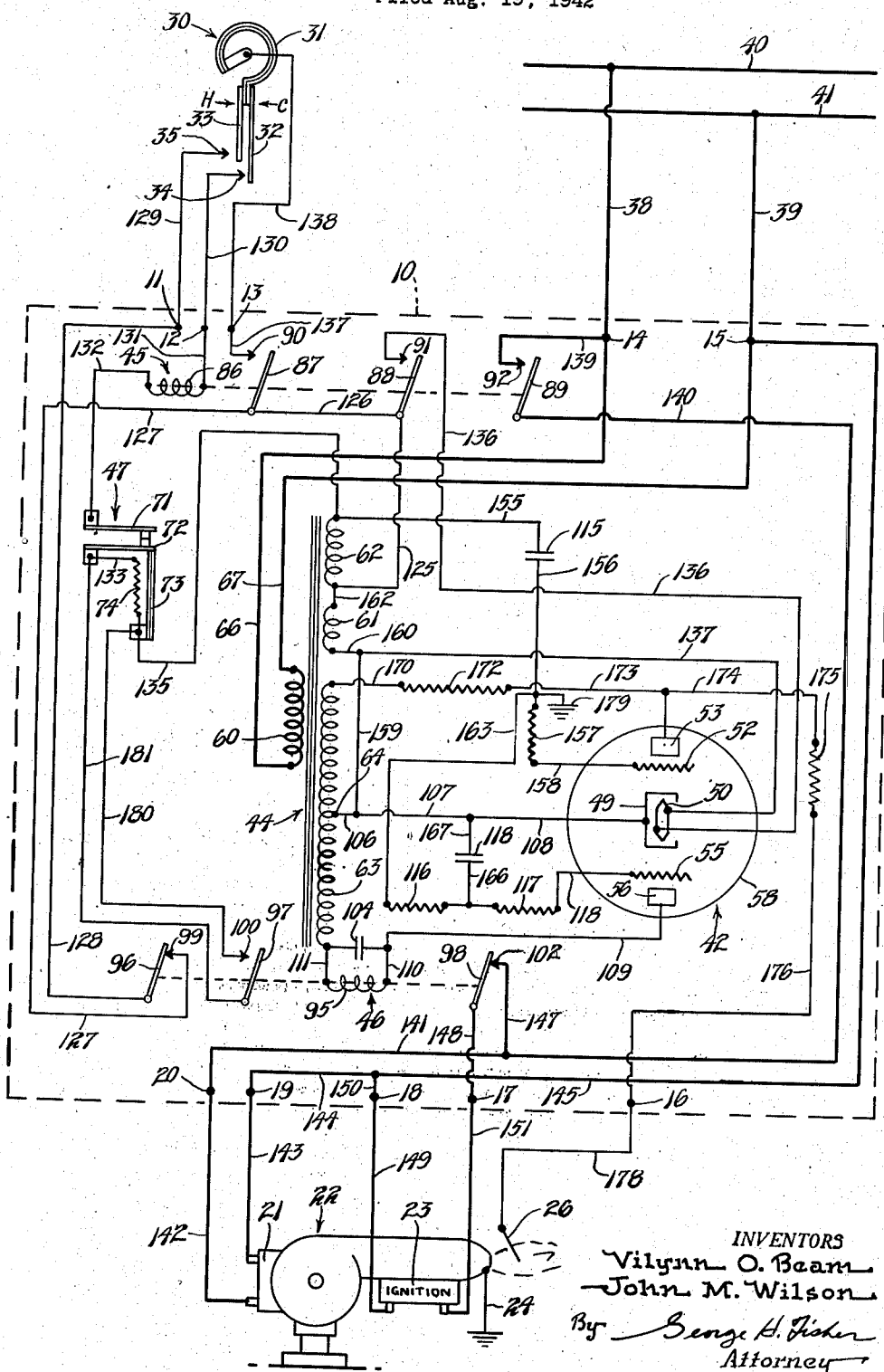


July 10, 1945.

V. O. BEAM ET AL
BURNER CONTROL DEVICE

2,379,871

Filed Aug. 19, 1942



UNITED STATES PATENT OFFICE

2,379,871

BURNER CONTROL DEVICE

Vilynn O. Beam and John M. Wilson, Minneapolis, Minn., assignors to Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., a corporation of Delaware

Application August 19, 1942, Serial No. 455,330

20 Claims. (Cl. 158—28)

The present invention is concerned with a burner control device and more particularly to one utilizing the conductive properties of a burner flame or utilizing the conductive properties of a photo-cell exposed to the burner flame to control the operation of the burner.

In the co-pending application of Vilynn O. Beam, Serial No. 450,613, filed July 11, 1942, there is described a control device designed to perform a controlling operation in accordance with the rectifying characteristics of an impedance connected across the gap in the circuit connections of the control device. This control device is designed to function in one manner if the gap is bridged by a rectifying impedance and in a different manner if the gap is bridged by a non-rectifying impedance regardless of the magnitude of the impedance. As brought out in said co-pending application, the impedance may take any desired form and particularly it may be the flame itself or a photo-cell responsive to the light produced by the flame.

An object of the present invention is to provide a burner control device utilizing certain features of the control device of the aforesaid Beam application and in which the elements are arranged so as to be peculiarly adapted for the control of a burner by a controlling switch such as a room thermostat.

A further object of the present invention is to provide a burner control means having an electronic discharge device in which one winding is both used to energize a relay circuit and also to control the bias on a control grid of the discharge device.

A still further object of the present invention is to provide a burner control device of the type set out in the previous object in which the bias on the grid is controlled by a condenser normally charged in one direction by a transformer winding and in which the same transformer winding also functions to energize a relay circuit controlled by a room thermostat or other controlling switch.

Other objects of the present invention will be apparent from a consideration of the accompanying specification, claims and drawing, of which the single figure is a schematic view of the burner control device connected to a thermostat and to a burner to control the operation of the burner by the room thermostat and in accordance with the condition of the burner flame.

Referring to the specific form of the apparatus shown in the drawing, the burner control device of the present invention is schematically indi-

cated as enclosed within a housing 10. Secured to this housing 10 are various terminals 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20. The terminals 11, 12 and 13 constitute the thermostat terminals; the terminals 14 and 15, the power terminals; the terminal 16, the flame electrode terminal; terminals 17 and 18, the ignition terminals, and terminals 19 and 20, the burner terminals. The part that these terminals play in the operation of the system will be more apparent from a subsequent description of the operation of the system.

In general, the burner control device 10 is employed to control the operation of a motor 21 of an oil burner 22. Associated with this burner is an electrical ignition means 23 of any conventional type, this ignition means being employed to ignite the fuel issuing from the burner. As is conventional practice, the nozzle of burner 22 is connected to ground as indicated at 24.

Associated with the burner 22 is a flame electrode 26. This electrode is adapted to extend into the burner flame and to form one terminal of a gap between it and ground bridged by the burner flame when such a flame is present. As will be pointed out later, the burner is controlled through the control device 10 of the present invention in accordance with the character of the impedance across this gap.

The burner control device 10 is also controlled by a control switch such as a room thermostat 30. This thermostat is of a conventional type comprising a bimetallic element 31 and a plurality of contact arms 32 and 33 designed to engage with contacts 34 and 35. The contact arm 33 is more widely spaced from contact 35 than is contact arm 32 from contact 34. Upon a drop in temperature, contact arms 32 and 33 are designed to be moved to the left. Because of this difference in spacing of contact arms 32 and 33 from their respective contacts, it will be obvious that upon a temperature drop, arm 32 first engages its contact 34 and contact arm 33 does not engage its contact 35 until a further drop in temperature has occurred.

The power terminals 14 and 15 are connected by conductors 38 and 39 to line wires 40 and 41 leading to any suitable source of power (not shown). Thus, terminals 14 and 15 are always at the same potential as line wires 40 and 41 and all circuits hereinafter referred to will be traced from the power terminals 14 and 15.

Referring now to the burner control device 10 which forms the subject matter of the present invention, this device generally comprises an elec-

tronic discharge device 42, a step-up, step-down transformer 44, a first relay 45, a second relay 46, and a safety switch 47.

The electronic discharge device 42 is of the double triode type, having a double cathode 49 energized by a heating element 50. The first triode comprises cathode 49, a grid 52 and an anode 53. The second triode comprises the same cathode 49, a grid 55 and an anode 56. As is usual, the various elements are housed within an envelope 58.

The step-up, step-down transformer 44 controls the energization of the electronic discharge device 42 as well as the various other electrical elements referred to. This transformer comprises a line voltage primary 60, low voltage secondaries 61 and 62 and a high voltage secondary 63. The high voltage secondary 63 is provided with a center tap 64. The line voltage primary 60 is permanently connected through conductors 66 and 67 to the power terminals 14 and 15. While any suitable voltage may be employed depending upon the voltage of the power source available and the operating characteristics of the electronic discharge tube, the primary winding 60 may, for example, be connected to a 110 volt source of power and the windings 63, 61 and 62 may be designed to operate at voltages of 600 volts, 6 volts and 24 volts, respectively.

The safety switch 47 may be of any suitable type, such as that shown in the patent to Frederick S. Denison, No. 1,958,081, filed May 8, 1934. As shown schematically in the drawing, the safety switch comprises switch blades 71 and 72, the lower switch blade 72 being pivotally mounted and held in contact making engagement with switch blades 71 by a bimetallic element 73. Located adjacent the bimetallic element 73 is a heater 74. Upon the bimetallic element 73 being heated by heater 74, for longer than a predetermined period of time, the upper end of bimetallic element 73 is warped to the right so as to permit switch blade 72 to fall away from switch blade 71. These switch blades can then be re-engaged only by a manual operation.

Relay 45 comprises a relay coil 86 and three switch blades, 87, 88 and 89, designed to cooperate with fixed contacts 90, 91 and 92. The switch blades 87 to 89 are normally biased out of engagement with the contacts and are moved into engagement therewith upon energization of relay coil 86. As will be more apparent from the subsequent description, the relay 45 is controlled by thermostat 30 and is energized by the secondary winding 62.

The relay 46 comprises a winding 95 and a plurality of switch blades 96, 97 and 98 designed to engage contacts 99, 100 and 102. Switch blades 96 and 98 are biased into engagement with contacts 99 and 102 while switch blade 97 is biased out of engagement with contact 100. Upon energization of relay coil 95, switch blades 96 and 98 are moved out of engagement with their contacts and switch blade 97 is moved into engagement with contact 100. The relay coil 95 has a condenser 104 connected in parallel therewith.

The relay coil 95 is connected in the output circuit of the lower triode of tube 42, this circuit being as follows: from tap 64 of secondary 63 through conductors 106, 107, 108, cathode 49, anode 56, conductor 109, conductor 110, relay winding 95, and conductor 111 to the lower terminal of secondary winding 63. Thus it will be seen that during the half cycles in which the lower end of secondary winding 63 is positive with

respect to the tap 64 and if the potential of grid 55 is sufficiently high with respect to cathode 49, a current will flow through the relay winding 95, the magnitude of this current being dependent upon the potential applied to grid 55. The condenser 104 acts to eliminate possible chattering of the relay.

The potential of grid 55 is determined to a large extent by the direct current potential existing across condenser 115. The A. C. voltage existing across condenser 115 tends to be filtered out by a filter network including resistors 116 and 117 and a condenser 118. The direct current voltage across condenser 115 is determined by several factors. In the first place, the condenser 115 is subjected to a direct current potential resulting from its connection in series with secondary windings 61 and 62, grids 52 and 55, and cathode 49. In other words, the condenser 115 is connected in the grid circuits of both triodes. As will be pointed out later, the direct current potential produced by this grid current tends to charge the condenser 115 in such a direction as to cause deenergization of relay coil 95. The condenser 115 is also subjected to a direct current potential when the flame electrode 26 is connected to ground through a flame of the proper characteristic. The direct current potential produced by this action tends to oppose the potential produced by the previous action and to render the potential of grid 55 sufficiently high to cause energization of relay coil 95. Certain other factors affect the potential of grid 55 and these factors will be explained subsequently.

OPERATION

With the various elements in the position shown in the drawing, the temperature to which thermostat 30 responds is above the desired value. Let it now be assumed that the temperature drops sufficiently to cause movement of contact blades 32 and 33 towards contacts 34 and 35. No energizing circuit is established until both contact blades have engaged the contacts 34 and 35. When this happens, a circuit is established through the relay coil 86 as follows: from the lower terminal of secondary 62 through conductors 125, 126 and 127, contact 99, switch blade 96, conductor 128, terminal 11, conductor 129, contact 35, switch blade 33, contact blade 32, contact 34, conductor 130, terminal 12, conductor 131, relay coil 86, conductor 132, switch blades 71 and 72, conductor 133, heater 74, and conductor 135 to the other terminal of secondary 62. The result of the energization of the relay coil 86 by reason of the establishment of the circuit just traced is that switch blades 87, 88 and 89 are moved into engagement with contacts 90, 91 and 92. The engagement of the switch blade 87 with contact 90 results in the establishment of a holding circuit for relay coil 86 as follows: from the lower terminal of secondary 62 through conductors 125 and 126, switch blade 87, contact 90, conductor 137, terminal 13, conductor 138, bimetallic element 31, contact blade 32, contact 34, conductor 130, terminal 12, conductor 131, relay coil 86, conductor 132, switch blades 71 and 72, conductor 133, heater 74, and conductor 135 to the other terminal of secondary 62. It will be noted that the circuit just traced is independent of contact blade 35 and contact 35. The result of this is that upon a rise in temperature, the circuit to relay coil 86 will not be interrupted until both contact blades 32 and 33 have separated from their contacts. In this way, a dif-

ferential in temperature is necessary to cause deenergization of the relay after it has been energized. Thus, chattering of the relay is avoided. Likewise, this circuit is independent of contact blade 96 and contact 99 of relay 46.

The engagement of relay switch blade 89 with contact 92 results in the establishment of a circuit to burner motor 21 as follows: from power terminal 14 through conductor 139, contact 92, switch blade 89, conductors 140 and 141, terminal 20, conductor 142, burner motor 21, conductor 143, terminal 19, and conductors 144 and 145 to the other line voltage terminal 15. At the same time, a circuit is established to the ignition means 23 as follows: from terminal 14 through conductor 139, contact 92, relay switch blade 89, conductors 140 and 147, contact 102, switch blade 98, conductor 148, terminal 17, conductor 151, ignition means 23, conductor 149, terminal 18 and conductors 150 and 145 to the other terminal 15. As a result of the establishment of these circuits, the oil burner motor is placed in operation to feed fuel through the nozzle and the ignition means is energized to provide for ignition of this fuel. Under normal circumstances, the issuing fuel will be ignited by the ignition means. It is highly desirable, however, that if ignition does not occur properly, the system will be shut down so that unignited fuel will not continue to issue from the nozzle. The engagement of relay switch blade 88 with contact 91 results in the establishment of the following energizing circuit to cathode heater 50: from the lower end of secondary 62 through conductor 125, switch blade 88, contact 91, conductor 136, cathode heater 50, and conductors 137 and 160 back to the lower terminal of secondary 61. The establishment of this circuit results in the energization of heater 50 so as to place the discharge device 42, after the lapse of a few seconds, into condition for operation.

The burner control device 10 is designed to function to check the presence of flame. As previously noted, the direct current potential across condenser 115 tends to determine the bias on grid 55 and hence whether the relay coil 95 is energized or not. In the absence of a flame and under normal conditions, current flows through the following circuit including condenser 115: from the upper terminal of secondary 62 through conductor 155, condenser 115, conductor 156, resistance 157, conductor 158, grid 52, cathode 49, and conductors 108, 107, 159 and 160, secondary 61 and conductor 162 to the lower terminal of secondary 62. Due to the rectifying action of the grid-cathode circuit, current flows through this circuit only when the upper terminal of secondary 62 is positive. In other words, condenser 115 is connected across secondaries 61 and 62 in series with a rectifier. The result of this action is that a direct current potential is impressed across condenser 115 so that the lower terminal of condenser 115 is negative and the upper terminal is positive.

As previously indicated, the resistors 116, 117 and condenser 118 form a filter network for applying the direct current potential across condenser 115 to the grid 55. It will be noted that the lower terminal of condenser 115 is connected through conductors 156, 163, resistors 116 and 117, and conductor 118 to grid 55. At the same time the cathode is connected through conductors 108, 107, 159 and 160 to the other terminal of the combined secondaries 61 and 62, which in turn are connected to the upper terminal of condenser 115. It is also to be noted that condenser 118 is

connected by conductors 166 and 167 between the junction of resistances 116 and 117 and the junction of conductors 107 and 108 leading to cathode 49. It is believed that it will be readily apparent that the condenser 118 is connected between the grid 55 and cathode 49 at a point intermediate the resistances 116 and 117. The condenser 118 hence tends to filter out any alternating current voltage components that would otherwise be impressed between grid 55 and cathode 49.

Due to the fact that grid 55 is connected to the lower end of condenser 115, which as previously noted is charged negatively when no flame exists, the grid 55 is at a sufficiently low potential with respect to cathode 49 that insufficient current flows in relay coil 95 to energize the same. Thus, under these conditions, the various switches of relay 46 occupy the position shown in the drawing. It is necessary, however, that this relay be energized to prevent the system shutting down. The action whereby the system is shut down will be referred to later. For the present, it is assumed that a flame properly occurs.

When flame does occur, a new energizing circuit is established through the condenser 115. This circuit extends from the upper terminal of secondary 63 through conductor 170, resistance 172, conductors 173 and 174, resistance 175, conductor 176, terminal 16, conductor 178, flame electrode 26, through the flame, conductor 24 to ground, through the ground to ground connection 179, and through conductor 156, condenser 115, conductor 155, secondary 62, conductor 162, secondary 61, and conductors 160, 159 and 106 to tap 64 of secondary 63. It will be noted that in the circuit just traced, a condenser 115 is connected in series with the flame gap and that portion of secondary 63 between tap 64 and the upper end of the secondary. The full voltage of the upper half of secondary 63 is not applied to the flame gap, however, since secondaries 62 and 61 are also included in the circuit. The voltage that is hence applied is the voltage across the upper half of secondary 63 minus the combined voltages of secondaries 61 and 62. As is indicated by the typical voltage values of the secondaries given in an earlier portion of the specification, the combined voltage values of secondaries 61 and 62 are relatively small as compared with that of the upper half of secondary 63. Hence, a relatively substantial voltage is applied across the flame gap.

In the circuit traced in the preceding paragraph the circuit was traced from the upper terminal of secondary 63 through flame electrode 26 to ground and through condenser 115 in the direction opposite to which the first mentioned condenser charging circuit was traced. While a certain amount of current flows through the flame in both directions, the current flow through the flame in the direction traced is much greater than that in the opposite direction. This is due to the rectifying property of the flame. It is well established that electrons tend to flow to a greater extent in the actual direction of propagation of the flame. Hence, the conventional current flow is greater in the direction opposite the propagation of the flame. As a result, the current flow through the flame and through the condenser 115 tends to impress across the condenser a direct current potential which is opposite in polarity to that impressed by the current flow through the grid circuits. The result is that the condenser 115 no longer tends to bias the grid 55 negative or at least does not bias it

sufficiently negative to cause deenergization of relay coil 95. Thus, sufficient current flow takes place in the output circuit of the triode including anode 56 and cathode 49 to cause relay coil 95 to be energized with the result that switch blades 96 and 98 are moved out of engagement with contacts 99 and 102 and switch blade 97 is moved into engagement with contact 100.

The movement of switch blade 96 out of engagement with contact 99 interrupts the original energizing circuit for relay coil 86. In view of the fact, however, that the holding circuit has been previously established by the engagement of switch blade 87 with contact 90, the relay coil 86 remains energized.

The engagement of switch blade 97 with contact 100 establishes a new energizing circuit to relay coil 86 as follows: from the upper terminal of secondary 62 through conductors 135 and 180, contact 100, switch blade 97, conductor 181, switch blades 72 and 71, conductor 132, relay coil 86, conductor 131, terminal 12, conductor 130, contact 34, switch blade 32, bimetallic element 31, conductor 138, terminal 13, conductor 137, contact 90, switch blade 87, and conductors 126 and 125 to the lower terminal of secondary 62. It is to be noted that this new circuit does not include the heater 74 and that the heater 74 is effectively shunted out by conductors 180 and 181, switch blade 97, and contact 100. The result is that heater 74 is substantially deenergized so that bimetallic element 73 is no longer heated. Because of the shunting of heater 74, switch blades 71 and 72 are allowed to remain in engagement to permit the system to continue in operation. In other words, since the flame has properly been established across the flame gap, it is desired that the burner remain in operation as long as thermostat 30 is calling for heat and the flame persists.

The separation of switch blade 98 from contact 102 interrupts the circuit to the ignition means 23 previously traced. The result of such interruption is that the ignition means is now deenergized. The system illustrated in the drawing is of the intermittent ignition type and in such systems it is customary to deenergize the ignition means as soon as flame is established.

Assuming that the flame does not go out, the system will now continue in operation until such time as the room thermostat is completely satisfied. In other words, it will remain in operation until both switch blades 32 and 33 have separated from their associated contacts 34 and 35. When this happens, all of the circuits previously traced to relay coil 86 are interrupted with the result that switch blade 89 separates from contact 92 to cause deenergization of the oil burner motor. At the same time, switch blade 88 separates from contact 91 to cause deenergization of the cathode heater 50. It is no longer necessary to heat the cathode because the moment the oil burner motor is stopped so that the flame no longer exists in the flame gap, the charge on condenser 115 resumes a value such as to cause relay coil 95 to be deenergized.

In this connection, it is to be noted that if after normal burner operation has been established the flame is extinguished for any reason, the relay 95 is promptly deenergized so as to cause switch blade 98 to reclose contact 102 and thus reenergize the ignition means. At the same time, the shunt circuit for safety switch heater 74 is broken, as described later. If the conditions are still proper for initiating combustion, the re-

energized ignition means will relight the burner and the cycle previously discussed will be repeated. If, however, the interruption of the burner flame is due to a condition which prevents the resumption of proper burner operation without manual intervention, the safety switch 47 will operate to shut down the system at the end of a predetermined period of time. This is due to the fact that the deenergization of relay coil 95 due to the interruption of flame also caused switch blade 97 to separate from contact 100 to break the shunt previously established around the heater element 74. As a result, the heater element 74 is re-energized to shut down the system within a predetermined period if combustion does not occur.

Likewise, if flame should not be established initially upon a call for heat by the thermostat, the safety switch heater would remain energized sufficiently long to shut down the system.

Presence of other conditions than flame or normal absence of flame

As discussed in the co-pending Beam application, previously referred to, this system not only is able to differentiate between a normal flame and the normal absence of a flame but is able to differentiate between flame conditions and various types of impedance conditions across the flame gap that might otherwise falsely indicate the presence of a flame. For example, if the system operated solely in accordance with the magnitude of the impedance across the flame gap, a short circuit condition would cause the system to operate as though a flame were present. This is extremely undesirable because it may happen that the flame electrode accidentally engages the burner. Again, it often happens that after long periods of use, carbon forms on the flame electrode until a point is reached such that the flame gap is actually bridged by the carbon. Under certain conditions, the impedance of the gap through the carbon may actually be almost identical to that of the impedance when a flame is present. Again, it is necessary to distinguish between a normal flame and such a high resistance impedance.

Consider first the situation in which due to the accumulation of carbon or for other reasons an impedance exists across the flame gap which is substantially the same in magnitude as the impedance of a normal flame. Under these conditions current flow across the flame gap and through condenser 115 will take place. However, such impedance is not rectifying so that this current flow is the same in both directions. It is essentially nothing more than alternating current and the potential impressed across condenser 115 due to this current flow therethrough has no direct current component whatsoever. Thus, the direct current potential across condenser 115 is exactly the same as that due to the current flow through the grid circuits. As previously pointed out, this potential causes the grid 55 to be biased to a point where relay coil 95 is deenergized.

When a short circuit condition exists between the flame electrode and ground, it is obvious that the impedance is again a non-rectifying impedance so that the direct current potential across condenser 115 tends to be the same. However, certain other factors enter into the operation due to the decreased impedance across the flame gap. It will be noted that as the impedance between flame electrode 26 and ground

becomes less and less, the grid 55 tends to be connected through a relatively low impedance directly to the upper end of secondary 63. Since the anode 56 is connected to the opposite end of secondary 63, the voltage impressed across grid 55 by this connection tends to be 180° out of phase. Were it exactly 180° out of phase, it would bias the grid 55 even more negatively and hence prevent the flow of current through relay coil 95. However, the condenser 115 and the flame impedance in effect form a phase shifting bridge, to one terminal of which the grid 55 is connected. The cathode 49 is connected to the other terminal. The result is that the increased voltage applied to the grid as a result of the decreased impedance across the flame gap tends to be shifted so that it is no longer 180° out of phase with respect to the voltage applied to anode 56. Were there no compensating factor, this voltage would tend to be displaced in phase to such an extent as to actually raise the potential of grid 55. However, the effect of the triode including anode 53 and cathode 49 is present to an increasing extent as the flame gap resistance is decreased. It is to be noted that any decrease in flame gap resistance tends to connect grid 52 to a point closer in potential to that of anode 53. Hence, the anode current of this triode is increased. This tends to produce a correcting shift in phase so as to bring the grid voltage more nearly 180° out of phase with the potential applied to anode 56. Reference is made to the copending Beam application for a fuller explanation of this action. In any event, through cooperative action of the anode 53, the triode including anode 56 and cathode 49 remains sufficiently non-conductive as to prevent energization of relay coil 95.

SUMMARY

It is to be noted that in the operation traced above, the secondary coil 62 through an ingenious circuit arrangement not only serves to energize the relay coil 86 but also serves to apply a voltage to the grid circuit of the triode including anode 53 and cathode 49. In other words, this secondary 62 not only is employed to energize the thermostatically controlled relay circuit but it is also employed to charge the condenser 115 negatively. Normally, it would be necessary to include two separate secondaries since the voltages supplied are to be distinctly different portions of the circuit which normally cannot be interconnected. Due to the ingenious circuit arrangement of the present device, however, the same secondary accomplishes both functions and thereby reduces the cost of the burner control.

It will be noted that we have provided an improved burner control device which functions with a minimum of parts to instantly detect the presence or absence of a flame and which is capable of differentiating between a normal flame condition and conditions closely simulating those of a normal flame.

While we have disclosed the use of a flame electrode for detecting the presence of a flame, a photoelectric cell could readily be substituted for the flame gap as disclosed in the previously mentioned Beam application. Such a cell due to its rectifying properties, when exposed to a source of light such as a burner flame, would introduce a rectifying effect similar to that of the flame itself. For this reason, whenever expressions such as "flame responsive means" and "upon the presence of a burner flame" are employed in the

appended claims, it is to be understood that these terms are to be construed broadly enough to be readable upon operation with either a photoelectric cell or a flame gap. In general, while we have disclosed a specific embodiment of our invention for purposes of illustration, it is to be understood that our invention is limited only by the scope of the appended claims.

We claim as our invention:

1. In a burner control means, controlling means adapted to be controlled by a main control switch and adapted to initiate steps normally resulting in a burner operation, a grid controlled electronic amplifier, means controlled by said amplifier adapted to control the burner after it is in operation, biasing means adapted normally to bias the grid of said amplifier so that its potential is within one range of values, flame responsive means associated with said grid adapted to shift the potential of said grid into a different range of values upon the presence of a burner flame, a first source of power connected to energize the output circuit of said amplifier, and a single second source of power connected to said biasing means and said controlling means for energizing both said biasing means and said controlling means.
2. In a burner control means, controlling means adapted to be controlled by a main control switch and adapted to initiate steps normally resulting in a burner operation, a grid controlled electronic discharge device, means controlled by said device adapted to control the burner after it is in operation, a transformer having a secondary winding adapted to supply an alternating potential, biasing means adapted normally to bias the grid of said device so that its potential is within one range of values, flame responsive means associated with said grid and adapted to shift the potential of said grid into a second range of values, and connections between said secondary winding and both said biasing means and said controlling means whereby both said biasing means and said controlling means are energized by one secondary winding.
3. In a burner control means, a grid controlled thermionic discharge device having a heater associated with an electron emissive surface, means controlled by said device adapted to control a burner, a transformer having a secondary winding adapted to supply an alternating potential, biasing means adapted normally to bias the grid of said device so that its potential is within one range of values, flame responsive means associated with said grid and adapted to shift the potential of said grid into a second range of values upon the presence of a burner flame, controlling means adapted to be controlled by a main controlling switch for initiating energization of said heater, and connections between said secondary winding and both said biasing means and said controlling means whereby both said biasing means and said controlling means are energized by said one secondary winding.
4. In a burner control means, controlling means adapted to be controlled by a main control switch and adapted to initiate steps normally resulting in a burner operation, a grid controlled electronic discharge device, means controlled by said device adapted to control the burner after it is in operation, a transformer having a secondary winding adapted to supply an alternating potential, an impedance connected to the grid of said electronic discharge device for controlling the magnitude of the current in said output circuit, connections

between said secondary winding and said impedance and operative to impress across said impedance a potential biasing said grid sufficiently negative to render said discharge device effectively non-conductive. flame responsive means associated with said grid and adapted to raise the potential of said grid upon the presence of a burner flame, and connections between said secondary winding and said controlling means whereby the said controlling means is energized by the same secondary winding that energizes said condenser charging circuit.

5. In a burner control means, controlling means adapted to be controlled by a main control switch and adapted to initiate steps normally resulting in a burner operation, a grid controlled electronic discharge device, means controlled by said device adapted to control the burner after it is in operation, a transformer having a secondary winding adapted to supply an alternating potential, a condenser connected to the grid of said electronic discharge device for controlling the magnitude of the current in said output circuit, connections between said secondary winding and said condenser and operative to impress across said condenser a potential biasing said grid so that its potential is within one range of values, flame responsive means associated with said grid and adapted to shift the potential of said grid into a second range of values upon the presence of a burner flame, and connections between said secondary winding and said controlling means whereby the said controlling means is energized by the same secondary winding that energizes said condenser charging circuit.

6. In a burner control device, first and second relays, a grid controlled electronic discharge device controlling the energization of said first relay, a second relay adapted to be controlled by a main control switch for controlling a burner to control the delivery of fuel thereto, means to terminate operation of said burner within a predetermined period of time, means controlled by said first relay for rendering said last named means inoperative in the event of energization of said first named relay by said discharge device prior to the expiration of said predetermined period of time, biasing means adapted normally to bias the grid of said device sufficiently negative to render said discharge device ineffective to energize said first relay, flame responsive means associated with said grid and adapted to raise the potential of said grid upon the presence of a burner flame, a first source of power operative to energize the output circuit of said discharge device, and a second source of power operative to energize said second relay, said operation terminating means, and said biasing means.

7. In a burner control means, a first relay, a grid controlled electronic discharge device controlling the energization of said relay, a second relay adapted to be controlled by a main controlling switch, means operative only upon energization of both relays to maintain continued operation of a burner, a transformer having at least two secondary windings, connections between one of said secondary windings, said first-named relay and said electronic discharge device constituting the output circuit of said electronic discharge device and controlling the energization of said first-named relay, biasing means adapted to be energized by a second of said secondary windings and normally operative to impress on the grid of said electronic discharge device a biasing voltage such that insufficient current

flows in said output circuit to energize said first relay, flame responsive means associated with said grid and adapted upon the presence of a burner flame to change the potential applied to said grid to increase the current flow in said output circuit, and further connections between said second secondary winding and said second relay to energize said second relay by said secondary winding under the control of said thermostat.

8. In a burner control device, a first relay, a grid controlled electronic discharge device controlling the energization of said relay, a second relay adapted to be controlled by a main controlling switch, means operative only upon energization of both relays to maintain continued operation of a burner, a transformer having at least two secondary windings, connections between one of said secondary windings, said first-named relay and said electronic discharge device constituting the output circuit of said electronic discharge device and controlling the energization of said first-named relay, a condenser connected to the grid of said electronic discharge device and controlling the magnitude of the current in said output circuit, connections between a second of said secondary windings and said condenser and operative to impress across said condenser a voltage such that insufficient current flows in said output circuit to energize said first-named relay, flame responsive means associated with said condenser and adapted upon the presence of a burner flame to change the energization of said condenser to increase the current flow in said output circuit, and further connections between said second secondary winding and said second relay to energize said second relay by said secondary winding under the control of said thermostat.

9. In a burner control means, a grid controlled thermionic discharge device having a heater associated with an electron emissive surface, means controlled by said device adapted to control a burner, a transformer having at least two secondary windings adapted to supply alternating potentials, biasing means adapted normally to bias the grid of said device so that its potential is within one range of values, means associated with said grid and adapted to shift the potential of said grid into a second range of values upon the presence of a burner flame, connections between one of said secondary windings and said heater for energizing said heater, controlling means adapted to be controlled by a main controlling switch for initiating energization of said heater by said secondary winding, connections between a second of said secondary windings and said controlling means for energizing the latter, and connections from said first and second secondary windings in series to said biasing means whereby said biasing means is energized by the same two windings as are employed to energize said heater and said controlling means.

10. In a burner control means, controlling means adapted to be controlled by a main control switch and adapted to initiate steps normally resulting in a burner operation, a grid controlled electronic discharge device, means controlled by said device adapted to control the burner after it is in operation, a transformer having a secondary winding adapted to supply an alternating potential, biasing means adapted normally to bias the grid of said device sufficiently negative to render said discharge device effectively non-conductive, means including a circuit having a gap adapted to be bridged by means exposed to a burner flame and responsive only to the presence of a direct

current component in the current flowing through said gap to raise the potential of said grid, and connections between said secondary winding and both said biasing means and said controlling means whereby both said biasing means and said controlling means are energized by said one secondary winding.

11. In a control means, a grid controlled thermionic amplifier having a heater associated with an electron emissive surface, biasing means adapted normally to bias the grid of said device sufficiently negative to render said amplifier effectively non-conductive, means including circuit connections having a gap adapted to be bridged by an impedance, said last-named means being operative to raise the potential of said grid upon the presence of an impedance of desired characteristics in said gap, a relay adapted to be controlled by a main controlling switch for initiating energization of said heater, a first source of power for energizing the output circuit of said amplifier, a second source of power operative to energize said heater, a third source of power effective to energize said relay, and connections whereby said second and third sources of power jointly energize said biasing means.

12. In combination; a transformer having windings including at least one secondary winding; a current translating means; a space discharge amplifier having an anode, a cathode, and a control element; means including connections between said windings, said anode, said cathode, and said current translating device and operative to cause either energization or effective de-energization of said device depending upon within which of two ranges of potential values said control element is maintained; biasing means for normally maintaining said control electrode at a potential within a first of said two ranges of values; means including a connection between said control element and a point on said windings, said connection including a gap adapted to be bridged by a rectifying impedance; said last named means being effective when said gap is bridged by a rectifying impedance to maintain said control element at a potential within the other of said two ranges of values against the action of said biasing means; a relay controlling the operation of said amplifier; and connections between said secondary winding and both said biasing means and said relay so that both said biasing means and said relay are energized by said one secondary winding.

13. In combination; a transformer having windings including at least one secondary winding; a current translating means; a space discharge amplifier having an anode, a cathode, and a control element; means including connections between said windings, said anode, said cathode, and said current translating device and operative to cause either energization or effective de-energization of said device depending upon within which of two ranges of potential values said control element is maintained; biasing means for normally maintaining said control electrode at a potential within a first of said two ranges of values; a connection between said element and a point on said windings such that the connection tends to maintain said control element at an alternating potential also within said first of said two ranges of values, said connection including a gap adapted to be bridged by a rectifying impedance; means associated with said connection and effective when said gap is bridged by a rec-

ment at a potential within the other of said two ranges of values against the action of said biasing means; a relay controlling the operation of said amplifier; and connections between said secondary winding and both said biasing means and said relay so that both said biasing means and said relay are energized by said one secondary winding.

14. In combination; a transformer having windings including two secondary windings; a first relay; a space discharge amplifier having an anode, a cathode, and a control element; means including connections between one of said secondary windings, said anode, said cathode, and said first relay and operative to cause either energization or effective deenergization of said relay depending upon within which of two ranges of potential values said control element is maintained; biasing means for normally maintaining said control electrode at a potential within a first of said two ranges of values; a connection between said element and a point on said one secondary winding such that the connection tends to maintain said control element at an alternating potential also within said first of said two ranges of values, said connection including a gap adapted to be bridged by a rectifying impedance; means associated with said connection and effective when said gap is bridged by a rectifying impedance to maintain said control element at a potential within the other of said two ranges of values against the action of said biasing means; a second relay controlling the operation of said amplifier; and connections between a second of said secondary windings and both said biasing means and said second relay so that both said biasing means and said second relay are energized by said second secondary winding.

15. In a control means, a grid controlled thermionic amplifier having a heater associated with an electron emissive surface, a transformer having three secondary windings each adapted to supply alternating potential, biasing means adapted normally to bias the grid of said amplifier sufficiently negative to render said amplifier effectively non-conductive, means including circuit connections having a gap adapted to be bridged by an impedance, said last-named means being operative to raise the potential of said grid upon the presence of an impedance of desired characteristics in said gap, controlling means adapted to be controlled by a main controlling switch for initiating energization of said heater, connections between a first of said windings and the output circuit of said thermionic amplifier, connections between a second of said windings and said heater, connections between a third of said windings and said controlling means, and connections whereby said second and third windings are connected in series to energize said biasing means.

16. In a burner control system, a burner, electrically operated means for controlling the flow of fuel to said burner, a main controlling thermostat, means controlled by said thermostat for initiating burner operation, a grid controlled electronic amplifier, means controlled by the amplifier and operative to control the burner after it is in operation, biasing means adapted normally to bias the grid of said amplifier so that its potential is within one range of values, flame responsive means associated with said grid adapted to shift the potential of said grid into a different range of values upon the presence of a burner flame, a first source of power connected to ener-

gize the output circuit of said amplifier, and a single second source of power connected to said biasing means and to said thermostatically controlled means for energizing both said biasing means and said thermostatically controlled means.

17. In a burner control system, a burner, electrically operated means for controlling the flow of fuel to said burner, ignition means for igniting the fuel supplied to said burner, a thermostat, means controlled by said thermostat for initiating energization of said ignition means, a grid controlled electronic amplifier, means controlled by said amplifier operative to control said burner, biasing means adapted normally to bias the grid of said amplifier so that its potential is within one range of values, flame responsive means associated with said grid adapted to shift the potential of said grid into a different range of values upon the presence of a burner flame, a first source of power connected to energize the output circuit of said amplifier, and a single second source of power connected to said biasing means and to said thermostatically controlled means for energizing both said biasing means and said thermostatically controlled means.

18. In combination, an electronic amplifier having a control electrode, a relay adapted to be controlled by said amplifier and having a relay winding and control elements actuated thereby adapted to control said amplifier, a plurality of sources of alternating power, one of said sources being connected to energize the output circuit of said amplifier, biasing means adapted normally to maintain said control electrode at a potential such that said amplifier is effectively non-conducting, connections between a second of said sources of power and both said relay winding and said biasing means for causing said single other source of power to energize both said relay winding and said biasing means, a connection between said control electrode and a point on said first named source such that the connection tends to aid said biasing means, said connection including a gap adapted to be bridged by a rectifying impedance, and means associated with said connection and effective when said gap is bridged by a rectifying impedance to maintain said grid at a different potential such that said amplifier is effectively conductive.

19. In combination, an electronic amplifier having a control electrode, a relay adapted to be con-

trolled by said amplifier and having a relay winding and control elements actuated thereby and adapted to control said amplifier, a transformer having a plurality of secondary windings, one of said secondary windings being connected to energize the output circuit of said amplifier, biasing means adapted normally to maintain said control electrode at a potential such that said amplifier is effectively non-conducting, connections between a second of said secondary windings and both said relay winding and said biasing means for causing said single other source of power to energize both said relay winding and said biasing means, a connection between said control electrode and a point on said first named secondary winding such that the connection tends to aid said biasing means, said connection including a gap adapted to be bridged by a rectifying impedance, and means associated with said connection and effective when said gap is bridged by a rectifying impedance to maintain said control electrode at a different potential such that said amplifier is effectively conductive.

20. In combination, an electronic amplifier having a control electrode, a relay adapted to be controlled by said amplifier and having a relay winding and control elements actuated thereby and adapted to control said amplifier, a transformer having a plurality of secondary windings, one of said secondary windings being connected to energize the output circuit of said amplifier, biasing means adapted normally to maintain said control electrode at a potential such that said amplifier is effectively non-conducting, connections between a second of said secondary windings and both said relay winding and said biasing means for causing said single other source of power to energize both said relay winding and said biasing means, a connection between said control electrode and a point on said first named secondary winding such that the connection tends to aid said biasing means, said connection including a gap adapted to be bridged by a rectifying impedance, and means including a condenser associated with said connection and effective when said gap is bridged by a rectifying impedance to assume a charge such as to maintain said control electrode at a different potential at which said amplifier is effectively conductive.

VILYNN O. BEAM.
JOHN M. WILSON.