# United States Patent [19]

**Griffin**

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[54] **FAIL-SAFE HEATING APPARATUS**


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[52] **U.S. Cl.** ..... **219/482,** 13/24, 219/327, 219/350, 219/509, 340/371

[51] **Int. Cl.** ..... **H05b 1/02**

[58] **Field of Search**.... 219/327, 350, 351, 480–486, 219/488, 502, 509; 307/24, 28, 38, 39; 340/251, 252 H, 253 B, 371; 13/24



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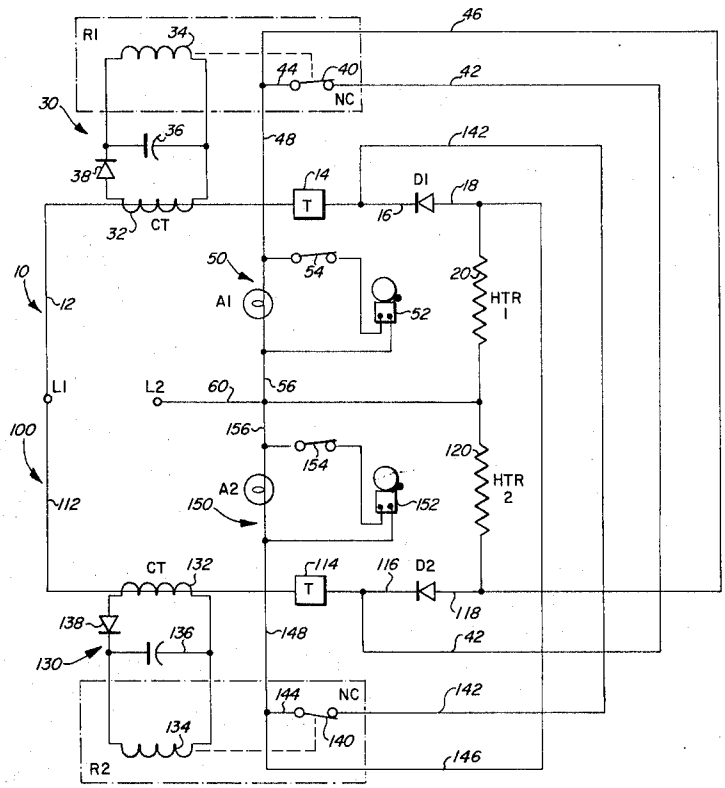
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[57] **ABSTRACT**

Fail safe heating apparatus is disclosed in which a pair of heater elements are interconnected for normal operation to operate on half voltage and each element is connected to an alarm system in case a malfunction and in such case of malfunction, the remaining heater element takes full voltage and thus replaces the malfunctioned element.


**6 Claims, 2 Drawing Figures**



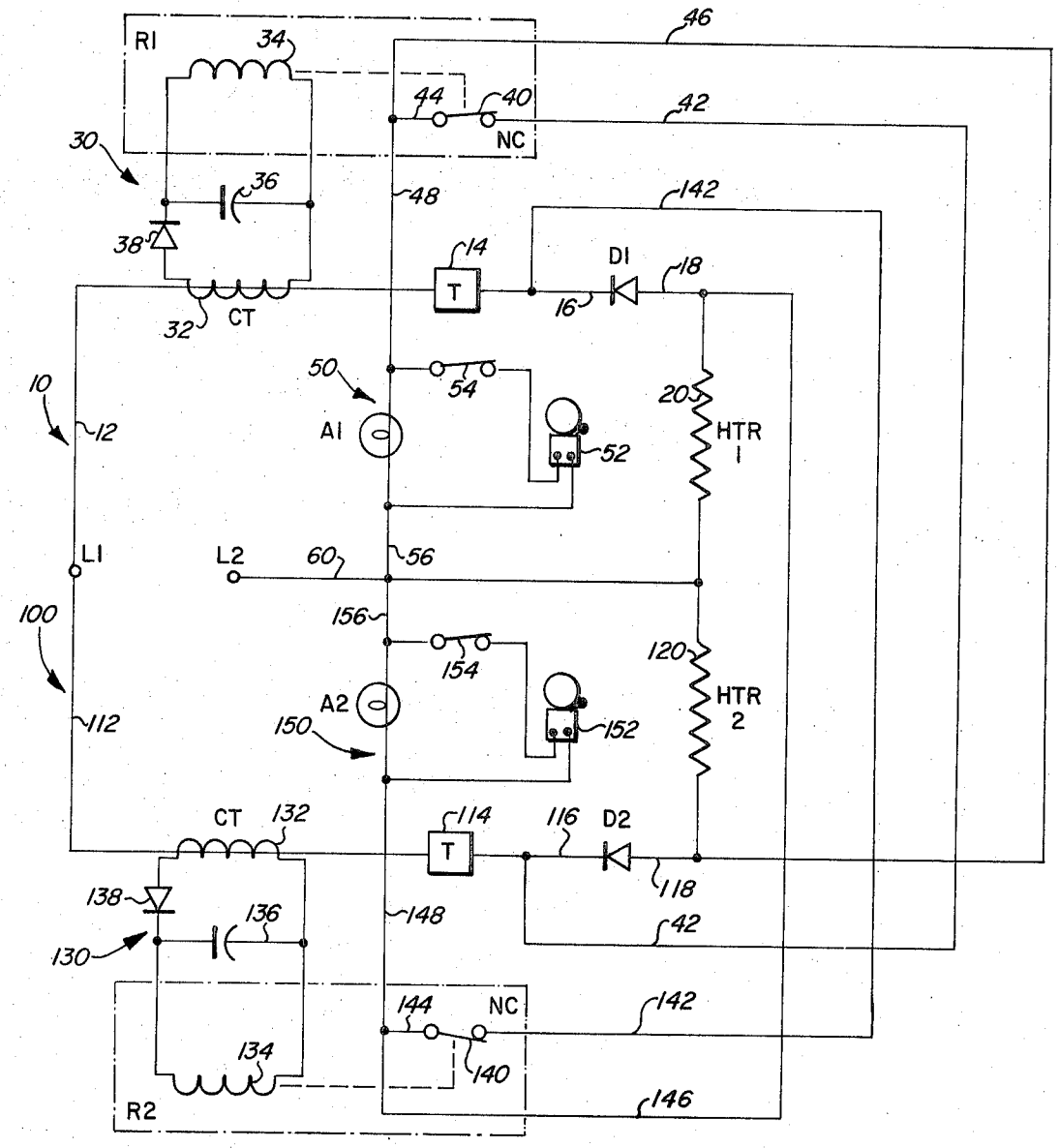

R1
34
46
44
40
NC
42
30
36
48
142
38
14
T
DI
18
32
CT
16
50
54
10
12
A1
52
20
HTR 1
L1
L2
60
56
100
156
120
154
HTR 2
A2
112
150
152
CT
132
114
116
D2
T
118
138
148
136
42
130
144
NC
142
134
140
R2
146

Fig-1

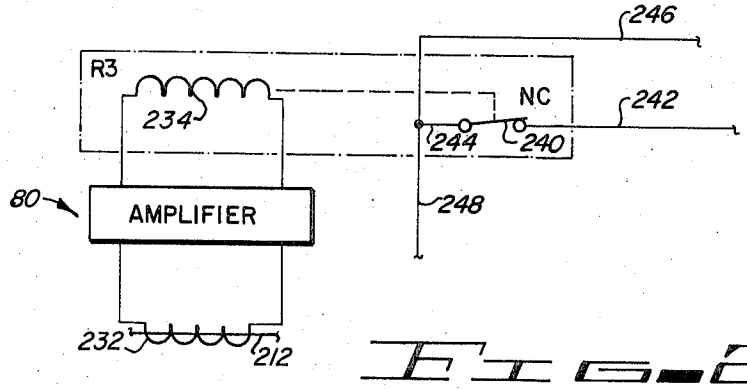

246
R3
234
NC
242
244
240
80
AMPLIFIER
248
232
212

Fig-2

# FAIL-SAFE HEATING APPARATUS

## BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to heating systems, and, more particularly, to heating systems which include a pair of heating elements and an alarm system for each element.

2. Description of the Prior Art

There are many industrial applications for heaters in which a malfunction of a heating element results in substantial damage or problems, such as in chemical or petrochemical plants. Ofter in such applications an alarm system is used in conjunction with a heating element such that a malfunction of the heating element, as for example the element burning out, results in an alarm going off. Alarms of these types are typically bells which ring and/or lights that flash. The sounding of the alarm gives notice of the malfunction and corrective measures are implemented to overcome the malfunction. However, during the "downtime" of the heater, valuable time is lost and substantial damage to processes and materials may result. Moreover, it is often difficult and inconvenient to replace a heating element. Accordingly, a system is desired which includes fail safe provision for continuing to supply heat to allow whatever processes are desired to continue in the event of a heater malfunction. None of the prior art systems have such provision.

## SUMMARY OF THE INVENTION

This invention includes a pair of heating elements, each of which operate simultaneously, and in the event of a malfunction of a heating element, the other element takes over the heating function of the malfunctioned element. In normal operation, each heating element operates at half voltage and, should one element malfunction, the remaining element operates at full voltage. An alarm system is incorporated in the heating apparatus.

Among the objects of this invention are the following:

To provide a new and useful heating system;

To provide a new and useful fail-safe heating system;

To provide a new and useful heating system utilizing a pair of heating elements;

To provide a new and useful heating system in which a pair of elements operate at half voltage each under normal conditions;

To provide new and useful fail safe heating system which includes an alarm system; and

To provide a new and useful fail safe heating system employing a pair of heating elements and each element includes an alarm system and a current transformer to actuate each alarm system.

## BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic circuit drawing showing the circuit employed in the present invention.

FIG. 2 is a schematic circuit representation of an alternate embodiment of a portion of the apparatus of FIG. 1.



## DESCRIPTION OF THE PREFERRED EMBODIMENT

Heating apparatus embodying the present invention is schematically shown in FIG. 1. Line voltage is connected to the apparatus through terminals L1 and L2. The apparatus comprises essentially a pair of circuits or systems, each of which is substantially a mirror image of the other, with the line voltage terminals L1 and L2 as the common denominator or common connection. However, the two systems are interconnected as will be described in detail. The two systems of the apparatus are respectively designated as first system **10** and second system **100**. From terminal L1, a conductor **12** extends to thermostat contacts **14**. Conductor **16** extends between thermostat contacts **14** and the positive terminal or anode of diode D1. A conductor **18** is connected to the negative terminal or cathode of diode D1.

For the second heating system **100**, conductor **112** extends from terminal L1 to thermostat contacts **114**. A conductor **116** extends between thermostat contacts **114** and the positive terminal or anode of diode D2. Conductor **118** is connected to the negative terminal or cathode or diode D2. Conductor **118** is connected to the negative terminal or cathode of diode D2.

While two pair of thermostat contacts **14** and **114** are shown, it will be understood that only one thermostat with two pair of contacts or the like may preferably be employed. If desired, two thermostats may be used.

A conductor **60** extends from terminal L2. One end of heating elements **20** and **120** of heaters number one and two, are connected to conductor **60** and the other end of each heating element is respectively connected to conductors **18** and **118**.

With the circuitry as described thus far, each heater element will be on when thermostat contacts **14** and **114** call for heat and close the respective heater element circuits. With diodes D1 and D2 allowing only half of the line voltage to pass, each heater element accordingly operates on only half voltage, but the total heat produced is the normal or desired amount.

Each heating system utilizes a current transformer to determine when current is flowing in conductors **12** and **112** respectively, such as when the thermostat contacts **14** and **114** call for the heating elements **20** and **120** to produce heat. At such times, the thermostat contacts close the circuits to allow current to flow in the respective conductors and components of the circuit. The first heating system **10** includes a current transformer **30**, which comprises a pair of inductors **32** and **34** connected in parallel, with a capacitor **36** connected in parallel with them and disposed between them. A diode **38** is connected in series between the inductors and intermediate the inductor **32** and the capacitor connected together. Inductor **32** is wound about conductor **12** and senses the current flowing therethrough. Inductor **34** comprises a coil for an appropriate relay **R1**, which may preferably be a reed relay. Relay R1 includes a pair of relay contacts **40** which are normally closed.

When current flows through conductor **12** to heater element **20** of heater number one, the current transformer **30** senses the flow of current and relay contacts **40** of relay R1 open.

The second heating system **100** also includes a current transformer. Current transformer **130** of the sec-

ond heating system is substantially the same as current transformer **30**, and it includes a pair of inductors **132** and **134** connected in parallel with a capacitor **136** in parallel with the inductors and intermediate thereto. A diode **138** is connected between the inductors and intermediate inductor **132** and capacitor **136**, with the positive leads or anodes of the diode and the capacitor connected together. Inductor **134** comprises a coil for relay **R2**, which is substantially the same as Relay **R1**. The relay **R2** includes a pair of relay contacts **140** which are normally closed.

Relay contacts **40** in relay **R1** are connected to a pair of conductors **42** and **44**. Conductor **42** extends between one side of relay contacts **40** and conductor **116** of the second heating system. Conductor **44** extends from the other side of relay contact **40** and is connected to conductor **46** and conductor **48**. Conductor **46** extends from conductors **44** and **48** to heater number **2** and conductor **118**. Conductor **48** extends from conductors **46** and **44** to alarm system **50**.

Alarm system **50** includes a warning light **A1** and an alarm bell **52**. The warning light **A1** and the bell **52** are connected in parallel with each other. One side of each is connected to conductor **48** and the other side of each is connected to terminal **L2** through a conductor **56** which extends to conductor **60**.

One end of relay contacts **140** in relay **R2** of the second heating system is connected by a conductor **142** to conductor **16** of the first heating system. The other side of relay contact **140** is connected to conductor **144**, which is in turn connected to conductors **146** and **148**. Conductor **146** extends from conductors **144** and **148** to conductor **18** and heating element **20** of heater number one in the first heating system. Conductor **148** extends from conductors **144** and **146** to an alarm system **150** which includes a warning light **A2** and a warning bell **152**. The warning light and warning bell are connected in parallel with each other, with one side of each connected to conductor **148**. The other side of the warning light and the bell is connected to terminal **L2** through conductor **156** and conductor **60**.

In operation, with line voltage connected to terminals **L1** and **L2** and the thermostat contacts **14** and **114** and closed, calling for heat, current flows through the heating elements of heaters one and two, at half line voltage in each heater due to the blocking action of diodes **D1** and **D2**. While current flows through conductors **12** and **112**, current transformers **30** and **130** activate the relay coils **34** and **134** to open relay contacts **40** and **140**.

If a malfunction occurs in a heater, as for example the heating element **20** of heater number one burning out and thus opening the circuit between conductors **18** and **60**, no current would flow in conductor **12** and thus current transformer **30** would turn off. This would result in the closing of relay contacts **40**. Current would accordingly flow through conductor **42** from conductor **116** of the second heating system through relay contacts **40** and through conductor **44** and conductors **46** and **48**. With current flowing through conductor **48**, warning light **A1** would turn on and warning bell **52** would be activated. A hand actuated switch **54** is shown in series with warning bell **52** and may be used to manually turn off the bell after a malfunction has been detected by appropriate personnel.

Current flowing through conductor **46** is shunted around diode **D2** in the second heating system to heating element **120** of heater number two which accordingly results in a full line voltage being applied to heater number two. With double the voltage in heater number two, the heating function of both heaters number one and number two is now completely and fully assumed by heater number two. This situation may continue until heating element number one has been replaced.

The same procedure as described in the preceding paragraph occurs if a malfunction happens in the circuitry of heater number two, as for example if element **120** of heater number **2** burns out causing the circuit to open. When the circuit opens, current ceases to flow in conductor **112** through current transformer **130**. Accordingly, the current transformer turns off and relay contacts **140** of relay **R2** close. Warning light **A2** and warning bell **152** are thus connected to terminal **L2** through conductors **60** and **156**, and to terminal **L1** through conductors **148, 144, 142**, and **12**.

The warning light and warning bell thus alert appropriate personnel that a malfunction has occurred in the circuit of heater number two. Manual switch **154** allows the warning bell **152** to be disconnected, if desired.

Diode **D1** is now shunted out of the heater circuit **10** with respect to heating element **20** of heater number one, and the heating element now receives full line voltage and accordingly the heating function of both heaters number one and number two is assumed by heater number one. Heater number two may now be repaired without causing "downtime" and the corresponding loss of convenience or expense otherwise necessitated if heater element number one were not able to completely assume the function of both heating elements **20** and **120**.

FIG. **2** discloses an alternate embodiment which may be required in some circumstances. If a heater element were to draw only a small amount of current, as in specialized applications, in place of a current transformer as described above, an amplifier **80** may be required to operate coil **234** of relay **R3**. As illustrated in FIG. **2**, an inductor **232** is wound about a conductor **12** through which current flows to a heating element. The inductor is connected to the primary winding of amplifier **80**. Inductor **234** is connected to the secondary winding of the amplifier. The inductor **234** comprises coil for an appropriate relay **R3**. When a small current is sensed in inductor **232**, the current is amplified by amplifier **80** to the extent that sufficient current is available to actuate coil **234** of relay **R3** to open relay contacts **240**, which are normally closed. The relay contacts **240** are disposed between conductors **244** and **242** and they connect conductor **242** to conductor **246** and **248** by way of conductor **244**. The contacts **240** and the respective connectors correspond to relay contacts **40**, conductors **42, 44, 46** and **48** of FIG. **1**. FIG. **2** is thus illustrative of an alternate embodiment of the apparatus of FIG. **1**.

The circuitry above disclosed and described comprises a "fail-safe" heating apparatus which includes a first and a second heater system. Either heating system can assume by itself the heating function of the other in case of a malfunction of one of the systems. Under normal circumstances, each heater system operates on only half voltage, but in the event of a malfunction, as an open circuit, the remaining heater system operates on full voltage until the other system is repaired and

again restored to its desired capacity. Under normal operating conditions and circumstances, current transformers are used to sense current flow through each heater system. If a heater system utilizes very small currents, then a current amplifier may be required.

It will be noted that indicator lights A1 and A2 will be operating at half voltage during normal operation. Accordingly, the intensity of the lights will be very low. This, in and of itself, indicates that the apparatus, including both heating elements, is operating property. However, the half voltage is insufficient to operate the alarm bells **52** and **152.** When a heating element malfunctions and accordingly the other heating element operates at full voltage, the appropriate warning light and warning bell receive full voltage and effect the ringing of the bell and the burning of the warning light at full intensity, thus signaling a malfunction.

While the principles of the invention have been made clear in illustrative embodiments, there will be immediately obvious to those skilled in the art many modifications of structure, arrangements, proportions, elements, materials, and components used in the practice of the invention, and otherwise, which are particularly adapted for specific environment and operative requirements without departing from those principles. For example, and not by way of limitation, the apparatus could include a pair of thermostats, one for each heating circuit, and each with its own paid of contacts for its associated circuit, rather than a single thermostat with a pair of contacts each heating circuit. The appended claims are intended to cover and embrace any and all such modifications, within the limits only of the true spirit and scope of the invention. This specification and the appended claims have been prepared in accordance with the applicable Patent Laws and the rules promulgated under the authority thereof.

What is claimed is:

**1.** Fail-safe heating apparatus comprising, in combination:

first and second terminals for providing a source of voltage;

a first heating circuit, including

a first heating element connected between the first and second terminals,

first sensing means for sensing current flow between the first terminal and the first heating element,

first relay means, including a first pair of normally closed contacts, for holding said first pair of normally closed contacts open in response to the sensing current flow between the first terminal and the first heating element,

a first diode between the first terminal and the first heating element for limiting the voltage to the first heating element, a second heating system, including

a second heating element connected between the first and second terminals,

second sensing means for sensing current flow between the first terminal and the second heating element,

second relay means, including a second pair of normally closed contacts, for holding said second pair of normally closed contacts open in response to the sensing of current flow between the first terminal and the second heating element,

a second diode between the first terminal and the second heating element for limiting the voltage to the second heating element;

first means for shunting the first diode to provide full voltage to the first heating element in response to the closing of the second pair of normally closed contacts in response to an interruption of the current flow between the first terminal and the second heating element as sensed by the second sensing means; and

second means for shunting the second diode to provide full voltage to the second heating element in response to the closing of the first pair of normally closed contacts in response to an interruption of the current flow between the first terminal and the first heating element as sensed by the first sensing means.

**2.** The apparatus of claim **1** in which the first and second sensing means for sensing current flows comprises a first and a second current transformer coupled respectively to the first relay means and to the second relay means.

**3.** The apparatus of claim **1** in which the first and second sensing means for sensing current flows comprises a first and a second current amplifier coupled to the first relay means and to the second relay means.

**4.** The apparatus of claim **2** in which the first means for shunting the first diode includes a conductor extending from between the first terminal and the first diode to one of the contacts of the second pair of normally closed contacts of the second relay means, and conductor means extending from the other contact of the second pair of normally closed contacts of the second relay means respectively to the second terminal and to the first heating element.

**5.** The apparatus of claim **4** in which the second means for shunting the second diode to provide full voltage to the second heating element includes a conductor extending from between the first terminal and the second diode to one contact of the first pair of normally closed contacts of the first relay means and conductor means extending from the other contact of the first pair of normally closed contacts of the first relay means respectively to the second terminal and to the second heating element.

**6.** The apparatus of claim **5** in which the first heating circuit includes warning apparatus for sensing the interruption of current flow between the first terminal and the first heating element, and the second heating circuit includes warning means for sensing the interruption of current flow between the first terminal and the second heating element.

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