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CONTROL APPARATUS

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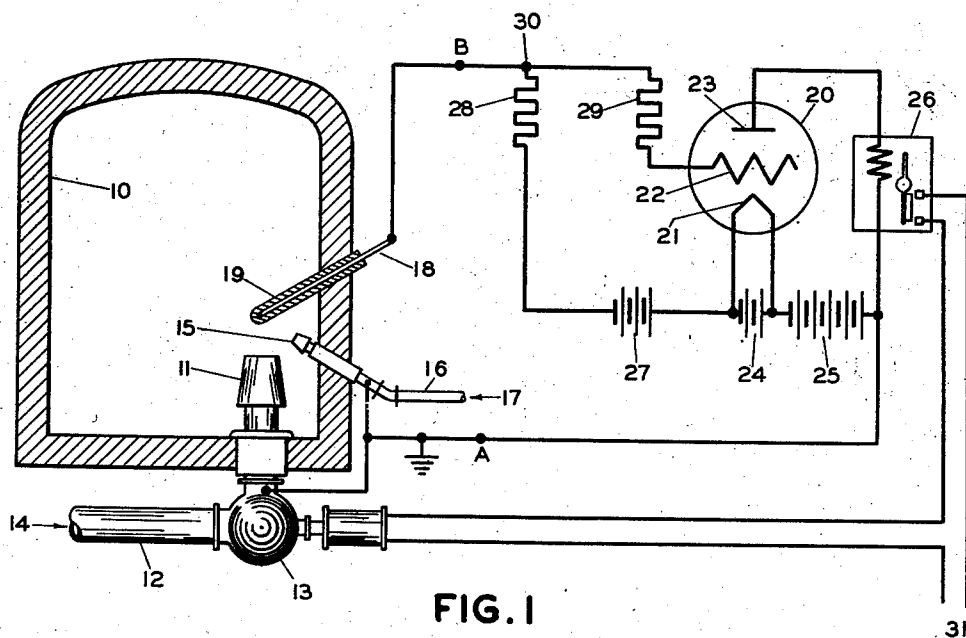


FIG. 1

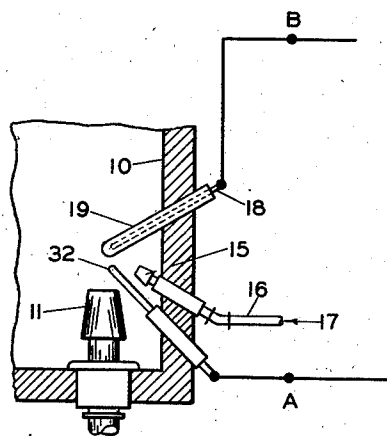


FIG. 2

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CONTROL APPARATUS

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11 Claims. (Cl. 158—28)

This invention relates to electrically operated control apparatus for industrial furnaces, and more particularly to automatic means embodying a safety shut-off, operative to discontinue the supply of fuel in case of extinguishment of the flame.

In industrial furnaces of the gas-fired type, it is essential in the interests of safety that there be at no time an accumulation of unburned gases which may become ignited at one time and cause an explosion. To this end it is necessary that gas be not admitted to the combustion chamber unless there be present an igniting agent whereby complete combustion of the gas will be assured, and that in the event of accidental extinguishment of the igniting agent, the supply of gas will be immediately discontinued.

It is a well-known fact that a flame and the ionized atmosphere immediately surrounding it are to some extent electrically conducting; and this principle has been made use of in a number of devices for purposes similar to that of the present invention. A well-known example of the application of this principle is found in U. S. Letters Patent No. 1,809,280 issued June 9, 1931 to D. D. Knowles, and wherein a metallic electrode exposed to the flame or to the heated products of combustion in a furnace forms a part of an electrically conducting path to be completed by said flame or said combustion products for the actuation of certain protective devices. It has been found, however, that in apparatus operating upon this principle there exist a number of inherent weaknesses among which may be named that due to the possibility of an alternative conducting path in parallel with the flame being provided by deposited soot or other conducting material so that in the event of extinguishment of the flame the conductivity of said path will simulate the condition of combustion and the protective function of the device be inhibited.

It is an object of this invention to provide means whereby in the event of temporary interruption of the fuel supply or the extinguishment of the flame or igniting agent for any reason whatsoever, valves controlling the admission of fuel to the furnace will be closed, and may not be reopened until normal conditions are established.

A further object is found in the provision of means to prevent sagging of the electrode which normally is exposed to the high temperature of the flame in such apparatus, and thus to eliminate the undesirable conditions arising upon the

A further object is found in the protection of the metallic electrode from direct contact with the flame and thus in the preservation of its surface from oxidation by said flame.

A further object is found in the provision of means whereby there is prevented false operation of the device due to formation on the electrode of an accumulation of soot which might bridge the gap between the electrode and ground normally essential to proper operation of the device and thus simulate the presence of a flame between the electrode and ground without actual combustion taking place. This is especially important in oil-fired installations.

A further object is found in the provision of means to assure that, not only is a pilot flame present, but that the region of the pilot flame has reached a temperature adapted to ignition of fuel before the main fuel supply is admitted to the furnace.

A further object is found in the provision of an inherent time delay characteristic in the turning on of the main fuel supply, without the introduction of a corresponding time delay in the shutting off of the fuel in the event of flame failure.

With these and other objects in view, it is proposed to utilize the high negative temperature coefficient of electrical resistivity possessed by certain refractory ceramics such as quartz, in combination with the electrical conducting property of flame or ionized gases, in a suitable electrical circuit.

It is a well-known fact that most ceramic materials possess high negative temperature coefficients, the electrical resistivity decreasing rapidly with increasing temperature; and the available list of natural and artificial materials of this nature provides a wide range of selection suited to various operating temperatures. Fused quartz, for example, at ordinary atmospheric temperatures possesses a resistivity approximating 2×10^{18} ohms per inch-cube (Smithsonian Physical Tables, 1934); while at temperatures of the order of 2,000° F., the corresponding value becomes 1×10^4 ohms per inch-cube (L. G. Hall in "Product Engineering," May, 1933). Quartz thus provides one example among many of materials eminently suited to the purposes of the invention. The term "ceramic" as hereinafter employed, may be taken to designate any of the group of refractory materials such as porcelain, Alundum or quartz, which are possessed of the negative resistance temperature characteristic

It is proposed to utilize the desirable property of a ceramic material for the purpose of the invention by providing an electrode having in association therewith an isolating or enclosing shield formed of said material, interposed between the electrode and the flame in a manner that the flame and the shield will be electrically in series. It is thus rendered essential, in order for sufficient current to flow for the operation of the protective devices, that not only must there be a conducting path in the part of the circuit represented by the flame, but that the ceramic shield must have reached a temperature exceeding a predetermined critical value, the attainment of which temperature involves a certain time interval which may be advantageously utilized in further increasing the safety features of the device.

In the drawing:

Fig. 1 is a diagrammatic representation of a control system utilizing the principles of the invention.

Fig. 2 is a partial view of a modification thereof. Referring now to Fig. 1 of the drawing:

The numeral 10 designates a furnace or enclosed space to be heated by the combustion of fuel at a burner 11 adapted to receive fluid fuel through a conduit 12 having therein an electrically operated valve 13, from a main supply 14. A pilot burner 15, receiving fluid fuel through a conduit 16, from an auxiliary supply 17, serves to ignite the fuel at the burner 11. The several objects of the invention hereinbefore referred to are directed to the avoidance of hazardous conditions in the event of extinction of the pilot burner 15 or the main burner 11, or of failure of any of the protective devices associated therewith.

Fixedly mounted in a position so as to lie in the paths of the flames from both the main burner 11 and the pilot burner 15 is a metallic electrode 18 enclosed in, and supported by, a tube 19 formed of quartz or similar ceramic material secured at its outer end to the wall of the furnace and sealed at its inner end, whereby direct contact of the flames or their immediately adjacent atmosphere with the electrode 18 is rendered impossible. While the electrical circuit with which the electrode 18 is associated may take any one of a variety of forms without departing from the spirit of the invention, there is shown for purposes of clarity a simple but operative circuit having the following structure and arrangement: a vacuum tube 20 having therein an electron-emitting filament 21, a control grid 22, and a plate 23, is included in a network including a battery 24 connected to the terminals of the filament 21 and adapted to supply current for heating the same to a temperature at which emission will take place, and a battery 25 connected between the filament 21 and the plate 23 and adapted to provide a plate supply voltage to maintain said plate at an electrical potential normally positive with respect to the filament 21. A relay 26 having an actuating winding and electrical contacts adapted to the control of the valve 13, is connected with said winding in series with the circuit between the battery 25 and the plate 23, so that said relay will respond to changes in the plate current. A battery 27 is connected to the grid 22 through two resistors 28 and 29 in series relationship, the voltage and polarity of said battery being such as normally to maintain the grid 22 at a potential sufficiently negative with respect to the filament 21 that the plate current is below the value necessary to energize relay

26. The positive side of the battery 25 is connected to a terminal A, which in turn is connected to both the main gas line 12 and the auxiliary gas conduit 16 and to ground. The electrode 18 is connected to a terminal B and thence to the junction point 30 between the resistors 28 and 29. The resistance of a flame between electrode 18 and the auxiliary gas conduit 16, together with resistor 28, form a voltage divider across the batteries 27, 24, and 25 in series. When no flame is present, the resistance between the point 30 and the positive terminal of battery 25 is substantially infinite and grid 22 is negative with respect to filament 21 by the potential battery 27. When a flame is present its resistance decreases the negative grid potential by changing the voltage gradient along said voltage divider formed by the flame resistance and resistor 28. As the potential of battery 25 may be several times that of battery 27, the flame resistance necessary to cause a substantial reduction in the negative potential of the grid 22 will be several times the value of resistor 28. The contacts of the relay 26 are connected to the actuating winding of the valve 13 and to a source of power 31 in such a manner that as the grid 22 becomes less negative with respect to the filament 21 with a corresponding increase in plate current, the resultant energization of relay 26 will cause the contacts of said relay to be actuated in a manner to open the valve 13 and turn on the main fuel supply to the burner 11. A direct connection between the electrode tube 19 and the metallic parts of either of the burners 11 and 15 would normally tend to apply a high positive voltage to the grid 22, and draw an undesirably large amount of current from the grid circuit. The resistor 29 located in the network between the electrode 18 and the grid 22 serves to limit to a safe value any current which might flow under said abnormal condition.

The ceramic tube 19, completely surrounding the electrode 18, when at ordinary atmospheric temperatures will have between its inner and outer surfaces an extremely high electrical resistance, which for all practical purposes may be considered equivalent to that of an open circuit. At temperatures above 800° F. the resistance of the ceramic material will drop sharply to a point below that of a flame of equivalent dimensions. Under this condition it will be apparent that the flame and the portion of the ceramic tube 19 in immediate contact therewith will function as two resistors in series, and that the total resistance between the electrode 18 and the burners 11 and 15 will be that of the combination. Since the portion of the ceramic tube secured to the wall of the furnace 10 will be relatively cold its conductivity will be low, and for the purposes of this invention that portion may be considered as a substantially perfect insulator. The proportioning and adjustment of the elements of the electron tube circuit are made such that the critical value of plate current sufficient to actuate the relay 26 will be attained when the resistance value in the branch of the network including the burners and the electrode 18 lies intermediate the cold resistance and the resistance when at operating temperatures. Thus it will be seen that in order for the relay 26 to function in a sense to open the supply valve 13, it will be necessary not only that there be a path of flame between the electrode structure and the burner structure but that the ceramic tube 19 be at a temperature approximating that of the flame. Temporary ex-

tion of either the auxiliary or main flame alone will not introduce a hazardous condition, because the remaining flame will serve to ignite any gas which may enter the furnace from the extinguished burner. Since the arrangement of the burners in relation to the electrode is such that either flame alone will provide a conducting path and will maintain the ceramic shield 19 at a conducting temperature, such an occurrence as the failure of one of the flames will not actuate the safety device; but the system will be retained in an operative condition. In the event of extinguishment of both flames, the conducting path provided by the ionized gases will disappear immediately, the grid 22 in the tube 20 will at once attain a negative potential sufficient to block the passage of current from the filament 21 to the plate 23, and the relay 26 will be released, causing the valve 13 to be closed and the fuel supply shut off substantially instantaneously. Operating conditions have shown that while it is important that the supply of gas be discontinued as quickly as possible upon extinguishment of the flame, a slight delay is not only permissible but desirable in the reignition. Since the ceramic tube 19 requires a certain time interval of heat application before it can attain a conductive state, it follows that such a delay characterizes its use as a part of the electrical circuit, thus rendering inherent to the system the desirable characteristic of a few seconds delay in starting up the furnace. It will further be obvious that the combination of the vacuum tube and associated circuits as shown is such that failure of the electric supply, of the vacuum tube 20, or of almost any other part of the circuit will result in an interruption of the plate current, with consequent instantaneous closing of the valve 13.

Should there occur an accumulation of soot or other conducting material upon either of the burners, the ceramic tube being substantially an insulator when in a cold state will effectively prevent completion of the circuit between the burners and the electrode, thus making possible automatic discrimination between a true condition of combustion and the simulation of such a condition by an accumulation of conducting material. It has also been found that in cases when a furnace has been shut down for some time there may be condensed water vapors in the gas lines or in the neighborhood of the burners; and where the products of combustion are brought into direct contact with a metallic electrode erratic performance sometimes results. The insulating and time delay characteristics of the cold ceramic tube will effectually prevent such undesirable performance. A further undesirable characteristic of devices of this nature having an unprotected metallic electrode is found in the tendency of the electrode to warp, sag, or become otherwise distorted due to the high temperatures to which it is exposed. The ceramic tube or shield 19 being formed of material having an extremely high melting point, tends to provide a permanent support for the electrode and prevents not only these undesirable distortions but also protects the material of the electrode from oxidation or other chemical attack in the presence of the flame.

While the invention has been shown as embracing both the main burner and the pilot burner in the electrical circuit, so that extinguishment of both flames is essential to cause the safety device to perform its function, it will

be obvious that, should circumstances render the same desirable, either burner alone may be connected in the electrical circuit without departing from the spirit of the invention. It will also be obvious that the protective device as herein disclosed and claimed is fully applicable to a furnace in which there is only one burner, and in which the pilot flame for ignition purposes is not present.

A further alternative arrangement of electrodes is shown in Fig. 2, in which the burners 11 and 15 are physically related to the furnace 10 exactly as shown in Fig. 1, and the electrode 18 with its ceramic shield 19 also appears in the form as hereinabove set forth. Instead, however, of having either or both of the burners definitely connected to the electrical circuit, there is provided a further electrode 32 positioned in the path of the flame in such a manner that said flame will tend to form between the electrode 31 and the ceramic shield 19 of the electrode 18 a conducting path whenever a flame is present. The terminals A and B represent the corresponding terminals as shown in Fig. 1, and the electron tube circuit of which they form a part is identical with that shown in Fig. 1. While in this form of the invention the electron tube circuit is not at any point definitely grounded, the burners may generally be assumed as being at ground potential. The performance of the circuit will be identical to that previously shown except that neither of the burners forms a definite part of the electrical circuit. It will be obvious that the shield 19 may be placed on either of the electrodes 18 and 31, or that both electrodes may be so shielded without departing from the spirit of the invention.

As hereinbefore pointed out, the desirable characteristics of the material forming the shield or tube 19 are primarily that it have pronounced negative temperature coefficient of resistivity, and that it maintain its structural form and gas-tight features through the whole range of operating temperatures. While there are a number of known materials, as, for example, Alundum, carborundum and magnesia, which possess these characteristics to a greater or less extent, it has been found that fused quartz possesses them to an optimum degree. A further advantage in the use of quartz lies in the fact that it is commercially available in a form suited to the purposes of the invention and that at suitably high temperatures it is readily worked to form a closed end over the tip of the electrode.

The terms and expressions which I have employed are used as terms of description and not of limitation, and I have no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described or portions thereof, but recognize that various modifications are possible within the scope of the invention claimed.

I claim:

1. In combination with a burner for fluid fuel, means for controlling the flow of fuel thereto, an element of material having a negative coefficient of electrical resistivity positioned in the path of the flame from said burner, and an electrical circuit including in series portions of said flame and said element, said circuit being responsive to changes in the total resistance of said portions, to operate said controlling means.
2. In combination with a burner for fluid fuel, means for controlling the flow of fuel thereto, an element of refractory material having a nega-

tive coefficient of electrical resistivity positioned in the path of the flame from said burner, and an electrical circuit including in series portions of said flame and said element, said circuit being responsive to changes in the total resistance of said portions, to operate said controlling means.

3. In combination with a burner for fluid fuel, means for controlling the flow of fuel thereto, an electrode, an element of refractory material having a negative temperature coefficient of electrical resistivity, and an electrical circuit including in series said electrode, said element and a portion of the flame from said burner, and responsive to changes in the combined resistance of said element and said flame, to actuate said controlling means.

4. In combination with a burner for fluid fuel, means for controlling the flow of fuel thereto, an electrode, an element of refractory material forming an enclosure for the same and positioned in the path of the flame from said burner, and an electrical circuit including in series said electrode, said element and a portion of said flame and responsive to changes in the combined resistance of said element and said flame, to actuate said controlling means.

5. In combination with a burner for fluid fuel, means for controlling the flow of fuel thereto, an electrode, an element of refractory material forming a support for the same and positioned in the path of the flame from said burner, and an electrical circuit including in series said electrode, said element and a portion of said flame and responsive to changes in the combined resistance of said element and said flame, to actuate said controlling means.

6. In combination with a burner for fluid fuel, means for controlling the flow of fuel thereto, an element having a negative coefficient of electrical resistivity, and an appreciable thermal inertia of response, positioned in the path of the flame at said burner, and an electrical circuit including a portion of said flame in series with said element and responsive to changes in the combined resistance of said flame portion and said element to operate said controlling means.

7. In combination with a burner for fluid fuel, means for controlling the flow of fuel thereto, an element of material having a negative temperature coefficient of electrical resistivity in contact with an ionized atmosphere produced by combustion of said fuel on said burner, and an electrical circuit responsive to changes in the combined series resistance of said element and a

portion of said ionized atmosphere, to cause said controlling means to interrupt the flow of fuel to said burner.

8. In combination, fluid fuel-controlling means, an element of material substantially non-conducting when cold and having when heated a negative temperature coefficient of electrical resistivity positioned in the flame of said fuel, and means responsive to changes in the series resistance of said element and a portion of said flame for actuating said fuel-controlling means.

9. In combination with a burner for fluid fuel, means for controlling the flow of fuel thereto, an electric circuit adapted to actuate said controlling means, an electrode juxtaposed to the flame of said burner, a shield formed of material electrically non-conducting when cold and having a negative temperature coefficient of electrical resistivity when hot, said shield being interposed between said electrode and said flame to prevent direct contact therebetween, said electrode and said burner being connected in said circuit in such a manner that current traversing the material of said shield and flowing through a portion of said flame in series therewith will actuate said controlling means to maintain the flow of fuel to said burner.

10. In combination with a burner for fluid fuel, means for controlling the flow of fuel thereto, an electric circuit adapted to actuate said controlling means, an electrode juxtaposed to the flame of said burner, a shield enclosing said electrode and formed of a material electrically non-conducting when cold and conducting when hot, said electrode and said burner being connected in said circuit in such manner that current traversing through the material of said shield and flowing through a portion of said flame will actuate said controlling means to maintain the flow of fuel to said burner.

11. In combination with a burner for fluid fuel, means for controlling the flow of fuel thereto, an electrode, a quartz shield forming an enclosure for said electrode and positioned in the path of the flame from said burner, and an electrical circuit between said electrode and said burner including portions of said flame and shield in series relationship and responsive to changes in the combined resistance of said portions to cause said controlling means to interrupt the flow of fuel to said burner upon the increase of the combined resistance of said shield and flame portions above a predetermined value.

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