filament **432**. Heat produced by the filament **432** causes the hydride **431** in the tube **430** to liberate gas rapidly, until sufficient force is developed to re-deflect the blister **426** back away from the electrode **433**, thus opening the power circuit, pultting out the lamp **436**, opening the relay **438**, and cooling the filament **432**. The cooling hydride **431** reingasses, lowering the pressure in the anti-sensor chamber **429**. The pressure in the sensor chamber **428** then forces the blister **426** back into contact with the alarm electrode **433**. The lamp **436** again lights, the filament **432** again heats, and the hydride **431** in the tube **430** again liberates gas. This make-break operation recycles at a rapid rate as long as pressure from the sensor **421** is available and so long as enough pressure can be developed by the hydride **431** to periodically overcome the sensor pressure.

Since the pressures from both the sensor **421** and the tube **430** are a function of their respective temperatures, the cyclic operation of the blister **426** may be made to provide a flashing alarm light **436** when pressures in the sensor chamber **428** are of the order of magnitude produced by non-extreme heating of the sensor **421**, or as it is commonly termed in the art, an "overheat" condition as contrasted with a "fire" condition. Relative values of heating levels and resultant gas pressure may be selected so that when the sensor **421** is heated to temperatures in excess of the "overheat" level, for example 1500° F., then gas is evolved at a more rapid rate from the sensor **421** and attains such a high pressure that the pressure derived from the tube **430** as a result of the alarm circuit closure is insufficient to separate the diaphragm blister **426** from the electrode **433**. The cyclic operation of the alarm system no longer occurs, and the signal is steady. The user can thus differentiate between an overheat condition and a fire in the areas sensed by the sensor.

The circuit of FIG. 2 also provides aural indication of the sensor condition. When current passes through the filament **432**, it also passes through the relay **438**, and rings the bell. Cyclic operation provides intermittent ringing of the bell **444**, while fire conditions cause a steady ringing of the bell **444**.

The variable resistor **437** in parallel with the lamp **436** regulates the magnitude of current flow to the filament **432** and thereby regulates the pressure that can be achieved in the anti-sensor chamber **429**. This resistor **437** makes it possible to vary as one pleases the temperature points causing intermittent operation and steady operation.

The testing system includes a tube **450** containing a quantity of metallic hydride **451** such as titanium hydride, and a filament **452**. The filament **452** is connected to ground at the point **445** and is connected to the power supply **440** via a resistor **453** and a test switch **454**. An annular cap **455** at the base of the tube **450** serves to contain the hydride **451** while allowing gas to pass between the tube **450** and the sensor chamber **428** at all times. Closure of the test switch **454** energizes the heater **452**, causing elaboration of gas from the hydride **451**. Gas pressure from this source then results in actuation of the alarm circuit if everything is satisfactory. It thus simultaneously tests the transducer system for leaks and the alarm system for proper operation.

As an example of magnitude of the circuit components and selected values used in a device in my laboratory, the following data is furnished. The resistance of the filament **432** was 12 ohms and that of filament **452** was 7 ohms. Both filaments were constructed of .002" diameter tungsten wire. Both tubes **430** and **450** contained about 0.2 gram of zirconium hydride. The transducing agent consisted of about 24 feet of 0.010" to 0 .015" diameter zirconium wire provided with a molybdenum-ribbon wrap constructed as shown in the parent application. The lamp **436** had a D.C. resistance of 13 ohms and was rated at 2½ volts. The resistor **437** was generally set to give a resistance of approximately 10 ohms with variation above and below that value. The relay **438** had an impedance of about 0.073 ohm, and the current source **440** was direct current at 28 volts.

(3) *Use of a Plurality of the Devices of FIG. 2 (FIG. 3)*

A source **460** of alternating current (or a pulsating direct current D.C. source) provides pulsating direct current to the transducers (after passing through a rectifier **461** if A.C. current is used). The warning circuits **462** are in parallel with each other, as are the test filaments **452**. A single resistor **463** and a single switch **464** are used for the test filaments **452**. Since the voltage supplied by the rectifier **461** is fixed, a series of variable resistors **465** are preferably employed to limit the current flow through the filaments **432** to a given maximum value. Continuous indication in the case of fire is obtained by proper setting of the variable resistors **465**.

FIG. 3 shows a neon warning light **466** in each warning circuit, while a single bell-circuit **467** is used to indicate fire, or overheat, at any or all the sensors **421**. A gas-filled lamp, such as each lamp **466**, presents a very high impedance until the potential across it is sufficient to cause a glow discharge to take place in the lamp, at which time its impedance is low. During the time that the blister **426** is in contact with the electrode **433**, a capacitor **475** draws a small charging current through a variable resistor **468**. When the voltage across the capacitor **475** reaches the firing potential of the lamp **466**, the lamp fires and discharges the capacitor **475** with the help of a resistor **469**, which has a high resistance. The capacitor **475** is then ready for another cycle of operation. The time constant of the lamp **466** and capacitor **475** circuit is fixed primarily by the values of voltage supplied by the rectifier **461** and the resistance of the resistors **468** and **465** and the capacitance of the capacitor **475**. Thus, the resistor **468** varies the interval over which the capacitor **475** reaches sufficient potential to discharge through the lamp **466**. If, while a blister **426** is cycling at a given rate, the resistor **468** is adjusted so that the capacitor **475** can reach the proper potential, the lamp will flash; but if the bleed of this charge by the resistor **469** is too great for the charging forces to overcome, the lamp **466** will not fire. Thus it may be seen that the minimum diaphragm cycling frequency at which the lamp will give indication of an overheat condition is set by the variable

resistor 468. Since the cycling frequency is proportional to the transducer temperature, the resistor 468 may be said to adjust the lowest temperature at the sensor A, at which overheat warning will occur.

This gas present freely in the sensor A sets up an ambient pressure. As the sensor environment becomes colder, this pressure would drop below its ambient, and it will become higher if the sensor tube temperature rises. Thus, when used in this manner, the device becomes a gas thermometer, the back pressure used in the diaphragm being proportional to the sensor temperature. Since this back pressure is produced by the current in the filament 432 resulting in outgassing the surrounding hydride 431, the average current passing through the filament 432 is proportional to the temperature of the sensor A. Therefore, by inserting an ammeter 470 in series with the filament 432, another visual indication of the average temperature may be obtained, and the ammeter 470 may be calibrated to read this temperature directly.

To those skilled in the art to which this invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the spirit and scope of the invention. The disclosures and the description herein are purely illustrative and are not intended to be in any sense limiting.

I claim:

1. A critical-temperature detection system comprising a sensor tube containing and confining gas which, when heated, raises the internal pressure of the tube; a diaphragm; a housing divided by said diaphragm into two chambers, namely, a sensor chamber in communication with said tube and its gas and an anti-sensor chamber; a solid material in said anti-sensor chamber of the type that liberates gas when heated and takes up gas when cooled, resulting in pressure changes in said anti-sensor chamber; and an electrical circuit including, in series, an indicator actuated by closure of said circuit, and a switch actuated by said diaphragm, being closed when the sensor chamber pressure exceeds the anti-sensor pressure by a certain amount, thereby closing the circuit, actuating the indicator, and heating said material, which then releases gas in said anti-sensor chamber to open said circuit, whereupon said material cools and reduces the pressure in said anti-sensor chamber, said device thus being able to cycle.

2. The system of claim 1 in which said sensor tube also contains solid material of the type that liberates gas when heated and takes up gas when cooled.

3. The system of claim 2 wherein there are: a second tube opening into said sensor chamber and otherwise closed; a gas-releasing transducing agent in said second tube; and electrical heating means for heating siad agent in said second tube and thereby releasing gas therefrom so as to test the action of said system.

4. The system comprising a plurality of units of claim 1 with a single electrical circuit incorporating all said circuits in parallel with each other.

5. The system of claim 4 having a single audible warning device in said last-named circuit, actuated when any of said switches closes.

6. The system of claim 1 wherein said indicator is a lamp that flashes on and off as the circuit cycles.

7. The system of claim 6 wherein said lamp is a gas-filled discharge tube.

8. The system of claim 1 wherein said indicator is an ammeter calibrated to read in terms of temperature.

9. A critical-temperature detection system comprising a sensor tube containing and confining noble gas which, when heated, raises the internal pressure of the tube; a diaphragm; a housing divided by said diaphragm into two chambers, namely, a sensor chamber in communication with said tube and its gas and an anti-sensor chamber; a solid material in said anti-sensor chamber of the type that gives off gas when heated and takes up gas when cooled, resulting in pressure changes in said anti-sensor chamber; and an electrical circuit including, in series, an indicator actuated by closure of said circuit; a heater filament embedded in said material, and a switch actuated by said diaphragm, being closed when the sensor chamber pressure exceeds the anti-sensor pressure by a certain amount, thereby closing the circuit, actuating the indicator, and heating said material, which then releases gas in said anti-sensor chamber to open said circuit, whereupon said material cools and reduces the pressure in said anti-sensor chamber, said device thus being able to cycle.

10. A critical-temperature detection system comprising a sensor tube containing a solid transducing agent that releases large quantities of gas when heated to critical temperatures and takes it up when cooled; a diaphragm; a housing divided by said diaphragm into two chambers, namely, a sensor chamber in communication with said transducing agent and the gas released therefrom and an anti-sensor chamber; a solid transducing agent in said anti-sensor chamber that releases large quantities of gas when heated; and an electrical circuit including in series indicator means actuated by closure of said circuit, electrical heating means for said agent in said anti-sensor chamber, and a switch closed by said diaphragm when the pressure in said sensor chamber overbalances the pressure in said anti-sensor chamber by a certain amount, closing of said circuit causing said heating means to heat the agent in said anti-sensor chamber and increase the pressure therein so as to tend to open said circuit so that said agent in said anti-sensor chamber acts to decrease the pressure in said anti-sensor chamber, resulting in cycling.

11. The system of claim 10 wherein there are: a second tube opening into said sensor chamber and otherwise closed; a solid transducing agent of the type in said anti-sensor chamber in said second tube; and electrical heating means for heating said agent in said second tube and thereby releasing gas therefrom so as to test the action of said system.

12. The system comprising a plurality of units of claim 11 with a single electrical circuit incorporating all said circuits in parallel with each other.

13. The system of claim 11 having a single audible warning device in said last-named circuit, actuated when any of said switches closes.

14. The system of claim 10 wherein said indicator means comprises an ammeter.

15. The system of claim 10 wherein said indicator means comprises a flashing lamp.

No references cited.

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,064,245 November 13, 1962

John E. Lindberg, Jr.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 35, for "pultting" read -- putting --; line 62, for "The" read -- Then --; column 5, line 38, after "circuit," insert -- electric heating means for heating said material, --.

Signed and sealed this 3rd day of September 1963.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents