United States Patent [15] **3,663,150**

Hapgood [45] **May 16, 1972**

[54] SAFETY IGNITION CONTROL SYSTEM

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[22] Filed: **Jan. 23, 1970**

[21] Appl. No.: **5,439**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 772,559, Nov. 1, 1968, abandoned.

[52] **U.S. Cl.** 431/66
[51] **Int. Cl.** F23n 5/14
[58] **Field of Search** 431/75, 78, 66

[56] **References Cited**

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[57] **ABSTRACT**

A control system for use in combination with any combustion type heating device to provide a fail-safe safety ignition system. A voltage source, circuit breaker, igniter, electrically actuated fuel source control means and serially connected ignition sensing means, of a material having a high positive temperature coefficient of electrical resistance, are incorporated in the system. The current due to varying resistance of the sensing means will develop from a high initial value to a lower average normal running current value upon satisfactory ignition. The system parameters are selected to automatically disconnect the fuel source in the event of a failure in the combustion cycle. The circuit which includes the sensing means may also include a temperature indicating device.

15 Claims, 6 Drawing Figures

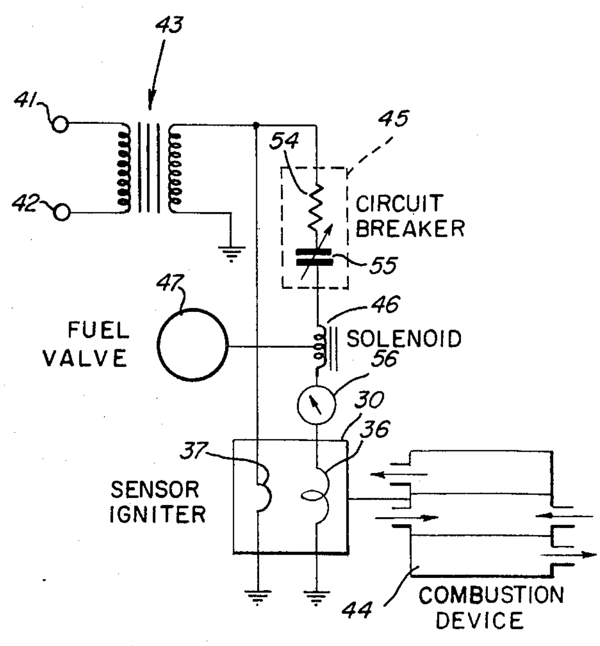


FIG. 1

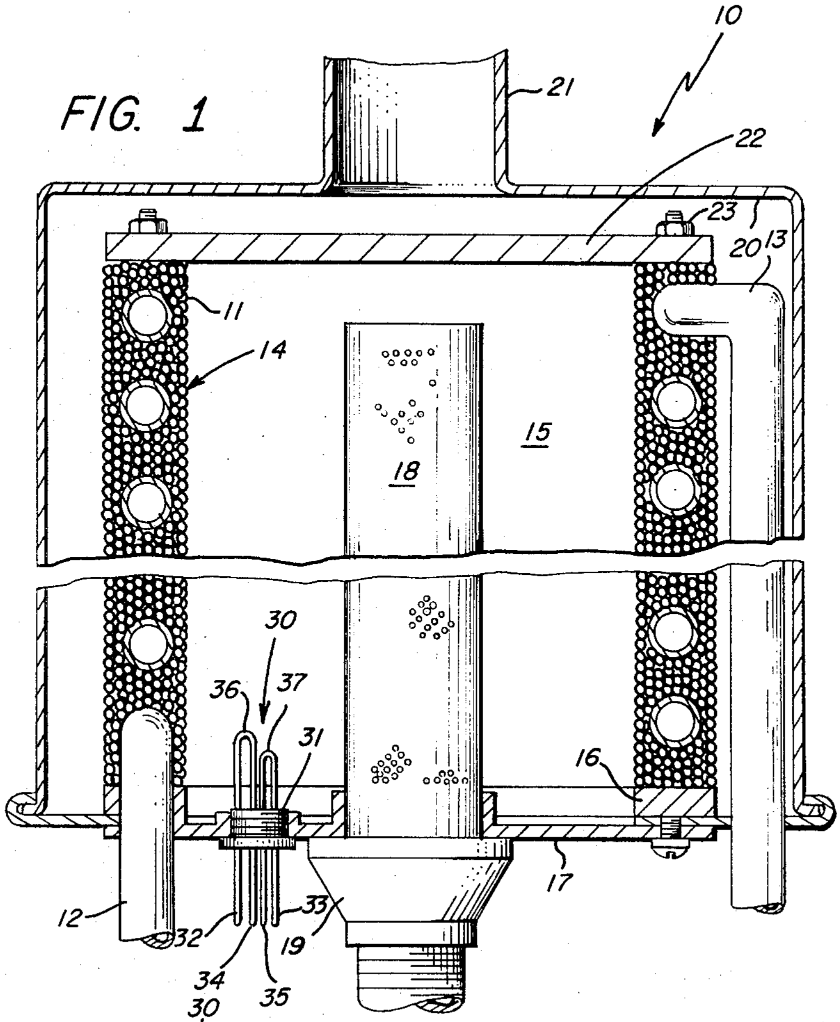
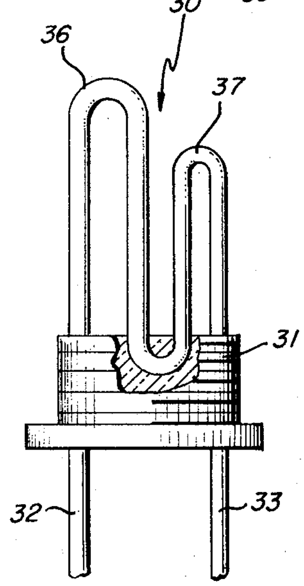


FIG. 2



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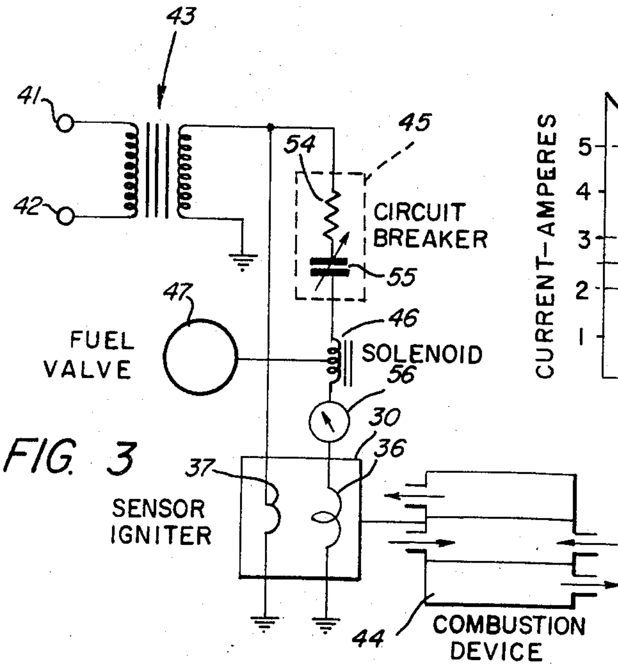

FIG. 3

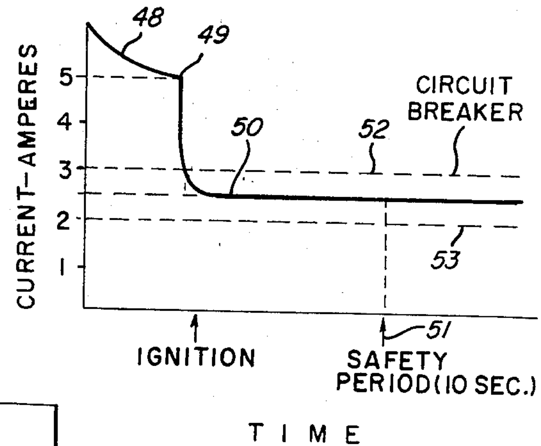

FIG. 4

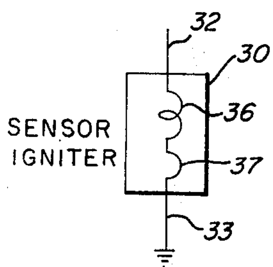

FIG. 6

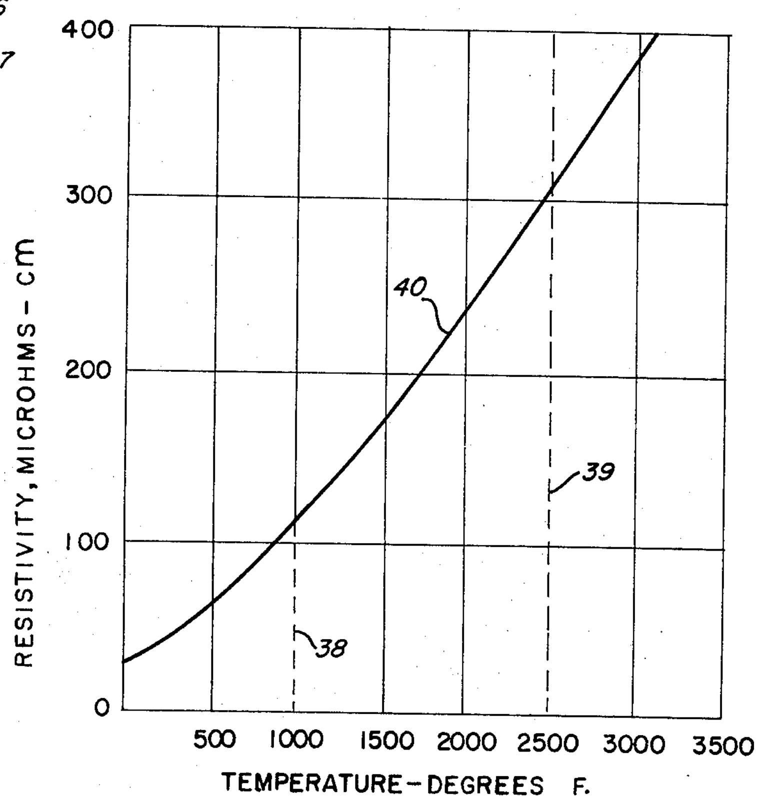

FIG. 5

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SAFETY IGNITION CONTROL SYSTEM

This is a continuation-in-part of application Ser. No. 772,559, filed Nov. 1, 1968, and now abandoned.

BACKGROUND OF THE INVENTION

In combustion type heating devices numerous fail-safe systems have been devised actuated by mechanical, optical or electrical means for detecting the failure of ignition and supplying corrective measures. Such means as flame sensors or temperature surveillance means utilizing ionization conductivity have been disclosed in combination with ignition means of the spark discharge type to automatically provide a safety ignition system. Additionally, many safety devices have been provided for gas operated apparatus by means associated with the pilot light flame. However, such prior devices have been unduly complex and expensive. Desirably, any simplification and reduction in cost of any fail-safe safety ignition control system for combustion type devices must nevertheless possess an inherent reliability and long life characteristic in order to yield an acceptable product.

SUMMARY OF THE INVENTION

In accordance with the teachings of the present invention a system for a simple, reliable and inexpensive fail-safe control system is disclosed for thermally and electrically performing the flame sensing function in combustion type heating apparatus. The system also incorporates appropriate flame igniting means. The sensing means comprising an element having a high positive temperature coefficient of electrical resistance is combined with circuit interruption means and fuel supply disconnect means to provide the fail-safe system. The material selected for the sensing preferably is molybdenum disilicide. Desirably, the resistivity of the sensing element at room temperature is low. At high temperatures, illustratively 2,500° F and above, the resistance is substantially higher by a factor of approximately three to one to provide for substantially reduced current values. Appropriate selection of the parameters of the sensing member will desirably provide a drop in current of approximately one-half to an average running current value when satisfactory combustion occurs and the sensing member temperature rises.

A circuit interruption means such as a circuit breaker having a predetermined minimum threshold value intermediate to the high initial current value and average normal running current values is interconnected with the fuel supply source and the sensing means. This circuit will provide for automatically disconnecting the fuel supply after a predetermined period of ignition failure by reason of the current value exceeding the predetermined circuit breaker minimum threshold value.

While any appropriate type of igniter may be used, preferably the igniter comprises an element of the same material as the sensor and may be connected in series with it or may be independently connected to a voltage source. Since the current through the sensor varies substantially with the temperature within the apparatus, the value of that current may be used to measure such temperature by connecting a current meter, calibrated to indicate temperature, in series with the sensor.

The safety ignition control system of the invention is substantially less expensive than prior art devices for similar purposes, without any sacrifice of its fail-safe properties. The electrical circuit of the disclosed system is equally applicable to any type fuel source and all combustion type devices.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, as well as specific illustrative embodiments, will now be discribed, reference being directed to the accompanying drawings in which:

FIG. 1 is a vertical cross-sectional view of an illustrative combustion type device incorporating the structure of the present invention;

FIG. 2 is an enlarged perspective view partially in section of an alternative embodiment of the sensor and igniter structure;

FIG. 3 is a schematic circuit diagram of an illustrative embodiment of a system according to the present invention;

FIG. 4 is a graph of current versus time explaining the operation of the present invention;

FIG. 5 is a graph of the electrical resistivity versus temperature characteristics of a material for the sensing means; and

FIG. 6 is a circuit diagram for the modification represented by FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, FIG. 1 illustrates an exemplary embodiment of a combustion type heat exchanger device **10** for the heating of circulating fluids. A helical conduit **11** is provided with an inlet connector **12** and an outlet connector **13** coupled to any conventional fluid source and utilization means. The conduit structure is embedded in a matrix structure **14** composed of a plurality of discrete thermally conductive bodies suitably joined together by metallurgical processes to provide a self-supporting structure. A central combustion chamber **15** is thus defined by the disclosed heat exchange device. A top plate member **22** is suitably secured to the matrix structure **14** by nut and bolt means **23** to enclose one end of the combustion chamber.

A lower support plate member **16** has secured thereto a closure member **17** which has appended thereto and centrally positioned within the combustion chamber a multi-ported burner assembly **18**. The fuel for the burner assembly may be provided in the form of an air-gas mixture underpressure from a source coupled to conduit **19** suitably secured to the end closure member **17**.

An outer wall enclosure member **20** surrounds the combustion heater and provides for the egress of the exhaust gases passing through the sintered matrix. A vent **21** extends laterally from the outer wall member **20** and may be coupled to any convenient outlet for the egress of the combustion gases. Elaboration of any associated electrical circuits or control means has been omitted in this illustration and will be discussed hereinafter.

In accordance with the teachings of the present invention the sensing means **36** and ignition means **37**, collectively indicated be the numeral **30**, may comprise members of varying dimensions of a resistance material to be hereinafter specified. The members are individually mounted on a ceramic base member **31** suitably secured to the end closure **17** so as to be exposed to the interior of combustion chamber **15**. The member **36** is provided with external connecting leads **32** and **34** and the member **37** is provided with external connecting leads **33** and **35**. While the ignition and sensing means have been indicated in a unitary supporting structure it is well within the precepts of the invention to provide separate ignition and sensing members in any desired position within the combustion device. In the illustrative embodiment the longer loop member **36** of larger cross-sectional area is utilized for performing of the sensing function and the shorter somewhat thinner loop member **37** serves as the igniter.

Referring now to FIG. **5**, the electrical resistivity versus temperature parameter of the preferred material will now be enumerated. The principal determining feature is that at low temperatures, illustratively from room temperature to for example 1,000° F., a very low resistivity is provided with resultant high currents. At the high end of the temperature range, however, particularly at combustion temperatures of 2,500° F. and above, the resistivity rises sharply to yield much lower currents. For conventional working embodiments the normal operating temperature range is indicated by the dotted line **38** or 1,000° F. for the lower end and dotted line **39** for the high end of 2,500° F. From the slope of the curve **40** it will be noted that the resistivity parameter increases by a factor of substantially 3:1 from a value of 100 microhms per centimeter. A material exemplary of the desired characteristics is a composition of a minimum of 90 percent molybdenum disilicide with approximately 10 percent of metallic and ceramic binder additions to provide an electrical resistance element. Such a material is available as "Kanthal Super" and provides the wide span of desired electrical resistivity parameters over the temperature range. The length and cross-sectional area of the respective sensing and ignition members of the applicable material are preferably selected in connection with the control circuit of the invention now to be described.

In FIG. 3 a schematic of an electrical control circuit is shown having a source of electrical potential coupled by means of terminals **41** and **42** to a low voltage transformer **43** to provide, illustratively, 5 volts which may be either direct or alternating current. In the case of direct current, an appropriate rectifier would be used to convert the alternating current to direct current. The applicable combustion type device is indicated generally by the numeral **44** and may be of the heat transfer module type described above. A solenoid **46** under the control of the sensor member **36** is used to control a fuel supply valve **47**. The igniter member **37** may be connected directly across the secondary of the transformer **43**. The control circuit further incorporates a circuit breaker **45** to provide for circuit interruption in the event that an abnormal current condition prevails after a predetermined time delay. Preferably, a **10** second period will suffice in most combustion applications. A standard circuit breaker which may be used in this circuit is one which includes a heater **54** and switch contacts **55** in series with the solenoid **46** and the sensor member **36**, the switch contacts **55** being adapted to open if and when the heating effect of the heater **54** exceeds a predetermined value.

The igniter loop **37** is designed to pass a relatively large initial surge of current, which may be, for example, 10 amperes. Thereupon, the igniter loop will immediately glow so as to provide ignition energy to fuel supplied through the fuel valve **47**. During the ignition cycle the current may drop to approximately 5 amperes, while maintaining the igniter loop at proper igniting temperature.

Upon energization of transformer **43**, the sensor loop **36** is also designed to pass a relatively large initial surge of current which prior to actual ignition may stabilize at a value of about 5 amperes. This large surge supplied to the solenoid **46** assures that the solenoid will open the fuel valve **47** to supply fuel to the burner **18**. However, the sensor loop **36** is designed to be longer and thicker than the igniter loop **37** and, therefore, its temperature is not raised to the extent which occurs in the igniter loop **37**, but rather remains at a comparatively low level until raised by the heat generated by the burning fuel. As a result, the resistance of the sensor loop **37** remains low until such burning takes place. Upon ignition the heat from the burning fuel will elevate the temperature of the sensor loop member at the high or 2,500° F. region to thereupon introduce a high resistance in the circuit. This high resistance will drop the current value to an average value of approximately one-half of the preignition current or approximately 2½ amperes. The selection of the cross-sectional area and length of the respective sensor and igniter loop members therefore will be determined by the desired operating parameters in the initial cold state and after ignition.

The fuel valve actuator **46** in the exemplary circuit is selected to have a pull-in current value of about 5 amperes. The drop-out current value will desirably be less than 2½ amperes or the average normal running current value as an additional safety feature. The circuit breaker with the aforementioned 10 second delay will have, illustratively, a predetermined threshold value intermediate to the average normal running current and the initial ignition current. In operation, should ignition fail, the relatively high initial current will continue in the control circuit without the subsequent drop normally caused by heating of the sensor loop member and this high value in excess of a circuit breaker rating of, for example, 3 amperes, will thereby cause a break in the circuit to automatically disconnect the fuel supply valve.

Referring to FIG. **4**, the operation is diagrammatically illustrated with the initial cold current surge indicated by the portion **48** of the current versus time curve. At the start point **49**, which in the illustrative embodiment was 5 amperes, ignition within the combustion chamber will result by reason of the glowing of the igniter loop member **37**. Successful ignition will result in a current drop to a value indicated by the portion **50** of the curve of approximately one-half the initial value or 2½ amperes. This latter portion represents the average normal running current in a normalized control circuit after ignition and the heating of the sensor loop member **36** to the high resistivity parameter. In the event that, after a safety period of 10 seconds, as indicated by the point **51**, the current values shown on the curve **50** are not realized, the circuit breaker, which is set to break the circuit at illustratively 3 amperes, as indicated by the dotted line **52**, will automatically function. The breaking of the circuit by reason of the continued high initial current will disconnect the fuel source from the combustion device **44**. The drop-out current value for the solenoid **46** is indicated by dotted line **53** at less than 2½ amperes.

From the characteristic curve of FIG. **5**, it will be seen that the resistivity of the sensor loop **36** and, consequently, the magnitude of the current flowing through said sensor loop is directly related to the temperature of the sensor loop. Changes in temperature produce relatively large changes in such current. Therefore, the magnitude of the current can be an accurate indication of the temperature of the sensor loop **36** and thus of the ambient temperature within the apparatus at such loop. For this purpose an ammeter **56**, calibrated to indicate temperature, is inserted in series with the loop **36**. Since the operation of the circuit breaker constitutes an indication of the temperature at the sensor loop **36**, it will be seen that, in general sense, both meter **56** and circuit breaker **45** can be considered temperature indicator devices.

Instead of an ingniter element of the type as described above for loop **37**, any other appropriate type of igniter may be used, such as, for example, a spark igniter. However, by using the igniter loop of the same type of material as the sensor loop, there two elements may be combined in an arrangement as shown in FIGS. **2** and **6**. In FIG. **2** the loops **36** and **37** are connected in series internally within the base **81** and the combined structure is provided with only two external leads **32** and **33**. In this case, the series combined sensor-ignitor, as shown in FIG. **6**, is substituted for the sensor-ignitor of FIG. **3** and the separate circuit for the igniter loop **37** in FIG. **3** is omitted. In this modification, the length and thickness dimensions of the loop **36** are so much greater than those of loop **36** that during the preignition period, the loop **36** remains at a comparatively low temperature, while the loop **37** is heated to ignition temperature. For example, the length and thickness dimensions of loop **36** may each be double those of loop **36**. Under such conditions, the influence of the loop **37** will predominate for ignition while that of the loop **36** will predominate to control the circuit breaker **45**. The advantage of the preferred embodiment of FIGS. **1** and **3** is that the ignition loop **37** is always energized to supply ignition energy, even when the circuit breaker has opened.

In many applicable combustion type heating devices the positioning of the sensing and igniter means will vary. The predetermined drop in the average normal running current upon the heating of the sensor loop member is the determining parameter in the selection of the respective dimensions of the electrical resistance elements having the desired positive coefficient of resistivity versus temperature properties. In most instances the sensor loop member dimensions will be a multiple of the igniter member length determined by the average normal running current. The primary feature is that the resistance valve be sufficiently high at the combustion temperature to make the circuit operative and the parameters of the circuit breaker means as well as the fuel supply control means will be accordingly determined. A working parameter in the design of such circuits may be the one-half current valve described herein for the minimum running current.

There is thus disclosed an inherently reliable, simple, inexpensive, fail-safe circuit for ignition systems in connection with applications involving combustion heating devices having a fuel supply source. Many variations, modifications and alterations will be apparent to those skilled in the art in accordance with the devices upon which the invention may be practiced. Such variations therefore are intended to be encompassed by the interpretation of the scope and breadth of the invention as set forth and defined in the appended claims.

What is claimed is:

1. A combustion control system comprising
a. a burner;
b. supply means for supplying fuel to said burner;
c. a resistance member comprising a material having a high positive temperature coefficient of electrical resistance disposed to be heated by the combustion of said fuel in said burner whereby said resistance of said member is substantially changed when heated by the combustion of said fuel for a predetermined time; and
d. control means responsive to the magnitude of current flow through said resistance member for shutting off the supply of fuel from said supply means to said burner a predetermined time after said fuel is first supplied to said burner during which there is no combustion in said burner.

2. A system as specified in claim 1 in which
a. there is provided ignition means for supplying ignition energy to the supplied fuel during an ignition period, and
b. said control means is responsive to the persistence of the magnitude of said resistance at a value below a predetermined value for a predetermined period of time after the beginning of said ignition period.

3. A combustion control system comprising:
a. a burner;
b. supply means for supplying fuel to said burner;
c. a resistance member comprising a material having a high positive temperature coefficient of electrical resistance disposed to be heated by the combustion of said fuel in said burner; and
d. time delay control means responsive to the magnitude of the resistance of said resistance member for controlling the supply of fuel through said supply means, comprising ignition means for supplying ignition energy to the supplied fuel during an ignition period, said control means being responsive to the persistence of the magnitude of said resistance at a value below a predetermined period of time after the beginning of said ignition period, a time delay relay having a current responsive device in series with a source of voltage and said resistance member, said current responsive device being operative to open a pair of contacts when a current above a predetermined value has passed through said current responsive device for a predetermined time, and a fuel control valve operable by a current responsive device in series with said contacts and a voltage source.

4. A system as specified in claim 3 in which the current responsive devices of said time delay relay and said fuel control valve, said resistance member and said contacts are all in series with a common voltage source.

5. A system as specified in claim 1 in which the electrical resistivity of said material at the high temperature end of the operating range is substantially greater by a factor of three relative to the electrical resistivity of said material at the low temperature end of the operating range.

6. A system as specified in claim 1 in which said resistance material is comprised principally of molybdenum disilicide.

7. In combination:
a combustion type heating apparatus;
a source of fuel; and
a means for ignition and sensing of combustion within said apparatus comprising:
serially connected members disposed in communication with the region of combustion within said apparatus;
one of said members being dimensioned to provide a low electrical resistivity at the low temperature end of the operating range of the apparatus and serving as the igniter means;
the other of said members serving as the sensing means;
an electrical control circuit interconnecting said fuel source and said ignition and sensing means to disconnect said fuel source a predetermined period of time after connection of said fuel source in the event of failure of said sensing means to achieve a predetermined high temperature and high electrical resistivity characteristics during said predetermined period of time with a resultant high current in the circuit in excess of a threshold value.

8. The combination according to claim 7 wherein the electrical resistivity of said material at the high temperature end of the operating range is substantially greater by a factor of at least about three relative to the electrical resistivity of said material at the low temperature end of the operating range.

9. The combination according to claim 7 wherein said resistance material comprises principally molybdenum disilicide.

10. In combination:
a combustion type heating apparatus;
a source of fuel; and
a means for ignition and sensing of combustion within said apparatus comprising:
serially connected members of a resistance material having a high positive temperature coefficient of electrical resistance disposed in communication with the region of combustion within said apparatus;
one of said members being dimensioned to provide a low electrical resistivity at the low temperature end of the operating range of the apparatus and serving as the igniter means;
the other of said members being dimensioned to provide a high electrical resistivity at the high temperature end of the operating range of the apparatus and serving as the sensing means;
an electrical time delay control circuit interconnected with the fuel source and said ignition and sensing means to disconnect said fuel source in the event of failure of said sensing means to achieve a predetermined high temperature and high electrical resistivity characteristics after a predetermined period of time with a resultant high current in the circuit in excess of a threshold value;
a source of electrical potential;
means for interruption of the circuit upon the occurrence of a predetermined threshold current value for a predetermined period of time;
means for disconnecting said fuel source in response to a predetermined current condition in the circuit;
said circuit having an initial high current value resulting in ignition of combustion and a lower average normal running current value resulting from heating of the sensing means by the said electrical control circuit;
said circuit interruption means having a threshold value to break the circuit should such a current value be prevalent after a predetermined period of time.

11. A safety ignition control system for combustion type heating apparatus having a source of fuel comprising:
means defining a combustion chamber in said heating apparatus;
serially electrically connected ignition and sensing members of a resistance material having a high positive temperature coefficient of electrical resistance exposed to the interior of said combustion chamber;
said ignition member being of a reduced cross-sectional area and length relative to said sensing member to provide for a low resistance to current at the low temperature end of the operating range of the apparatus;
an electrical time delay control circuit interconnecting said igniter and sensing members and said fuel source including:
a source of electrical potential;
circuit interruption means having a predetermined minimum current threshold value;

electrically actuated means to disconnect said fuel source;

said circuit having an initial high current value passing solely through the igniter member to rapidly elevate the temperature thereof to the ignition point of combustion;

said circuit further having a lower average normal running current value determined by the heating of the sensing member by the generated combustion heat; and

said circuit interruption means being adapted to break the circuit upon failure of combustion and continuance of the circuit current value above the minimum threshold value for a predetermined period of time.

12. A safety ignition control system according to claim **10**, wherein the cross-sectional area and length of said ignition member are approximately one-half of the sensing member similar dimensions.

13. A temperature responsive device comprising:

a. a resistance member comprising a material having a high positive temperature coefficient of electrical resistance disposed to be subjected to an ambient temperature;

b. means for supplying a current through said resistance member; and

c. means responsive to the magnitude of the resistance of said resistance member for discontinuing said current through said resistance member a predetermined time after said current is first supplied to said resistance member.

14. A device as specified in claim **13** in which said temperature indicating means comprises a current responsive device in series with said resistance member and a source of voltage.

15. A device as specified in claim **13** in which said resistance material is comprised principally of molybdenum disilicide.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,663,150 Dated May 16, 1972

Inventor(s) William H. Hapgood

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the Specification

On the Title Page, item [63], change "772,559" to --772,557--

Column 1, line 3, change "772,559" to --772,557--.

Column 4, line 4, change "glowing" to --slowing--.

Column 4, line 45, change "36" (second occurrence) to --37--.

Column 4, line 51, change "36" (second occurrence) to --37--.

Signed and sealed this 13th day of March 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

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