

Feb. 15, 1966

H. L. KIRK

3,235,708

EXPLOSIVE-PROOF ELECTRIC RADIANT HEATER

Filed July 29, 1963

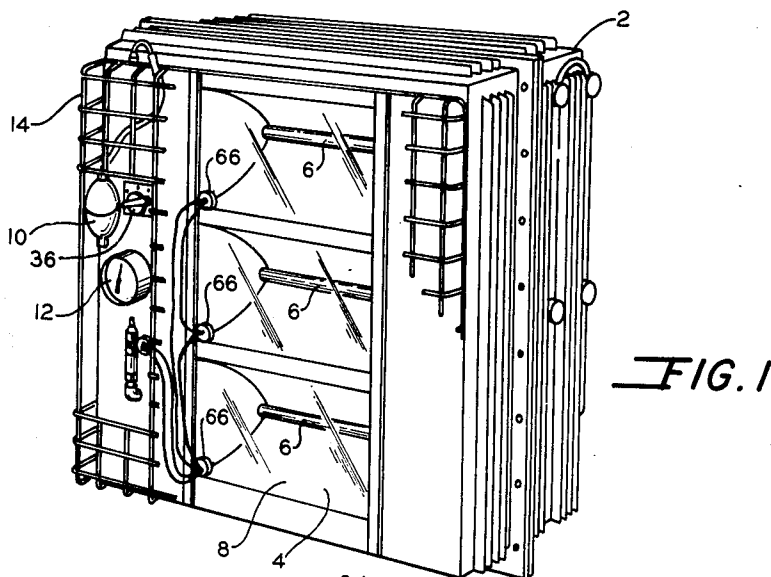


FIG. 1

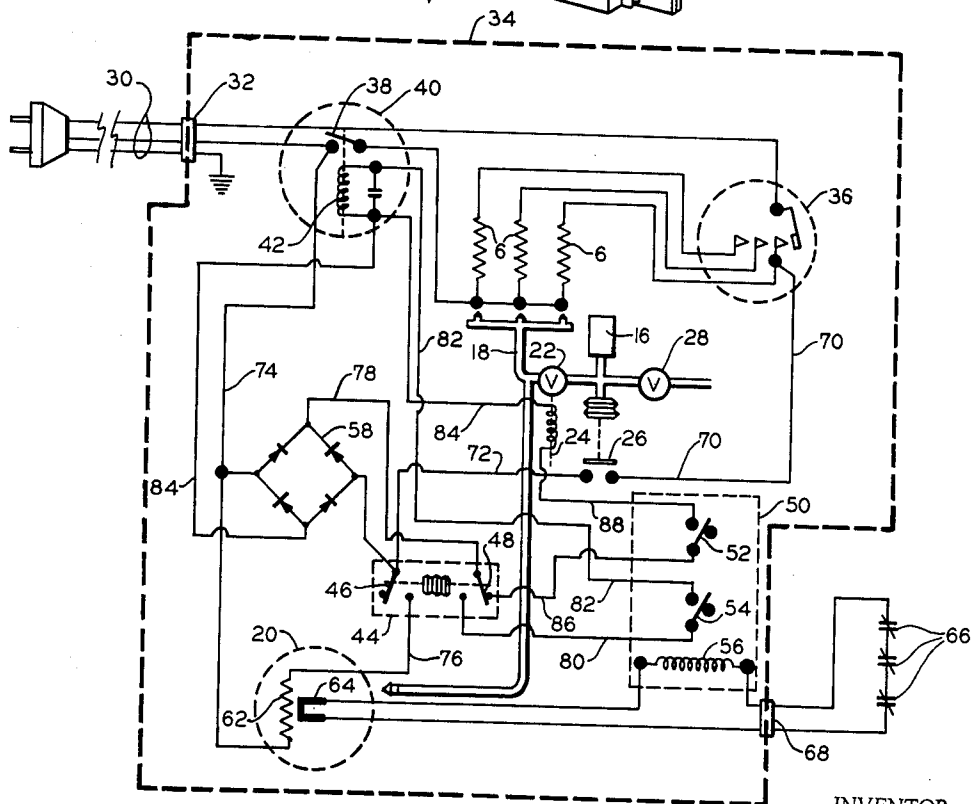


FIG. 2

INVENTOR.
HAROLD L. KIRK

BY

Edward C. Arney

ATTORNEY

1

3,235,708 EXPLOSION-PROOF ELECTRIC RADIANT HEATER

Harold L. Kirk, Bettendorf, Iowa, assignor to American Air Filter Company, Inc., Louisville, Ky., a corporation of Delaware

Filed July 29, 1963, Ser. No. 298,247
6 Claims. (Cl. 219—358)

This invention relates to an explosion proof radiant heater and control arrangement therefor.

One object of the invention is the provision of a radiant heater for use in potentially explosive atmospheres and having a control arrangement which functions to prevent the ignition of the explosive atmosphere by the operation of the heater.

A more specific object is the provision of a heater having a control circuit which functions to permit energization of radiant heating elements or emitters initially only in response to satisfaction of several conditions indicating safe operating conditions, and de-energizes the emitters and prevents contact of explosive vapors therewith while the emitters cool if they are accidentally subject to being exposed to the explosive vapors.

The type of radiant heater with which the invention is concerned is an electrically powered heater adapted to supply heat to personnel, such as jet aircraft maintenance personnel, working in potentially explosive atmospheres. In such an environment the necessity of adequate safety features will be readily appreciated.

In accordance with the invention, electrically powered radiant heating elements or emitters are encased within an air tight casing provided with a lens face through which the heat is transmitted by radiation to the personnel requiring the heat. The casing, within which the emitters and most of the circuitry controlling these elements are contained, is made air tight to prevent the entrance of explosive vapors. A supply of liquid coolant under pressure is provided and is disposed to be discharged upon the emitters and throughout the interior of the casing to cool the emitters rapidly and prevent the admission of explosive vapors if the pressurization of the casing is lost while the emitters are energized. Switch means responsive to the casing pressure, the coolant supply pressure, and selected exterior surface temperatures on the casing, are provided in a circuit which controls energization of the emitters. The coolant pressure responsive switch, the casing pressure responsive switch, and the casing surface temperature responsive switches are all required to be in a position indicating safe operating conditions before the emitters may be energized. After energization of the emitters, if the lens should be broken, or the casing loses its pressure for any reason, the emitters are de-energized, and a solenoid controlling a coolant valve is energized to permit release of the coolant over the hot emitters to cool them, and throughout the casing to exclude the hazardous vapors until the temperatures within the casing are reduced to a safe level.

An initial time delay preventing energization of the emitters until all circuits and temperatures are safe is provided by a millivolt circuit powered by a thermoelectric power generator energized under conditions of adequate casing pressure and coolant pressure. The thermoelectric power generator also serves as a source of power for a short period after casing pressure is lost and the emitters are de-energized to hold the circuit to the coolant valve solenoid closed so that coolant can be released.

2

The invention will be described in connection with the accompanying drawing illustrating an embodiment thereof by way of example, and wherein:

FIGURE 1 is a perspective view of a radiant heater embodying the invention; and

FIGURE 2 is a schematic representation of the control circuit and coolant system for the radiant heater according to the invention.

The box-like housing or casing 2 for the heater is an air tight structure provided with a glass lens 4 on one face with the radiant heating elements or emitters 6 disposed in reflectors 8 to radiate heat through the lens. A hand squeeze bulb 10 is used to pressurize the casing, and a guage 12 indicates the pressure within the casing. A wire grid 14 is provided over the face of the lens to reduce the chance that it will be accidentally broken.

If the lens 4 is broken while the emitters are energized and therefore hot, it is necessary to rapidly cool them and to prevent their contact by potentially explosive vapors while they are cooling. To this end a coolant distribution system capable of flooding the hot emitters and filling the heater casing with inert vapor to exclude the potentially explosive vapors is provided.

The coolant system part of FIG. 2 will be described first and includes a supply of coolant in a pressurized container 16 connected to a distribution network of tubes 18 for conveying the fluid when released, the tubes extending to several outlets adjacent the emitters 6 and adjacent a thermoelectric power generator 20. The coolant is, under normal conditions, prevented from entering the distribution network 18 by means of a normally closed valve 22 operable to an open position when solenoid 24 is energized. The coolant system condition is integrated into the power control circuit by means of a coolant pressure responsive electrical switch 26 held in a closed position when the cooling pressure is adequate to insure quick discharge of the coolant through the system, and which operates to an open position when the coolant pressure is for any reason reduced below a value adequate to obtain satisfactorily quick discharge. Preferably the coolant container 16 is rechargeable and therefore a charging valve 28 in a charging line is provided as shown.

The preferred fluid as presently contemplated is a fluorochemical liquid having an extremely low viscosity at low temperatures such as minus 65° F. and which is non-toxic, non-combustible and electrically inert. One suitable fluid is a liquid identified as FC-75 manufactured by Minnesota Mining and Manufacturing Company.

The heater of this example is designed to operate on 115 volt, 60 or 400 cycle A.C. power which is brought into the casing by the power line 30 through a pressure connector 32. The confines of the pressurized casing are represented by the heavy broken line outline 34 and all components shown within this outline are physically within the pressurized space in the casing, and all elements shown outside of the outline are exposed to the atmosphere surrounding the casing.

The manually operated selector switch 36 has one side connected to the power line and is operable to an "off" position, or any one of three "on" positions for selecting varying degrees of heating. This switch 36 and the switch 38 forming part of the power relay 40 must be closed to energize the emitters 6. The power relay switch 38 is actuated from its normally open position to a closed position when winding 42 is energized.

The casing pressure responsive switch assembly 44 includes a normally-open, single-pole, single-throw switch

46 operable to a closed position in response to adequate casing pressure, and a single-pole, double-throw switch 48 also shown in a position corresponding to inadequate casing pressure and operable to the alternate position in response to the adequate casing pressure.

The relay assembly 50 includes normally-open, single-pole, single-throw switches 52 and 54 responsive to the condition of a millivolt circuit which includes the winding 56 which controls the position of switches 52 and 54. One suitable relay of this character is commercially available from Penn Controls, Inc., as No. 5RB1U1. When the millivolt circuit is in a completed condition and carries adequate current, the corresponding energization of the winding 56 in the millivolt circuit effects the closure of the switches 52 and 54.

The source of D.C. power for actuating the power relay winding 42 when the proper switches are closed is the full wave rectifier 58.

The power source for the millivolt circuit is the thermoelectric power generator 20 which includes a heater component 62 and an electrical power generator component 64. One example of a suitable generator 20 is that identified as No. 349-1333 manufactured by Penn Controls, Inc. The generator element 64 is connected in series with the winding 56 (which controls the actuation of switches 52 and 54), and a series of normally-closed surface temperature responsive switches 66 (also shown in FIG. 1) disposed on the exterior of the casing 2 and adapted to operate to an open position to break the millivolt circuit in the event of an excessive temperature being sensed by any one of these switches 66. Suitable switches for this purpose are manufactured by Metal and Controls Corp., and identified by the No. C4344. A pressure tight connector 68 is provided on the casing for the passage of connecting wires between the switches 66 and the remainder of the millivolt circuit.

Before the emitters 6 may be energized, a number of conditions indicating the possibility of safe operation of the heater must exist. The principal conditions include the manual closure of the heat selector switch 36, an adequate coolant supply pressure, an adequate casing pressure, energization of the millivolt circuit for a sufficient time, and the lack of an excessive exterior surface temperature of the casing. The sequence of steps which take place to energize the emitters 6 follows. The power line 30 is connected to a source of alternating current power, and the hand squeeze bulb (FIG. 1) is operated to pump up the casing interior pressure to a selected value (such as 10 to 15 inches water column) in excess of the pressure required to actuate the casing pressure switches 46 and 48. When the gauge on the exterior of the casing indicates an adequate pressure, the manual selector switch 36 is closed to a low heat position. Assuming that the coolant supply pressure is sufficient to hold switch 26 closed, the rectifier 58 is energized through line 70 connected to the low heat contact of the selector switch 36, switch 26, line 72 connected to one side of the rectifier 58, and line 74 completing the circuit from the rectifier back to the A.C. power line. It is noted that the rectifier can be energized even though the casing pressure is inadequate, but nothing further will happen toward energizing the emitters 6 until casing pressure is adequate.

However, with adequate casing pressure, switch 46 is in a closed position and this results in energization of heater 62 (in parallel with the rectifier when switch 46 is closed) of the thermoelectric power generator through line 76. Adequate casing pressure also results in operation of the switch 48 to its alternate position connecting one side of the rectifier output through line 78 and line 80 with one side of switch 54 of the millivolt circuit powered relay 50. When the switch 54 closes in response to a condition of winding 56 indicating energization of the millivolt circuit and the lack of unsafe temperatures sensed by switches 66 of the millivolt circuit, then the

circuit to the power relay winding 42 is completed through line 82 connected from switch 54 to one side of winding 42, and line 84 connected from the other side of winding 42 back to the other side of the rectifier output.

A circuit is also provided to permit the energization of the solenoid 24 which controls the coolant valve 22. This circuit includes, starting with one side of the output of rectifier 58, line 78, switch 48 in its position corresponding to inadequate casing pressure, line 86 connecting switch 48 with switch 52, line 88 between switch 52 and one side of the solenoid 24, and line 84 from the other side of solenoid 24 back to the output of the rectifier.

The solenoid 24 for the coolant valve is energized to permit the release of the coolant only under a condition in which the emitters 6 have been in an energized condition and there is then a failure of casing pressure. In tracing the coolant release circuit it will be apparent that switch 52 must be in a closed position for the circuit to be completed, and the closure of this switch is initially accomplished only in a situation wherein the other switch 54 of the relay has also been closed to energize the emitters.

The character of the thermoelectric power generator 20 provides an initial time delay of about two minutes between the energization of the heater component 62 and the generation of sufficient power by the generator component 64 to actuate the switches 52 and 54 through winding 56. This time delay enables the operator to check the casing pressure gauge and other elements before the power relay winding 42 is energized through closure of switch 54 in response to the completed and energized millivolt circuit. When the power relay 42 closes the switch 40, one or more of the emitters 6 are energized in accordance with the position of the selector switch 36.

With the emitters 6 energized, if the pressure of the coolant supply drops below a selected value resulting in switch 26 opening, or if any one of the exterior switches 66 opens in response to a sensed unsafe temperature, the emitters will be de-energized; in the first case by de-energizing the rectifier 58 and in the second case by opening switch 54 in the circuit to the power switch relay winding 42. In neither case is there any discharge of the coolant since the casing pressure is adequate and there is no reason for rapid cooling of the emitters.

However if the casing pressure drops below the selected level while the emitters are energized, switch 46 will open and switch 48 will operate to its illustrated position in response to the reduction in case pressure. Opening of switch 46 de-energizes heater 62 of the thermoelectric power generator, but the residual heat results in the generator component 64 continuing to generate enough power that winding 56 holds switches 52 and 54 in their closed position for a short period while the coolant release circuit is energized with power from rectifier 58. The rectifier of course remains energized so long as the selector switch 36 and coolant pressure switch 26 are closed. The completed circuit through the solenoid 24 includes line 78, switch 48 in its inadequate casing pressure position, line 86, switch 52 in its closed position held there in response to continued energization of the winding 56, line 88, solenoid 24, and line 84 back to the rectifier. Upon release of the coolant through opening of valve 22, the coolant pressure switch 26 will open and de-energize the rectifier 58 and the coolant valve will again return to its closed position.

While the coolant valve 22 is open the emitters 6 are flooded with the coolant to effect their rapid cooling and isolate them from the atmosphere. The heater is incapable of again being operated until the supply of coolant is replenished and pressurized to a value resulting in closure of switch 26.

As will be appreciated that by those versed in the art, the millivolt circuit arrangement incorporating the surface temperature responsive switches 66 permits the use of

wiring outside of the casing which is not encased nor sealed within rigid conduit, as heretofore disclosed in my patent application S.N. 188,806, filed April 19, 1962, now Patent No. 3,160,738, granted December 8, 1964. The thermoelectric power generator arrangement further produces the initial time delay before switch 40 can be closed and also produces a sufficient time delay after casing pressure is lost to hold switch 52 in a position permitting energization of the coolant valve solenoid 24 even though the circuit to the power switch relay winding 42 is opened.

The invention claimed is:

1. A radiant heater construction and control system comprising:

- (a) an air tight casing adapted to be pressurized and having electrical heating means therein;
- (b) a supply of coolant under pressure adapted upon release to be discharged interiorly of said casing and to cool said electric heating means;
- (c) means restricting energization of said electrical heating means to an initial condition of at least a minimum pressure in said casing, at least another minimum pressure of said coolant supply, and selected surface temperature conditions of said casing below a predetermined value; and,
- (d) means for de-energizing said electrical heating means and releasing said coolant upon a reduction of pressure in said casing below said first minimum pressure.

2. A radiant heater construction and control system comprising:

- (a) a pressurized casing having electrical heating means therein;
- (b) a supply of coolant under pressure adapted upon release to be discharged interiorly of said casing to rapidly cool said electric heating means;
- (c) a power switch controlling power to said electrical heating means;
- (d) a normally closed valve controlling release of said coolant, and a solenoid for actuating said valve;
- (e) a power control circuit operable to close said power switch under normal operating conditions indicating adequate coolant pressure, adequate casing pressure, and a safe exterior casing temperature, and operable to open said power switch and to energize said solenoid to a valve open position releasing said coolant in response to a reduction in said casing pressure below an adequate level.

3. The construction and system of claim 2 including:

- (a) a millivolt circuit including a millivolt power generator energized in response to an adequate casing pressure and an adequate coolant pressure, and further including, in series, normally closed switch means responsive to selected exterior surface temperatures, and relay means for controlling switch means in said power control circuit.

4. A radiant heater construction and control system comprising:

- (a) a pressurized casing having electrical heating means therein;
- (b) a supply of coolant under pressure adapted upon release to be discharged interiorly of said casing to cool said electric heating means;
- (c) a power switch controlling power to said electrical heating means;
- (d) a normally closed valve controlling release of said coolant, and a solenoid for actuating said valve;
- (e) a power control circuit operable when completed to actuate said first switch means to a closed position, said circuit including coolant pressure responsive switch means in a position indicating adequate coolant pressure, casing pressure responsive switch means in a position indicating adequate casing pres-

sure, and casing exterior surface temperature responsive switch means in a position indicating safe exterior surface temperatures, said casing pressure responsive switch means being operable to an alternate position in response to a reduction in casing pressure to an inadequate level to open said power switch, and to energize said solenoid to a valve open position for releasing said coolant.

5. A radiant heater construction and control system comprising:

- (a) a pressurized casing having electrical heating means therein;
- (b) a supply of coolant under pressure adapted upon release to be discharged interiorly of said casing to cool said electric heating means;
- (c) a power switch controlling power to said electrical heating means;
- (d) a normally closed valve controlling release of said coolant, and a solenoid for actuating said valve;
- (e) a circuit for controlling operation of said power switch including casing pressure responsive switch means, and coolant pressure responsive switch means, and switch means responsive to the condition of a millivolt circuit;
- (f) said millivolt circuit including, in series, a millivolt power generator, relay means operating said switch means responsive to the millivolt circuit condition, and normally closed switch means responsive to selected exterior surface temperatures of said casing; and
- (g) a circuit for energizing said solenoid including said casing pressure responsive switch means in a position corresponding to an inadequate casing pressure, and said millivolt circuit responsive switch means in a position corresponding to an energized millivolt circuit.

6. A radiant heater construction and control system comprising:

- (a) a pressurized casing having electrical heating means therein;
- (b) a supply of coolant under pressure adapted upon release to be discharged interiorly of said casing to cool said electric heating means;
- (c) a normally closed valve controlling the release of said coolant, and a solenoid for actuating said valve;
- (d) a power switch controlling power to said electrical heating means;
- (e) second switch means responsive to said coolant pressure;
- (f) third switch means responsive to said casing pressure;
- (g) fourth switch means responsive to exterior surface temperatures of said casing; and
- (h) circuit means operable to close said power switch in response to a position of said second switch means indicating adequate coolant pressure, said third switch means indicating adequate casing pressure, and said fourth switch means indicating safe casing exterior surface temperatures, and operable to open said power switch and to actuate said solenoid to a valve open position releasing said coolant in response to operation of said third switch means to a position indicating a reduction in said casing pressure below an adequate level.

References Cited by the Examiner

UNITED STATES PATENTS

459,872	9/1891	Tommasi	240—11.3
2,418,283	4/1947	Wilson	219—354 X
2,447,922	8/1948	Tuck	240—11.3

RICHARD M. WOOD, *Primary Examiner.*