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FLAME CONTROL APPARATUS

George W. Nagel, Pittsburgh, Pa., assignor to
Westinghouse Electric Corporation, East Pitts-
burgh, Pa., a corporation of Pennsylvania

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My invention relates to electric discharge apparatus and has particular relationship to apparatus for controlling fuel burners.

Patent 1,809,280 to D. D. Knowles is illustrative of the prior art of which I am aware on fuel burner control apparatus. The system shown in Figure 1 of the Knowles patent includes a grid glow tube having a blocking electrode. This electrode is connected to a flame probe; another flame probe is connected to the anode of the tube. The supply source is connected directly to the anode and through the exciting coil of the fuel valve relay to the cathode. In the operation of the Knowles device, the grid becomes negative in the absence of a flame between the probes and maintains the tube non-conductive. When a flame is ignited between the probes, the negative charge on the grid leaks off through the flame and the tube becomes conductive.

The system shown in Figure 1 of the Knowles patent has not proved entirely satisfactory. For the proper operation of the grid glow tube, it is essential that the gas in the tube be maintained at a predetermined critical pressure. If the clean-up action of the discharge in the tube is sufficient to reduce the pressure below the critical magnitude, the grid fails to function effectively and the tube becomes conductive even in the absence of a flame. A dangerous condition may thus be established by reason of unstable operation of the tube.

The Knowles Figure 1 system is also relatively costly. For proper operation of the tube, the anode cathode voltage which must be impressed across the tube should be of the order of 440 volts. Since the power available at the utility receptacles is of the order of 115 volts in most localities, a transformer must be interposed between the commercial power buses and the tube. The cost of such items as this transformer so raises the price at which systems such as that disclosed in Knowles Figure 1 may be made available as to render such system expensive for industrial use and prohibitory for use in homes.

The difficulties arising from instability of operation of the grid glow tube are avoided in a system such as is shown in Figure 2 of the Knowles patent. The systems shown in this view include a thermionic tube in lieu of a grid glow tube. A thermionic tube, however, requires facilities for heating the cathode, such as a filament transformer. This item and others like it incident to the use of a thermionic tube increases the cost of a fuel burner control system rendering its use in the home prohibitive.

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The control system, including the thermionic tube, has another disadvantage which resides in the fact that the operation of the system must be delayed for a predetermined time interval after power is applied to permit the cathode to reach a proper temperature for operation. When the system is utilized to control a fuel burner which is in operation for long time intervals such as that of a central heating system for a house, this disadvantage is not a severe handicap. Once power is supplied to the thermionic tube in such a system, the cathode is heated. Thereafter, it remains in proper operating condition during the long time intervals during which the system is in operation. The cathode heating time delay is, however, a severe disadvantage in fuel burners which operate intermittently for short time intervals and are turned on and off repeatedly. Such fuel burners are encountered in clothes dryers.

When a clothes dryer is to be put into operation, the housewife inserts the clothes in the tank, plugs the power supply conductor into a receptacle and closes a push button. She expects that immediately on the closing of this push button, the fuel burner system will operate and she permits the button to open a second or two after she closes it. If a delay of 20 seconds to a minute is involved in the cathode heating time, the system will fail to operate on the reopening of the button. The housewife will then continue to open and reclose the push button repeatedly and on finding that the burner fails to operate continuously, will phone for a service man. Adequate printed instructions will not ameliorate this situation.

It is, accordingly, an object of my invention to provide a stable low cost control for a fuel burner particularly for use in the home.

Another object of my invention is to provide a fuel burner control system which shall operate instantaneously on the closure of its power supply circuit.

A further object of my invention is to provide a fuel burner control system the components of which shall perform their functions when subject to potentials directly available at receptacles supplied from a public utility power station.

An ancillary object of my invention is to provide a novel circuit for an electric discharge device of the ignition electrode type.

An incidental object of my invention is to provide a fuel burner control system particularly suitable for use in a clothes dryer or similar appliance which is operated intermittently.

Another incidental object of my invention is

to provide a fuel burner system in the operation of which the fuel shall be shut off on the failure of any of the components which are likely to fail.

In accordance with my invention, I provide a fuel burner control system including an electric discharge device of the cold-cathode ignition-electrode type. Such a device includes a pair of cold main electrodes and a firing electrode disposed adjacent to one of the main electrodes. To render the discharge device conductive, an auxiliary discharge is initiated between the firing electrode and its adjacent main electrode. The ionization produced by the auxiliary discharge causes a discharge to be produced between the main electrodes. A potential of the order of fifty volts between the firing electrode and to adjacent electrodes is sufficient to fire the auxiliary discharge. With this discharge present, a potential of the order of one hundred volts between the main electrodes is sufficient to fire the main discharge.

In accordance with my invention, flame probes are so connected between the firing electrode and the other electrodes of the discharge device that in the absence of a flame the discharge device is non-conductive. When a flame is burning, a potential is impressed between the firing electrode and its adjacent main electrode and the auxiliary discharge is fired. The resulting firing of the main discharge causes the valve controlling the flow of fuel to the burner to be held open to permit the continuous flow of fuel.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment when read in connection with the accompanying drawing, in which:

Figure 1 is a view in vertical section showing a clothes dryer including a fuel burner control system in accordance with my invention;

Fig. 2 is a view in section taken along line II--II of Figure 1;

Fig. 3 is a circuit diagram of a fuel burner control system in accordance with my invention, and

Fig. 4 is an electric discharge device of the type used in a fuel burner system in accordance with my invention.

The apparatus shown in Figures 1 and 2 comprises a container 5 in which a clothes tank 7 is mounted rotatable. The tank 7 is mounted at an angle to the vertical walls of the container and is provided with a neck 9 which extends through an opening 11 in a slanting portion of the top of the container. This opening is covered by a door 15 which may be pivoted to the open position. Clothes may be inserted in the tank 7 after opening the door.

The tank is rotated from an electric motor 17 and as it is rotated, warm air flows over a portion of its surface and in certain dryers circulates within the tank 7. This air is derived from a flue 19 in the lower region of the container 5. Near one end of the flue, a fan 21 driven from the motor 17 rotates. The fan draws air from an opening 23 in one side of the flue and passes the air around a gas flame 25. The gas for the flame is derived from a conductor 27 provided with a suitable valve 29. The operation of the valve is controlled from a flame control unit 31.

The flame control unit 31 is shown diagrammatically in Fig. 3. The unit includes a gaseous

electric discharge device 33 of the cold-cathode type having an anode 35, a cathode 37 and a firing electrode 39 disposed adjacent to the cathode. The dryer is provided with power supply cable 41 terminated by a jack 43. When the jack is plugged into a receptacle (not shown) of a commercial alternating current supply source (not shown), the cathode 37 is connected to one terminal 45 of the power supply through a resistor 48 and the anode 35 is connected to the other terminal 49 through the exciting coil 51 of a relay. To prevent the relay from chattering as the alternating current supplied varies, a capacitor 53 of substantial magnitude is connected across the exciting coil 51. The current-limiting resistor 48 protects the tube 33. The firing electrode 39 is connected to the terminal 47 to which the cathode is connected through a resistor 55. The latter resistor should preferably be of a magnitude of the order of the ionization resistance of a flame.

The unit 31 is provided, in effect, with two flame probes. One of the flame probes is an ordinary plate 57 preferably composed of stainless steel. This probe is connected directly to the firing electrode 39. The other flame probe may be a ground conductor of the burner, but in the preferred practice of my invention, is a part of the ignition assembly 59 of the burner.

The ignition assembly comprises a U-shaped metallic bar 61 secured to a refractory insulating plate 63 of the dryer and a rod 65, which passes through the plate 63 slidably, and is secured to a magnetic plunger 67. The plunger 67 and rod 65 are urged into engagement with the cross piece of the U-plate 61 under the action of a spring 69. The U-plate is connected to the terminal 49 of the supply to which the relay coil 51 is connected. The rod 65 is adapted to be connected to the other terminal 47 of the supply through a solenoid 71 and a pair of contacts 73 of a normally open starting push button 75. The gas valve solenoid 77 and a pilot lamp 79 are adapted to be connected in parallel across the terminals 47 and 49 through the other normally open contacts 81 of the push button 75.

When the jack 43 is in the receptacle, the potential of the supply line, usually approximately 115 volts, is impressed between the anode 35 and the cathode 37 of the discharge device 33. So long as there is no flame 25 in the burner, the impedance between the probes 57 and 61 is high compared to the impedance 55. The potential of the supply line is therefore impressed between the U-plate 61 and the other flame probe 57 and the potential between the firing electrode 39 and the cathode 37 is low. The discharge device 33 is non-conductive.

When the housewife closes the push button, the pilot light 79 is energized and the gas valve is momentarily opened by the closure of one set of contacts 81 of the button. Gas flows through the burner opening. By the closure of the other set of contacts 73 of the button, the rod 65 is vibrated out of and into engagement with the U-bar 61 in the same manner as the hammer of a door bell. The contact 80 connected to the rod 65 makes and breaks engagement with the fixed contact 82 connected to coil 71, causing the vibratory motion. The resulting spark which occurs at the junction of the rod 65 and U-bar 61 ignites the gas and a flame 25 burns in the region of the flame probes 57 and 61. A substantial fraction, equal to approximately half, of the source potential is now impressed between the

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firing electrode 39 and the cathode 37. This potential is, for the 115 volt 60 cycle supply ordinarily available, of the order of 50 volts R. M. S. and is sufficient to produce a discharge between the firing electrode and the cathode at an instant in the half period of the source when the source potential is near its maximum. A potential derived from the source which is approximately equal to its maximum potential; that is, of the order of 100 volts R. M. S., is at the same instant impressed between the main electrodes 35 and 37 of the discharge device 33. Once the auxiliary discharge is initiated between the firing electrode 39 and the cathode 37 this potential, of the order of 100 volts R. M. S., is sufficient to initiate the discharge between the main electrodes 35 and 37. The discharge device 33 is conductive during each half period of the supply during which the anode 35 is positive relative to the cathode 37. During the intervening negative half periods, it is non-conductive. However, so long as the probes 57 and 61 are under the influence of a flame, the auxiliary discharge will be re-ignited during each positive half cycle of the supply potential and the main discharge is re-initiated following the ignition of the auxiliary discharge.

The current flow through the discharge device 33 causes the relay (51) to be actuated. During the intervals during which the anode-cathode potential of the discharge device is negative and the latter is non-conductive, the exciting coil 51 of the relay is maintained energized and the relay maintained actuated by discharge current derived from the capacitor 53 connected in parallel with the coil. The normally open contacts 83 of the relay are closed, thus closing a circuit through the valve solenoid 77. They also close a circuit in parallel with the valve solenoid through the pilot lamp 79. The valve solenoid is now maintained energized and valve 29 remains open as long as the flame 25 continues to burn. If the flame is extinguished for example by a gust of wind, the firing of the auxiliary discharge during each positive period of the supply is discontinued, the discharge device 33 is rendered non-conductive, the relay (51) opens and the gas valve 29 closes blocking further flow of gas. Because the discharge device functions instantaneously and the relay and solenoid are quick acting, the gas flow is discontinued substantially instantaneously and any possibility of explosion is eliminated. False closing of the valve 29 by reason of flame flicker is precluded by the operation of capacitor 53 in delaying the opening of the relay (51). The delay introduced by the network including the relay coil 51 and the condenser 53 is of the order of 1 second. During this second the valve 29 does not close even if the flame is extinguished. However, the gas flow during this short interval is inappreciable. This delay may be reduced where the gas flow is at a high rate by reducing the magnitude of the capacitor 53.

The connection of the relay coil 51 and its shunt condenser in the conductor between the power supply line 49 and the anode 35 of the discharge device is an important feature. When current flows through the discharge device, the shunt condenser 53 is charged. If this condenser were connected in the power supply bus 47 between the terminal of the supply and the conductor to the anode of the discharge device, the firing potential available for igniting the auxiliary discharge after the discharge device 33 had conducted during one or a few half periods would

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be reduced by the potential impressed on the condenser. Under such circumstances an auxiliary discharge frequently would not be ignited and the discharge device would fail to become conductive, the valve 29 would close and the burner would be turned off. The same condition would be produced if the relay coil 51 and its shunting condenser 53 were connected between the cathode 37 of the discharge device and the terminal 49 of the supply to which it is connected.

In the event of failure of any of the components of the system which are likely to fail, the gas valve 29 closes or remains closed. The gas valve 29 is closed unless the valve solenoid 77 is energized. If an open circuit occurs in the valve solenoid or its conductors or if the solenoid is burned out, the valve remains closed. The solenoid 77 remains deenergized unless the relay (51) is energized by current flow through its coil 51. Should the relay coil or its conductors be open circuited or should the coil be burned out, the relay will remain deenergized and the valve 29 will remain closed. If the discharge device 33 should fail, current will not flow through the relay coil 51, the relay will remain unactuated and the gas valve 29 will remain closed. Should the flame probes become short-circuited by a relatively low resistance such as soot, for example, the drop produced by the source potential across the flame probes 57 and 61 will be small, and the potential between the anode 35 and firing electrode 39 will be too small to effect transfer of the auxiliary discharge to the anode 35.

I have constructed and successfully tested a flame control system of the type described herein. In the system tested, the components have the following properties:

Flame probes (57, 61)—stainless steel rods
 Relay (5)—2500 ohm single contact type (Potter
 Brumfield type LS-1)
 Capacitor—50 microfarads
 Discharge device—1C21 (.0A4-G may also operate satisfactorily under certain conditions)
 Cathode resistor—910 ohms
 Firing electrode resistor—22 megohms
 Gas valve—115 volt A. C.
 Power supply—commercial 114 volts A. C. 60 cycle

My flame control system may be sold at a price within the reach of the vast majority of people desiring such controls for their homes.

While my invention has been shown herein as included in a clothes dryer, it may be included in a fuel burner system of any type. My invention is particularly suitable for domestic fuel burners of low B. t. u. capacity.

My invention is shown herein in its specific aspects as controlling the fuel supply to a gas burner. It may be utilized to control the fuel supply to an oil burner or even a coal burner. In the latter situation, the coal stoker rather than the fuel valve is controlled. Soft coal and oil flames deposit carbon to a greater extent than gas flames. However, no difficulty is to be anticipated from the carbon deposit, because in the event that it is excessive, the discharge device will fail to conduct and the fuel valve will be maintained closed until the electrodes are cleaned or the carbon is burned away.

Certain advantages are pointed out above as residing in the specific structure and arrangement of the components included in my system as shown herein. However, other components and other arrangements may fall within the scope of

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the broader aspects of my invention. For example, the resistors 48 and 55 may be replaced by impedances of other types. The relay coil 51 may also be connected in the power supply conductor 47 rather than in the conductor between the anode 35 of the device and power supply in situations in which the serious disadvantages inherent in this connection are counteracted by other advantages.

While I have shown and described a certain specific embodiment of my invention, I am fully aware that many modifications thereof are possible. My invention, therefore, is not to be restricted except insofar as is necessitated by the appended claims.

I claim as my invention:

1. In combination an electric discharge device having a gaseous medium at a low pressure, at least a first main electrode, a firing electrode adjacent to said first electrode and a second main electrode, said firing electrode and first main electrode being so spaced and dimensioned that said device is adapted to have an auxiliary discharge initiated between said firing electrode and said first electrode to produce a discharge between said main electrodes; first and second voltage terminals for supplying a potential to said discharge device; a connection between said first electrode and said first terminal; circuit means including a load between said second terminal and said second electrode; a fixed impedance between said firing electrode and said first terminal; a first probe connected to said second terminal, a second probe connected to said firing electrode; said probes being normally insulated from each other but in operation having a conductive path established therebetween; said fixed impedance being so selected that an auxiliary discharge is initiated between said firing electrode over said first electrode only if said conductive path is established.

2. In combination an electric discharge device having a gaseous medium at a low pressure, at least a first main electrode, a firing electrode adjacent to said first electrode and a second main electrode, said firing electrode and first main electrode being so spaced and dimensioned that said device is adapted to have an auxiliary discharge initiated between said firing electrode and said first electrode to produce a discharge between said main electrodes; said auxiliary discharge being initiated if a potential of the order of 50 volts R. M. S. is impressed between said firing electrode and said first electrode and said discharge between said main electrodes being initiated in the presence of an auxiliary discharge if a potential of the order of 100 volts R. M. S. is impressed between said main electrodes; first and second voltage terminals for supplying a potential to said discharge device; a connection between said first electrode and said first terminals; a connection including a load between said second terminal and said second electrode; a fixed impedance between said firing electrode and said first terminal and a variable impedance between said firing electrode and said second terminal; said fixed impedance being so selected that an auxiliary discharge is initiated between said firing electrode over said first electrode only if said variable impedance is less than a predetermined magnitude.

3. Apparatus for controlling the operation of a fuel burner including a conduit for supplying fuel to be burned and a mechanism operable when closed to block, or when open, to permit

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the flow of fuel through said conduit; comprising in combination an electric discharge device having a gaseous medium at a low pressure, at least a first main electrode, a firing electrode adjacent to said first electrode and a second main electrode, said firing electrode and first main electrode being so spaced and dimensioned that said device is adapted to have an auxiliary discharge initiated between said firing electrode and said first electrode to produce a discharge between said main electrodes; first and second voltage terminals for supplying a potential to said discharge device; a connection between said first electrode and said first terminal; circuit means including a motor between said second terminal and said second electrode; said motor being adapted to maintain said mechanism open when said current flows; a fixed impedance between said firing electrode and said first terminal; a first probe connected to said second terminal, a second probe connected to said firing electrode; said probes being adapted to be disposed in a flame produced by said fuel when it is burned; said fixed impedance being so selected that an auxiliary discharge is initiated between said firing electrode over said first electrode only if said conductive path is established.

4. Apparatus for controlling the operation of a fuel burner including a conduit for supplying fuel to be burned and a mechanism operable when closed to block, or when open, to permit the flow of fuel through said conduit; comprising in combination an electric discharge device having a gaseous medium at a low pressure, at least a first main electrode, a firing electrode adjacent to said first electrode and a second main electrode, said firing electrode and first main electrode being so spaced and dimensioned that said device is adapted to have an auxiliary discharge initiated between said firing electrode and said first electrode to produce a discharge between said main electrodes; first and second voltage terminals for supplying a potential to said discharge device; a connection between said first electrode and said first terminal, said connection including a resistance low compared with the ionization resistance of a flame of said fuel when it is burned; circuit means including a motor between said second terminal and said second electrode; said motor being actuable by current flow through said circuit and adapted to actuate said mechanism; a fixed impedance between said firing electrode and said first terminal; said fixed impedance having a resistance of the order of magnitude of the ionization resistance of said flame; a first probe connected to said second terminal, a second probe connected to said firing electrode; said probes being adapted to be disposed in the flame produced by said fuel when it is burned; said fixed impedance being so selected that an auxiliary discharge is initiated between said firing electrode over said first electrode only if said conductive path is established.

5. Apparatus for controlling the operation of a fuel burner including a conduit for supplying fuel to be burned and a mechanism operable when closed to block, or when open, to permit the flow of fuel through said conduit; comprising in combination an electric discharge device having a gaseous medium at a low pressure, at least a first main electrode, a firing electrode adjacent to said first electrode and a second main electrode, said firing electrode and first main electrode being so spaced and dimensioned that said device is adapted to have an auxiliary discharge ini-

tiated between said firing electrode and said first electrode to produce a discharge between said main electrodes; said auxiliary discharge being initiated if a potential of the order of 50 volts R. M. S. is impressed between said firing electrode and said first electrode and said discharge between said main electrodes being initiated in the presence of an auxiliary discharge if a potential of the order of 100 volts R. M. S. is impressed between said main electrodes; first and second voltage terminals for supplying a potential to said discharge device; a connection between said first electrode and said first terminals; a connection including a motor responsive to the resultant current flow between said main electrodes adapted to maintain said mechanism open when said current flows, said motor being connected between said second terminal and said second electrode; a fixed impedance between said firing electrode and said first terminal and a variable impedance between said firing electrode and said second terminal; said fixed impedance being so selected that an auxiliary discharge is initiated between said firing electrode over said first electrode only if said variable impedance is less than a predetermined magnitude.

6. Apparatus for controlling the operation of a fuel burner including a conduit for supplying fuel to be burned and a mechanism operable when closed to block, or when open, to permit the flow of fuel through said conduit; comprising in combination an electric discharge device having a gaseous medium at a low pressure, at least a first main electrode, a firing electrode adjacent to said first electrode and a second main electrode, said firing electrode and first main electrode being so spaced and dimensioned that said device is adapted to have an auxiliary discharge initiated between said firing electrode and said first electrode to produce a discharge between said main electrodes; said auxiliary discharge being initiated if a potential of the order of 50 volts R. M. S. is impressed between said firing electrode and said first electrode and said discharge between said main electrodes being initiated in

the presence of an auxiliary discharge if a potential of the order of 100 volts R. M. S. is impressed between said main electrodes; first and second voltage terminals for supplying a potential to said discharge device; a connection between said first electrode and said first terminals; said connection including a first resistance low compared with the ionization resistance of the flame of said fuel when it is burned; a connection including a motor actuable by current flow through a conductor thereof and adapted to actuate said mechanism, said motor being connected between said second terminal and said second electrode; a capacitor connected in parallel with said motor, a fixed impedance having a resistance of the order of magnitude of the ionization resistance of a flame of said fuel when it is burned between said firing electrode and said first terminal and a pair of flame electrodes adapted to be disposed in a flame of said fuel when it is burned, said firing electrodes being connected through said ionization path to said second terminal; said fixed impedance being so selected that an auxiliary discharge is initiated between said firing electrode over said first electrode only if said variable impedance is less than a predetermined magnitude.

GEORGE W. NAGEL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,872,880	Briesky et al.	Aug. 23, 1932
1,880,871	Denison	Oct. 4, 1932
1,936,784	Diamond	Nov. 28, 1933
2,003,624	Bower	June 4, 1935
2,081,091	Kempel	May 18, 1937
2,231,420	Gille	Feb. 11, 1941
2,295,885	Yates	Sept. 15, 1942
2,352,240	Wolfner	June 27, 1944
2,411,888	Long et al.	Dec. 3, 1946